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QRPp

The NorCal QRP Club ... the QRPer's Companion

From the Editor

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This issue marks the beginning of the sixth year of QRPp and NorCal will celebrate another anniversary of the founding of the club at Dayton. Jim and I will again be in attendance, and NorCal is proud to share a booth again with the G-QRP Club. Please stop by and say hello if you go to Dayton.

NorCal will also sponsor the annual Dayton Building Contest on Saturday night. The judging will begin at 8:00 PM and there will be 3 divisions:

NorCal K8FF Paddles
2N2222 Design Contest
K5FO Unlimited Class

We will award 3 prizes in each classification and if the past is any indication, it will be one of the highlights of the Four Days In May Qrp event. ARCI is officially sponsoring FDIM for the first time this year, and major changes have been made. The price has been dropped from $30 to $10 with ARCI subsidizing the event. I applaud this change, the time has come for ARCI to step forward and sponsor a QRP Forum and they have done so.

NorCal will also make a major announcement at Dayton that will affect QRP world wide. I can't tell you the details in this issue, but full details will be in the next QRPp.

The Tixie, a marriage of the Pixie and the TiCK keyer by Embedded Research has appeared since the last issue. It is a direct result of an article by Chuck Ludinsky that appeared in the Winte 97 issue of QRPp. Brad Mitchell and Gary Diana, of Embedded Research, very quickly developed a board for the article, and they have a kit of a board and a TiCK 2B keyer chip available now.

They are offering the TIXIE board and TiCK keyers as follows:
TIX-1 = TiCK-1 Chip (DIP) + TIXIE PCB - $10 + S&H
TIX-2 = TiCK-2 Chip (DIP) + TIXIE PCB - $12.50 + S&H
TIX-2B = TiCK-2B Chip (DIP) + TIXIE PCB - $15.00 + S&H

Shipping and handling charges for all TIXIE orders is $2.50 within the U.S. and $5 DX.

Please make checks and money orders payable to Embedded Research. All payments should be in US dollars.

The TIXIE PCB is approximately 3" square, and has room for additions and modifications. It has board-mounted audio and paddle jacks, as well as a board mounted switch for TiCK operation. The TiCK chip and TIXIE board also include a copy of the QRPp article written by Charles J. Ludinsky, K1CL, as well as a TiCK datasheet, and some hints on where to get the various parts.

To order your TIXIE , send order with payment to:

Embedded Research
PO Box 92492
Rochester, NY 14692

I am also especially pleased to announce the "Back to the Future" project which will be NorCal's way of honoring Doug DeMaw, W1FB. This issue features 2 projects, the Tuna Tin 2 Transmitter and the Herring Aid 5 Receiver. The next issue will have a matching VFO and Amplifier for the series. Don't forget to stop by the NorCal booth at Dayton to say hello to Jim and I. 72, Doug, KI6DS

The NJ-QRP "MicroBeacon"

by: George Heron N2APB, Bob Applegate K2UT, and Joe Everhart N2CX

INTRODUCTION

At one of our regular show 'n tell meetings not so long ago, some of us NJ-QRPers were brainstorming on what we might do as a follow-on project to our successful Rainbow Tuner kit. Besides looking for a project that would be useful in the shack, this project would need to be instructional for all members wishing to participate in the design, protytping and testing of the project. In fact, we were commenting on how our project might follow "standard phases" that real companies use to develop products.

Well, someone commented on how he'd love to be able to actually work on some of the code that goes into a PIC microcontroller. Another mentioned how he had the start of a keyer code for a PIC. And yet another mentioned that it would be real cool to get a beacon on the air whenever we had a club meeting. VOILA, a club project was born ... the NJ-QRP MicroBeacon!

This "Concept and Requirements" article is the first in a series describing the birth and evolution of the MicroBeacon. Over the coming months we'll be chronicling how the project progresses — from our lively discussion of the requirements up front, to the (hopefully) successful build of multiple units for our members wishing to use the project at the end.

We're not sure if we'll be kitting the project for the general QRP community. Right now it's envisioned as being more of a hands-on club project, but we'll see how we progress and what the general interest level is for others watching us on the sidelines. Who knows, maybe a bag 'o parts and these articles might do for a simple kit.

UNITED WE STAND

The MicroBeacon is a project **collaboratively** designed by our NJ-QRP club members. As a group and over time, we are taking this project through some of the standard "phases" of an industry design: requirements, design, construction, test and operation. We'll have a "project manager" who will be the champion of the overall effort through the phases, coordinating, communicating and arranging the necessary steps along the way.

Any member may be involved in any stage of the project, and he'll be making an important contribution to the hardware, software, construction or testing of the MicroBeacon, typically under the guidance of one of the club Elmers. In fact, any member contributing to the development of the project will be allowed to keep the components for himself at the end, yielding an operational MicroBeacon for his own use! The goal is to have has as many members as possible involved in the project, organized into teams within the different phases. The NJ-QRP members gave a resounding endorsement to this whole approach.

SO, WHAT'S A BEACON ANYWAY??

Okay, here's where we get into some of the nuts and bolts of the product development ... the ***Concept Phase.*** A beacon is a device which automatically transmits a repeating signal, often with predictably varying power levels. The beacon transmission usually contains the callsign, power level being used, and a code word which can be later used to verify successful reception of the signal.

This concept is nice and relatively usable as-is, but not too many hams would be rushing out to build, buy or otherwise operate a beacon ... there's just not that many instances for when you would use one. Perhaps for field measurements for antenna patterns, for propagation studies, or for club meeting events. (This last use is actually a pretty cool idea ... envision a beacon operating during the advertised time of a club meeting, with the club issuing certificates for those who successfully copy the club call on its beacon!)

So what else can you do with a beacon project? Well, let's take a look at the basic blocks of a beacon to better understand what it is — then we can determine other interesting dimensions of the project.

The primary fixed function of a beacon is to transmit a signal with a repeating cycle. The signal consists of an International Morse code character stream with which the processor (using hardware, software, monkeys, whatever) keys the transmitter. In addition, the processor sets an output RF power level by switching in and out sections of the attenuator bank.

We could easily think of designing the project in separate stages or as three distinct modules. We could later design higher quality/resolution components to replace the "basic" ones provided in the original design. We could even provide different types of controllers — fixed hardware, preprogrammed microcontroller, or a flexible and downloadable "firmware" controller. There's LOTS of flexibility in this design!

Now here's a key concept. Understanding that the processor is merely an "pre-programmed keyer", why not extend the functionality of the project to be a memory KEYER as well as a beacon?! "Oh no, YAK" (Yet Another Keyer) ... yaaaawwn. Ahhh, but suppose we open up the software for this PIC keyer! And the design algorithm, flow charts, variable map, timing loops, and everything else that goes into the making of a PIC keyer! Not many vendors (if any at all) do this level of open design. Boy, now THAT would be an interesting twist, and what an instructional value that would be for those of us looking to understand software programming of these cute little microcontrollers, eh?! Plus, if all you're interested in is a keyer for your nifty new NorCal/K8FF Paddles, you're all set with this project. Sure, you could use a simple TiCK chip about the size of your daughter's tooth filling, but this would be **your** software, running on a controller **you** made. Pretty cool.

And the last *concept* of note would be again based on MicroBeacon's modular approach to the design. You could actually construct the Beacon in modular components: plug the controller into your Sierra, OHR or Green Mountain rig; use the controller to key the cute little Micronaught transmitter that fits inside a fountain pen; or use the switched RF attenuator for known micropower level operation of your regular station. Flexibility deluxe!

REQUIREMENTS

A requirements specification is one of the key steps in the evolution of a successful product. It serves as a constant reminder to the designers when they get embroiled in all sorts of perhaps unneeded bells and whistles. And the Requirements also serve as a guide for testing the product at the end of the cycle.

We have a full-blown 15-page set of descriptive requirements for the MicroBeacon, but shown below is a shortened listing of the important ones.

To set the stage ... "The NJ QRP MicroBeacon is a low parts count, low cost keyer beacon with attenuator control of the transmitter's RF output levels. It can be used as a normal iambic keyer with memories during normal operation, or as a short-term beacon which can transmit a message repeatedly at varying power levels."

1. Full iambic keyer support with self

completing dits/dahs and both dit and dah memories. The speed range will be approximately 5 to 40 WPM.

2. Multiple user-programmable memories. Eight memories will be included.

3. An optional computer control port. The beacon can operate without this interface installed.

4. Memories and other beacon functions can be programmed from the computer port or from the paddle.

5. Three programmable output bits shall be provided for control of the RF attenuator. These bits can be controlled from the paddle, from the computer port or from the memories.

7. Ability to auto-replay any of the memories. This is how beacon functionality is achieved.

8. Ability to turn the output ON or OFF directly from a memory. This is used to turn on a solid carrier when operating a beacon.

9. Low parts count = easy construction.

10. Low cost … less than $20 with all new parts, or less than $10 with a reasonably stocked junk box.

11. Printed circuit board construction, as small as reasonably possible using standard (non-SMC) components. The PCB will include appropriate test points to aid in the construction and test.

12. Current draw less than 20ma at 12 VDC for normal operation. The attenuator may require some additional power. QRP/field operation is a goal.

13. The beacon will drive the target rig via an open collector transistor. When "key down," the output will be grounded.

14. Open design. Analysis, design and source code details shall be made available to readily facilitate duplication. Anyone with access to appropriate development tools should be able to improve and/or experiment with our software.

15. A simple user interface, offering as much "soft flexibility" (e.g., LCD display unit) and multi-pushbutton control of beacon functions (keyer speed, memories and attenuator) as appropriate.

16. Adjustable QRP HF transmitter power output controlled by the microcontroller.

17. TBD power levels or attenuation levels. To minimize control leads required from the microcontroller, a maximum of 8 levels is recommended, which could be accomplished with three control leads. Alternatively, two leads could control a maximum of four output levels.

18. Output levels should be stable and repeatable within approximately 1 dB.

19. DC operating power = 12V

20. If a programmable attenuator method is used, SWR reflected back to the beacon transmitter should not exceed 1.5:1 for protection of the transmitter and to ensure predictable output RF power.

21. Small size (no more than a few cubic inches) and light weight (under 1 pound) are desired to facilitate portable operation.

22. A weather cover is desired to allow operation out-of-doors.

PHASING OUT FOR NOW …

The NJ-QRP MicroBeacon has now just completed the Requirements Phase, with the members "approving" the specs at a recent club meeting after iterating the pro's & con's on our listserver for a number of weeks. You can keep abreast of current developments by checking the MicroBeacon section of the NJ-QRP "Online Journal" at http://www.njqrp.org.

We'd like to recognize and thank Bob Applegate, K2UT, our project manager for the MicroBeacon. Bob has been driving the concept and requirements discussion and will be in charge of subsequent phase activities. We'd also like to acknowledge Joe

Everhart, N2CX, our club Elmer, mentor and overall analog and RF design guru. You'll be seeing some superb QRP attenuator analysis coming from Joe in our next installment (options, trade-offs, benefits and drawbacks of different approaches). We'll also see the initial software design construction for the PIC microcontroller. Good stuff!

See you in the Analysis and Design phases next time! 72, George Heron, N2APB, g.heron@dialogic.com

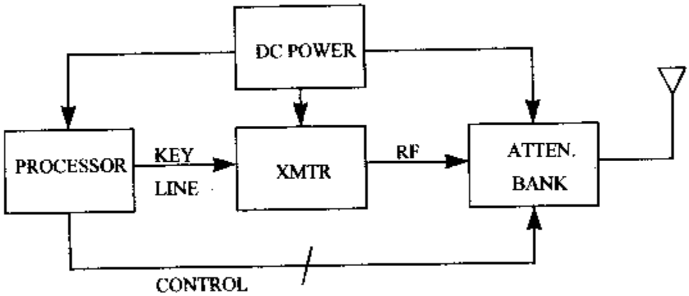

FIGURE 1 - SIMPLIFIED BEACON FUNCTIONAL BLOCK DIAGRAM

Power Amplifier Development with Your Transistors

by Adrian Weiss, W0SRP
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[Reprinted with permission by the author. Originally printed in QST, May, 1976, pp. 25-27.] One of the more exciting phases of ham radio today is the use of rf power transistors in transmitter amplifier stages. Solid-state design has obvious weight and power-drain advantages, especially in gear that may be used for mobile or portable operation. Development of balanced-emitter rf power transistors, virtually blowout proofand superior to earlier types in regard to stability, gave great impetus to use of all-solid-state equimpent in both the hf and vhf stages.

For the amateur who wants to do other than make exact copies of described equiment, a problem has been lack of understandable information that will permit him to work out transmitter designs for transistors he may have on hand or be able to pick up at moderate prices. Even when good information is available, it may be for only the vhf range, or the circuits described may not necessarily be the best available for amateur band use. Unlike vacuum tubes, solid state devices may exhibit wide variations between individual units of the same type. This is in part the result of applications design for top quality production runs intended for military or space use, whereas the amateur may have to contend with second or third level quality. There is also the matter of the practical unreliability of mathematical calculations used in solid state amplifier design. Johnson and Artigo have noted that competent engineering can produce "ball park" errors ranging from -22 to +25 percent between calculated values and those that actually work.[1]

Assumptions

The objective here is to allow the average amateur to circumvent the above obstacles, by placingemphasis on the actual device on hand through in circuit measurements made during amplifier development. The method is based on several general assumptions which will hold in most cases. A reader unfamiliar with solid state amplifier basics is encouraged to study papers by Franson, Hayward, Hejhall, and others.[2]

It is assumed that the base input impedance of the amplifier will be quite low, in the range of 1 to 15 ohms. The input matching network must be able to transform this low impedance to whatever is present at the output of the driver stage. This could be 50 ohms, as in using an amplifier with a separate exciter such as one described by the author in an earlier article, [3] and shown in the photograph, or some higher value if the exciter is to be an integral part of a complete transmitter. A reactive component will be present in the base input impedance, so the interstage matching network must tune the base input circuit to resonance, as well. The amplifier will operate properly only when both conditions are satisfied.

Any balanced-emitter device will have an absolute minimum gain of about 6 dB if operating properly. Efficiency will be 45 to 65 percent. At least 8-dB gain is expected normally. On this basis, the drive required for 10 Watts output is 1.25 Watts. In practice, the writer has found the 2N5590 can be driven to about 12.5 Watts output with 1 Watt of drive. In another application the 2N5590 delivered 5.5 Watts of clean output with only 220 mW of drive about 14 dB of gain. A word of caution is in order here: Maximum efficiency is obtainable only at the collector voltage specified by the manufacturer. Don't expect high efficiency if a 28 volt device is operated at 12 volts.

Practical Circuit Details

Hayward discussed choosing values for the base swamping resistor, collector rf choke, bypass capacitors, and other components of the typical Class-C amplifier. Bearing in mind that these criteria are not official "dogma", the reader is advised to familiarize himself with them. There are several usuable circuits, descriptions of which can be found in the refereences and in the RCA RF Power Transistor Manual. The author prefers the input network shown in Fig. 1, because it will yield paractical component values in nearly all cases.

If the amplifier is to be used with a separate exciter, as in this instance, the input network is designed and adjusted to match the low base input inpedance to 50 ohms, the usual output impedance of such an exciter. Where the amplifier is to be part of a transmitter, the collector circuit of the driver can be connected in place of J1. To provide for matching the capacitors C1 and C2 should be made variable in this case. A better way would be to make a toroidal matching transformer similar to L2, L3, L4, using slight alterationf for this application given under Fig. 1. In the first case there are two unknowns present: The output capacitance of the driver and the input impedance of the amplifier base. This makes optimum adjustment rather complicated, since the output capacitance of the driver stage varies with its collector load impedance. With the tuned circuits in both stages, the driver can be optimized for 50 ohms and will work equally well when the amplifier is installed.

There are additional advantages. The tuned network will provide at least twice the harmonic rejection, and there will be much less loading of the previous stages by the final amplifier. The latter is very important in simple VFO controlled transmitters, where pulling of the oscillator can result in considerable difference in frequency between the SPOT and OPERATE conditions.

The circuit used for the output network is a matter of personal preference.

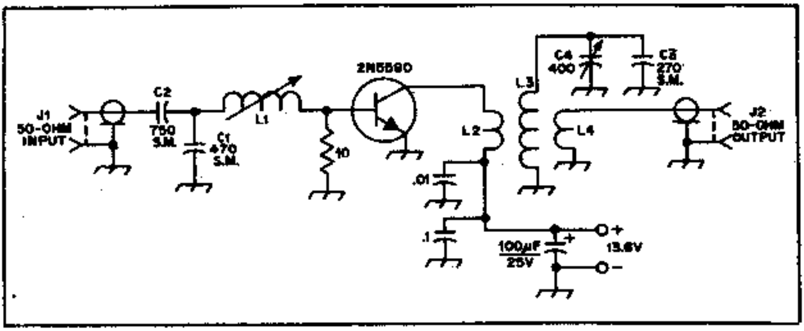


Fig. 1 — Schematic diagram and parts information for the K8EEG 40-meter amplifier. Capacitor values not otherwise marked are in pF. Some parts are numbered for text reference only. All grounds should be made directly to the transistor emitter strip. C1, C2 — Final values given; can be made variable as with C3-C4, for experimental purposes.

C4 — 400-pF miniature trimmer. Small broadcast-type capacitors suitable for low-power applications. See text.
L1 — 9 turns No. 22 enamel, closewound on 1/4-inch dia. slug-tuned form.
L2 — 2.5 turns No. 22 enamel, closewound on Amidon T-50-2 toroid core.
L3 — 13 turns, spaced to occupy entire core of L2.
L4 — 4.5 turns, spaced over 1/3 of core.
In using the toroidal circuit for interstage coupling, make L1 1 to 2 turns for 10- to 40-ohm collector load impedance, and 4 turns for 40 to 80 ohms.

The double link tank shown yielded an efficiency in excess of 50 percent at 7.0 MHz, so it was left in. In a 20 Meter application the efficiency was about 40 percent. Conversion to the network described by Hayward (reference 2) brought the efficiency up to 62 percent.

Test Equipment

Three simple instruments, shown schematically in Fig. 2, were used in the development of the amplifier: A roughly calibrated wavemeter capable of tuning to the desired frequency and to its second harmonic, a power output indicator, and an impedance bridge. The wavemeter, Fig. 2A, was calibrated with the aid of a multi-band transmitter.

The power output meter, Fig. 2B, should be isolated from the transmitter and dummy load by shielding and RFC2. Actual output is obtained by the formula: Power Out = Voltage Squared divided 2 times R1. The meter is used to measure power output from a driver or amplifier stage during develomental work. Remember that it is not frequency sensitive. It will read combined fundamental and harmonic power, hence the need for the wave meter.

The variable impedance bridge, Fig. 2C, is similar to one described by Hayward (reference 2), except that the diode is connected to the arm of a 1000 ohm variable control, instead of the junction of two 470 ohm resistors. The control can be calibrated by connecting fixed resistors of known value across the output. Adjust the control for null, and mark down the resistance value used for that setting. When you want a circuit to look like, say, 70 ohms, you set the control to 70 and adjust the circuit for null. Parts placement is not critical, but it is wise to use short lengths of coaxial line in connecting the bridge into the circuit to be test, and to ground both braids at the same point. If the bridge is to be used only between 50 ohm circuits, coaxial connectors will be suitable, as shown.

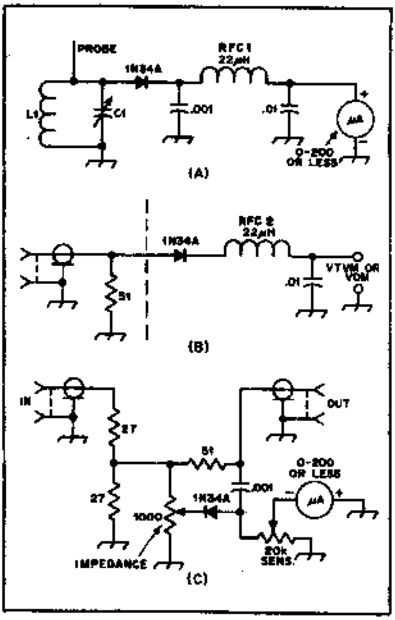
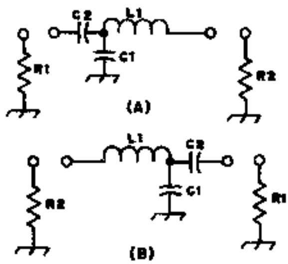


Fig. 2 — Simple test equipment used in optimizing the solid-state amplifier includes a wavemeter, A, a power-output indicator, B, and a variable impedance bridge, C. Values of L1 and C1 depend on the band being checked. Parts designations are for text reference.



$$X_{L1} = Q_L R_2$$

$$X_{C2} = \frac{R_2 (Q_L^2 + 1)}{Q_L} \bullet \frac{1}{\left[1 - \frac{X_{C1}}{Q_L R_1}\right]}$$

$$X_{C1} = R_1 \sqrt{\frac{R_2 (Q_L^2 + 1)}{R_1} - 1}$$

Fig. 3 — Basic circuit for use with Tables 1, 2 and 3. Circuit A, for Tables 1 and 2, shows the network for input matching. B is used in matching the amplifier to 50-ohm output. The formulas are for operating conditions other than those assumed in the tables.

Construction and Testing

Armed with the above assumptions and test equipment, we can monitor several aspects of the circuit operation in the process of getting the amplifier to work properly. This is a rough duplication of the procedure followed in the manufacturer's laboratory in determining the performance characteristics of a device for given sets of conditions. These appear later on a data sheet. Our purpose is not quite the same, in that we are not looking for a set of "numbers." Rather, we seek to take into account automatically the actual characteristics of the device *on hand*, in achieving optimium operation for our application.

An experimental amplifier can be bread boarded or built on a circuit board similar to the one shown. It is recommended that a single parallel tuned circuit be used for the output side of the amplifier during developmental work on the input matching. It can be replaced when the work is completed. Calculated values for both input networks, and the output network, Fig. 3A and B, respectively, are given below for the hf bands.

Table 1

Input Network

R1 = 50 ohms, R2 = 5 ohms Q = 5

MHz	3.5	7	14	21	28
X_{L1} = 25 ohms	1.25	0.63	0.29	0.2	.18uH
X_{C1} = 31 ohms	1400	700	380	260	170pF
X_{C2} = 64 ohms	750	370	180	150	85pF

Table 2

Input network connected to driver stage collector and load impedance of 70 ohms. (1.25 W at 12V DC), R1 = 5 ohms, Q = 5

MHz	3.5	7	14	21	28
X_{L1} = 40	1,25	0.63	0.29	0.2	0.18uH
X_{C2} = 21	1700	1100	580	380	260pF
X_{C1} = 64	750	370	180	150	85pF

Table 3

Output Network, final collector impedance 8 ohms, (10 W output at 13.6V DC), 50 ohm load. (From Motorola AN-267)

MHz	3.5	7	14	21	28
X_{L1} = 40 ohms	2.0	0.95	0.49	0.3	.23uH
X_{C1} = 65 ohms	720	350	175	125	90pF
X_{C2} = 89 ohms	530	260	140	90	65pF

The formulas given in Fig. 3 can be used to calculate approximate values, should the driver stage operate at a different power level or load impedance. C1, C2, and L1 should be variable, to allow for initial adjustments. Inexpensive broadcast receiver capacitors, 365pF, are ideal for tuning. Where higher capacitance is needed, fixed value micas can be connected across the variables. A 40 meter amplifier is shown in Fig. 1 with component values arrived at by experiment, as described below.

Apply at least 500mW of drive to the network through the impedance bridge. The network is adjusted for deepest null, first by C1, where the indication will be broad, then by C2, which gives a deeper null, and finally by L1. This is done with the wavemeter coupled to the final amplifier tank, and the output meter connected to the tank as an indicating load. No dc voltage is applied to the amplifier thus far, as only the feed through eneergy will be monitored at this point. With one watt of drive there should be 5 to 15mW showing on the output meter, when the latter is tuned to the drive frequency. Remove the impedance bridge and repeak slightly for maximum feed-through indication.

Set the wavemeter to the second harmonic frequency. If the drive is clean and the circuits are properly tuned, there should be little or no output detectable at the harmonic frequency. Recheck tuning for minimum harmonic level, if any shows. Optimum adjustment should give maximum fundamental output and rejection of harmonic output.

Apply collector voltage, with no drive. If the transistor is the balanced emitter type, full collector voltage may be used. With other types it is well to start with about 70 percent of the maxiumu. Decouple the wavemeter, in anticipation of the 40-dB increase in power to be expected, and apply drive. Readjust both input and output networks for maximum output and minimum harmonic power. The wavemeter should be coupled to the lead going to the output meter for the latter check, as harmonic currents circulate in the output tank, and coupling to it will give an erroneous reading of harmonice level when the amplifier is running normally. Measure the dc input power and the rf output power and compute the efficiency which should be at least 40 percent. Substitute the double tuned tank circuit for the simple parallel tuned one, if the output is low.

If an external exciter is to drive the amplifier, no further adjustment is required, and the amplifier is ready for service. If you intend to connect the input network directly to the driver collector, the impedance bridge is set to the desired collector load impedance figure (70 ohms for 1.25W at 12V) and adjustment is made for best match. Each of these steps monitors some aspect of circuit operation, using the actual components available, and gives assurance that optimum results are being obtained.

References:

1) Johnson and Artico, "Fundamentals of Solid State Power Amplifier Design, " Part III, QST, April, 1973.

2) Franson, "How to Use RF Power Transistors," Ham Radio, January, 1970. Hayward, "Increased Power for the Solid State

Amplifier, " QST, May, 1972. Lowe, "15 Watt Solid State Linear, " QST, December, 1971. Hejhall, "Broadband Solid State Power Amplifiers,": QST, March 1972. Schoening, "Transistorized Ampliefier for 40 Meters," 73, August, 1964. White, "Thermal Design of Transistro Circuits," QST, April 1972.
Weiss, "Multiband FET VFO QRPp Transmitter, " Ham Radio, July 1972

End-Fed Half-Wave Antennas

by Joe Everhart, N2CX
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Hams in general and QRP'ers in particular are always on a quest to find the "ultimate" antenna. Of course there is no single skywire that fills everyham's needs, but there *is* one type that belongs in the casual portable qrp'ers bag-o-tricks. What I'm talking about is a classic historical aerial, the end-fed half-wave antenna (EFHWA, pronounced EFF-WAA"). It is extremely simple to build put up and use and, in spite of its simplicity, has the benefit of giving repeatable, efficient and effective performance.

Many antennas used for portable operation suffer from lack of effectiveness. That is, they don't produce the number of QSO's expected, as compared to operation from a home location. Most of the time this stems from the fact that the antennas used when going portable are intentionally simple and, because of this they don't put you few watts of where they belong.

One type of "simple" antenna used for portable operation is the vertical antenna. Now a quarter-wave vertical antenna with a good ground system can be very effective. But often portable use dictates an antenna that is not a full quarter wavelength long, and a ground system that is far from optimum. Consider two things: 1.) According to the ARRL Antenna Book, a vertical antenna with fifteen 1/4 wave ground radials may have an efficiency of only 50%. And with fewer radials the efficiency suffers even more. 2.) Efficiencies of short mobile whip antennas listed in the same reference is often only 10% or so - and that is with a car body as a ground plane. With a poorer ground, it is even worse! So, unless you have a full-size vertical antenna with an extensive ground system, you are converting most of your transmitter power to heat, not tickling the ionosphere.

Another popular portable-use antenna is the random length wire, used with a tuner. If done properly, this antenna can be very good. Unfortunately, it can be hard to tell just what "done properly" means. If the antenna is shorter than a quarter wavelength, it suffers from the same efficiency problems as the vertical antenna. Plus, unless you choose the length correctly, the radiation part of the antenna may be at your operating position, wasting power radiating into ground-level surroundings, rather than being up in the air squirting out where it belongs. And, because of the unknown nature of its impedance, the random length wire antenna needs a tuner capable of matching over a wide range of impedances.

One of the best choices for portable operation is the center-fed half-wave dipole antenna. It has the benefit of being very effective and not too difficult to erect properly. On the down-side, it does require end supports at the right spacing and height. And you have to contend with a heavy feedline at the center which has to be brought away from the dipole at right angles or performance will be degraded. Multiband operation is possible, but the best way to do this with a dipole requires an open-wire feedline and a relatively complicated tuner.

Now if you take a half-wave dipole, eliminate the feedline and feed it directly at the end, you have an antenna that has many of the advantages of the dipole with few of the limitations of other portable antenna methods. This antenna has been described in the ARRL Antenna Book and other amateur radio publications for years, but it lately it has gotten little attention. Both NN1G and W1FMR have made reference to it in 72 within the last couple of years, but it doesn't seem to have "caught on" very well.

Without the feedline, the antenna is a snap to put up. More about configurations later, but, freed of the restrictions of the center feedline, the EFHWA fits into situations that would be difficult for the dipole. When erected well of the ground, clear of surrounding objects, it is as efficient as the dipole and it is effective because radiation from it is predictable so that the signal goes where you want it to go. And though it needs a tuner, the half-wave antenna has a predictable impedance so a simple tuner is sufficient.

Also, because it is only a single wire with a couple of insulators (and a simple counterpoise), the EFWHA is lightweight and small so it is easy to store and transport - things to consider for portable use. Since it doesn't have to support a center feedline, physical strength is not an issue. A temporary portable antenna can use ordinary small diameter stranded hookup wire and insulators made of scraps of Plexiglass or small sections of PVC pipe. The whole "shootin' match" will fit inside a zip-lock plastic bag and fit in a coat pocket!

The total overall length of the EFHWA is an electrical half wavelength, calculated from the formula L (Ft) = 468/F(MHz) where L is the overall wire length in feet and F is the desired operating frequency in Megahertz. This is the length of wire right from the tuner terminal to the insulator at the far end. The formula is approximate, taking into "end" effect which makes the antenna shorter than a half wavelength in free space. Extreme accuracy isn't necessary, since even the simplest tuner will make up for inaccuracies of a five percent or so. (Actually, the end impedance approaches infinity at exact rsonance, so making the wire slightly longer than exactly a half wave allows it to be matched to 50 ohms without heroic measures.) Additionally a wire that is close to a multiple of a half wavelength has the same impedance characteristics, so, for example, a wire cut for 40 meters will also be useful on 20, 15 and 10 meters with a suitable tuner.

As mentioned earlier, you can put up your wire in a number of different ways. Probably the most common method is to make it an inverted L as shown in Figure 1. The antenna wire is stretched vertically as high as possible from the operating position, then horizontally to make up the remaining length. This is usually the most practical way to put up the antenna for 7 MHz and below because of the lengths involved. If supports are available, one useful way of arranging the "L" is to make half the length vertical and the remainder horizontal. Since radiation takes place in the middle of a half-wave antenna, this gives a combination of vertical and horizontal polarization to cover both local and distant propagation.

Another method is the inverted "Vee" as in Figure 2. This is really the same as the inverted Vee dipole often used with center-fed antennas. As with center-fed inverted Vee dipoles the center should be as high as possible limiting its usefulness to the lower frequency bands. And there, the center should be no less than 20 feet or so above the ground or the antenna will waste its power on heating earthworms.

A sloping wire as illustrated in Figure 3 is very convenient to use, particularly on the amateur bands above 7 MHz, where lengths are shorter. It needs only one high support and, if that one is high enough, puts the radiating center portion of the EFHWA fairly high in the air. The more vertical the antenna becomes, the lower its radiation angle, making it useful for distant contacts. Radiation tends to favor the direction of the slope.

Taking the sloper to the extreme limit results in a vertical antenna (Figure 4). When the EFHWA is used vertically, it suffers few of the shortcomings of shorter vertical antennas. With its high feed-point impedance, its efficiency is not dependant on an extensive ground system. And since the radiating portion of the antenna is well above ground, it is not wasted by absorption in foliage or buildings. It has a very low angle of radiation so it is most effective for distant contacts.

The EFWHA can be used as a "stealth" antenna for use in motels or in houses or apartments where antennas are discouraged or prohibited. The wire can be sneaked out an upper story window and run horizontally to a convenient tree or other structure. Small diameter wire 20 feet in the air can be very difficult to see unless you know just where to look. W1FMR has reportedly reduced this art to a science.

Making use of the fact that a half-wave wire is also resonant on its harmonics, an effective 7 and 14 MHz antenna can be made. A 14 MHz half-square antenna (see Figure 5) can thus be used on 7 MHz as well. On 14, it has a low angle radiation characteristic at right angles to the long side of the horizontal section for dx. And on 7 MHz, it is an end-fed half-wave with a horizontal mid-point for high angle close-in contacts. With a good ground system the antenna could also be used a compromise quarter-wave (Marconi) antenna for three-band usage.

While the EFHWA does need a ground connection, it need not be very complicated. The ground or counterpoise connection simply acts to decouple the tuner and rig from the antenna system by providing a path for ground current. A quarter wavelength wire (half the antenna length) laid out along the ground or tucked out of the way is adequate. Outdoors either the counterpoise or a short jumper to a large metallic structure such as an automobile or camper works, too. When on end of the antenna is indoors such as in a motel room, a heater radiator or air conditioner can be pressed into service. Try whatever ground you have to see if it works. If find hand capacitance effects with your tuner or if you have a "hot" chassis on your rig, try the quarter-wave counterpoise wire to cool things off.

Tuners for EFHWA use are a snap. While common commercial wide-tuning range units can be used, a simple parallel tuned circuit is adequate. Figure 6 shows the schematic diagram for the tuner portion of the Rainbow Bridge/Tuner, co-winner of the 1996 NorCal design competition. Tuning both 30 and 40 meters, it uses a single toroidal inductor with an inductance of about 6 microhenries and a mica compression tuning capacitor with a minimum/maximum range of about 20 to 100 picofarads.

The antenna and ground are connected across the tuned circuit while a 50 ohm coaxial cable is connected to taps on the inductor. The tuned circuit presents a high impedance to the antenna, while the tapped inductor steps this impedance down to 50 ohms. Adjusting the tuning capacitor tunes out slight reactance variation if the antenna is not an exact electrical half wavelength.

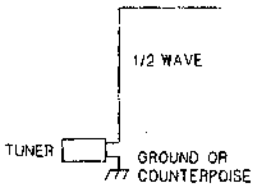

FIGURE 1 - INVERTED L

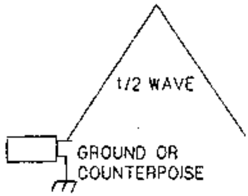

FIGURE 2 - INVERTED L

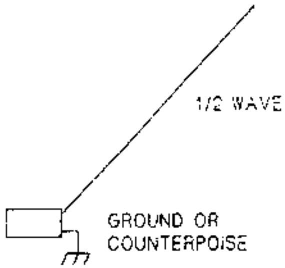

FIGURE 3 - SLOPER

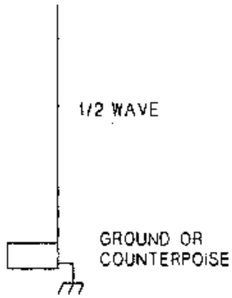

FIGURE 4 - VERTICAL

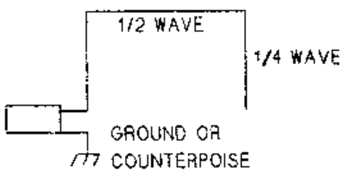

FIGURE 5 - HALF-SQUARE

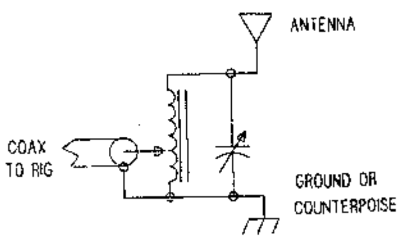

FIGURE 6 - SIMPLE TUNER

The tuner is adjusted by tuning the capacitor for lowest SWR. The correct tap position is determined by changing taps until the SWR is below 1.5:1. With the values shown, the tuner will cover 30 meters with a 46 foot antenna or 40 meters with one about 67 feet long. The tuner has been operated at power levels up to 5 watts although it would probably be adequate for several times as much. Simple scaling of the coil and capacitor values will allow used on other bands as well.

Other tuners have been described in amateur radio literature with a variety of construction ranging from large air-wound inductors and high voltage capacitors to tuners with a capacitor house in a plastic 35-mm film canister with the coil wound on the outside.

I urge you to try the EFHWA for portable QRP hamming. It is truly a minimalist antenna with maximum performance. 72/73, Joe E., N2CX

Application of the Blue Sky Engineering, K1MG Digital Clock /Counter Kit

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The K1MG Digitial Clock/ Counter (DCC) kit is a low internal frequency, counter and 24 hour clock designed for installation within or for use with kit / home built and other radios which can benefit from a frequency counter. This discussion will be based upon the application of the DCC to provide a more accurate frequency display for use with my Tentec Century 22. The DCC is capable of directly measuring and displaying frequencies of up to 32 MHz and the VFO measurement may be combined with up to 31 offsets for use with multiple band rigs. The resolution of the DCC is 100 Hz.

The Tentec Century 22 (C22) doesn't have an external VFO output. This was implemented by taking one of the two auxilliary power 12V phono jacks and removing the power connection. This jack was then fed a signal from the PTO (VFO) by soldering a length of RG-174 from the PTO output to the center pin of the phono jack. The remaining 12V aux. jack was used to power the DCC. The C22 is a double, direct conversion rig that mixes the VFO frequency (6.5 to 6.0 MHz) with the output of a fixed frequency crystal oscillator to develop the operating frequency. Thus, to accurately display the frequency, it is necessary to measure the VFO frequency and subtract that from the crystal oscillator frequency.

I installed the DCC in a small Radio Shack enclosure (P/N 270-233). Basically any enclosure that is about 5" wide, 2.5" tall and 1.75" deep or larger should work. If you only intend to use the unit for a single band, a smaller enclosure will suffice since you won't need room for a band select switch. You should mark the holes and display opening using the circuit board before it has been stuffed. Though the DCC is also intended for installation within a rig, an external enclosure works quite well.

Construction:

The next phase of the project is building the DCC. Mike Gipe, K1MG, the designer of the DCC includes a detailed instruction manual that provides step by step assembly instruction as well as detailled instructions for use of the DCC. Note, it is advisable to read the introductory materials (i.e. the section entitled "Construction

Options") since this may impact how the DCC is assembled. Although quite small, assembly is not difficult due to the breakdown of the assembly into reasonable page by page increments. A soldering iron with a very fine tip will help make it easier, particularly with the large IC and the LCD display. The instructions also include an intermediate testing step to insure that the initial assembly has proceeded correctly.

The final phase of the board assembly is the installation of the LCD display and the control switches. With this step be very careful not to mount the LCD too close to the board since it may damage the display or short some of the leads protuding from the board. If soldering the LCD to the board, suggest that you also apply a couple of strips of electrical tape to the back of the display to provide some additional protection. If you anticipate that you will want access to the rear side of the board (though not needed), you may want to consider installing two 20 pin SIP machine pin sockets to receive the LCD display. Though not provided, these are available through Mouser, Digikey and Allied. Note that socketing will affect the height that the push buttons need to protrude above the board.

Interfacing:

The DCC has 2 push buttons switches that are installed to select the display mode (Khz display (default), MHz display and 24-hour clock display). These switches are normally push buttons mounted on the front (LCD) side of the board. The board also has space for 2 more, rear mounted push buttons that are used for setting the frequency and the clock (Up/Down).

The DCC provides for two power sources: A main power source (i.e. 8V to 18V) and a 6V battery backup supply. The 6V backup battery can be a 6V lithium photo battery or 3 to 4 size AAA cells. The backup battery is only needed if you intend to use the clock feature. It is not needed for the unit to remember the offset frequecies: These are written into the uP memory within a few seconds after you have set a new displayed frequency.

In addition to the battery/main power inputs and the frequency (VFO) input, the board has 5 digital inputs for selection of the 31 offset frequencies. The offset select lines are internally held high. The offsets are are "selected" by grounding combinations of the individual select lines. Although 5 bits of data would normally represent 32 different choices, the 32nd position (represented by 11111 or none of the lines grounded) does not provide for offset storage. Because of this, even if you only want to use the counter for a single band rig, it will be necessary to ground at least one of the select lines in order to store an offset.

In my application, I found a 4 bit (gray code) non-detented rotary encoder that enabled me to have 15 or 16 different offsets. (CTS Series 288 Rotary Encoder, Digikey P/N CT3003-ND, $3.35 each). The gray code is a switch code that provides 16 unique combinations of the 4 bits but it is not in the normal hexadecimal sequence (0000, 0001, 0010, 0011, ...). However, as long it provides unique combinations for each position, the sequencing of the bits is irrelevant. It is important to note the position where none of the lines are grounded: You will not be able to store an offset in that switch position unless you have grounded the fifth select line. The encoder has two sets of three contacts: The two center contacts of each set are connected together and grounded and the remaining 4 contacts are connected to 4 of the 5 select inputs.. Some users will want to use a select line for switching between different offsets for receive and transmit. With this switch (encoder), I set the switch to the same angle / orientation as the band switch on the rig so that it will display the Khz portion of the output with the rig's band switch representing the MHz.

An alternative to the rotary encoder would be use of a single pole, multiple position switch and a CMOS encoder chip (i.e. a 74HCT147 10 to 4 line priority encoder). Be sure that the voltages from the CMOS chip are not higher than the supply voltage on the DCC. A CMOS encoder is recommended since a TTL encoder would require pull-up connections on the output lines. This approach is not as elegant as the rotary encoder above but it will allow use of conventional rotary switches or for installation and switch position sensing within a rig.

The measured frequency may either be added or subtracted from the stored internal offset frequency to yield the display frequency. Note, it is not necessary to input the specific offset frequency. The DCC will automatically store the offset frequency by setting the displayed frequency to the known frequency of operation.

The DCC was installed in the RS enclosure by attaching the DCC onto the aluminum panel of the enclosure using 4 size 4-40 screws. I used a scroll saw to make easy work of the display opening though a nibbling tool will also work well. Mike recommends that small diameter spacersbe used (instead of nuts) to hold the board off of the panel since there is not much clearance around the 4 holes at the corners. I used a phono jack (RCA style) for the external power connection and a 1/8" mono phone jack for the VFO signal, both mounted on the rear of the enclosure. The top of the enclosure has the up/down push buttons.

Once installed in the enclosure, the DCC is calibrated by adjusting a variable capacitor on the rear of the DCC board so that the measured frequency is in agreement with the displayed frequency. Mike recommends use of a 30 MHz signal for the calibration step and to be sure that none of the offset selection lines are grounded when performing the calibration. Once calibrated, button up the enclosure, attach it to your rig and a power source. Set the offsets by setting the displayed frequency on the DCC to match known operating frequencies (i.e. WWV, CHU, W1AW code practice frequencies) and after moving the switch to the position which corresponds to that band. When you have set the frequency, don't move the band select switch until the display shows " - - - - " which means it is writing the offset to memory; otherwise you will need to reset the offset.

Some additional wrinkles to consider are: Instead of using the two push button switches on the front for selecting the MHz or clock modes, use a miniature SPDT (or DPDT) center off switch. This allows you to set these modes (or leave the DCC in these modes) without having to hold down the button.

I recommend that you seriously consider Mike's suggestion that the up/down setting push buttons be located on the outside of your enclosure. If you have a lot of offset frequencies to set, it can be quite awkward to set these when having to use the buttons on the rear of the DCC. The next one I build will only have externally mounted switches. Note, push buttons should be used for the up/down switches (not a center off SPDT switch) since selection of frequency addition or subtraction modes is toggled by pushing the up and down buttons simultaneously.

Mike has a number of suggestions for options which can reduce the current drawn by the DCC (normally at 17 ma in operation). One additional suggestion is the use of a low dropout, low quiessent current regulator. Examples of these are the LP2950CZ-5.0 and the LT1121CZ-5. The LP2950CZ-5.0 is available from Digikey, P/N LP2950CZ-5.0-ND. $2.42 and Allied Electronics, P/N LP2950CZ-5.0, $1.59 (Unfortunately these companies have $25 and $50 minimum orders). The LP2950-5 is directly pin compatible with the 7805 regulator (the LT1121CZ-5 is reversed) but it should also have at least a 1 uF capacitor across the output to prevent oscillation. The 3.3 uF capcitors (C1, C8) provide this needed capacitance. A capacitor directly across the LP2950-5 will adversely affect the output voltages in this application. Refer to the ARRL's QRP Power book, pg. 3-12 (Kleinman, Lau; 1996) for additional discussion.

The Digital Clock/Counter kit is available from Blue Sky Engineering Company; 400 Blossom Hill Road, Los Gatos, CA 95032. The current price of the kit is $29.95 plus S/H and any applicable taxes. Contact Mike Gipe via e-mail at: Mgipe@reliablemeters.com. Much of the DCC details provided above are from the K1MG DCC kit manual, Michael A. Gipe (1997). I found Mike extremely helpful in solving any problems encountered.

73 (es 72) de N9WR, Don

The N7RI *Un*optimized 2n2222 DSB TX

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Have you ever thought about building a simple QRP phone transmitter? I've long wanted to build one of those simple double sideband transmitters found in Doug DeMaw's QRP NOTEBOOK, Wes Hayward and DeMaw's SOLID STATE DESIGN and elsewhere. The Norcal 2N2222 competition seemed like a great opportunity to try it. I have no formal background in electronics, but I knew that I could post questions to qrp-l and be sure of getting help.

Realizing that I was going to have to use circuits designed for other transistors, I decided to actually *read* the first chapter of SOLID STATE DESIGN. The small-signal model presented cuts through the bewildering tangle of information in a transistor data sheet and tells us that, for purposes of small signal amplification, NPN silicon transistors are pretty much equivalent. Some have more gain than others, or can handle more collector current, or higher drive levels. I breathed a big sigh of relief! No real redesigning of low level circuits would be needed, so long as I used circuits originally designed for NPN silicon transistors. By sticking to HF, I wouldn't have to worry about the relatively low fT of the 2N2222 transistor. Now what about the power amplifier?

Help on this question came from a qrp-l discussion of an idea due to W1FB, who simulated RF power transistors by paralleling 2N2222s, adding 1 ohm ballasting resistors to the emitters of the 2N2222s. With this piece of information, I was ready to start piecing together a transmitter.

I decided to start with a final amplifier. If I could get a watt of output with 2N2222s, I might have a fighting chance of making some phone contacts. And if I couldn't get the DSB circuits to work, at least I could drive the amp with an oscillator, and work cw!

One priority was to build a circuit as free as possible from spurious emissions. Even a QRP sideband rig can generate a lot of splatter. Just ask AA6UL about his 5W sideband rig. One year, his splatter singlehandedly wiped out the entire Zuni

Loop Field Day operation on all bands for nearly two hours. Rumor has it that he changed his call and moved out of state — to Virginia, I think.

Since Class A amplifiers are noted for low spurious output, I imitated the Class A linear power amplifier for the WA7MLH DSB transceiver, described on p. 202 of SOLID STATE DESIGN (1986), simulating the 44C6 transistor with paralleled 2N2222s. The WA7MLH amplifier is designed for a standing current of 250 ma and an output of about 1 W PEP DSB. I started with four 2N2222s in parallel. With an ammeter in line with the collector, and no drive applied, I watched the idling current hit 250 ma and keep on going, and felt the 2N2222s getting quite hot. After adding a 100 ohm collector resistor, the transistors were still quite hot, so I added four more transistors, for a grand total of EIGHT parallel 2N2222s. Now the 2N2222s were much cooler, and the idling current stabilized. I dropped the collector resistor down to 30 ohms, and the idling current rose to a steady 240 ma, just 10 ma less than the idling current of the original WA7MLH Class A amplifier.

To drive the final, I decided to build a copy of the linear RF amp that W1FB uses at the end of the DSB generator he displays on p. 139 of the QRP NOTEBOOK (2nd Edition, 1991), replacing the 2N5179 with a 2N2222. With a crystal-controlled 2N2222 oscillator connected to the the input of the driver, I measure about 2 watts of output from the final. (The VXO has strong enough output to drive the amplifier out of Class A. See below.)

Convinced that I could actually produce enough RF to be heard, it was time to begin construction of the audio and modulator circuitry. I found a 2N2222 mike preamp circuit on p. 60 of UNDERSTANDING AMATEUR RADIO (1977), and soldered an electret mike element to the input.

My past experiences with homebrew balanced modulators had been disappointing. I hadn't been able to detect ANY carrier suppression. My guess was that the modulator hadn't been adequately isolated from the oscillator. This time I put the modulator on a separate board, and used miniature coax to join them.

Bingo! A dramatic dip in carrier strength (from 10 db over 9 to S6 on my ricebox meter) now occurs as the balance pot is adjusted. Do you think it helped that I used hot carrier diodes hand matched by Dan himself? I don't know, but I like to think so. I used half of one of Dan's DBM "kits" to make the modulator.

With only one stage of amplification between the balanced moldulator and the final, I could hear audio with my ricebox, but there was not even a trace of wiggle in the power meter, and no hint of feedback, even with the electret mike element a foot away from the ricebox speaker. So I inserted another amplifier stage (exactly the same circuit) between the modulator and the final. Now I got plenty of feedback, but still no needle wiggle from the power meter. OK, how about ANOTHER copy of the driver stage? (In fact, W1FB daisy-chains four of these amplifiers to form a broadband amplifier strip on p. 135 of the QRP NOTEBOOK. I have omitted the 4:1 broadband matching transformers between the stages.)

With three driver stages, I got needle wiggle! I have no way to measure PEP DSB output directly, but judging by the wiggle of the power meter while hollering 'Hola!', I'd say it's somewhere near a watt. This is confirmed by indirect measurements. If my reading of SOLID STATE DESIGN is correct, and the final is operating in Class A, it's maximum efficiency is 50% — and more likely somewhere around 30%. The best possible output is

50% - and more likely somewhere around 30%. The best possible output is 50% of the the DC power the final consumes when idling. The measured idling current is 240 mA, and the voltage between collector and emitter is 6V. So my best possible output (if I'm not overdriving the final) is 50% of .24 amp x 6V or 720 mW.

It was time to put the little DSB transmitter to the test. My dipole, which had come down several days before in a wind storm, had to be hoisted back up into the trees. Kim, KD6WJK, helped me get the ends back up to 40+ feet, but, as darkness fell, the center insulator was still trapped by a branch at 20 feet. That would have to be good enough. That night, I replaced the VXO used for testing with my W1FB Universal VFO for 40M. (This is not a 2N2222 circuit. I have yet to build a 2N2222 VFO - and receiver!)

At 8:45 AM the following morning, N2LTW in New Jersey gave an east coast call for check-ins for the North Central Amateur Radio Service (North CARS) net on 7240. I hollered my call, and he acknowledged the 'N7', but couldn't get the rest. "Wait a few minutes and we'll try it again. Conditions are improving by the minute!"

My 8 paralleled 2N2222's, soaking up 240mA standing current in class A, squeezing out less than one watt double sideband, had been heard!!

At 9:15 AM, N2LTW called again for "the N7". This time, Jim copied my call, name, weather report (this is a road and weather net) and "homebrew one watt double sideband". He relished the latter fact, and conferred upon me "paid-up life time membership in North CARS"! This ranks right up there with my "lifetime honorary membership" in the Mississippi QRP Club, obtained as a result of a 49er QSO with one of the founders.

To squeeze out a little more power, I dropped the collector resistor to 10 ohms. The standing current rose to 500 mA, Vce increase to 7.6V, so my ceilingoutput is currently nearly two watts. Needle wiggle has increased proportionally. The 2N2222s are now hot to the touch during transmit. For the moment, my heat sinks consist of lengths of desoldering braid molded to fit, soldered, and afixed to each 2N2222 with heat sink compound. One QRP-L correspondent suggests drilling out a small aluminum block and inserting the insulator wrapped metal cans. Currently my transistors are in the oversized transistor sockets recently on sale from Dan's Small Parts. I also have plenty of spares on hand.

Running at this power level, and riding a crest in long wave QSB on 40 M at about 11:00 AM, I reeled in an S7 report from Jim AB4CZ in Atlanta, Georgia, who was interested to hear about the 2N2222 competition, and asked about the circuit design. He also very graciously offered to find my address via the internet and send a QSL card.

Let me emphasize that this is purely an experimental circuit pasted together by a rank amateur. It is in NO way optimized! For example, no attempt has been made to match any of the circuits. An easy first step in improving the performance would be adding a mic gain pot and an amp gain pot for the RF amplifiers (W1FB uses a 1K pot in the emitter circuit of the second stage).

This 2N2222 project has taught me that a person with very little back ground in electronics, and no test gear beyond a VOM, wattmeter and a receiver, but who has a willingness to read and to experiment, can have a heck of a lot of fun building gear from scratch and operating it. 72, Ralph, N7RI

Putting the Pixie on 20 and other Pixie Tweaks

by Charlie Panek KX7L
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The increase in sunspot activity motivated me to modify the Pixie QRP transciever developed by WA6BOY (1) and put it on 20 meters. Along the way, I added a few other enhancements to the little rig to make it more enjoyable.

I recently became re-acquainted with the world of QRP, after a hiatus of many years in QRO land. I surrendered to the irresistable bargain of a '38 Special kit, and had some very pleasant QSO's with it while on summer vacation. This, in addition to seeing solar flux numbers above 100 again, got me to thinking about putting a simple QRP rig on 20 or 15 meters. Most of the really simple designs I'd seen, however, were for rigs on 40 or 80m. Not having a tremendous surplus of spare time, I needed a simple design to mess with. The Pixie caught my eye in that regard. How could it get much simpler?

The only part of the Pixie design that really needs to change for 20m is the output matching network/low-pass filter. As a starting point, I took the values for L3, C6 and C7 that the late W1FB used in his version of this design, and scaled them by 7/14. Picking the nearest standard values resulted in the output network of Figure 1. C6 is now 220pF, C7 is 330pF, and L3 is 0.56 uH. Testing on the bench confirmed that these values are indeed optimum for maximum power output.

The other critical component to change, of course, is the crystal. Here, I got lucky. My first attempt to get a reasonably priced crystal for 20, from Dan's Small Parts, fell short. He had sold out and was temporarily out of stock. Then through the miracle of the internet, I found that John, VE6XT had a new 14.060 MHz crystal languishing in his drawer. And he was willing to part with it! A few days later, and an envelope from Canada put me on the air with my Pixie.

Up till now, my tinkering with the Pixie had just involved testing on the workbench. Now I hooked the rig up to headphones, a 9 Volt battery, and a real antenna and... Music! What's this? Really LOUD music to boot! A few minutes of listening confirmed that it was a local AM broadcast station. Now this station is at least 10 miles away, and definitely not in the 50 kW class, so I can only assume that if I have problems with BC interference, so will most other hams in all but the most rural areas. Not wanting to completely redesign the output network, I came up with a "quick fix" that seems to work quite satisfactorily. 12 turns of wire on a T-30-6 ferrite core will resonate nicely with a 220 pF capacitor at 14 MHz. This high-Q resonator is then coupled into the antenna circuit with a 3 turn winding on the toroid. The result: the AM broadcast station was either eliminated or reduced to a whisper (depending on band activity). As an added bonus, transmitter harmonics also dropped significantly.

Listening to the QRP frequency with the rig on a busy Saturday afternoon presented another problem though: There was just too much coming through the headphones! Maybe I've been spoiled by too many years of listening to commercial rigs with crystal filters, but between the RTTY signals up 10 kHz and the QRO ragchews *down* 10 kHz, there was just too much high frequency squeaking in my ears. A closer look at the design revealed why. The LM386 is designed as a audio amplifier for portable radios, tape players and such where something like high fidelity audio is desired. As used in the Pixie, it does indeed offer that, giving a flat frequency response from below 50 Hz to above 20 kHz! Further perusal of the data sheet for the LM386 uncovered a circuit labelled "Amplifier with Bass Boost". Perhaps it would be possible to add some filtering to help my ringing ears without complicating this little rig too much!

Adding a 2k resistor in series with a 6800 pF cap between pins 1 and 5 of the amplifier effectively reduces its gain at high frequencies, by paralleling the 2k ohm resistor with the internal feedback resistor of 15k ohms. At low frequencies the impedance of the 6800 pF cap is high enough so that gain is determined by the 15k ohm resistor. Additionally, I changed C9, the 10 uF cap between pins 1 and 8 to a value of 4.7 uF. This moves the low frequency roll-off of the gain up more into the communications audio range. In addition, I changed C11, the 10uF output coupling cap to 1 uF. Here, you may need to use your judgement. If you intend to drive a speaker, or low impedance headphones, this may reduce the low frequency gain too much, and you may want to stick to 10uF. With my 500 ohm headphones, all of the above changes resulted in a -3dB bandwidth from 200 Hz at the low end to 1.6 kHz at the high end.

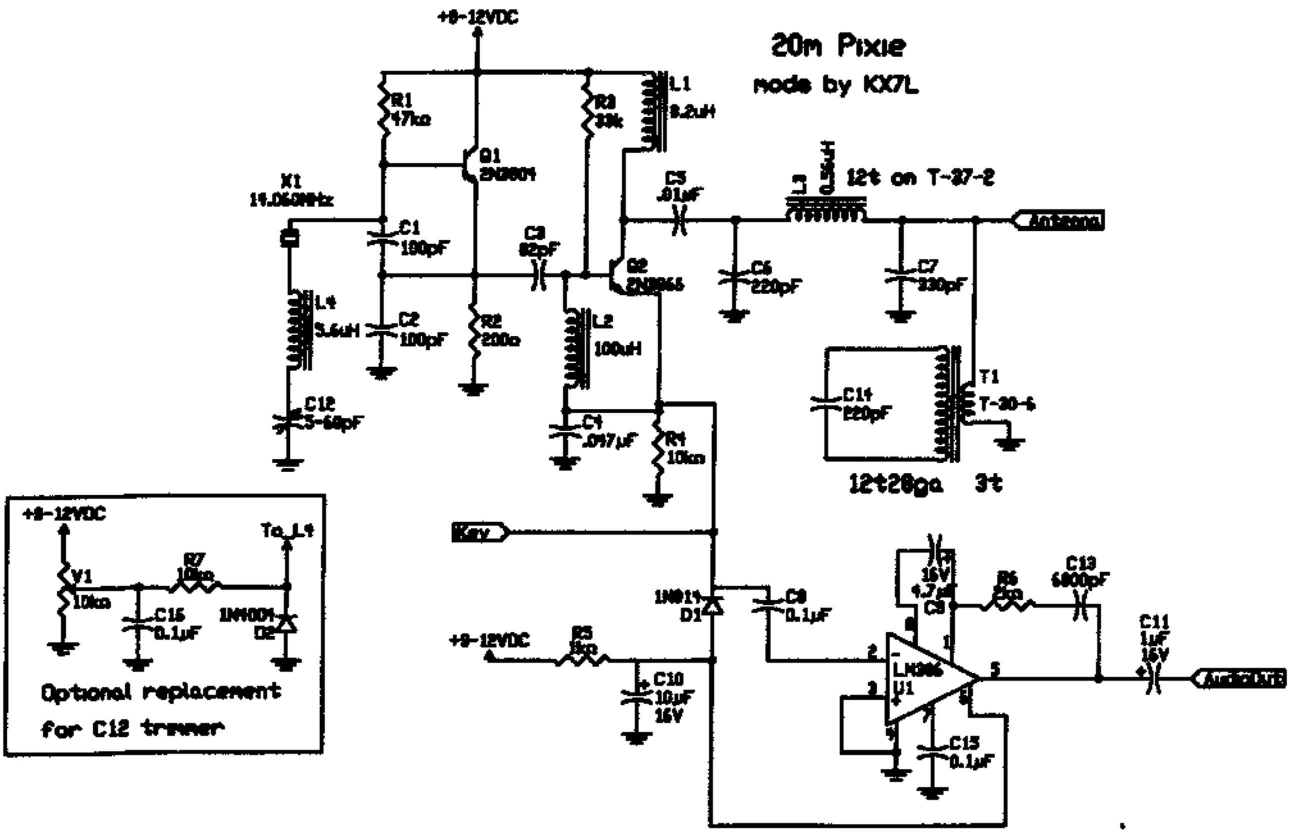
As one who has chased DX for many years with "just" 100 watts and wire antennas, I've always been a believer in the power of answering a CQ on exactly the frequency where the other guy is listening. This prompted me to try to put some sort of VXO circuitry in my Pixie. Since one can generally "tune" a crystal oscillator more if the crystal is at a higher frequency, I had hopes that I could get a usable tuning range out of a 14 MHz rock. Luckily, the Colpitts oscillator used in the Pixie lends itself readily to a VXO circuit. Simply lifting the ground lead of the crystal, and putting a 5.6uH molded choke and a small trimmer cap in series with that lead did the trick. Using a 5-60 pF ceramic trimmer I was able to tune from 14.050 to 14.062 MHz.

In measuring the frequency range of the VXO, I also noted an added benefit. When going from receive to transmit, increased loading on the oscillator causes its frequency to shift upwards about 250 to 350 Hz. It's not quite as much offset as I'd like, perhaps, but I can use it to my advantage, if I remember to tune on the low side of the station I'm calling.

There was one drawback to the VXO circuit as I implemented it. The ceramic trimmer capacitor I used has a riveted connection for the rotor, which generates a moderate amount of electrical noise when it is turned. Use of a larger, higher quality variable capacitor should help this situation, although it rather ruins the tiny size of the rig.

Another option for the VXO is to replace the trimmer cap with a "varicap" and a potentiometer. This does work, although the oscillator output level drops still a litte more, and the tuning curve I got was somewhat bizzare: fairly fast at either end of the pot, and the tuning actually changed direction near the middle of the tuning range. (i.e. the frequency went down and then back up again as the pot was advanced.) I think this may be due to the non-linearities of the diode, and the rather large signal nature of the signal across it. But it worked well enough to resist further complicating the rig.

There's no free lunch, however. With the VXO circuitry installed, I noticed that my power output had dropped to below 50mw! Now QRPp is a great thing, but I was hoping for more power output than that! I suspect that the addition of the choke and capacitor reduces the Q of the oscillator, and thus its output amplitude. Reducing the emitter resistor, R2 from 1.5k down to 200 ohms helped to bring the out-


20m Pixie
made by KX7L
+9-12VDC
R1
47kΩ
Q1
X1
14.060MHz
C1
100pF
C2
100pF
L4
5.6uH
C12
5-60pF
R2
200Ω
C3
82pF
R3
33k
L1
8.2uH
Q2
L2
100uH
C4
.047µF
R4
10kΩ
C5
.01µF
L3
0.56uH
12t on T-37-2
C6
220pF
C7
330pF
Antenna
C14
220pF
T1
T-30-6
12t28ga 3t
Key
1N914
D1
C8
0.1µF
+9-12VDC
R5
1kΩ
C10
10µF
16V
16V
4.7µF
C9
R6
C13
6800pF
C11
1µF
16V
LM386
U1
C15
0.1µF
+9-12VDC
To L4
V1
10kΩ
R7
10kΩ
C16
0.1µF
1N4001
D2
Optional replacement
for C12 trimmer

put level up. I was still seeing less than 200 mW though, so I replaced the 2N3904 at Q2 with a 2N3866A that I had lying about, and changed L3 (the output filter inductor) from a molded choke to a powdered iron toroid (12T on T-37-2). Now power out was around 250 mW. (1/2 watt at 13V) Much better! It should be noted that the gain of the transistor stages is set by the beta of the individual transistors, so if you can "cherry pick" a particularly hot pair of devices for Q1 and Q2, you can make quite a difference in the output power.

Finally, it was time for a QSO with this little rig. So one afternoon, I was able to get a little "shack time" and started listening around 14.060. After a couple unsuccessful attempts, I heard a fairly strong station calling CQ, so I gave him a call. He came right back with a 599 report! Wow! But then he gave his QTH as Woodinville, WA. Only about 10 miles away. Oh well. Still, I had a nice QSO with Alan, KB7MBI, and he reported a good sounding signal from the little rig.

I've really enjoyed building and tinkering with the Pixie. I hope that it will motivate others who may not have the time or inclination to tackle a more ambitious design project, to put together a simple rig like this. Nothing matches the feeling of accomplishment of going from a handful of parts, to a QSO in just a day or two! 72, Charlie, KX7L

WE6W Contest Pixie

by Ed Loranger, we6w
we6w@qsl.net

Back in April, 1997, I found this neat little transceiver during a internet search on the computer. Pixie2. Neat, I thought, who would believe that with two transistors and an LM386 audio amp IC, you'd have a transceiver?

It was my first-ever rig. But I treated it like a toy, and as a QRP greenhorn, I treated the Pixie2 more as a 'Remote Practice Oscillator', than a "real" rig. As 1997 progressed and I learned what QRP really meant, the Pixie2 was no longer a toy. I no longer hoped for a contact -- I expected it.

Then came the Xmas 1997 "Pixie/40-9er Contest". That's when it hit me, why not build one just for the contest? Make it RF tight, eliminate the annoying broadcast AM station interference, and really build a performer?

So my Christmas Contest Pixie2 was born. And a whole 3 days until the contest! No problem. One look at the schematic and you'll see this ain't no normal bred pixie. Shielding is prevalent, mini-coax feed between stages, extra RF bypass capacitors, and 5 millihenry ferrite chokes strategically placed to minimize AM BC interference. Ferrite beads, even a little one transistor audio pre-amp.

CONSTRUCTION

Everything is junkbox except the coaxial power jack I picked up at Radio Shack. I was careful in construction. Prefering the "ugly" method, I decided I would build the rig from left to right and keep all leads short and near the ground plane. I would hacksaw PCB material, solder as shielding and walls, eventually creating my Copper Contest Pixie2.

I made a xtal socket by cutting out a 3 leg section of a wirewrap 14 DIP socket. Pulled the middle lead out. Perfect for the mini crystal. I punched and filed a rectangular slot and epoxied the socket in place. The sturdy socket legs were structurally superior, providing support for the entire oscillator section. I added manual rit switching and was done with the oscillator.

The Power Amp/Det/Mixer went together in a like manner, with semi-rigid coax fed through some PCB shielding to the PI output filter. I was careful to leave room for the transistor heat sink, and allow replacing the transistor as well. Hey, I was planning on running on 12 volts and off a car battery, I expected smoke!

I finished the stock Pixie2 just hours before the start of day 2 of the contest. I had severe BC band interference and enjoyed (?) two hours of talk shows. I even worked the rig outside, away from powerlines, but I live only 2 miles from a very powerful local AM Radio station. Something had to be done.

AUDIO SECTION

I decided to add broadband RF Chokes at the speaker and Key Jacks. Also a RF Choke to the input of the LM386. I had earlier discovered that the LM386 audio seemed a bit weak and later deduced it was definately starved for current. I listened to the Pixie2 as I varied power from my other rig, and sure enough -- audio clipping and severe distortion on strong signals. I was bent on improving this. At this point I had just finished using the stock Pixie2 to get only (2) contacts in the contest. So I pressed on for more improvements.

I added the zener diode for better voltage regulation to the LM386, also I needed to double the current so I changed the 1 KOhm supply tap to 500 Ohms. The 470uF cap improved dynamic response of the LM386 and provided plenty of energy storage for audio peaks when driving an external speaker, which it does very nicely. In fact, my next mod may be a volume control -- Ouch!

Final audio enhancements occured well after the Pixie/40-9r contest. I received my Winter 97 QRPp magazine and modified the one transistor audio preamp for the Pixie2. The Base input impedance was raised by adding the 1 Kohm emitter resistor, eliminating any loading of the PA emitter resistor. The extra drive allowed me to add the 100 Ohm resistor in the LM386 gain line between pins 1 and 8. The hope here is that when the battery gets low, I won't be driving the LM386 so hard.

In order to limit current thru the key contacts, I added a 100 Ohm resistor from the switching diode to the keyed line.

OPERATION

How does it perform? Once I added the RF Chokes and the 470 uF audio bypass capacitor, nearly all of the BC band interference was gone. In fact, I couldn't add the audio preamp until I had greatly reduced the BC interference.

I operated Straight Key Night with it. I often get immediate responses to my CQ's. I have spent an entire week operating the Pixie2 without any desire to use my other rigs. It is fun! And besides, just plug in a 5 or 10 MHz crystal and pick up WWV for FREE. No need to build a special receiver for that. The rig makes a great frequency spotter and I have aligned my HW-8 with the Pixie2 at my side.

ARE THERE MORE MODS?

You bet. I'm hoping to add a twin-tee sidetone in the future. Maybe separate out the receive/transmit paths and add a little power amp, say 1 watt with parallelled 2N2222A's. Plug-in Band Modules? Who Knows.

SUMMARY

I have really enjoyed this rig. And I will continue to enjoy it for many years to come. But most importantly, building the Pixie2 is an exciting project. So simple to build, yet the completed project delivers the world of QRP to the palm of your hand.

72, Ed WE6W

[Editor's note: The schematic is in the center foldout section]

The St. Louis Loop

by Walter Dufrain, AG5P
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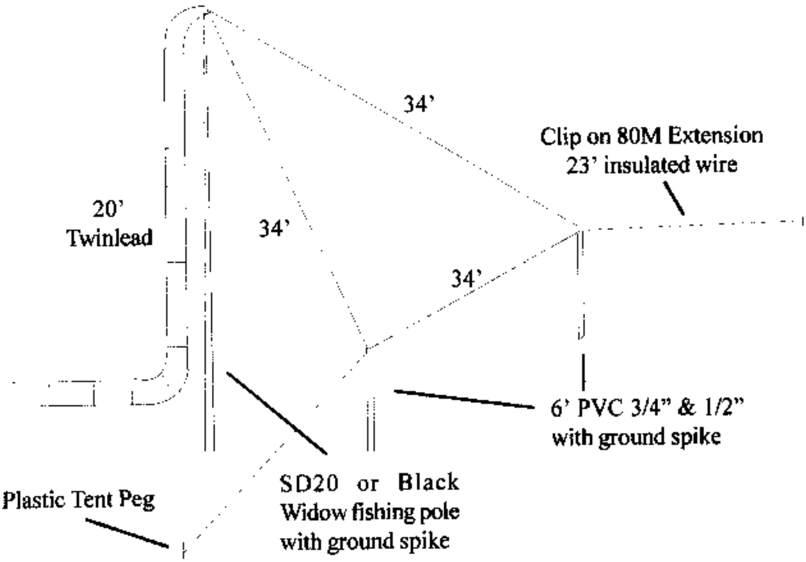

loop, plus being able to mount it horizontal or vertical, and still give good results in the field, has produced the St. Louis Loop.

Advantages:

1) Multi-band operation 40-10 Meters using transmatch and balanced line. 80 Meters is possible with clip-on extensions.
2) Ground independent, no radials required.
3) Quiet on receive, closed loop.
4) Field repairable, with only a pocket knife.
5) Fast setup and take down, using the SD or Black Widow fishing pole, 20 ft.
6) Small footprint, and could be an attic antenna.

On 40 meters the St. Louis Loop operates as a 3/4 wavelength loop that is stub loaded. Radiation pattern on 40 Meters is near vertical, skywave, however, with the slanted loop the operating range is extended. Radiation pattern for 30 Meters and up is more omni-directional with the plane of the loop. The highter in frequency, normally the lower the take-off angle.

Designed primarily as a protable, horizontal, low elevation loop, the formula for cutting is 984/f MHz or at 7 MHz = 140 feet. The St. Louis Loop uses 102 feet, 34 feet per side (#22 or #20 awg magnet wire or larger) and 20 feet of 300 ohm twin lead (Radio Shack, clear #15-1158) as a stub load. The end of the stub is attached directly to the transmatch, a longer balanced feed line can be used or attach a 4:1 balun and coax. Ring lugs are used to separate the 34 ft. sections for easy installation since it eliminates the need for measuring the locations of the wire supports and keeps the sides symmetrical.

A 1 3/4" per side plexiglass triangle is used for the feed point. It has 3 holes, 2 small #6 holes for the 2 brass screws and knurled nuts to attach the loop to the feed line, and the 3rd hole is 1/4" to just slide over the Black Widow first section, or it can be supported by nylon line when using other supports, the ring lugs are also for ease in attaching nylon line to the two corners. There are many more ways to accomplish mounting and supporting the St. Louis Loop, but this method seems to be the fastest and no other supports are needed.

My special thanks to Dave Gauding, for consulting on this project. 72, Walter.[This article printed with permission from "The Peanut Whistle", Journal of the St. Louis QRP Society, September 1997.]

Converting Commercial SWR/Wattmeters to QRP Sensitivity

by Bill Hickox, K5BDZ
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Turning your 100 watt to 300 watt commercial SWR bridge, either in a tuner or stand-alone, into one that will read QRP levels is usually as simple as changing the diodes coming from the RF pickup toroid in the SWR/Pwer sensing circuit. Most old "cheap" CB strip-line type SWR bridges originally came with germanium diodes, and should read QRP power levels as manufactured. However, most antenna tuners and SWR/ Power bridges manufactured today use two (2) silicon diodes such as 1N914, 1N4148, etc.

Changing thise cheap "300 watt" tuners from MFJ and others to read QRP levels is as simple as changing out the two silicon diodes and replacing them with two germanium diodes. I prefer using the germanium 1N270 or equivalent due to the higher voltage rating over the 1N34. However, the 1N34's and 1N60's I've used work at the 100 watt output level very well.

Germanium diodes conduct at 0.2 to 0.3 volts, whereas the silicon diodes conduct at 0.6 to 0.7 volts. QRP power levels, especially on reflected power levels, produce very low voltages that drop out at silicon diode levels but still conduct at germanium diode levels and can be read by metering circuits. In other words, germanium diodes are more sensitive at lower power levels.

Note: be sure to use the same diode polarity when removing the 1N914's and replacing with germanium diodes. My US 270 (1N270) germanium diodes used in all my commercial conversions will indicate full scale easily at 5 watts, most work full scale at 1 watt, and some full scale at less than 1 watt. Most recent conversion? A Swan ST-3 tuner picked for a song at a hamfest because "the wattmeter is broke". Broke turned out to be a burned out diode. With my US270 diode conversion, it reads full scale at 400 mW.

It's taken me longer to write this than to convert the MFJ-941C I just bought for $15. It works to 2 watts full scale with my US270 diodes. How much are the new MFJ QRP tuners???

While we're talking about diodes in RF paths, I'd like to add some food for thought. Electronic switching of RF paths, i.e. antenna front end filters, crystal filters, etc. often use 1N4148 or 1N914 diodes and allow too much unwanted signal "bleed through" around them due to their internal diode capacitance. An inexpensive alternative to the HP diodes always mentioned could be the 1N916 silicon diode. The

1N916 has much less capacitance than does its above brothers (only about 3 to 4 pF) and often will cure the bleed through problems simple and inexpensively. Same voltage and other specs as 1N914, etc. Naysayers? Build B4U Bitch!

Back in 1956 I was a high school freshman and new conditional class with a screen modulated Globe Scout 65 (40 watts AM). I wanted to get on 15 Meters. I had a 100' longwire going to the Northwest, fed through a Heathkit AC-1 Antenna Coupler (which I still have!) as well as a homebrew trapped W3DZZ dipole for 80-10 running east-west. I put a coax "T" connector at the tuner input, to feed both antennae at the same time on 15 meters. What happened? Bob W5FBQ and I were calling the first Alaskan station I had ever heard. The Alaskan station came back to me, giving me a 40 over S9 signal report, and only gave Bob a S9. Bob was running 100 watts from a Johnson Viking II into a three element beam pointed toward Alaska!

All in our little ham club back then told me what I did just couldn't be done! All except one. Aubrey Hunter, W5YLG (deceased) told me, "Now Bill, you know why they all say it can't be done. They're all afraid to try it so it will never work for them. You questioned it, tried it and it worked! Always remember that!" And I have. Thanks Aub, your teachings live on.
72, Bill, K5BDZ
[This article reprinted with permission from "The Peanut Whistle", Journal of the St. Louis Qrp Society, Sept. 97 issue.]

QRPpaddles

by Jim Nestor, WK8G/2

[This article reprinted with permission from the NJ QRP Club's Web Page, http://www.njqrp.org/mbrproj/qrp-40.html]

Over my 30 year ham career, I've done a lot of homebrewing. I've built everything from a 6 meter transverter to a computer-controlled switching system for VHF/UHF gear.

Once (and once was enough) I even rewound a power transformer. For about the last ten years, I have been exclusively a QRP CW guy and built lots of portable rigs for camping and traveling. But, I digress.

One of my proudest moments as a homebrew gear builder came when I was snowed in for a weekend. I built a vacuum tube (remember those?) and reed relay CW keyer without leaving the house. Everything from the aluminum for the chassis to all the pieces/parts to finish the job came from the junk box. It worked as advertised and I was really proud of my "Snowed-in Keyer". No more straight keys and glass elbows for me.

Since then, I've had dozens of keyers, the fanciest being a CMOS memory model from Logikey. I've also build a number of Curtis chip models, and recently a couple of PIC-based kits from Embeded Research, an Atomic keyer which I put in an Altoids box, and a Tick keyer which I built into a Wilderness 40A.

The Tick keyer is about as small, functional, and inexpensive as possible. I'll probably build one into all my homebrew rigs. So much for the keyers.

I've always had a problem finding suitable paddles. For that first homebrew keyer, I swapped with a friend for a chrome plated Vibroplex single lever paddle and thought I was in Heaven for awhile.

That was about the time that some troublemaker thought up the idea of using two levers and something called "iambic keying". Of course, neither my keyer circuit nor the Vibroplex couldn't be "iambicized", so I started the quest for the perfect combination of keyer circuit and paddles.

Actually, I never did really master the Iambic keying thing. Instead, I still use sort of a sideswiping action (incurable case of Lake Erie Swing) with the dual lever apparatus. Nonetheless, I can cruise along at 25-30 words per minute without becoming fatigued. So, the bottom line is I am addicted to dual paddle iambic keying.

Over the years, I've owned lots of paddles including Benchers, MFJs, and Vibroplex Iambic and a German Schurr Wabbler.

The Schurr is the smallest iambic paddle I've owned so far, and about one-half the size of the Vibroplex. It is a beautiful machine hand crafted from polished brass with a great feel. Almost perfect.

Although I paid a king's ransom for it three years ago, it has actually appreciated in value. I tried to convince my XYL that we should invest in more "paddle futures" as part of our retirement planning, but she wouldn't buy it. Guess I'll have to make do with one Schurr for now.

I've carried the Schurr on camping trips and even on a journey to Australia. The problem is, it is still too big, too nice and too fragile for travel use. I've broken the Plexiglas paddles a couple of times and even cracked the Plexiglas cover on one trip. I hate to abuse a piece of fine machinery, so I finally decided that it deserves to stay on my operating table at home.

What I built. Thus began the search for a suitable travel paddle. I decided that it must be very small to fit in a briefcase or backpack, have few adjustments that can jar out of adjustment, look nice, be reliable, and most importantly be inexpensive. In summary, it had to be: small, simple, cheap.

I figured that if it was small enough and cheap enough, I could take two with me on long camping trips in case one of them broke. There's nothing worse than equipment failure when you're sitting under a tree in the woods playing radio. I've done some interesting backwoods repair jobs, but that's another story. Radio Shack doesn't sell paddle parts.

I read all the catalogs and ham magazine advertisements and followed the postings on the Internet. It looked all over Europe and Asia/Pacific on business trips. No luck. Everything I found was too big, too expensive, or too flimsy for my specifications. Back to the old drawing board. In desperation, I decided to build one myself.

My Dad used to say, "When it comes to machinery, Jim's a pretty good electrician". Although I've owned a small metal lathe and milling attachment, my machinist skills are limited to making a few brass drawer knobs. I could never aspire to the precision and quality of work in the Schurr paddles.

The question was, just how precise does a simple paddle have to be to be usable? Likewise, how adjustable does it have to be if I'm the only one using it? And finally, how small can it be and still be comfortable to use?

I collected some pieces of brass, a few nuts and bolts and some plastic and began to try to answer those questions.

First, I "choked up" on the handles of the Schurr to see how long the paddle arms really needed to be and found that about 2 inches seemed OK. I cut a couple of pieces of 3/16" square brass to that length and laid them out on the bench.

Working around the paddle arms, I figured that the paddle base would have to be about 1-1/2" square to hold the pivots and contacts. I cut a scrap of ½" thick red oak to that size. That raised two more questions, what kind of bearings should I use to pivot the paddle arms, and how could I keep that tiny base from tipping over and sliding around on the table.

Following the KISS principle (Keep It Simple Stupid), I tried a number of pivot bearing schemes. The final result proved to be simple for effective. It consists of a pivot upright of 3/16" round brass rod topped by a 4.40 nut as a flat bearing surface. A 4.40 brass bolt goes through a smooth hole in the paddle arm and threads into the upright.

By carefully adjusting the bolt and nut, I was able to get a pretty smooth swiveling motion on the paddle arm, but the bolt still wobbled about in the 4.40 thread. A tiny drop of LocTite solved that problem. The mechanical details are shown in the measured drawings which are much larger than full-size.

The small size of the base was a tougher nut to crack. Traditionally, paddle bases are made large and heavy to solve the wobbling/sliding problem. I didn't want either size or weight, so another approach was called for. I remembered some QRP-L postings about using non-skid materials to stop sliding. I tried using Velcro to stick the paddles to the table with some success, then I found the ultimate solution at the office supply store.

I bought a package of "business card magnets" which consisted of a thin rubberized magnetic surface on one side and "stickum" on the other. They are designed to hold business cards to file cabinets and grandchildren's pictures to the refrigerator. The material can be cut with regular scissors.

I had successfully used a strip of this material on the bottom of the Atomic Keyer's Altoids box to hold it to the top of the mobile rig. so cut a piece to fit the paddles oak base. Sure enough, it would stick nicely to anything made of steel.

I tried sticking the paddles to the top of the mobile rig, but that wasn't a comfortable keying position. Neither could I use them hanging from the refrigerator.

I attached another magnetic strip to a small computer mouse pad. Success! The two magnets clung tightly enough to minimize wobble and the mouse pad stayed put on the desktop.

Buoyed by that discovery, I moved ahead to finish the prototype. To keep things simple, all of the brass paddle pieces were made from 3/16" square bar and 3/16" rod. They were cut with a hacksaw in a miter box, drilled with a drill press, and finished with fine sand paper and steel wool to a reasonable shine.

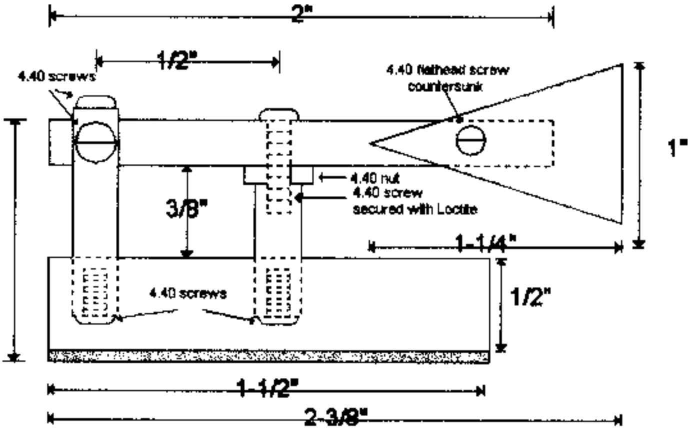
The oak base was carved out a bit on the bottom to leave room for the cable connections. The uprights for the pivots and contacts were drilled through and tapped with a 4-40 thread, then secured in the holes with epoxy.

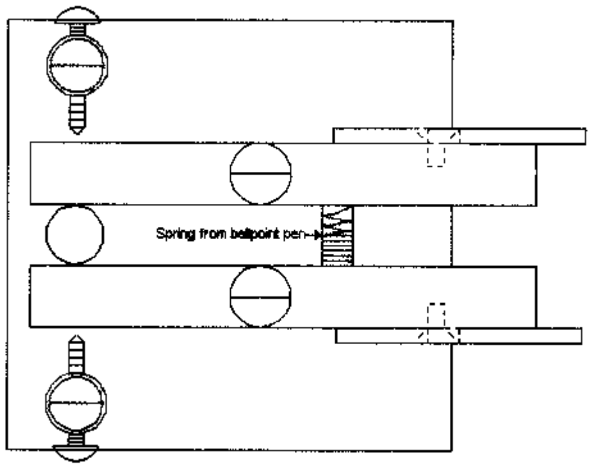
Paddle tension is provided by a piece of brass spring salvaged from a ball-point pen. It isn't adjustable, but the feel is "just about right". Because of the small size and magnet base, a light two-finger keying style is recommended.

The contact screws were hand-filed to a point to minimize resistance. The Bencher style paddles were cut from plastic and secured with countersunk 4.40 flathead screws.

I must admit that I'm as proud of these tiny paddles as anything I've ever built. While they don't compete with the Schurr in terms of precision and appearance, they do the job intended. For travel purposes, the paddles and cable, a set of Walkthing earbuds, and a small screwdriver all fit into a 4" x 2" x 1-1/2" project box.

The total cost for materials was about $5. Of course, the labor was free. I never did use the lathe. A drill press is probably essential to get the holes straight. A hack-

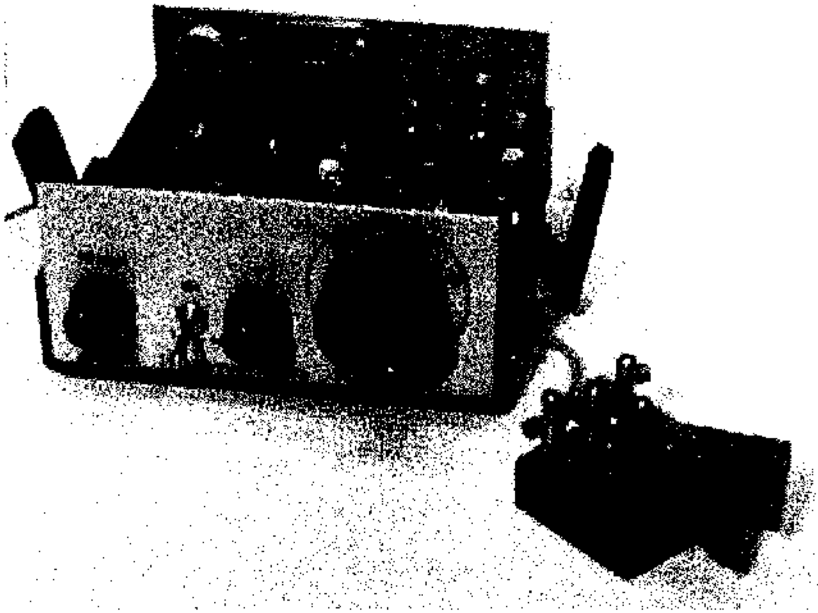




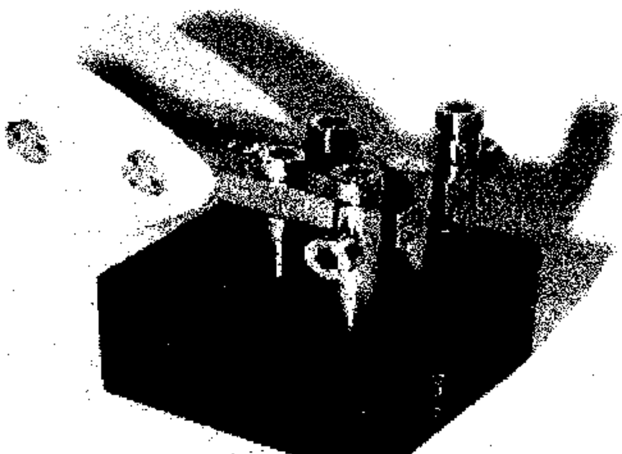
saw and tap wrench rounds out the tool requirements.

This article wasn't intended as a complete "how to" with step-by-step directions. Likewise, the drawings are a bit rough and the dimensions approximate. Rather, it chronicles one ham's quest and maybe it will motivate others to experiment and refine the design. If you take your time measuring, cutting and drilling, you too can build a FB set of paddles. Here's a picture of the paddles with a Wilderness 40A QRP transceiver. As a point of reference, the 40A is about 4-12" wide and 2" high.
<Picture>

Of course, I am now hooked on paddle-making. I need a second set as spares for camping, I want an all-brass model for show and tell, and maybe a fancy one with a rosewood base. Then there's the question of the perfect size and shape and material for the finger pieces. And maybe a thin piece of steel would work better than the mouse pad. 72, Jim, WK8G/2



Paddles made by the author, WK8G/2



Paddles made by Dave, VE7PCC, from the article.

The Saturday Night Special - A Simple 2N2222 Receiver Design with a Surprise

by Ori Mizrahi-Shalom, AC6AN
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I have played a bit with my receiver design yesterday and I'd like to pass it on to you. It uses 6 transistors - 2N2222 of course... that's very much deliberately done, so people can stick it in a plastic box of an oldie transistor radio that says "6 TRANSISTORS" on it! Remember? I'll continue the work on the transmit side, but the receiver is the highlight here.

I use an IF can for the pre-selector in the front-end, three crystals at 3.686 MHz and one trimcap for the VXO. The rest are about $2 worth of transistors, resistors and caps. I measured 54 dB voltage gain into a high-impedance earphone that you can get at Fry's for $3.95. Compare that to the 49er at 49dB (or less) and the Pixie at 50 dB (or less). Not world-class, but people can add 2 audio stages with 2222s or one LM380 that will pierce their ears... I've opted to go with the latter... It's a "green" radio. I designed it around 6.8-7.2V supply, so people can use a rechargeable Nicad battery to power the litttle critter.

This article describes my entry for the 2222 contest. I call it the "Saturday Night Special", following the theme of the "Ugly Weekender", just much simpler to build... in... one Saturday night, of course! Here are the details of the receiver.

Most DC receivers suffer from one or more of::

(1) poor selectivity
(2) AM rectification (BCI)
(3) instability or oscillations due to high audio gain
(4) hum

I wanted to solve all these problems and design a receiver with a superhet performance but a direct-conversion simplicity. The trick is to have some gain distribution and isolation between stages, just like in a good superhet design. So we start with an RF amplifier stage. Yes, the dynamic range is degraded a bit, but that's not the focus of this receiver anyway. You could also design the RF amp with high power handling, if you wish. I didn't.

Next you have a crystal filter. A CRYSTAL FILTER?! I can some readers jumping... Yep, at the receive frequency! If you are running a net, you design a 500Hz narrow filter, make sure all radios are aligned to the same center frequency (that's a lot of matched crystals...) and off you go - gone the interference, welcome narrow IF - oops... RF filtering!!!

With that one simple filter we got rid of:

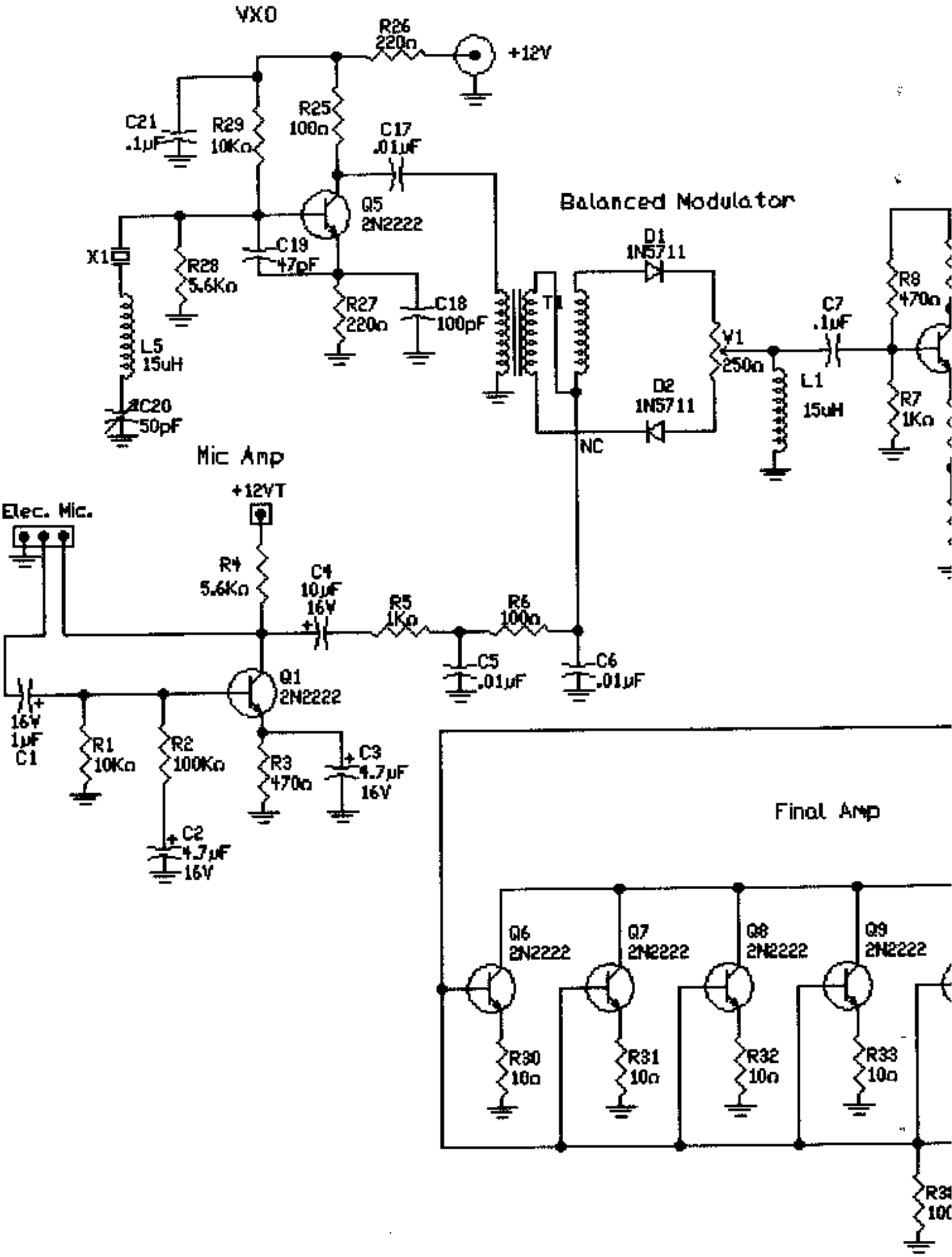
(1) adjascent channel QRM
(2) AM rectification (BCI)

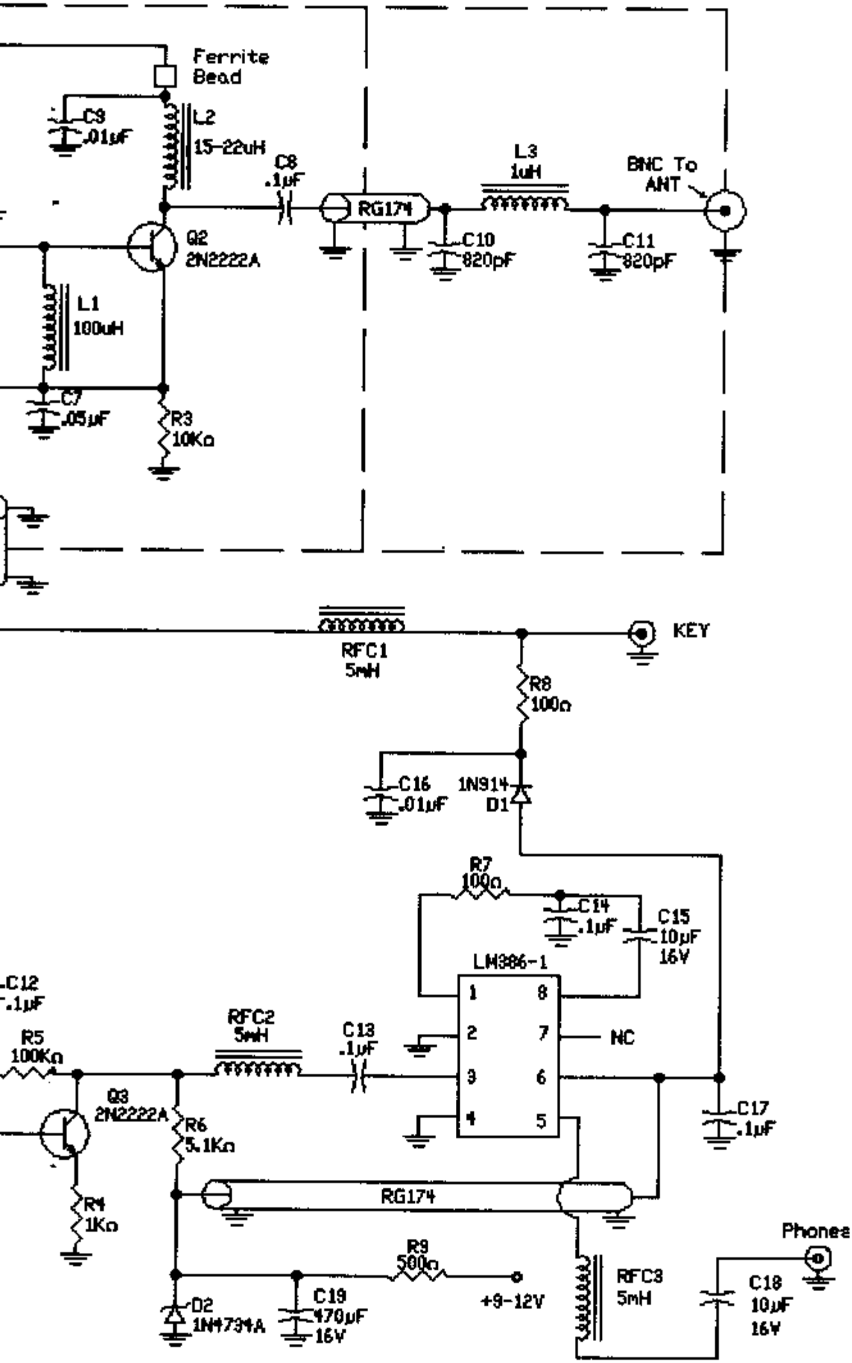
Well, how lucky, problems (1) and (2) above are gone! Now what about (3) and (4) , you're asking?! OK, since we have split the receiver into the RF and AF sections, and split the gain between them - still mostly audio gain but not all - we have less gain at one particular frequency and that makes the stage less susceptible to oscillations.

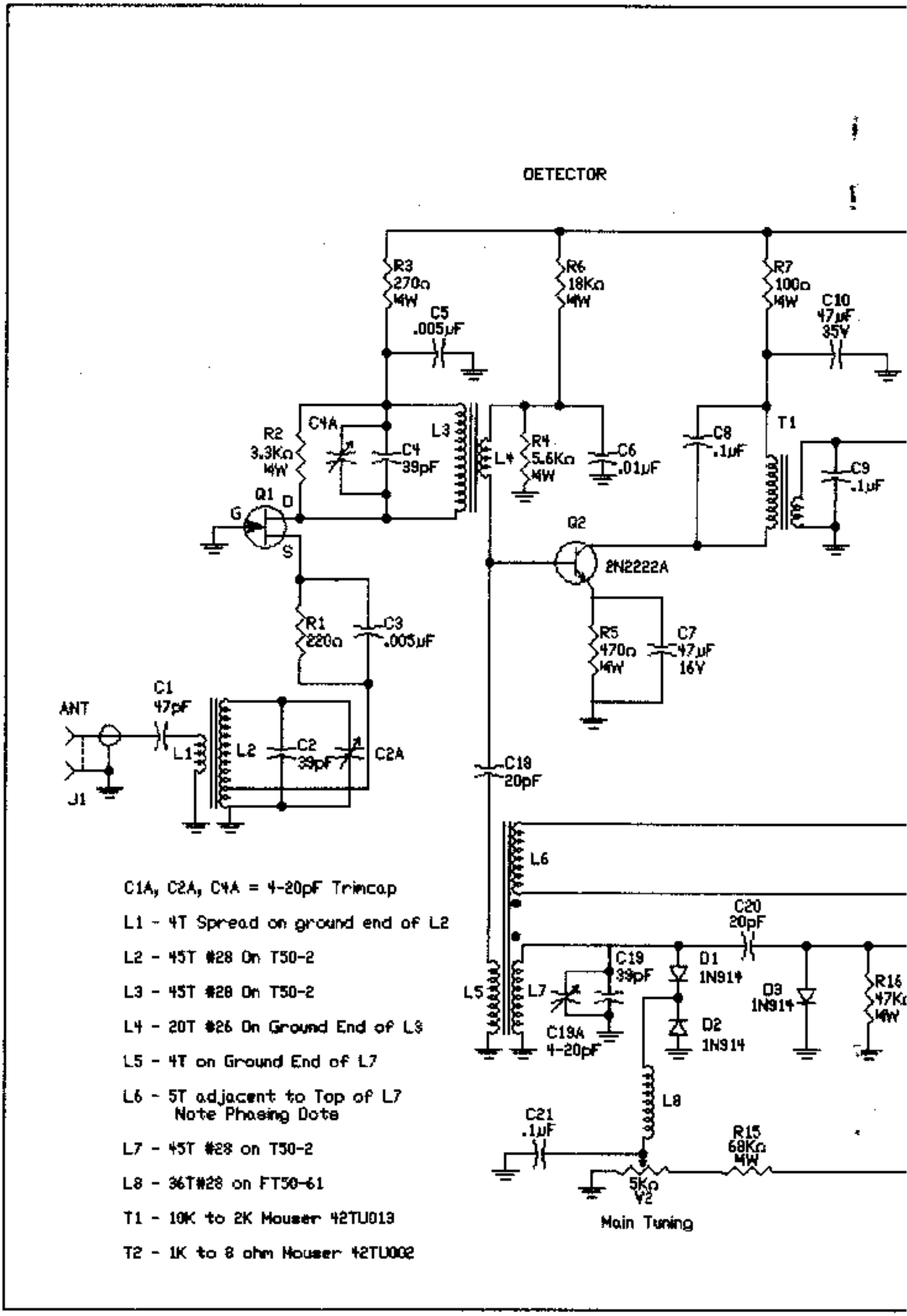
Audio signal feeding back into the RF stage gets blocked by the crystal filter, so we have to worry about local feedback in each stage only, with its lower gain. Well, sounds like we have just solved problem (3) above... at least improved the situation.

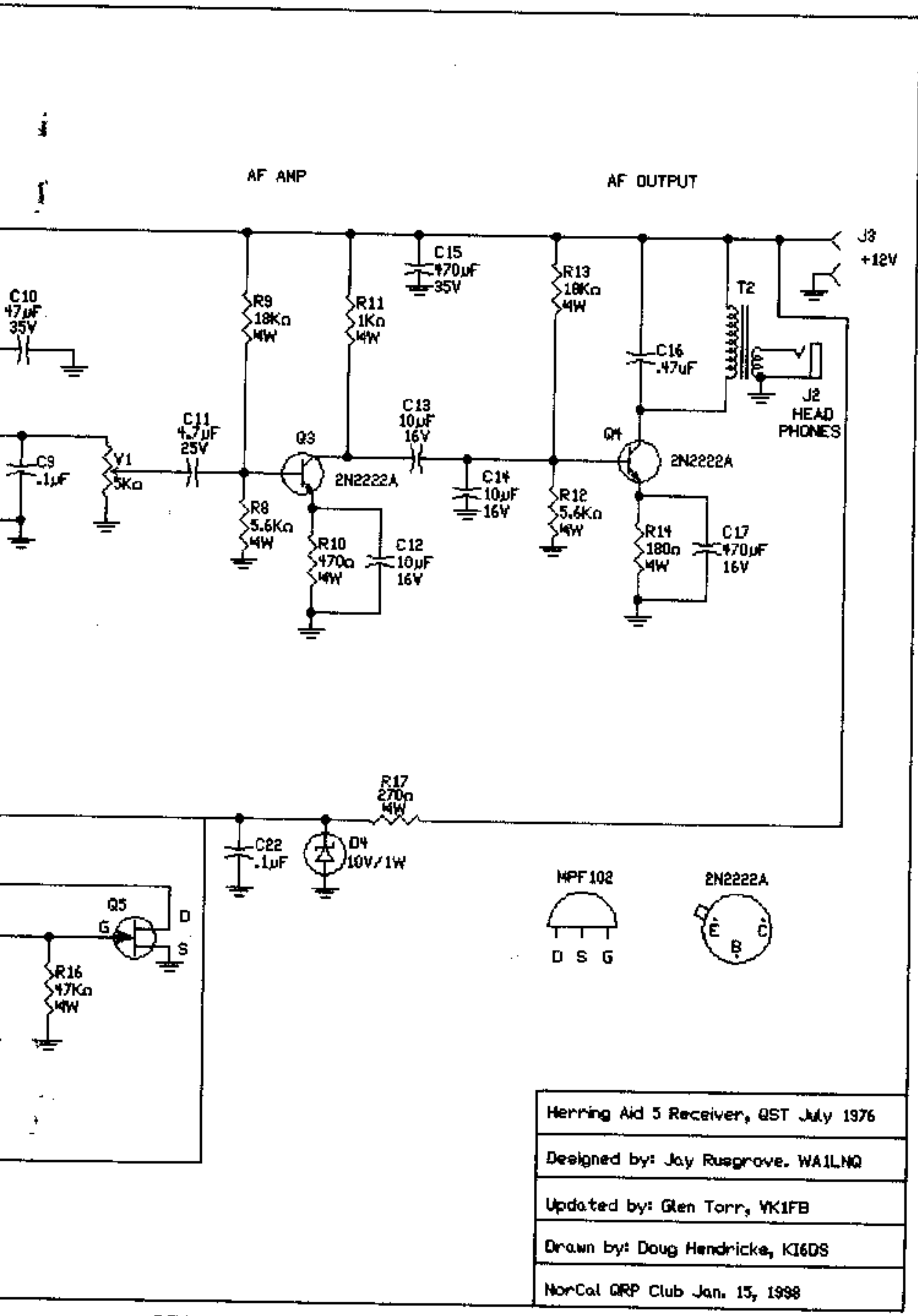
Now, for the grand finale, the hum. That one comes mainly from excessive audio gain and poor supply rejection. Now,

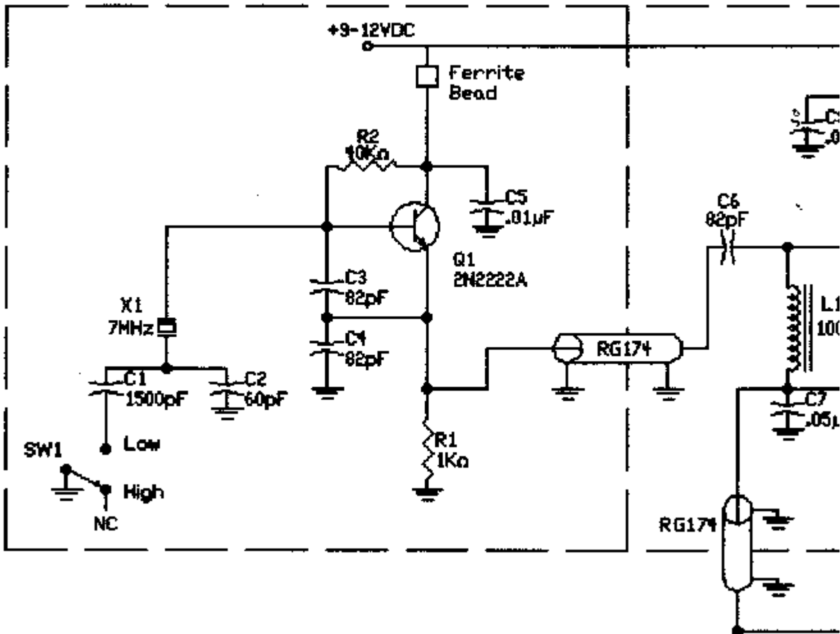
N7RI DSB Tr


VXO
R26
220Ω
+12V
C21
.1µF
R29
10KΩ
R25
100Ω
C17
.01µF
Q5
2N2222
Balanced Modulator
X1
R28
5.6KΩ
C19
47pF
R27
220Ω
C18
100pF
L5
15uH
C20
50pF
T1
D1
1N5711
V1
250Ω
D2
1N5711
NC
C7
.1µF
L1
15uH
R8
470Ω
R7
1KΩ
Mic Amp
+12VT
Elec. Mic.
R4
5.6KΩ
C4
10µF
16V
R5
1KΩ
R6
100Ω
C5
.01µF
C6
.01µF
Q1
2N2222
16V
1µF
C1
R1
10KΩ
R2
100KΩ
R3
470Ω
C3
4.7µF
16V
C2
4.7µF
16V
Final Amp
Q6
2N2222
Q7
2N2222
Q8
2N2222
Q9
2N2222
R30
10Ω
R31
10Ω
R32
10Ω
R33
10Ω

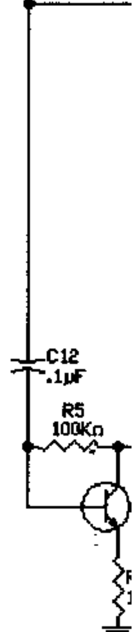

Ferrite Bead
C9 .01µF
L2 15-22uH
C8 .1µF
RG174
L3 1uH
BNC To ANT
C10 820pF
C11 820pF
Q2 2N2222A
L1 100uH
C7 .05µF
R3 10KΩ
RFC1 5mH
KEY
R8 100Ω
C16 .01µF
1N914 D1
R7 100Ω
C14 .1µF
C15 10µF 16V
LM386-1
C12 .1µF
R5 100KΩ
RFC2 5mH
C13 .1µF
NC
Q3 2N2222A
R6 5.1KΩ
C17 .1µF
R4 1KΩ
RG174
Phones
R9 500Ω
+9-12V
RFC3 5mH
C18 10µF 16V
D2 1N4734A
C19 470µF 16V


DETECTOR
R3
270Ω
¼W
C5
.005μF
R6
18KΩ
¼W
R7
100Ω
¼W
C10
47μF
35V
R2
3.3KΩ
¼W
C4A
C4
39pF
L3
L4
R4
5.6KΩ
¼W
C6
.01μF
C8
.1μF
T1
C9
.1μF
Q1
G
D
S
Q2
2N2222A
R1
220Ω
C3
.005μF
R5
470Ω
¼W
C7
47μF
16V
ANT
C1
47pF
L1
L2
C2
39pF
C2A
J1
C18
20pF
L6
C20
20pF
L5
L7
C19
39pF
C19A
4-20pF
D1
1N914
D2
1N914
D3
1N914
R16
47KΩ
¼W
L8
C21
.1μF
R15
68KΩ
¼W
5KΩ
V2
Main Tuning
C1A, C2A, C4A = 4-20pF Trimcap
L1 - 4T Spread on ground end of L2
L2 - 45T #28 On T50-2
L3 - 45T #28 On T50-2
L4 - 20T #26 On Ground End of L3
L5 - 4T on Ground End of L7
L6 - 5T adjacent to Top of L7
Note Phasing Dots
L7 - 45T #28 on T50-2
L8 - 36T#28 on FT50-61
T1 - 10K to 2K Mouser 42TU013
T2 - 1K to 8 ohm Mouser 42TU002


AF AMP
AF OUTPUT
J3
+12V
C10
47µF
35V
C15
470µF
35V
R9
18KΩ
¼W
R11
1KΩ
¼W
R13
18KΩ
¼W
T2
C16
.47uF
J2
HEAD
PHONES
C11
4.7µF
25V
Q3
C13
10µF
16V
Q4
2N2222A
C9
.1µF
V1
5KΩ
2N2222A
C14
10µF
16V
R8
5.6KΩ
¼W
R12
5.6KΩ
¼W
R14
180Ω
¼W
C17
470µF
16V
R10
470Ω
¼W
C12
10µF
16V
R17
270Ω
¼W
C22
.1µF
D4
10V/1W
MPF102
2N2222A
Q5
G
D
S
D S G
E B C
R16
47KΩ
¼W
Herring Aid 5 Receiver, QST July 1976
Designed by: Jay Rusgrove, WA1LNQ
Updated by: Glen Torr, VK1FB
Drawn by: Doug Hendricks, KI6DS
NorCal QRP Club Jan. 15, 1998



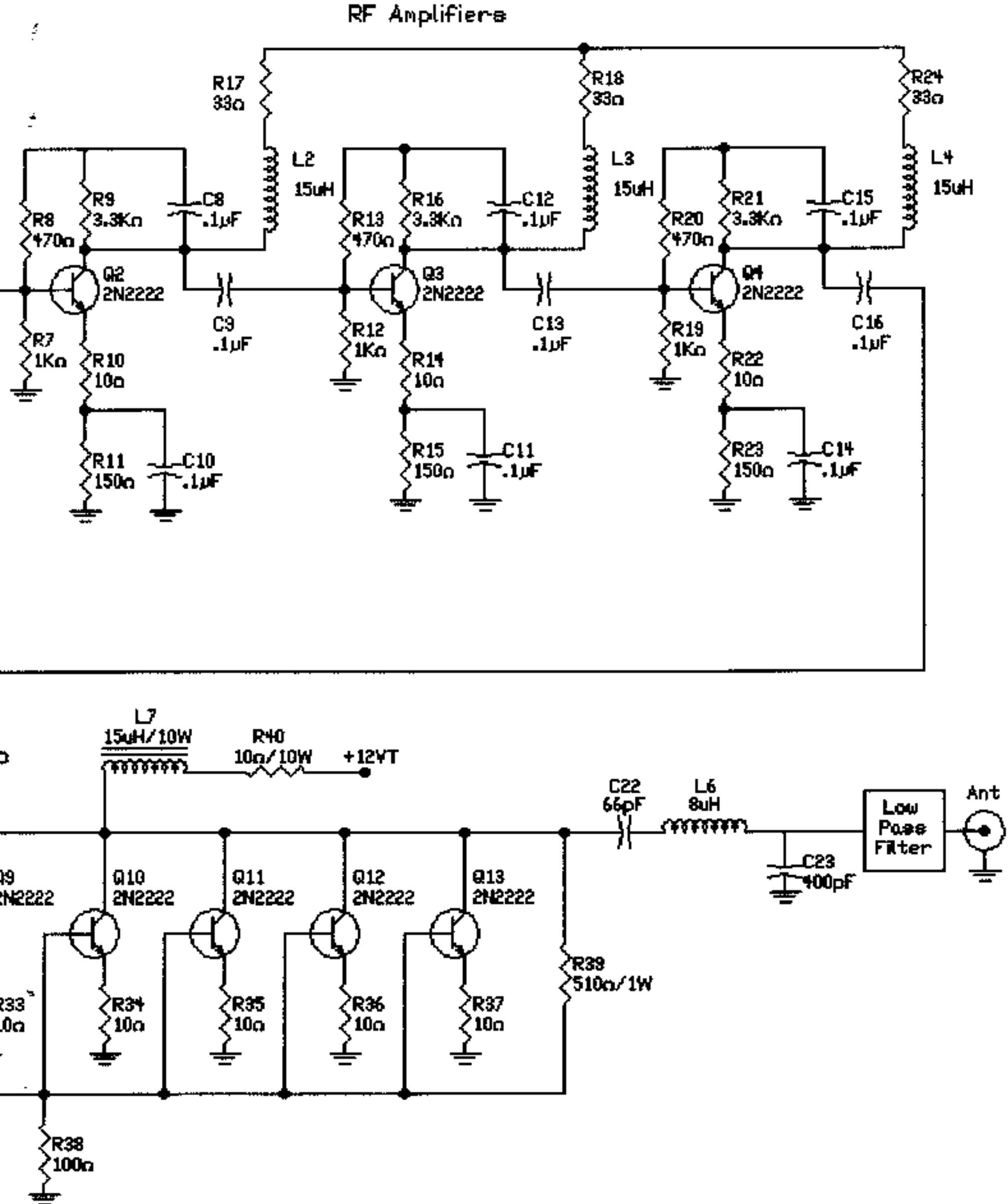
RFC 1,2,3 = Mouser #434-6H-851 Or
5 Turns #28 on Mouser 542-FB73-287
Dashed Lines = Shield from pcboard stock, grounded
RG174 Used for interconnects.



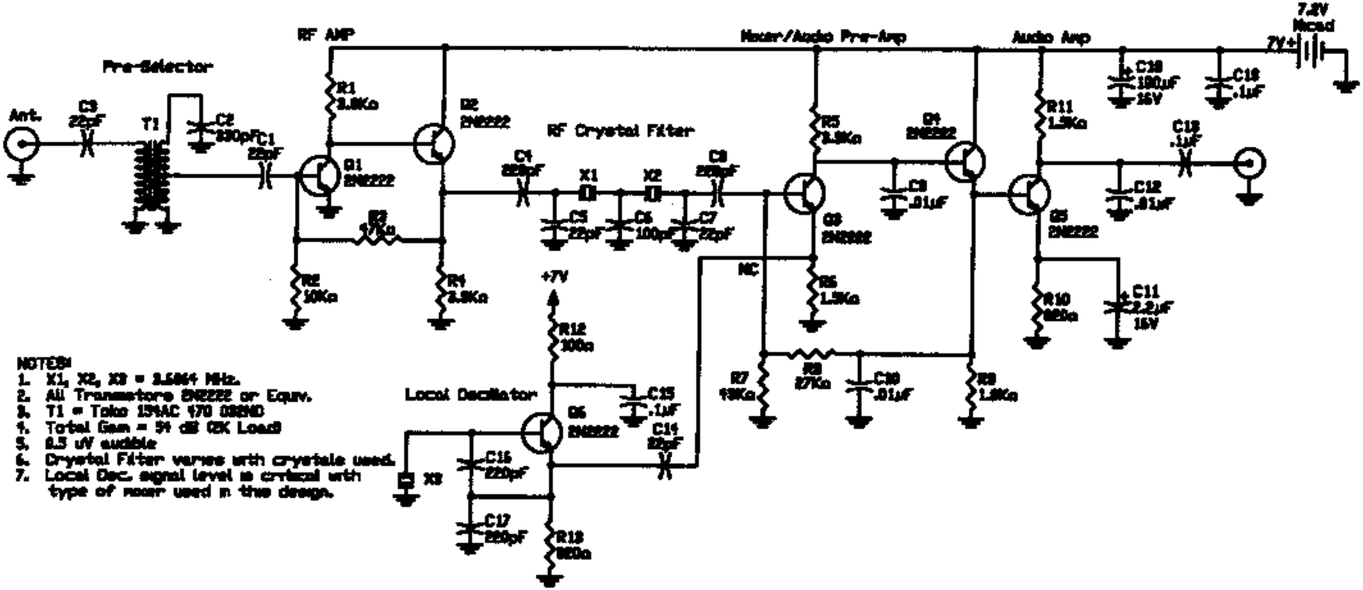
WE6W Contest Pixie

Designed by Ed Loranger, WE6W

SB Transmitter



The Saturday Night Special



the gain distribution we built into this receiver means that less of the supply noise that goes into the early (RF) stages of the receiver will make it into the audio stages - the same benefits of the superhet concept of gain distribution with enough inter-stage filtering. It's also less likely to pick up 60 Hz hum by direct induction from AC circuits, if the total audio gain is lower. Voila - we've just reinvented the solution to problem (4).

So, what's left?! Not much... If you follow the principles in a coherent manner you will realize all the above benefits in your receiver too. OK, other options. Now those that want a VXO with some tuning range, what would they do? No problem. Design a wider crystal filter - a few KHz wide. You still get the isolation between stages, so BCI is gone and a strong station outside the filter passband would be muted considerably. No more "I can hear all the band coming in my earphones"... Yes, you can do some filtering at the audio stage, but you will not get rid of all the crud a receiver without a sharp IF/RF filter might generate. Another interesting idea: you could also come up with a scheme that retunes the center frequency of the narrow CW crystal filter as you tune your VXO - back to the old TRF concept on a small scale!!! Any volunteers?!

My implementation - which is only one possible implementation - uses NPN circuits throughout. We do have a 2222 contest, right?! You can implement this CONCEPT with op-amps, canned mixers, or what have you. My circuit starts with a preselector - parallel L/C - coming from an antenna or a T/R switch. The RF gain stage is a direct-coupled two transistor circuit, much like the one in SSD pp. 21 fig. 10. A two-pole crystal filter follows that, feeding a mixer/audio amp. The mixer/audio-amp is a "tricky" circuit. I again used the above two-stage circuit as an AF amplifier, feeding the LO into the emitter resistor of the first transistor. That stage is a hybrid stage! It's a mixer and it's part of the audio feedback gain stage! I love "tricky" circuitry...

I follow with another gain stage with direct coupling and use some caps to remove stray RF past the mixer AND give an audio low-pass characteristics to this amplifier. That's additional filtering for free! I needed the caps for RF cleanup anyway... The bottom line is a receiver that use only 6 transistors total (including a local oscillator), with outstanding performance - for a DC receiver. I have not implemented the TX chain yet. That's the more mundane task in a transceiver design. Large signals, known quantities... But receivers - they always present a challenge!

I hope this article brings the homebrew DC receiver designs one step ahead. Now, that is a challenge! 73, Ori, AC6AN

The Herring Aid 5 "Back to the Future"

by Glenn Torr, VK1FB
glentorr@ozemail.com.au

Introduction

This article describes changes made to the "Herring-Aid Five" receiver presented by Jay Rusgrove, then WA1LNQ, in the July 1976 issue of QST to allow the design to be duplicated with readily available components. The original circuit was designed so that the constructor could obtain all the parts from Radio Shack and many of these parts are no longer available.

In keeping with the theme of using food containers as chassis for these designs this receiver was built onto an oval shaped Scottish Herring can hence the name. Construction was similar in general layout to the Tuna Tin 2.

The first change necessary was to get a PCB which suited the new component foot prints and allowed for changes to the circuit where needed, to this end Doug Hendricks, KI6DS, laid out a new PCB using CirCad. Prototypes of this board were generated by Gary Diana, N2JGU. The new board is rectangular which will allow the constructor more flexibility in the choice of chassis or enclosure.

The parts substitutions were made in such a way as to have as little impact on the original design as possible. The main changes have involved the substitution of toroids for the original solenoid style inductors. This then lead to the addition of trimmer capacitors, as inductance adjustment was no longer practical by squeezing up or stretching out turns. Audio transformers T1 and T2 were replaced with readily available equivalents as were the semiconductors.

The Receiver

This receiver is a "minimal" direct conversion design in which the designer has traded a little performance for ease of construction with the then widely available components. I think the most unusual part of this receiver is the use of a single unbalanced BJT as the mixer in a 40 meter receiver, I imagine this unusual choice would cause severe problems where broadcast station interference was present. As the designer of the original receiver noted audio bandwidth was left wide enough to allow for the reception of SSB and AM signals. The up side of this is that it allows for the use of the receiver for these modes, the downside is that it compromises the receiver's CW performance.

The Circuit

The incoming 40-meter signal is coupled to the source of Q1 via a tuned circuit consisting of L1, L2, TC1 and C1. Q1 is a grounded gate RF amplifier and has its source tapped down L2 to preserve the Q of that tuned circuit. The output of the RF amplifier is coupled to the Mixer by another tuned circuit consisting of C2, TC2, L3 and L4. These tuned circuits provide all of the 7 MHz selectivity. Q2 then mixes the VFO with the incoming RF and the resultant Audio signal is amplified by Q2 and coupled by T1 to the audio gain control. Q3 and Q4 are conventional common emitter audio amplifier stages; the audio output is coupled to low impedance phones by T2. The VFO consists of Q5, which operates as an un-buffered voltage tuned VFO. Ordinary silicon diodes such as 1N4148 are used as varactor diodes in this circuit. The tuning pot provides a voltage variable from 0 to approximately 800 mV, which allows the oscillator to tune approximately 100 kHz at 7 MHz.

Construction

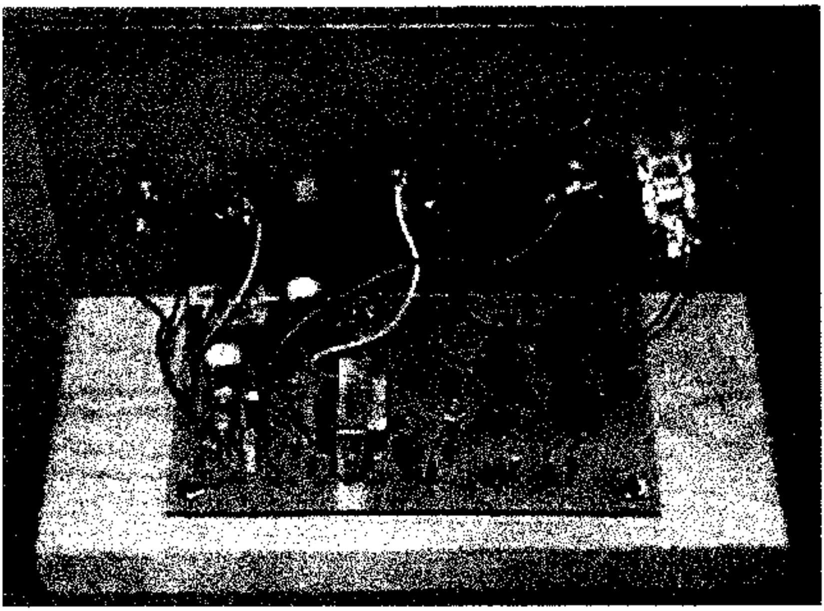
Note: The description by Doug, KI6DS and Dave, AD6AY of their debugging of an early prototype which appears on the NorCal page is invaluable companion reading to this section. I commenced by building and adjusting the VFO. The VFO was designed to cover a range of any 100 kHz of 40 Meters for 180 degrees of rotation of the tuning potentiometer, which suits the vernier drive originally, used. I first wound L7 which consists of 45 turns occupying about five-sixths of the T-50-2 toroid. L6 consists of 5 turns immediately adjacent to the top of L7 and noting the phasing in the circuit. L5 consists of 4 turns over the ground end of L7. VFO output with the pot at the low frequency position (ground) is fairly low so as only 180 degrees of pot travel is used I set the pot to about 20 degrees up from ground and then adjusted the frequency to be 7.000 MHz with TC3 (across C4). If necessary a turn or two can be added to or deleted from L7 to achieve the desired range, it may be easier to replace the relevant capacitor, C19, with a slightly different value. This gave my receiver a range of 7.000 to 7.100 MHz. If the oscillator does not oscillate try reversing the terminations of L6.

The 180 degree requirement can be addressed either by using a vernier drive similar to the original or constructing a frequency scale with 7.000 MHz at 9 o'clock, 7.050 MHz at 12 o'clock and 7.100 MHz at 3 o'clock and simply ignoring the unused portion of the tuning pots travel.

The rest of the receiver can now be constructed. L2 consists of 45T on a T-50-2 toroid, tapped up 5 turns from ground; L1 consists of 4 turns over the ground end of L2. L3 consists of 45T on a T-50-2 toroid with L4 consisting of 20 turns across L3. When completed C2A and C4A can be adjusted for best signal strength using live signals or an appropriate signal source such as a 40-meter QRP transmitter into a dummy load. C2A and C4A should each allow 2 peaks in incoming signal level per 360-degree rotation of the trimmer. If only one peak is obtained it may be necessary to add a turn or two (if the peak corresponds the plates fully meshed) or remove a turn or two if the peak corresponds to the capacitor plates fully unmeshed. Alternatively it may be easier to increase or reduce (respectively) C2 and C4.

Performance

The performance of the Herring-Aid Five is better than I expected however it has some limitations due to the earlier mentioned design tradeoffs. Additionally the receiver is able to copy SSB signals; this is a useful feature for the beginner but is a limitation when using CW. I have been unable to find Scottish Herrings in VK and in any case I prefer to build this type of equipment on a wooden base with a front



Rear View of Herring Aid 5 Receiver

panel for the controls so that I can see and play with the circuit at any time

Conclusion

This receiver offers a number of attractions. It allows you to experience the performance of the humble single BJT mixer. Nothing is hidden in IC's; all voltages are available for observation. It provides a platform to experiment with one circuit block while leaving the others constant. The effect of a modification is more clearly seen e.g. a high gain IC audio amplifier could be constructed outboard and audio fed to it from the audio gain pot to observe the benefit or otherwise of higher audio gain on overall performance.

I have made numerous decisions and assumptions in converting this design to modern parts and have not explained these decisions in any detail. Please feel free to contact me with any suggestions, questions or observations. I am not an expert but rather a keen learner and I make no claim that modifications I have made are the ultimate. I have enjoyed "playing" with this circuit and believe there is a lot of fun to be had "Back in the Future."

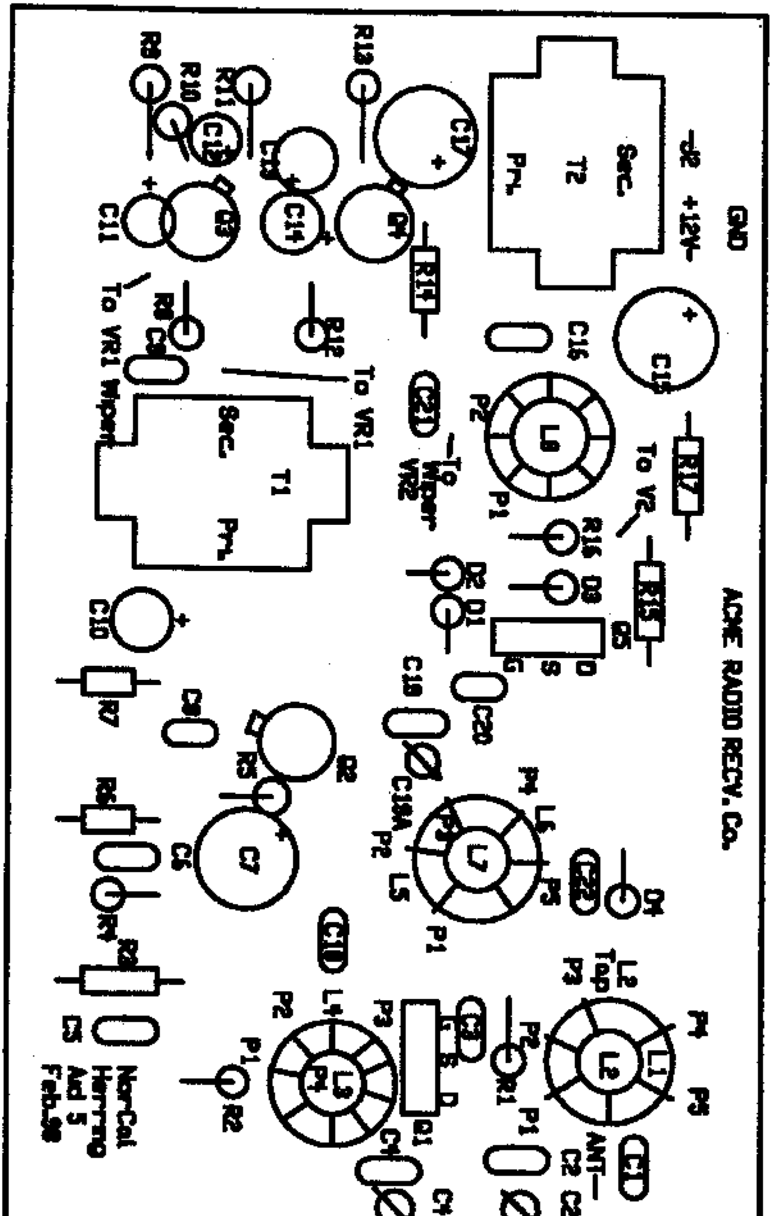
I would like to thank Jay Rusgrove for the fine original design and article, Doug Hendricks, KI6DS, for his tireless work in laying out the PCB and coordinating the project, Gary Diana, N2JGU, for prototyping the PCB, Dave Fifield, AD6AY for his work with Doug on one of the prototypes and his suggested improvement to L4 and finally Doug DeMaw, W1FB (SK) for giving us so much. 72, Glen Torr VK1FB

Herring Aid 5 Parts List

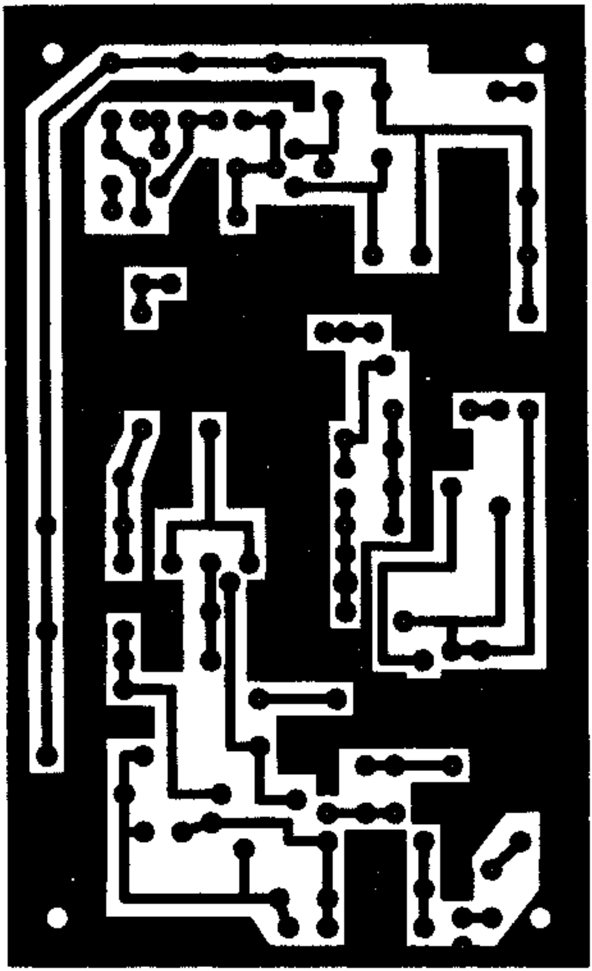
3	C2A,4A,19A	4-20pF Trimcap
2	C18, C20	20pF
2	C2, C4, C19	.39pF SM
1	C1	47pF Disc
2	C3,5	.005 uF
1	C6	.01 uF
4	C8,9,21,22	.1 uF
1	C11	4.7uF/25V Elec.
3	C12,13,14	10uF/16V Elec.
1	C7	47uF/16V Elec.
1	C10	47uF/35V Elec.
2	C15,17	470uF/35V Elec.
1	C16	.47uF
1	D4	10V/1W Zener
3	D1,2,3	1N914/1N4148
3	L2,4,7	T50-2
1	L8	FT50-61
2	Q1,5	MPF102
3	Q2,3,4	2N2222A
1	R7	100 ohm
1	R14	180 ohm
1	R1	220 ohm
2	R3,17	270 ohm
2	R5,R10	470 ohm
1	R11	1K
1	R2	3.3K
3	R4,8,12	5.6K
3	R6,9,13	18K
1	R16	47K
1	R15	68K
1	T1	10K-2K Transfmr. Mouser 42TU002 or 42TM002
1	T2	1K-8ohm Transfmr. Mouser 42TU013 or 42TM013
2	VR1,2	5K Pot

Misc. Connectors for headphones, power and antenna, knobs, case, stranded hookup wire.

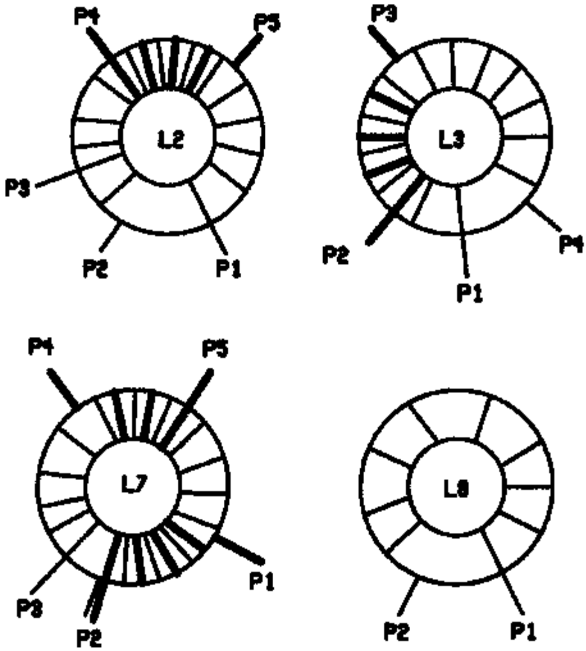
Circuit boards for this project are available from FAR Circuits, 18N640 Field Court, Dundee, IL 60118. The cost is $7.50 per board plus $1.50 S&H for up to 4 boards. Order the NorCal Herring Aid 5 Receiver Board.



Parts Layout for the NorCal Herring Aid 5 Receiver



Board Layout for the Herring Aid 5 Receiver, XRay View From Top



Coil Winding Diagrams for the Herring Aid 5

Trouble Shooting the NorCal Herring Aid 5

by Doug Hendricks
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Dos Palos, CA 93620
ki6ds@dpol.k12.ca.us

I finished the Herring Aid 5 prototype on the board that Gary Diana made for me on a Thursday night. Plugged in the power, hooked up the antenna, put the headphones on and expected to hear that wonderful hissing sound that you expect from a receiver. Nada, nothing!! Egads, it doesn't work. I looked at the parts, check it twice, checked the toroid connections, but alas, nothing helped. What to do?? I called Dave Fifield, trouble shooter extroidinaire and a good friend. I asked him if he would have time to look at the rig if I were to drive over to San Jose. Dave is a good friend and can't say no, so he said sure come on over, but it had to be about 4 PM or so on Sunday as he had a huge list of honeydo's to finish for the XYL.

With that in mind, I packed up the board, the schematic, the layout, the parts placement drawing and the original article and drove the 125 miles one way to Dave's house. (One advantage to having lived in western Kansas, distances don't mean a lot. Ask anyone who has lived in west Texas, the Oklahoma Panhandle or anywhere out west. We are used to driving.) When I arrived Dave greeted me at the door and we sat out to debug the receiver (Dave doing the work, I was watching and listening as he very patiently explained what he was doing and why).

One problem we had was this was a new layout, done by me, and it was not tested. I watched as the old master himself went to work. He told me that he was going to use the "Paul Harden, NA5N" method. He would start at one end of the schematic and check each section. I sat down and watched as Dave did the following.

First of all he checked for 12 volts at the supply and then for 9.1 volts on Q5. (The schematic calls for a 10V zener in series with a 270 ohm resistor, but Dave had suggested using a 9.1V zener in series with a 390 ohm resistor over the phone when I couldn't find a 10V zener.) Had the 12 volts at the supply, but oops, there was only 1 volt or so at the drain of Q5, which is the FET in the VFO. Dave turned to me and said, this is not good, we must have 9 volts or so. Something is loading down the circuit. He then checked the layout against the schematic, R16, D3, C22, R17 and D4 were all soldered in correctly and in the proper position. Dave had a bewildered look and asked where I had gotten the transistor. I replied that it came from my stash, but it was not the MPF102 called for but rather a J310. (I thought they were interchangeable, and as I was soon to find out, they are not always.) Dave replaced the J310 with an MFP102 and bingo, 9.1 volts, just as it should be.

Next he said that we would see if the VFO was VFOing. He hooked up the scope, and nothing, not a sine wave in sight. He looked at the circuit, checked all the parts and determined that the coil was wound out of phase, so he reversed the leads for L6, and again, like magic, bingo we had an oscillator. He measured the frequency, and it was at 6.8 MHz, which was a little low. It was easier to lower the capacitance in the circuit by changing a cap than it was to change the turns on the toroid, so Dave replaced a 39 pF with 5 pF and we measured the high end. Oops, now it was at 11.2 MHz for the high end. He looked at me, and I know that he knew, but he asked what value we should try next. I suggested 22pF as it was inbetween the two values that we tried. He soldered it in and voila, the top end was about 7.8 MHz and using trimcap C19A he was able to set the bottom of the tuning range at 6.998 MHz, which was close enough for us. One thing, the 5 pF that we tried first was a regular disc ceramic, it drifted several hertz per minute, but when he replaced it with a 22 pF Silver Mica, the vfo was much more stable. The point is use NPO's, Silver Micas or Polystyrene's in VFO's not 20% disc ceramics.

Ahhh, now we had a vfo, and Dave hooked up the signal generator at 7.040 MHz and he listened for it. It was there!! But weak, very weak. The mds of the receiver was only at -80dB, not very good. Lousy in fact. Dave said not to worry, that we had some tweaking to do. The circuit has two tuned circuits that need to be peaked and are set by peaking a trimcap in each circuit (C2A and C4A). The first one came up very nice with two peaks, which is what you are looking for when you use a trimcap. Bruce Florip wrote a nice article on this in a past issue of QRPp. But the other one only had one peak. Dave explained that this meant that the circuit was not reasonat at 7MHz. So he tried removing capacitance (again much easier than adding or removing turns) and it worked. Soon he had two peaks in the adjustment. He adjusted both of them back and forth, as they were interactive. Finally he was satisfied. Now, lets see what it does. Only -100 dB of mds. Terrible. Dave read the original article and saw that Jay Rusgrove got an mds of -130 dB!! Something was wrong.

Dave looked at the circuit, and then he asked about the transformers. Were they the same? No one was a 10K to 2K and the other was a 1K to 8 ohm. He checked them out for proper placement of the primary and secondary and they were correct. Then he asked if I was positive that I put the right transformer in the right place on the board. I wasn't so we checked the part numbers with a Mouser catalog, and sure enough, I had reversed them on the board.

Dave had me repeat after him, "Doug, I am a dummy. Doug, I am a dummy." That is supposed to exorcise the dummy demons or the badgers or something. Dave unsoldered the parts, exchanged them and tested the rig. Maybe -110 dB. But still something was wrong. Then Dave looked at the bias resistors on the 3 2N2222 transistors and he said, "Ah Hah! I see the problem." One of the bias resistors was 560 ohms instead of 5.6K, it does make a difference. He switched it out, and tested the receiver. He still wasn't satisfied. Then he sat down and studied the schematic. He decided that we weren't getting enough coupling at L3 and L4. This was one of the coils that was changed from the original Radio Shack modified part to a toroid. He rewound it and changed it from L3 at 45 Turns and L4 at 5 turns to L3 at 45 turns and L4 at 20 turns. He resoldered the toroid, and what a difference. Dave tested the mds, and it was at -123 or so. Very good for such a simple receiver. The rig works!! Thanks to Dave for doing such a neat job, and helping me to learn some more about trouble shooting. I can't wait for the Elmering sessions to begin. 72, Doug, KI6DS

Back to the Future: The Tuna Tin 2

by Doug Hendricks, KI6DS

Doug DeMaw, W1FB, was one of the founding fathers of QRP building and design. He authored several hundred articles for QST, and several books that are still used daily by QRPers throughout the world. NorCal has decided to honor Doug with a tribute that we think he would have enjoyed, the "Back to the Future" project. We will update a series of projects that were first presented over 20 years ago with modern available parts, and also will provide circuit boards to fit those parts for those who wish to build these designs. The first of these projects is the Tuna Tin 2, designed by Doug himself. The "Back to the Future" project is hereby dedicated to the memory of Doug DeMaw, W1FB, enjoy.

The Tuna Tin 2 was originally designed by Doug DeMaw, W1FB in 1976. It appeared in QST, and was subsequently built by hundreds of QRPers, who were attracted to the project by the relatively easy parts availability. In fact, at the time of publication of the article, you could stop by the local Radio Shack and pick up everything needed except for the crystal.

When I looked at the article in the summer of 1996 and decided to build another Tuna Tin 2, I discovered that all of the parts were not available from Radio Shack. I contacted Dave Meacham, W6EMD, and he agreed to look at the article and update the parts to modern, available parts sources. Because we were changing the physical size of some of the parts, it meant that a new board would have to be layed out. That was to be my contribution to the project. The board was layed out and the new schematic drawn with Circad which is available free on the internet at http://www.holophase.com. The free version is demo version that is not crippled and is very useful for the average ham. You have the ability to printout circuit board patterns to a laser or inkjet printer with the demo version. About the only way the demo version differs from the full version is in the ability to generate Gerber files and PCX output. Holophase even has a special price for hams, $295 vs. $995 for non-hams. Contact them for details.

The Circuit:

W1FB did a great job describing the circuit, so I decided to use his description from page 15 of QST, May 1976.

A look at the schematic will indicate that there's nobody at home, so to speak, in the two-stage circuit. A Pierce type of crystal oscillator is used at Q1. Its output tickles the base of Q2 (lightly) with a few milliwatts of drive power, causing Q2 to develop approximately 450 milliwatts of dc input power as it is driven into the Class C mode. Power output was measured as 350 milliwatts (1/3 W), indicating an amplifier efficiency of 70 percent.

The collector circuit of Q1 is not tuned to resonance at 40 meters. L1 acts as a rf choke, and the 100 pF capacitor from the collector to ground is for feedback purposes only. Resonance is actually just below the 80 meter band. The choke value is not critical and could be as high in inductance as 1 mH, although the lower values will aid stability.

The collector impedance of Q2 is approximately 250 ohms at the power level specified. Therefore, T1 is used to step the value down to around 60 ohms (4:1 transformation) so that the pi network will contain practical values of L and C. The pi network is designed for low Q (loaded Q of 1) to assure ample bandwidth on 40 meters. This will eliminate the need for tuning controls. Since a pi network is a low-pass filter, harmonic energy is low at the transmitter output. The pi network is designed to transform 60 to 50 ohms.

L1 is made by unwinding a 10 uH Radio Shack choke (No. 273-101) and filling the form with No. 28 or 30 enamel covered wire. This provides an inductor of 24 uH. [Note: this part is no longer available from Radio Shack, so W6EMD subbed a 22 uH inductor here.] In a like manner, unwind another 273-101 so that only 11 turns remain, (1.36 uH). The 11 turns are spaced 1 wire thickness apart. Final adjustment of this coil (L2) is done with the transmitter operating into a 50 ohm load. The coil turns are moved closer together or farther apart until maximum output is noted. [Again, this part is not available, so W6EMD subbed a toroid, T37-6 (yellow) with 21 turns of #26 wire.] The wire is then cemented into place by means of obby glue or Q dope. Indications are that the core material is the Q1 variety (permeability of 125), which makes it suitable for use up to at least 14 MHz.

T1 is built by removing all but 50 turns from a Radio Shack No. 273-102 rf choke (100 uH). The ferrite core in this choke seems to be on the order of 950, in terms of permeability. This is good material for making broadband transformers, as very few wire turns are required for a specified amount of inductance, and the Q of the winding will be low (desirable). A secondary winding is added to the 50-turn inductor by placing 25 turns over it, using #22 or #24 enameled wire. The secondary is wound in the same rotation sense as the primary, then glued into position on the form. Tests with an RX meter show this to be a very good transformer at 7 MHz. There was no capacitive or inductive reactance evident. The primary winding has an inductance of 80 uH after modification. [Although the RS 273-102 is still available, W6EMD also replaced it with a toroidal transformer, as it just looked better and as long as you *have to wind a toroid, you might as well wind two.)*

Increased power can be had by making the emitter resistor of Q2 smaller in value. However, the collector current will rise if the resistor is decreased in value, and the transistor just might "go out for lunch," permanently, if too much collector current is allowed to flow. The current can be increased to 50 mA without need to worry, and this will elevate the power output to roughly 400 mW.

One of the goals of this project was to provide readily available parts plus an easy source for circuit boards. I layed out the board and sent the artwork to Fred Reimers at FAR Circuits, 18N640 Field Court, Dundee, IL 60118, who is making boards available for $5 plus $1.50 shipping and handling for up to 4 boards.

I suggest that you do the metal work on your chassis before you start stuffing and soldering the parts on the board. You will first have to drill a hole to accommodate the connector that you have chosen for your key jack. You may use 1/8", 1/4" or phono here. The choice has been left to the builder. But whatever connector you choose, make sure that it is mounted in the center of the rectangle shown for J1, as J1 must be insulated from ground, as it is the means for applying 12V to the circuit. 12V is connected to one side of the jack, and when the key is closed, the resulting short circuit connects the 12V to the circuit.

W1FB wired his Tuna Tin 2 on a chassis made from a Tuna can, and I suggest that you do the same. He mounted his on the bottom, using a set of nibbling tools to cut all but about 1/4" of the bottom out, leaving the 1/4" rim to solder to. I decided to mount my board on standoffs that are connected to the bottom of the can and hold the board up to the edge of the rim. I then was able to put rubber feet on the bottom of the can. If you chose my method of mounting, you will need to drill 3 mounting holes in the board and then matching holes using the board as a template.

After you drill the mounting holes in the base, you will need to drill the holes for the 3 phono connectors and the SPDT toggle switch in the sides of the can. I mounted the Switch directly opposite the middle connector, and mounted the three connectors on the same side of the can about 1 1/4" apart. See Fig. 1 for a diagram that shows the placement of the connectors and the switch. W1FB chose to put his switch between the antenna and the receiver connectors, but I thought that I would like to have the power and antenna connectors on the back of my rig and the antenna switch on the front.

Next wire the chassis as shown in the diagram. I used pieces of wire about 4" long to make the connections between the connectors and the board. See Fig. 1 for the wiring diagram.

You are now ready to install and solder the parts. Refer to the parts list and the layout in Fig. 2. Be sure to check the schematic too. When you have finished, you are ready for the smoke test. Apply 12V power to the power connector, hook up a dummy load or 40 meter antenna to the rig, connect a key to the key jack, switch to transmit, and hit the key. You should hear a tone in a nearby receiver that is tuned to the frequency of your crystal.

If you have trouble getting your rig to work, DeMaw even had a trouble shooting section to his original article that is repeated here from page 16, QST, May 1976.

The voltage shown in the schematic will be helpful in troubleshooting this rig. All dc measurements were made with a VTVM. The rf voltages were measured with an rf probe and a VTVM. The values may vary somewhat, depending on the exact characteristics of the transistors cho-

sen. The points marked 1 and 2 (in circles) can be opened to permit insertion of a dc milliammeter. This will be useful in determining the dc input power level for each stage. Power output can be checked by means of an rf probe from J2 to ground. Measurements should be made with a 51 or a 56 ohm resistor as a dummy load. For 350 mW of output, there would be 4.4rms volts across the 56 ohm resistor.

Operating voltage for the transmitter can be obtained from nine Penlite (AA) cells connected in series (13.5 volts). For greater power reserve one can use size C or D cells wired in series. A small AC operated 12 or 13 volt regulated dc supply is suitable also, especially for home station work.

FAR Circuits has the boards for the NorCal Version of the Tuna Tin 2 ready. If you want to build an updated version with modern, easy to find parts, the board is available from FAR Circuits. Here is the info:
Order the NorCal Tuna Tin 2 Board, (please specify the NorCal version) at $5 each plus $1.50 S&H for up to 4 boards from:

FAR Circuits
18N640 Field Court
Dundee, IL
60118

Crystals for the rig can be ordered from Doug Hendricks for $3 each with the following frequencies available: 7.040, 7.122. Make check or money order out to Doug Hendricks and NOT NorCal. Send to Doug Hendricks, 862 Frank Ave., Dos Palos, CA 93620.

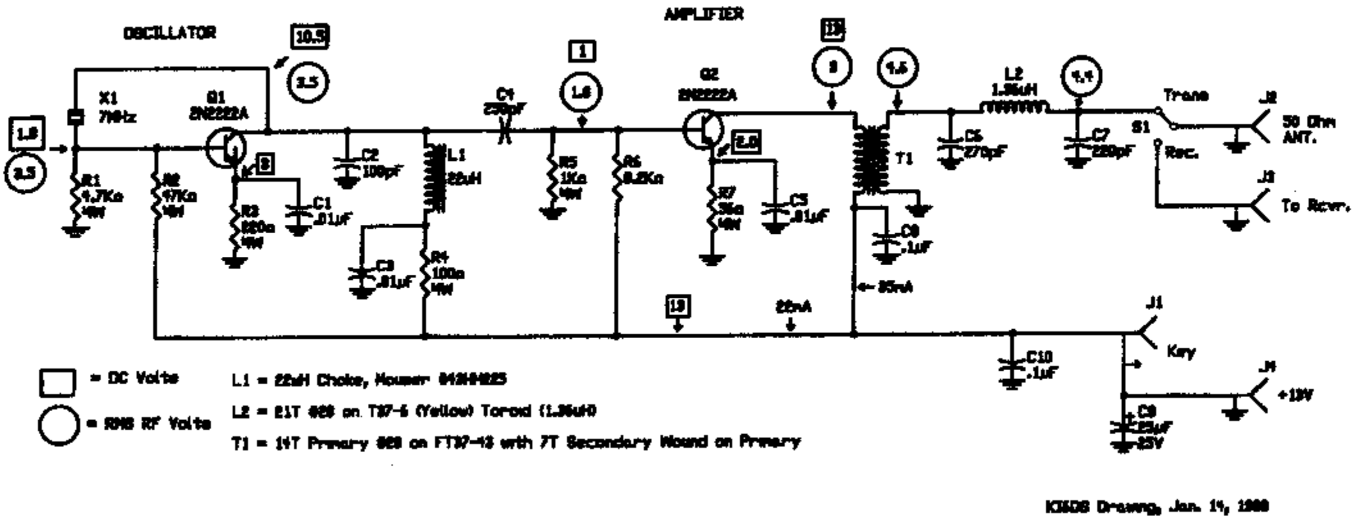
Tuna Tin 2 Parts List

C1 .01uF
C2 100 pF
C3 .01uF
C4 220pF
C5 .01uF
C6 270pF Silver Mica or Disc (100V)
C7 220pF Silver Mica or Disc (100V)
C8 .1uF
C9 22uF/25V Elect. radial or axial (mounted off board)
C10 .1uF
L1 22uH (Mouser 43HH225 or 7 turns #26 on FT37-43 Toroid)
L2 21T #26 on T37-6 Toroid (yellow)
Q1 2N2222A (Metal Case)
Q2 2N2222A (Metal Case)
R1 4.7K
R2 47K
R3 220 ohm
R4 100 ohm
R5 1K
R6 8.2K
R7 56 ohm
T1 14T Pri. 7T Sec. on FT37-43 Toroid
X1 40 meter crystal in HC49U style case.

All resistors are 1/4 watt, all capacitors on the board have .25" hole spacing.

You will also need stranded hook up wire, 1/8" or 1/4" key jack, 3 RCA Phono jacks, 1 SPDT Switch, 1 empty Tuna can.

Tuna Tin 2 Transmitter
Designed by Doug Demaw, W1FB
Updated Parts by Dave Meacham, W6EMD



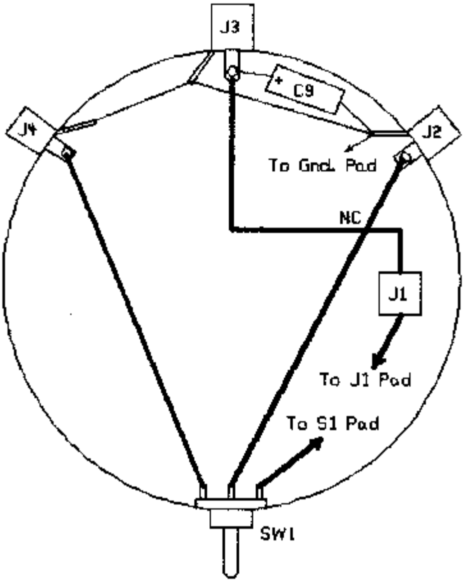


Fig. 1 Tuna Tin 2 Wiring Diagram

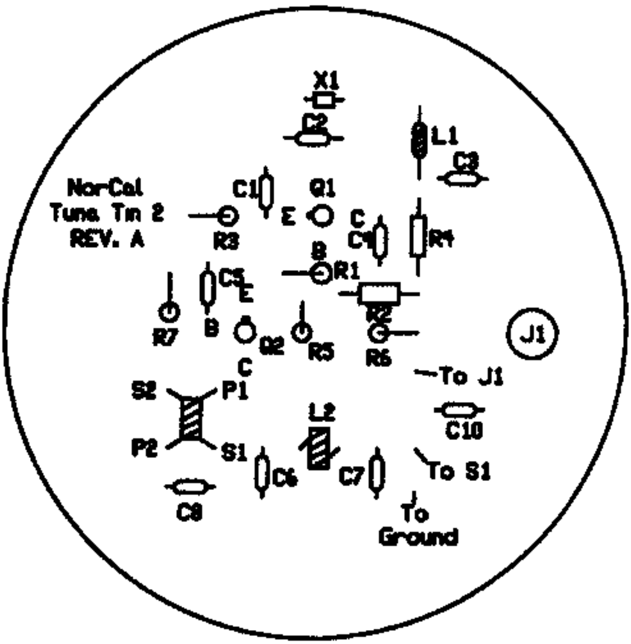


Fig. 2 Parts Layout For Tuna Tin 2

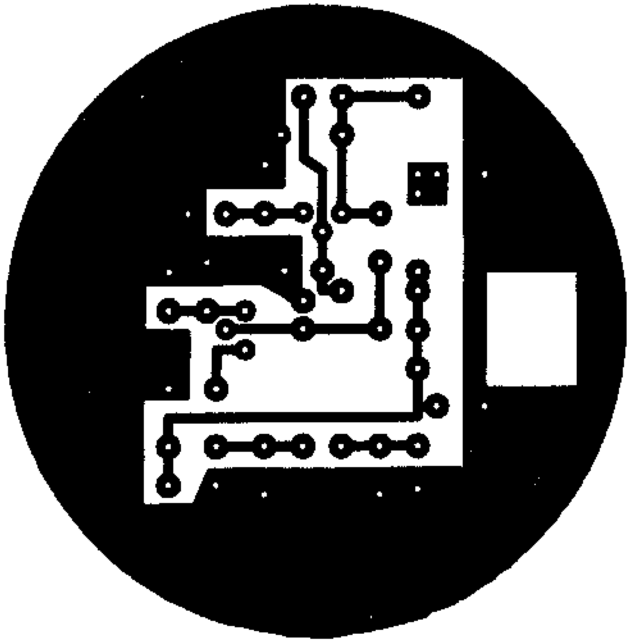
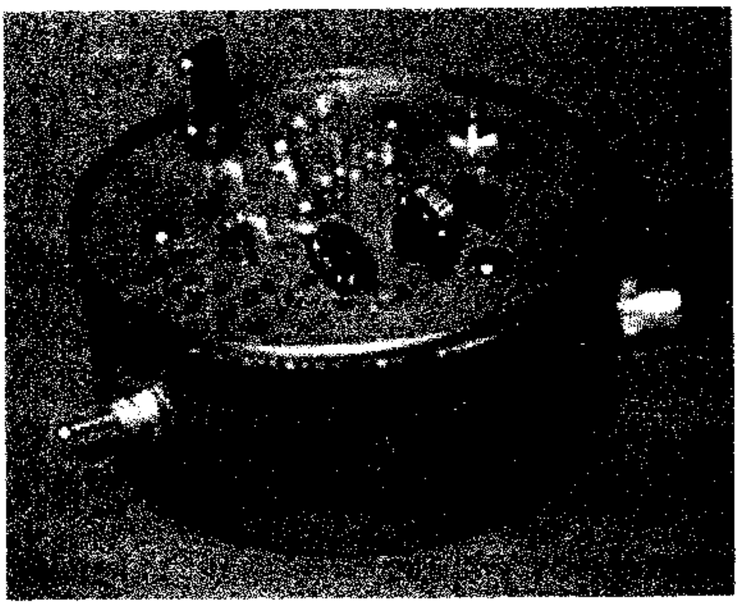


Fig. 3
PC Board Layout Pattern for Tuna Tin 2. Xray View from Component Side.



Adventure Radio Society Events

by Russ Carpenter, AA7QU
47227 Goodpasture Road
Vida, OR 97488

The Spartan Sprints

A monthly contest in which participants operate from home, but are encouraged to use the same portable and lightweight equipment they would use in an outdoor, human-powered expedition.

The Flight of the Bumblebees

A contest on the last Sunday of July in which 50 Bumblebees from all over the country reach their sites by human power and are chased by home-based operators and each other.

The Top of the World

A contest held during a four-hour segment of the ARRL VHF contest in June. Participants reach their mountain top sites by human power.

The Power of One

A contest held on the second Sunday of September. Participants operate both from home and from sites they have reached with human power. Everyone runs one watt.

WAS/PQ

An ongoing opportunity to work as many states as you can during a single event, from a site reached by human power. The power for all participants is one watt. The rules for WAS/PQ are a marvel of simplicity. Just work any domestic event from a site you reach with human power‹we define "human power" as skiing, snowshoeing, walking, biking, rowing or paddling. The distance traveled to your site is at your discretion. You can operate from any location, running five watts or less.

Submit your results to us. We will maintain a page on the ARS Web Site showing the results of all who submit WAS/PQ logs to us. If you contact more states in your next outing, submit your results again, and we will update the page. ARS will issue handsome certificates to all who submit logs, showing the number of states you worked. So whether you work three states, or thirty-three states, we will be happy to document your accomplishment.

Participants are strongly encouraged to use our automated contest reporting system, which is found in the ARS Web Site at http://www.natworld.com/ars. If you choose to use a paper log, please include at least the following:

- Your full name and callsign;
- The event in which you operated.
- Date of the event; and
- Total number of states contacted.

You may also want to add soapbox information, such as the equipment used, your operating location, interesting contacts, successes and challenges.

You don't need to be a member of ARS to participate in the ARS events, but we would welcome your interest in becoming a member. Inquiries may be directed to ARS' membership chairman. His name and address are Richard Fisher, nu6SN, 1940 Wetherly Street, Riverside, CA 92506 (e-mail nu6SN@aol.com).

Russ Carpenter, AA7QU, is the Contest Manager. Mail paper logs to him at 47227 Goodpasture Road, Vida, OR 97488. You can reach Russ by mail, by phone at (541) 896-0263, by fax at (541) 896-0310 or by email at russ@natworld.com.

Thoughts on the 'Huff-n-Puff' Frequency Controller

by Dave Benson, NN1G

Note: This article was adapted from Dave Benson's (NNIG) presentation at Pacificon.

Some QRP applications are a just crying out for a solution. In early '97, QST ran an article on a VFO frequency stabilization scheme using some seven ICs. Needless to say, most of what's needed for a 'Huff-n-Puff can be squashed into one chip! More recently, Lee Richey's article in the Sept.'97 issueof QST tackled the subject with a more modem approach, using a PIC microcontroller.

Prior to publication of Lee's fine article, I'd looked at a 'Huff-n-Puff' implementation as an adjunct to better wide-range VFO stability. See Figure 1 for a schematic for a 'rock-bottom' VFO stabilizer. As with the frequency counter, we need some way of determming frequency, so the pre-amplifier at the upper left of the schematic converts an LO input to 5V logic. This implementation uses a digital shaft encoder rather than a conventional tuning pot or cap. The 2 shaft encoder (phase A and B) signals are used to tune the VFO up or down, and the 'Step Size' pushbutton is used to toggle between coarse and fine tuning steps.

The 'business end' of this controller is a FET op-amp configured as an integrator. If either of the two op-amp input resistors is conducting current, the integrator is charging, and the output voltage is increasing or decreasing to modi~ the VFO frequency. This can be used as both a tuning mechanism and a frequency-stabilization mechanism, as I'll describe shortly.

Why are there two resistors there? Good question! A rule of thumb for a huff-n-puff is that the frequency stabilization should result in excursions of no more than about 10 Hz. This permits the VFO to do its thing without objectionable wavering in pitch. To accomplish this fine frequency control, pulses used to correct frequency must have a very fine resolution. One way to achieve this is to make the charging resistor quite large, and this ac-

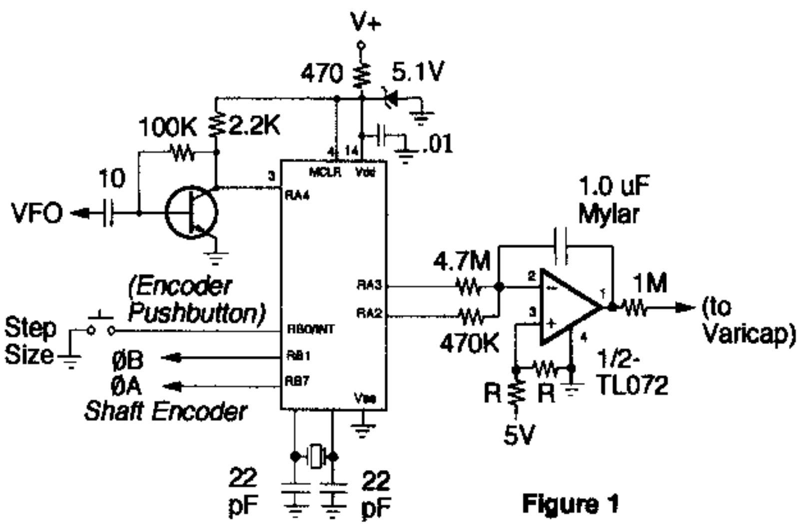
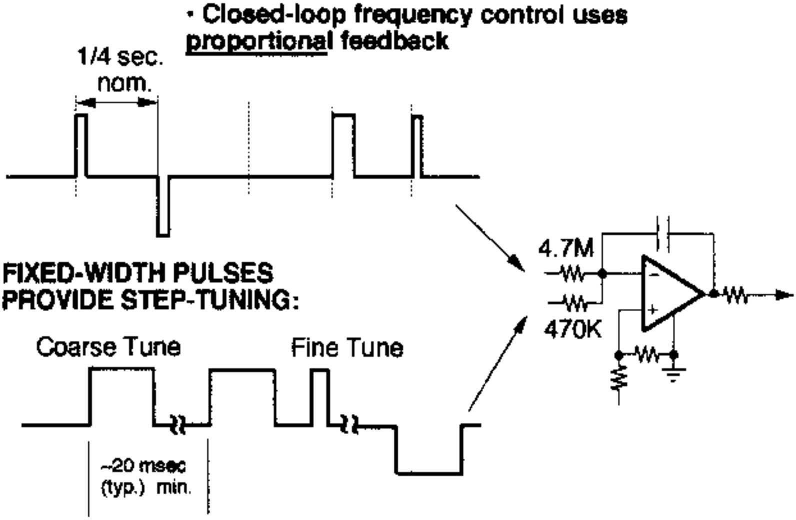


Figure 1

Figure 2- '*the gory details*'



Both signals use the PIC Tri-state capability when no frequency change is required.

complishes the task quite nicely. On the other hand, if this frequency controller is also being tuned digitally, you want a step size of some 300-500 Hz (in the coarse tune setting) to cover the band reasonably quickly. If you're tuning the shaft encoder rapidly, you may be inputting frequency changes as rapidly as every 20 msec (for a 32-step encoder). There's no way the integrator can keep up with these commands with the long time constant of the larger resistor. A second - smaller value- resistor is added to take care of this more rapid frequency change. Needless to say, after you've tuned the dial, the frequency-control scheme has to know that something changed and start again from the new frequency. For a shaft encoder input, this is easy - the tuning software tells the 'huff-n-puff it's time to start over. For a conventionally tuned scheme, the trick is in recognizing that a recent excursion was too big to be drift, and must have been a control input- this starts the 'huff-n-puff over again. With either of these schemes, the actual frequency is irrelevant - "it's all relative".

'Huff-n-Puffs' - the Gory Details

Let's delve into some of the details of what makes this critter work. Figure 2 shows the two types of frequency control this scheme uses. The top waveform illustrates the signal waveform into the larger, or closedloop frequency resistor. The PIC is programmed to count for about a quarter of a second at full resolution (no prescalar). Only the 8-bit counter value is kept - because it's all relative, since we don't care about the overflow bits.

The state of the counter is compared with the counter state saved from the last sample taken and saved a quarter second ago. If the count result is the same as the last sample, the PIC output remains tristated (shut off) and there's no change to the integrator output. If, however, the result has changed, the PIC outputs a brief logic '1' or '0' to step the integrator output down or up respectively. It's important to note that this control should be proportional in nature. In other words, larger detected errors should result in larger (wider) control pulses. This lets the 'huff-n-puff' keep up with cold-start drift and additional drift due to thermal changes during long key-downs. In practice, I saw less than 10 Hz drift from a cold start.

The second waveform shows how the shaft encoder commands frequency changes. Rotation of the shaft encoder causes fairly wide logic '1' or '0' pulses out of the second PIC output, the polarity of the pulses determines which way the integrator will charge. The pulses come in two lengths, the longer of the two corresponding to coarse tuning. If you viewed the output of the integrator as you rotate the shaft encoder, it simply resembles a 'staircase' as the integrator is charged

Initiallzation: This implementation simply turns on the one of the logic signals to the integrator for several seconds, the op-amp output ramps up to about half-scale (-6V) and stops. (this is referred to as a 'feature"- you get a feel for overall band activity as signals go whizzing by!) With a little more hardware (such as that seen in Lee's article), the initialization can be essentially instantaneous if the integrator output is set to a predetermined value.

'Why bother with an op-amp integrator?'

You could dispense with the integrator and just use an R-C network - but it would be wrong!. This scheme works well around half-scale on an R-C network. Unfortunately, as the DC voltage approaches one of the supply rails (0 or 5V), the charging pulses no longer have much effect on frequency. This will require a disconcerting amount of knob-turning for a shaft encoder design and the tuning characteristics becomes markedly unsymmetrical! This difficulty isn't seen if you're simply locdng to an existing (conventionally-tuned) design.

I need to take a moment to talk about component quality in this application. It's imperative to keep the drift sources mrtimized here. While the "huff-n-puff' goes a long way to improve stability, the use of feedback isn't a panecea! The VFO itself should adhere to all the standard practices used to ensure a quality signal, and the integrator components themselves have some special requirements. Good voltage regulation is a must at the PIC and integrator reference supplies. The integrator op-amp itself needs to be a FET-input type such as the TL072 - this effectively eliminates op-amp input bias current as a source of drift. The quallty of the charging capacitor is paramount to success here. If you use a junkbox special such as a ceramic disk or even an electrolytic, you'll discover that after tuning to a new frequency, the loop is quite busy trying to hold the new frequency steady for a while. This is due to self-heating - the current inrush on large voltage changes actually self-heats the capacitor due to internal losses! It's imperative, then, to use a temperature-stable capacitor such as a mylar or polyester type. (By the way, you see this same temperature problem exhibited in audio oscillators used for sidetone generation-there's a pronounced 'yoop' with some capacitor types as the oscillator starts up.)

I'd like to touch on one of thornier problems encountered with the 'huff-n-puffs', namely that of T-R switching and RIT. If the key-up and key-down LO frequencies vary noticeably in pitch, whether deliberate (RIT) or unwanted (LO loading and other effects) there needs to be a way to switch the LO frequency rapidly back and forth between receive and transmit frequency. A simple controller such as the one I've described is not adequate for the demanding CW application- any LO shift will be corrected by the loop and will be perceived as a slow 'yoop'. It's more than adequate for sideband, though.

Because the stability requirements of 10 Hz or under translate to a gate time of 100 msec or more, this poses a dilemna for rapid T-R switching. Ten-Tec resolved the issue (and not very successfully) in their Scout series by letting the LO free-run during transmit periods. (This had the important side benefit of letting them use the PIC controller as a keyer as well.). Unfortunately, after long transmit periods, the 8-bit counter may well be off "into the next county". In other words, the drift has exceeded the logic's modulo-256 arimethic capability. As a result, the Scout was infamous for re-locking itself at a new frequency after long key-down periods. This was overcome in Lee Ritchey's design - he captured the key-down (transmit) LO frequency in a second timing register and used that as a second timing reference. Lee also considered the modulo-256 issue and his design apparently overcomes that "restart in the next-county" problem. His scheme also accomodated RIT through the use of a 3rd reference frequency and a '4066 analog switch to manipulate the VFO control voltages..

I'll offer one other thought on RIT here. With the pre-mixed LOs used in the Wilderness Sierra and the SWL GM-series, there's an opportunity to 'pull' the heterodyne crystal oscillator to provide RIT. By closed4ooping only the tunable portion of the pre-mixed LO, the 'huff-n-puff doesn't interact at all with the RIT function.

I hope I've provided some useful "food-for-thought". This is fertile ground for the experimenter, and hopefully we'll see additional interest in this area! 73, Dave Benson- NN1G

Building the NorCal K8FF Paddles in the UK

by Ted Williams, G0ULL
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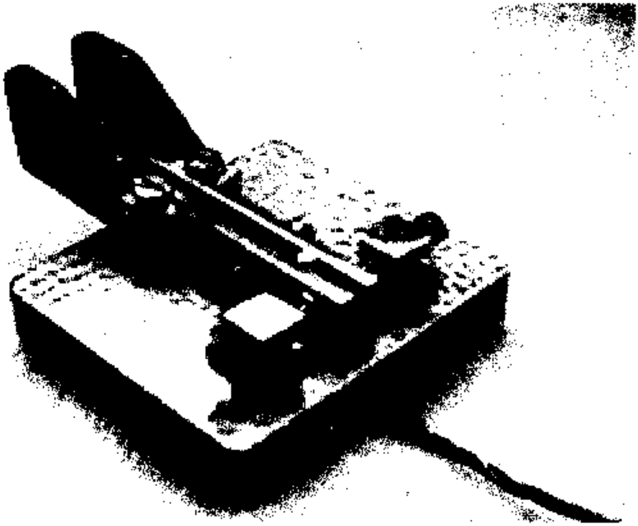
In the summer of 1997, Doug and JoAnne Hendricks visited England, meeting along the way a few hams of whom I was one. He enthused over a forthcoming kit for a paddle key by NorCal, and having akeady constructed the superb NorCal 38S kit, my ears pricked up. Now, international mailing of chunks of brass and iron is an expensive business, so I asked Doug if it was possible to get hold of the drawings so I could fabricate it from scratch. One, (or was it two ?) computer crashes later I received a set of very creditable drawings so I could see what I was up against. If all else failed I could still buy the kit. (there are a couple of errors in Doug's drawings, but it doesn't affect construction)

Machining the brasswork looked possible, even for an amateur machinist like me, but the problem was in sourcing the magnet and the bronze bearing in the UK. After a bit of thought, it was clear that the magnet attracted the two paddles together, rather like a spring. Further, the bearing pivot could reasonably be made of polished steel rather than the elegant bronze solution specified. Also, in my younger days of messing with car engines, I learned the frustration of trying to set tappet spacing by adjusting a screw and a locknut, so on the key I've changed that to a set-screw at right angles to the adjuster, with a scrap of nylon to avoid damaging the adjuster's thread. This led to a modified design which I've sketched here for interest, and you can see it has had the effect of turning the



Ted Williams, G0ULL's version of the NorCal K8FF Paddles
Steve Smith, G0TDJ photo.

NorCal design almost inside out, though the parentage is still obvious.

I couldn't work an Iambic paddle reliably to save my life, so the prototype was handed over to Steve, GOTDJ who is our local Morse guru, for an opinion. He is also a photographer and provided the pictures. The main criticism was that the body was a bit too light, making it necessary to hold it down with the free hand. He offered two solutions, heavier base and/or sticky feet.

I asked 'Tandy' (I think Radio Shack in the US) if they had clear sticky feet, and after some funny looks they provided clear plastic stick-on feet about 7/16 inch diameter of skid-resistant polyurethane, and there is no doubt they give much improved friction. In addition, I have specified in the sketches a slightly larger base than the model, to increase the weight.

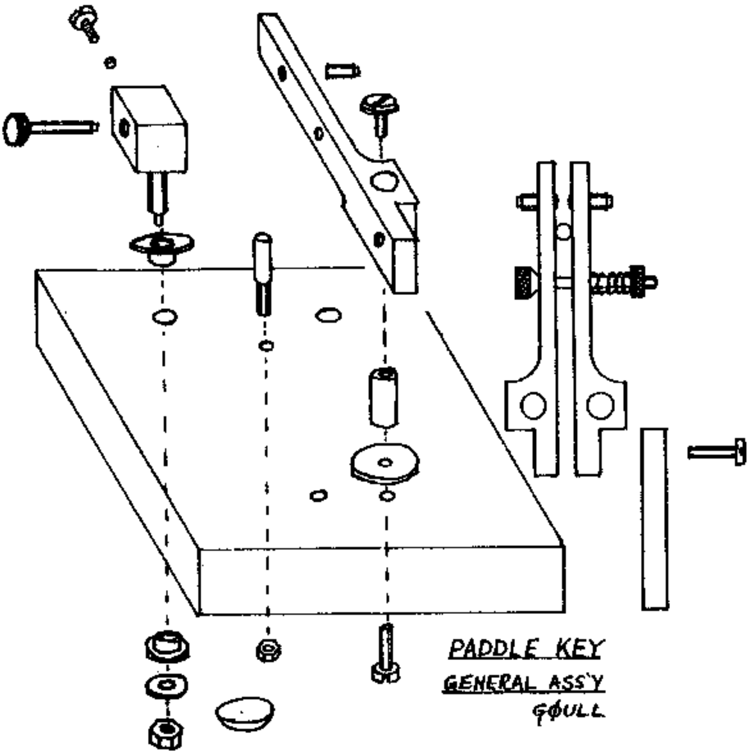
It was suggested to Steve that the key could be made quieter by making the centre rest post of plastic rather than brass. This was vetoed on the basis that the click provided useful audible feedback to the sender.

My first mistake was in mentioning to Doug that I'd made these mods to suit UK sources, and hence this article. That man is a HUSTLER!

JUST A FEW POINTERS

The paddles CAN be filed out of 3/8 inch square brass bar, after sawing (junior hacksaw) most of the metal out; it is not essential to machine them. It is absolutely vital that the pivot hole be accurately square to the paddle, and correct size. I drilled it with a 0.182 in diameter drill, (#14 drill if you have those in the US), and using a hand reamer in a tap wrench or holder reamed it to 3/16 inch precisely, removing about 0.0055 inches on the diameter. For those unacquainted with the parallel reamer, it looks like a drill bit without the twist, having parallel flutes with a small taper lead, and is used for removing small amounts of material in accurately sizing a hole.

At this stage, both hole and bearing pivot are the same diameter, so it won't go



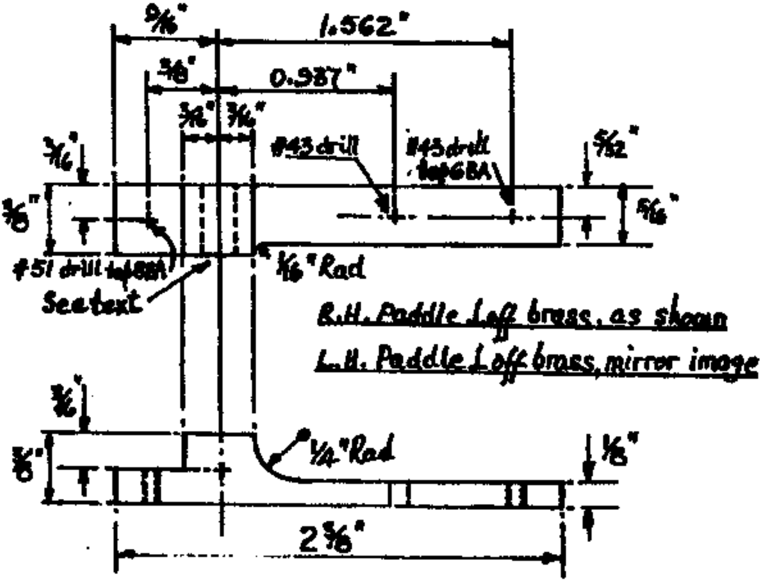
in. I then used a crude D-bit made of the bearing steel to get it close to a fit before finally lapping in the bearing using a tine abrasive - I used Brasso, a mild abrasive metal polish. This is all a bit painstaking, but well worth while. Wash the parts thoroughly when satisfied with the fit, then oil it.

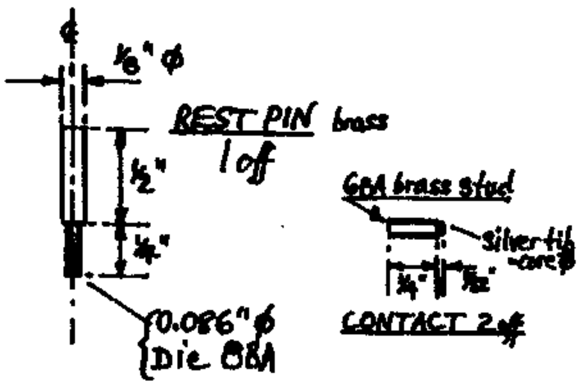
Before you ask what a D-bit is, mine is simply a piece of the bearing steel 3 or 4 inches long, ground or filed to a long taper at one end, say 3/4 inch, down to about a third of the diameter - it is not critical. The cross-section is, of course, D-shaped. Rub it flat on a whetstone until the edges are clean and sharp, then file a rough square on the other end to give it purchase in a tap wrench. With a bit of oil, rotate it into the hole, removing a minute amount of material, giving a tight fit. This is converted to a running fit by using the actual bearings and a bit of fine abrasive, as described. You can buy proper D-bits, but they are expensive, so why waste money?

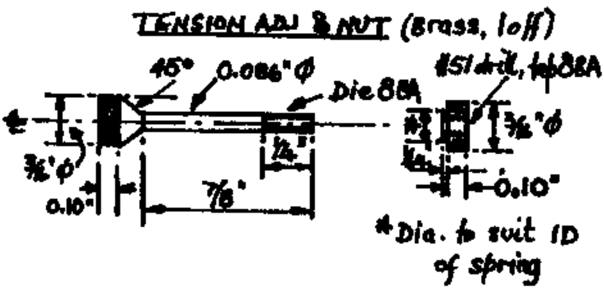
In my view, the paddle handles look much better in dark tinted material, which I was able to 'rescue' from an old printer cover, than in clear plastic.

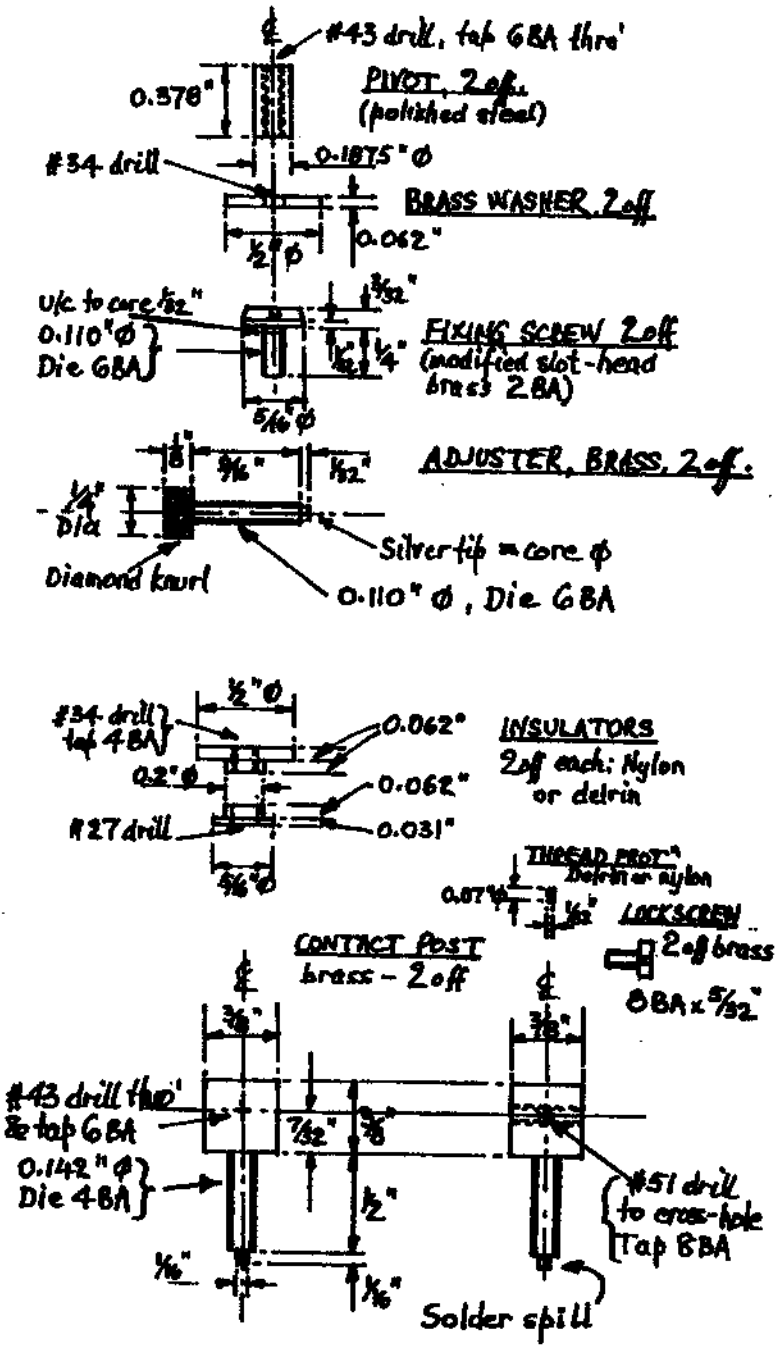
For the other parts, I have to admit that a small modellers' lathe is a huge asset, and well worth the relatively modest outlay - cheaper than a rig. It's fun finding out how to use it, too. Once you have it you will findso many tasks for it that you wonder how you ever managed without However clever and detailed the electrical design of a project may be, the actual assembly is always a mechanical process requiring mechanical piece-parts.

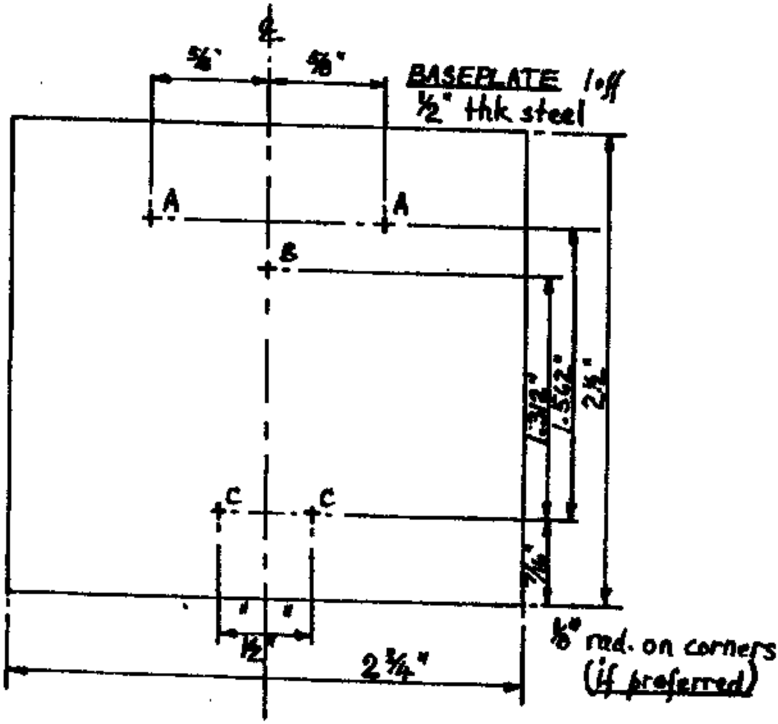
The adjusting screws used are hand-


9/16"
1.562"
3/8"
0.987"
3/16"
3/16"
7/16"
#43 drill
#43 drill tap 6BA
5/32"
5/16"
5/16"
#51 drill tap 8BA
See text
1/16" Rad
R.H. Paddle 1 off brass, as shown
L.H. Paddle 1 off brass, mirror image
3/16"
5/16"
1/4" Rad
1/8"
2 3/16"


1/8" φ
REST PIN brass
1 off
1/2"
1/4"
0.086" φ
Die 8BA
6BA brass stud
Silver tip
1/4"
3/32"
CONTACT 2 off

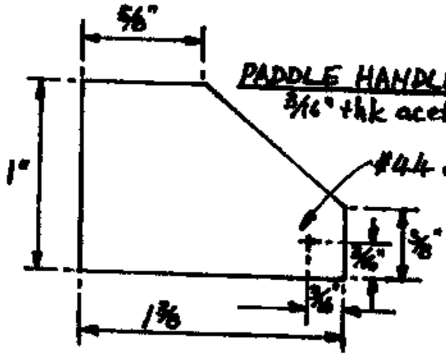

TENSION ADJ & NUT (Brass, 1 off)
45°
0.086" φ
Die 8BA
#51 drill, tap 8BA
3/16" φ
3/16" φ
1/4"
0.10"
7/8"
0.10"
* Dia. to suit ID of spring


#43 drill, tap 6BA thro'
PIVOT, 2 off.
(polished steel)
0.378"
#34 drill
0.1875" Ø
BRASS WASHER, 2 off
0.062"
U/c to core
0.110" Ø
Die 6BA
FIXING SCREW 2 off
(modified slot-head brass 2BA)
ADJUSTER, BRASS, 2 off.
Dia
Diamond knurl
Silver tip = core Ø
0.110" Ø, Die 6BA
#34 drill
tap 4BA
0.062"
INSULATORS
2 off each: Nylon or delrin
0.2" Ø
0.062"
#27 drill
0.031"
THREAD PROT'
LOCKSCREW
2 off brass
8BA x 5/32"
CONTACT POST
brass - 2 off
#43 drill thro'
& tap 6BA
0.142" Ø
Die 4BA
#51 drill
to cross-hole
Tap 8BA
Solder spill



HOLES:

A = #7 drill c/b 0.375" ϕ x 0.312" dp on rear
B = #44 drill c/b 0.250" ϕ x 0.312" dp on rear
C = #34 drill c/b 0.250" ϕ x 1/4" dp on rear



Jon GOULL
1998

made and knurled for a good finish, but for a working key it is perfectly adequate to use standard machine screws with no loss of performance. I do like to tip the contacts by soldering on a little bit of sterling silver - pure silver is too soft - to give them improved performance. The silver should be available from craft shops, and I think JoAnne might know of sources. Just a scrap of sheet metal around One millimetre thick is all that is needed. Finish by doming the end and polishing.

On the question of polishing, after the finest grade of abrasive paper, try putting Brasso on a sheet of thick paper on a flat surface and rub the brasswork on it, finishing with a soft cloth. Do avoid careless use of abrasive papers such that everything turns up barrel-shaped. Hint: Silver polish is even finer than Brasso.

Finally, the spring is a very weak one and came out of the junk box, but there is plenty of latitude with the adjuster. For information, I used a compression spring, natural length 0.2 inch, OD 0.15 inch and having 5 turns of 0.012 inch diameter steel wire.

SCREWSIZES

I don't know US screw sizes and I do not have much in the way of metric tools, soI use good old standard BA sizes (British Association), commonly used in electrical work but now outlawed by the EU. To help in choosing alternative threads, here are a few details on the 4, 6 and 8 BA screw threads used.

	4BA	6BA	8BA
Outside diameter	0.1417	0.1102	0.0866
Core diameter	0.1105	0.0852	0.0664
Threads per inch	38.46	47.85	59.17

The number drills used are: #7=0.201; #34=0.111; #43=0.089; #44=0.086;#51=0.067 inches. 72, Ted, GOULL

Footnote: The operating difficulty I have with an Iambic twin paddle is much reduced with the simpler regime on a single paddle key, though the mind does go walkabout on occasion. Consequently, using the same techniques of construction I have designed and built a prototype smgle paddle which has akeady been presented to the Morse guru for test, and initial comments are encouraging. Once again, its parentage is obvious. I'll give Doug details if there is any interest. Ted

Coming QRP Events in 1998

NorCal QRP to the Field Contest

Saturday, April 25th

Dayton Hamvention May 14,15,16 & 17

HamCom in Dallas, TX June 5,6 & 7

Ft. Tuthill, Flagstaff, AZ, July 24,25 & 26

Pacificon, Concord, CA Oct. 16,17 & 18

QRP HINTS & KINKS

A NorCal Exclusive

Illustrated by Paul Harden, NA5N

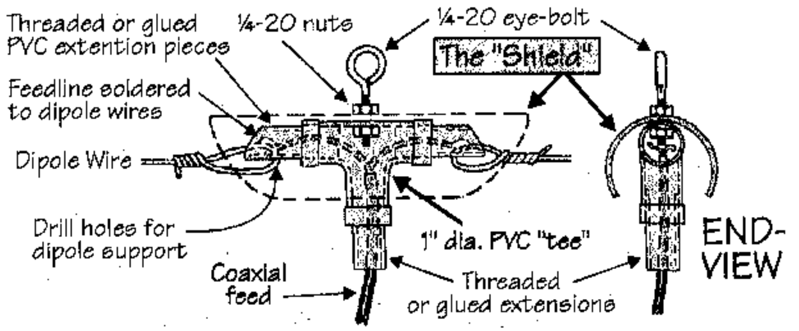
#7 Antennas & Two Classic W1FB Rigs

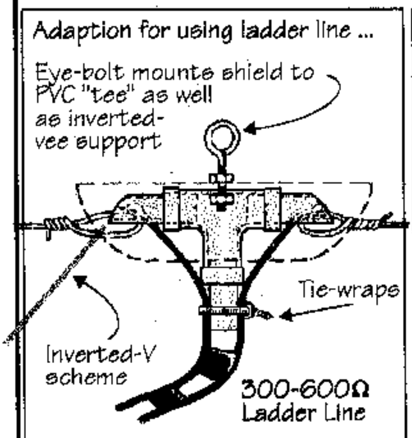
(A tribute to Doug DeMaw, W1FB)

The N5DUQ "El Niño-Proof" Rain Protector Dipole Shield

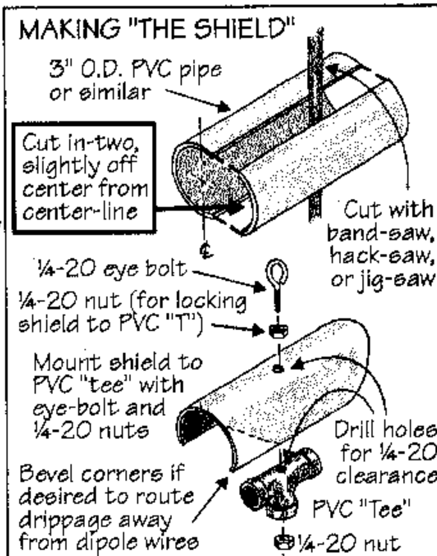
From Burl Keeton, N5DUQ
Oklahoma City, OK

If you live in a wet area (or in "El Niño's" path), here's a clever way to protect the apex of your dipole or inverted-vee from rain, ice and snow. It is an adaption of using a PVC "tee" for the dipole feedpoint by adding a shield (or hood) to keep the feedline connections to the dipole wires dry. Burl has used this scheme for 3 years and reports virtually no change in SWR or tuning during rains or snow.

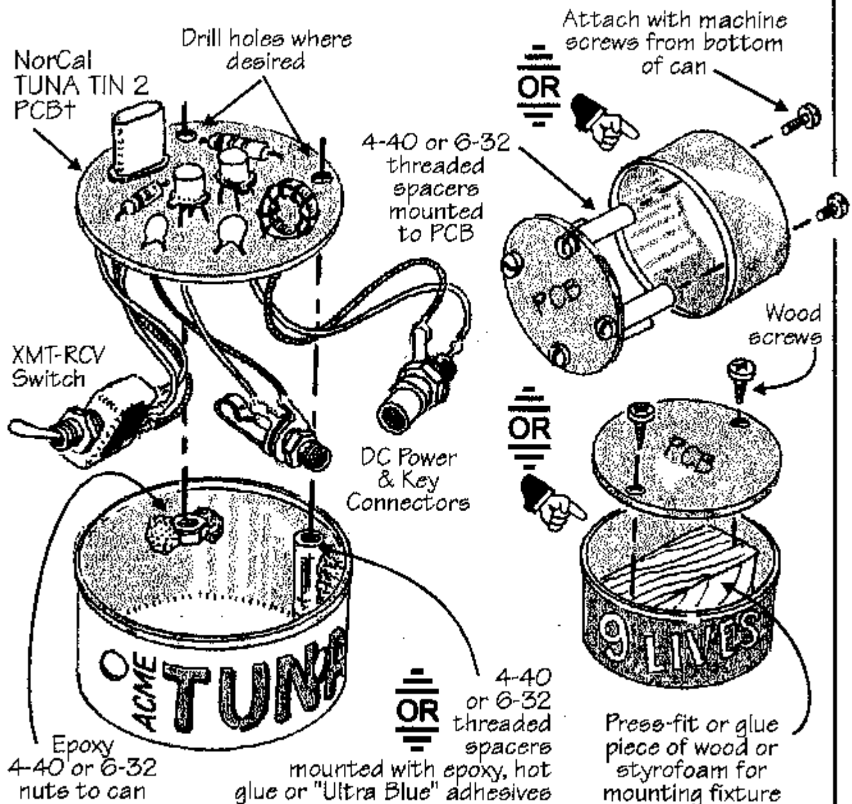




Make shield from PVC pipe or other non-conducting material -- do not use sheet metal or aluminum that will alter tuning or absorb RF!



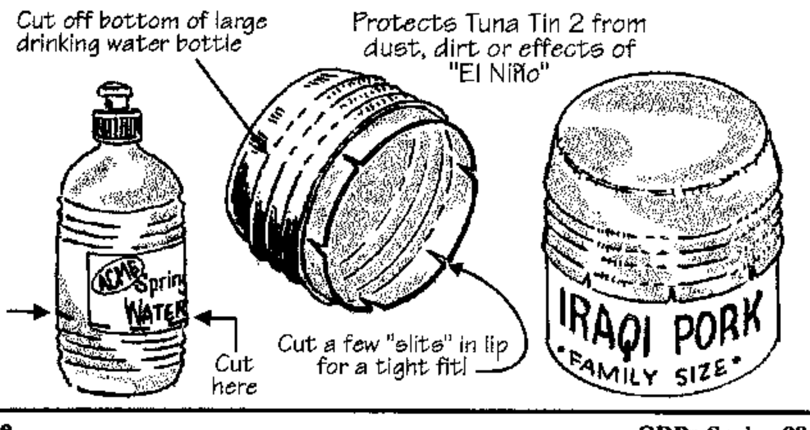
BACK to the *FUTURE*... TUNA TIN 2



† NorCal "round" Tuna Tin 2 PCB Available from FAR Circuits

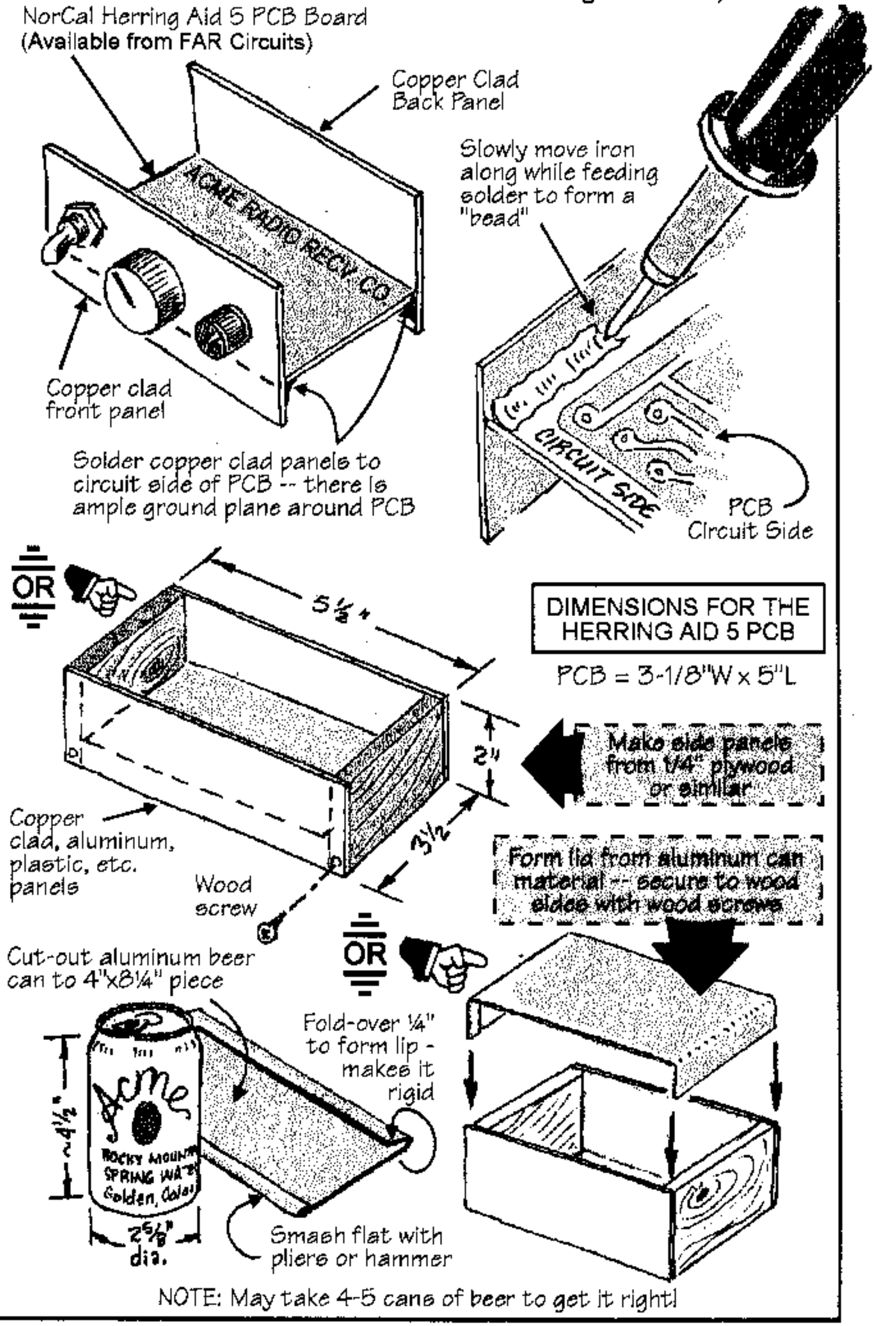
TUNA TIN 2 "DUST COVER"

From Denny Payton, N9JXY



BACK to the *FUTURE...* HERRING AID 5

From Doug Hendricks, KI6DS

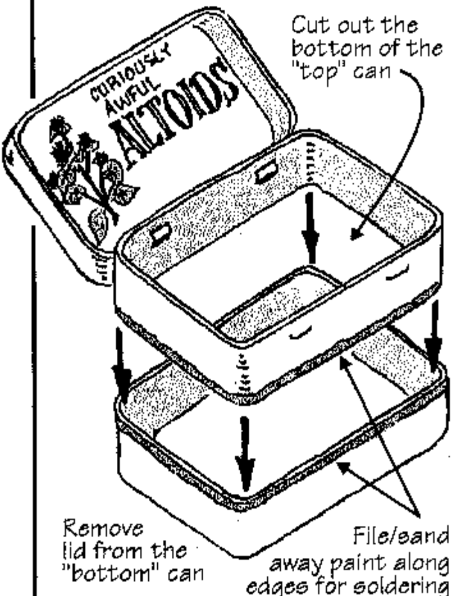


NOTE: May take 4-5 cans of beer to get it right!

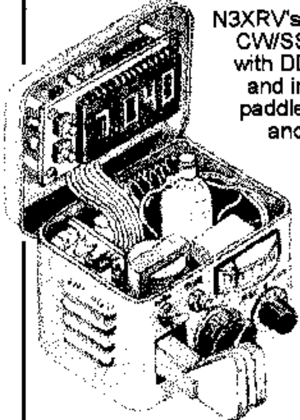
ALTOID CANS - "Double Your Pleasure!"

From Chris Cartwright, N3XRV

Using just a 35W iron, Chris has "**glued**" together two Altoid cans for a deeper, larger enclosure for those curiously special projects.



Solder the two cans together where they join, file and sand smooth afterwards and paint for the final finish.



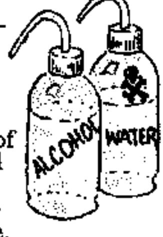
N3XRV's all-band 25W CW/SSB transceiver with DDS PLL tuning and internal NorCal paddles, TiCK keyer and K1MG digital display -- built into stacked Altoid cans.

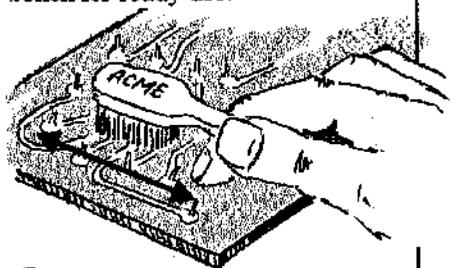
Hey ... it could happen!

DEFLUXING PCB's

From Gary Surrency, AB7MY
Chandler, AZ

Remove solder flux with *denatured (wood) alcohol* by scrubbing with an old tooth brush and rinsing remaining residue with water, then dry fully. Let solvents drain off the board. Keep squirt bottle of de- ionized/distilled water and alcohol handy on the work-bench for ready use.





OR — Use acetone or nail polish remover for stubborn flux areas, but use with caution, as acetone *will* damage plastic (like meter faces) and some components (like polystyrene capacitors)!!!

On-line Data Sheets

From Andy Fox, KK7HV

Here's a few web sites of the major semiconductor companies that contains useful component data sheets and application notes.

www.analog.com/
www.semiconductors.philips.com
www.ti.com/corp/docs/
www.linear.com/
www.national.com/design

Thanks for all the support and submissions to *QRP Hints & Kinks*. Send your ideas to NA5N@Rt66.com or to Paul Harden, P.O. Box 757, Socorro, NM 87801. *--72, Paul NA5N*

NorCal K8FF Paddle Kits

The NorCal Paddle Kit will consist of all the parts needed to build the kit, including the base, machined brass parts, and all hardware. The kit is unfinished. The machining has been done for you, but it is up to you to finish the kit by polishing the brass parts and painting or plating the base. The cost of the kit is $30 plus $5 shipping and handling in the US, $10 shipping and handling for Western Europe and Canada, and $15 shipping and handling for the Pacific Rim. To order send your check or money order (US Funds Only) to: Jim Cates, 3241 Eastwood Rd., Sacramento, CA 95821, USA Make checks and money orders out to Jim Cates, NOT NorCal.

For those of you in the United Kingdom and Western Europe. You may order your paddle kits from our European agent and pay in English pounds. The cost is 25 UK pounds and includes shipping. Steve Farthing, 38 Duxford Close, Melksham, Wiltshire, SN12 6XN

QRPp Back Issues Pricing:

1993 - $10, 1994 - $15, 1995 - $15, 1996 - $15, 1997 - $15 (Avail. Feb. 1, 1998) Full year sets available. NO individual issues available, sets will not be broken up.

Shipping: US

$3 for 1 - 3 issues, $5 for 4 - 5 issues.

Shipping: Canada

$3 for 1 issue, $5 for 2 - 3 issues, $7 for 4 -5 issues.

Shipping: DX Europe & South America

$5 for 1 issue, $7 for 2 - 3 issues, $10 for 4 - 5 issues

Shipping: DX Pacific Rim, Australia & New Zealand

$5 for 1 issue, $10 for 2 issues, $15 for 3 issues, $20 for 4 issues, $25 for 5 issues

All funds US funds only. Make check or money order to Doug Hendricks, NOT NorCal. Please send orders to: Doug Hendricks , 862 Frank Ave. , Dos Palos, CA 93620, USA

QRP Frequency Crystals

NorCal has available the following crystals in HC49U cases for $3 each postage paid in th e following frequencies: 7.040 MHz, 7.122 MHz., 10.116 MHz. Send your order and payment in US Funds only to: Doug Hendricks , 862 Frank Ave. , Dos Palos, CA 93620, USA. Make check or money order to Doug Hendricks, NOT NorCal.

QRPp Subscriptions

QRPp is printed 4 times per year with Spring, Summer, Fall and Winter issues. The cost of subscriptions is as follows: US and Canadian addresses: $15 per year, issues sent first class mail. All DX subscriptions are $20 per year, issues sent via air mail. To subscribe send your check or money order made out to Jim Cates, NOT NorCal to: Jim Cates, 3241 Eastwood Rd., Sacramento, CA 95821. US Funds only. Subscriptions will start with the first available issue and will not be taken for more than 2 years. Membership in NorCal is free. The subscription fee is only for the journal, QRPp. Note that all articles in QRPp are copyrighted and may not be reprinted in any form without permission of the author. Permission is granted for non-profit club publications of a a non-commercial nature to reprint articles as long as the author and QRPp are given proper credit. The articles have not been tested and no guarantee of success is implied. If you build circuits from QRPp, you should use safe practices and know that you assume all risks.

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Pre-sort
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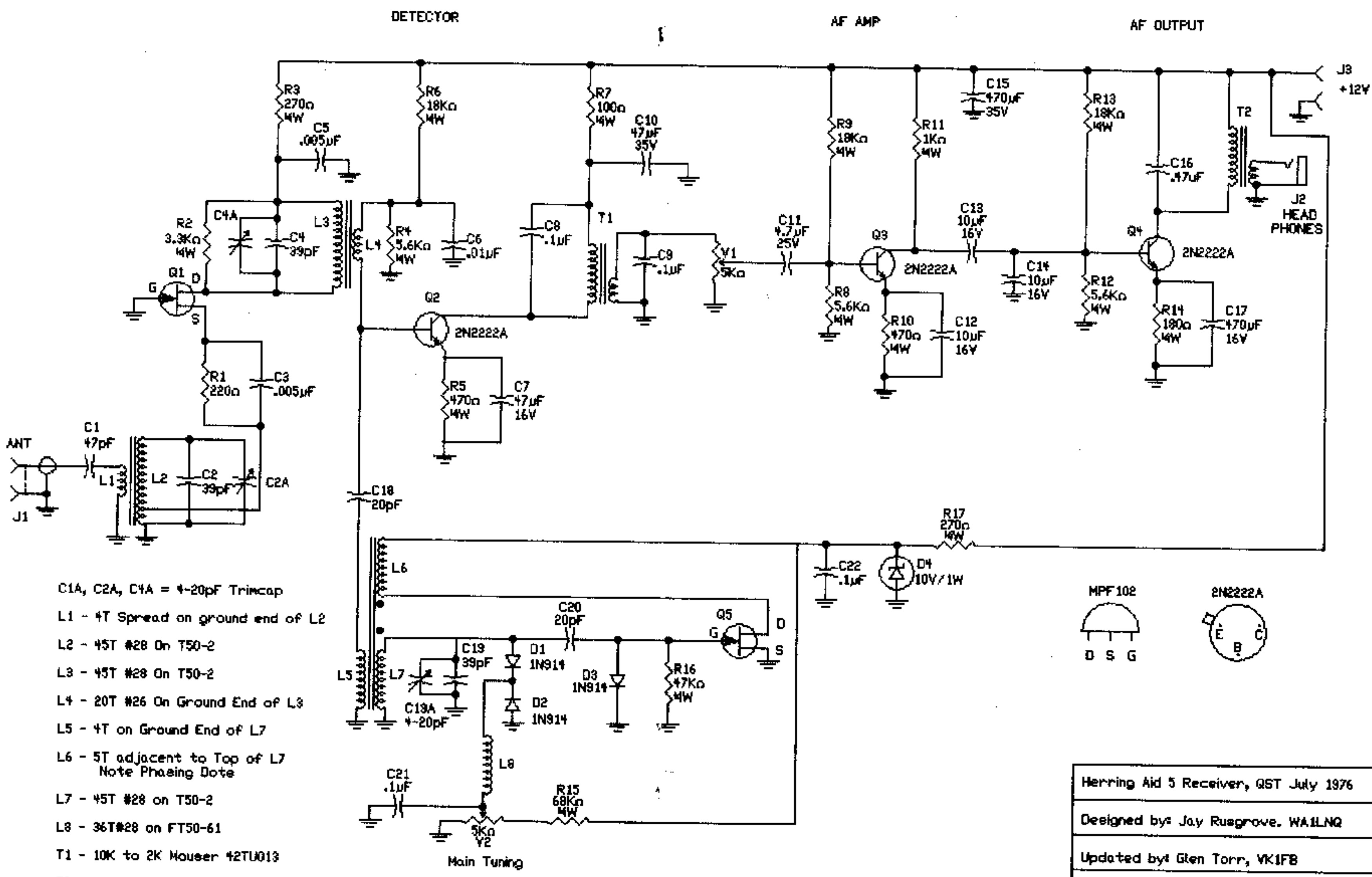


C1A, C2A, C4A = 4-20pF Trimcap

L1 - 4T Spread on ground end of L2

L2 - 45T #28 On T50-2

L3 - 45T #28 On T50-2

L4 - 20T #26 On Ground End of L3

L5 - 4T on Ground End of L7

L6 - 5T adjacent to Top of L7
Note Phasing Dots

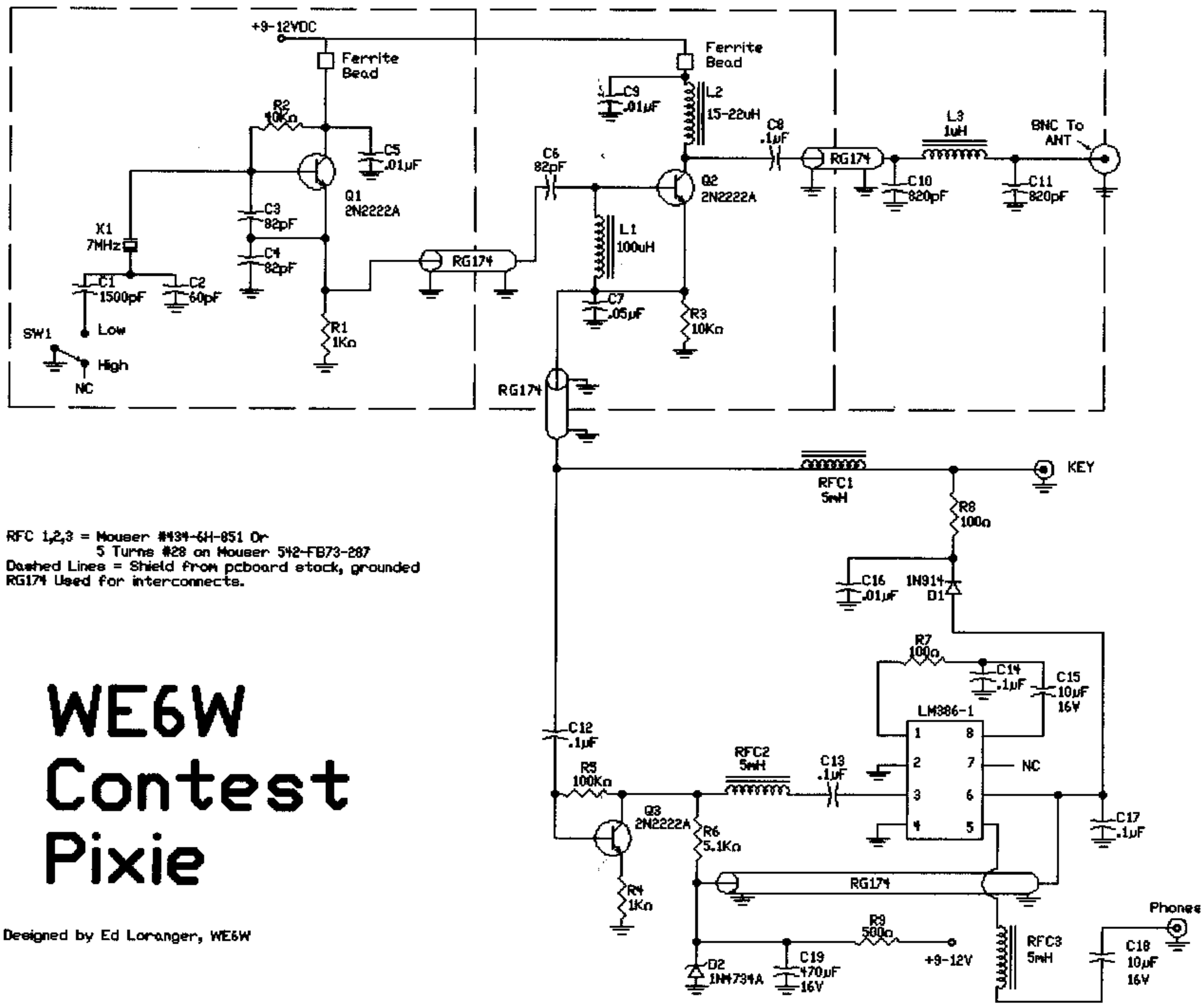
L7 - 45T #28 on T50-2

L8 - 36T#28 on FT50-61

T1 - 10K to 2K Mouser 42TU013

T2 - 1K to 8 ohm Mouser 42TU002

Herring Aid 5 Receiver, QST July 1976
Designed by: Jay Rusgrove, WA1LNQ
Updated by: Glen Torr, VK1FB
Drawn by: Doug Hendricks, KI6DS
NorCal QRP Club Jan. 15, 1998

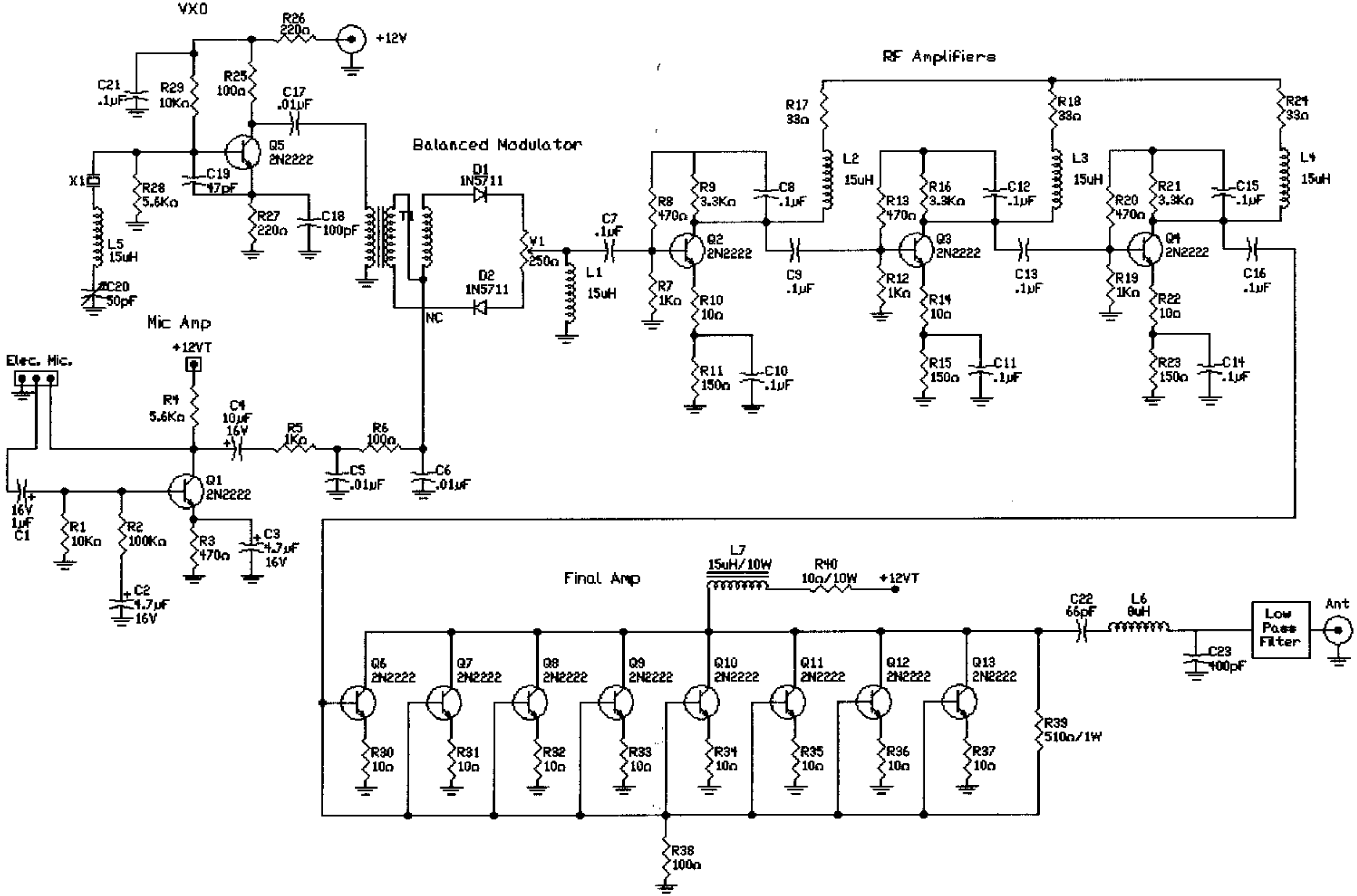


RFC 1,2,3 = Mouser #434-6H-851 Or
5 Turns #28 on Mouser 542-FB73-287
Dashed Lines = Shield from pcboard stock, grounded
RG174 Used for interconnects.

WE6W Contest Pixie

Designed by Ed Loranger, WE6W

N7RI DSB Transmitter



Vol. VI, No. 2 Summer 1998

QRPp

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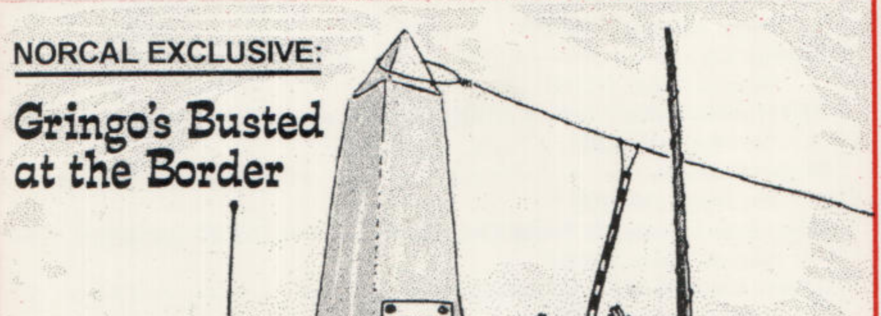
Construction Galore:

- *The new NorCal kit: The "NorCal 20"*
- *More 2N2222 rigs from WB4TPW, N6CM & AD6CR*
- *The Spy Rig, K2UD*
- *More neat stuff from Jim Pepper, W6QIF*
- *Sierra mods, OH2ZAZ*
- *"St. Louis Express" Antenna from NFØR*
- *QRP Hints & Kinks*

NORCAL EXCLUSIVE:

Gringo's Busted at the Border



QRP TO THE FIELD from the NM/TX/MEXICO Border

Journal of the Northern California QRP Club

Table of Contents

From the Editor

by Doug Hendricks, KI6DS
209-392-3522 ki6ds@dpol.k12.ca.us

This is going to be short and sweet this time. Congratulations to Jim Cates, Chuck Adams and Wayne Burdick, three prominent NorCal members who were inducted into the QRP Hall of Fame along with Gus Taylor, of the G-QRP Club at Dayton this year. I will have the full story next issue.

Be sure to read the NorCal 20 kit announcement in this issue. Full details on the next kit. And there are several 2N2222 Design Contest articles in this issue. There will be 3 more to come. Finally, the Pacificon announcement is on page 3. Hope to see you there. Remember, NO EXTRA CHARGE for the QRP events.

Pacificon 98
QRP Forum Announcement

NorCal QRP Club is pleased to announce that they are again sponsoring the QRP Forums at Pacificon 98. We have lined up a world class set of speakers and are very proud to announce the following schedule:

8:00 Bill Jones, KD7S, "Building Cheap Cabinets for your QRP Projects"
9:00 Joe Gervais, AB7TT, "How to operate QRP contests in the Field and have fun"
10:00 Paul Harden, NA5N, "Solar Activity and how it affects QRP"
11:00 Dave Fifield, AD6AY, "Designing the NorCal 20"
12:00 - 1:00 Lunch on your own.
1:00 Ade Weiss, W0RSP, "Propagation Charts and how to use them"
2:00 George Dobbs, G3RJV, "The G3RJV 6 Pack"
3:00 Roy Lewallen, W7EL, "QRP Field Day Operation"
4:00 Roy Lewallen, W7EL, "Antennas for Field Day

Then we will meet again at 7:00 for the QRP Open House. There we will have the judging for the annual NorCal Building Contest. This year there are 3 divisions:

NorCal Transistor Transceiver Contest

1. Design a QRP Transceiver for any band.
2. Use as many transistors as you wish.
3. Use any kind of transistor, i.e. NPN, PNP, FET, MosFET, etc.
4. Passive mixers may be used. TUF-1's, SBL-1's etc. are ok, IC's such as NE602's, the Plessey series and the 1496's are not
5. No IC's may be used other than 3 pin voltage regulators.
6. Design must be accompanied by a legible schematic on 8.5 x 11 paper, use as many pages as needed.
7. A brief description of the circuit and the design, this must be typed and may be up to 5 pages.
8. Need not be present to enter, but entrant is responsible for getting entry to and from Pacificon. Jim Cates and I will not be able to handle any entries.
9. Winners of Dayton 2N2222 Contest not eligible.
10. Entrants to 2N2222 contest not eligible for entry in K5FO unlimited class.
11. Judging to take place at the NorCal QRP Open House at Pacificon, Saturday, Oct. 17th at 8 PM.
12. Entry in the contest will give QRPp first rights at publication of the article on the project.
13. Diodes, such as LED's, pin diodes, silicone, germanium, shottky, etc. areacceptible.

The purpose of this contest is to avoid using IC's so that a betterunderstanding of the circuit will be apparent.

K5FO Unlimited Contest

Open to any QRP Project built since Pacificon 97.

NorCal K8FF Paddles

Open to all NorCal K8FF Paddles.

Note: Prize winning entries at Dayton are not elegible for this contest. Also, Participants do not have to be present to enter, but must make their own arrangements to get entries to and from contest.

Pacificon 98 will be held on Oct. 16, 17, and 18th with the QRP Forums held Oct. 17th. The convention is at the Sheraton Hotel in Concord, CA. Please contact the hotel directly for special rates. There will be a charge by Pacificon to get into the convention. But there is NO additional charge to attend the QRP Forums. NorCal QRP Club is paying the airfare and hotel accomadations for the speakers. This is our way of saying thank you to our members.

The NorCal 20 Transceiver Project Announcement

by Doug Hendricks, KI6DS
862 Frank Ave.
Dos Palos, CA 93620
209-392-3522 ki6ds@dpol.k12.ca.us

The NorCal QRP Club is very proud to announce their latest project, the NorCal 20, a 20 Meter Transceiver with the following features:

*Superhet Receiver
*5 Pole Crystal Filter
*AGC
*TFM-2 Mini-Circuit Mixer (similar to SBL-1) for the front end, NOT another NE602 front end.
*Variable power output 0 - 5 Watts
*Varicap tuned VFO, standard 10K pot shipped with kit, but board layed out for 10 turn pot to drop in. User bandwidth selectable from 10kHz to 200kHz on any portion of the 20 Meter band.
*RIT/XIT
*Self-contained Custom Keyer chip designed exclusively for NorCal by Brad Mitchell and Gary Diana of Embedded Research.
*LM380N 2 Watt Audio Chip. Easily drives a speaker.
*Frequency Readout via Audio Fequency Annunciator. A PIC chip is used as a frequency counter with audio output. In automatic mode, a beep is generated ever kHz. When you stop tuning, the last two digits of your frequency is announced in Morse. You may also push a button to announce your frequency. In manual mode, the frequency only is announced by pushing a button. User selectable modes. Custom designed by Mike Gipe of Blue Sky Engineering.
*All parts, controls, connectors, knobs supplied.
*No wiring. All parts chassis mounted.
*Double sided, plated through, solder masked, silk screened board, commercial quality.
*Custom aluminum case, using the St. Louis Tuner/SST style case. 1.5" high x 4.5" x 4.5"
*Comprehensive Manual, written in the build a section, test a section style.
*No exotic test equipment needed to build
*Over 225 board mounted parts. No surface mounted parts
*Full QSK, No Relays, No thump!
*9 MHz IF, 5 MHz VFO

This is a full fledged NorCal Project, and is not one of our "Design Contest Rigs". This design was commissioned by Jim Cates and myself to fill a specific need and some backround is necessary.

Some of you may not know it, but in 1996, NorCal and the G-QRP club did a project together where we kitted 20 Epiphyte 2 transceivers to give away to third world country hams who cannot afford ham equipment. These were mostly students who were licensed at school and operated the school station, but when they graduated, they had no way of getting on the air. NorCal supplied the boards, all board mounted parts except for the filter and Toko coils, and the G-Club put the kits together, provided the coils and filters and Derry Spittle wrote the manual The rigs were sent to several countries and were highly successful and very well received. This project cost over $2000 which came from excess funds in NorCal and G-QRP Club.

Last summer I visited George Dobbs, G3RJV, who is the leader of the G-QRP Club and one of the most famous hams in the world. During my visit, the subject of the Epiphyte kits came up, and George said to me that we must find a way to get many, many more kits to third world countries.

The response to the article about the Epiphyte kits in Radcom had generated a deluge of requests for kits.

I thought about our conversation for several months and then one day I was looking through some old QST's doing research for the "Back to the Future" Tuna Tin 2 series and came across the articles on the ARRL Project Goodwill. This was a project that sent 500 stations to 3rd world countries in 1979. The project included a separte transmitter and direct conversion receiver, and several stations were put on the air; but there were some problems. Dave Sumner, K1ZZ, of the ARRL told me that the band, 20 meters, was perfect, but that the builders in th third world countries had trouble with the kits because of their being separates, and the DC receivers were not that hot.

When I ran the NorCal 20 project by him, he was very enthusiastic and has encouraged us to do the project as we will learn and profit from the ARRL's mistakes. I am not being critical of the ARRL here, just pointing out that they were the first to try this idea, and they learned a lot from it and have very graciously shared that information with us so we don't have to reinvent the wheel.

Jim and I talked over the idea and decided that we would go for it, but we had to come up with a way to finance it. I told Jim that I thought the best way was to sell kits at a higher price than normal, and totake the excess and use it to provide kits for the 3rd world countries. Jim agreed and we started.

The first objective was to find a designer. There are many competent designers in NorCal, but this one had to be special. The main emphasis on the design of this transceiver was that it was going to be used in 3rd world countries, and the receiver had to be solid, and we could not use a NE602 front end. One of the designers that I have worked with is Dave Fifield, who had mentioned to me while working on the 38 Special that he wanted to design a transceiver with a "real front end" some day.

Dave was perfect. He knew the conditions in Europe, as he is from England originally and has lived and worked in theMiddle East. RF conditions in those countries are far different than here in the US. I called him, explained what Jim and I wanted to do, and asked him if he was interested in designing the NorCal 20. He readily accepted, and we were on our way.

We put together a team to work on the NorCal 20. Dave is the chief designer, but is getting consulting help from Dave Meacham, W6EMD, who is an expert on Filters and RF, Mike Gipe, K1MG, who is helping with the integration of the frequency counter and testing the overall design. Brad Mitchell and Gary Diana have designed a custom keyer chip for the rig. Bill Jones and Doug Hauff have spent many hours working on the design of the case. They came up with some exotic ideas, but they just wouldn't work with our constraints of having to ship to 3rd world countries. Finally, we settled on the St. Louis Tuner/SST type case. Paul Harden will do the illustrations in the manual and checktheprototypes for spectral purity and evaluate the design. Richard Fisher will proof the manual. Jerry Parker is in charge of Web Page publicity. George Dobbs and the G-QRP Club will handle distribution of the rigs to the 3rd world countries. Jim Cates will handle the orders and shipping. Dave Gauding and Jim Smith of the St. Louis QRP Club have helped with parts procurement. And I am the project manager.

We have built 3 prototypes and had them all on the air. This is round one. From this round we found a list of things as long as your arm that need to be fixed, and they will be in round 2. After that we will evaluate the design and make a decision as to the need for another round of testing. But we will not go to production until this rig is ready and right.

It will be thoroughly tested by the best that we have, and we will make every effort to assure you that the NorCal 20 is the best kit that we can make.

The kit will sell for $95, and we will only sell 500 kits, and with the proceeds from the 500 kits, we will kit another 500 to send to the G-QRP Club for distribution to hams in 3rd world countries at no cost to them. The kits will be hand carried to the hams in the 3rd world countries to assure that they get to the proper destination.

Orders for the kits will be accepted starting Aug. 1st. Here is the ordering information. Send a check or money order in US funds for $95 plus $5 shipping in the US, $10 Canada, and $15 DX for each kit ordered. Send your orders to:

Jim Cates
3241 Eastwood Rd.
Sacramento, CA 95821
USA

Make checks or money orders out to Jim Cates, not NorCal. US funds only. European members may order from Steve Farthing. The cost is 65 pounds Sterling. Steve's address is:

Steve Farthing
38 Duxford Close
Melksham, Wiltshire
SN12 6XN
England

Steve will relay the information to Jim and the kits will be shipped from the US.

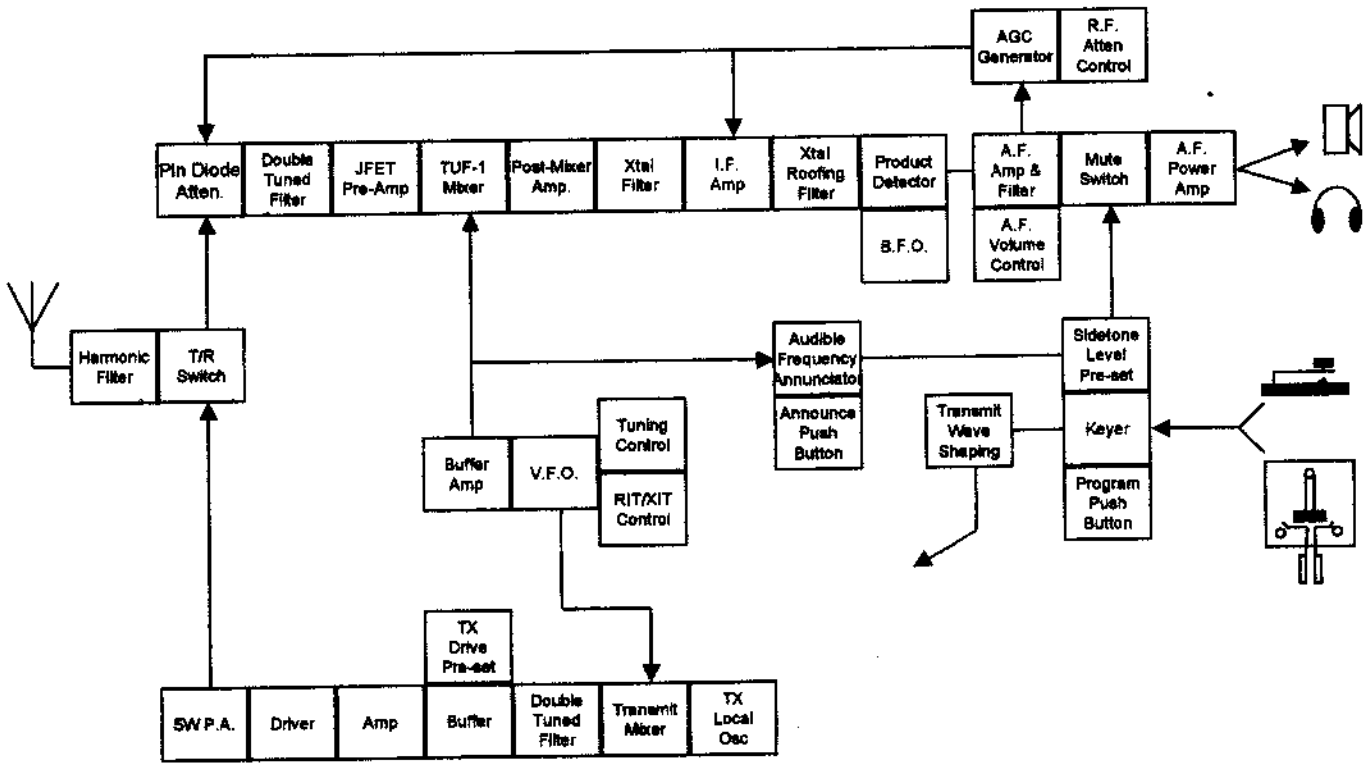
Some of you may wonder why we are charging $95 for the kit when we are obviously able to kit 2 radios for that price. Why not sell one radio for $50? Well, NorCal has caused a problem with the QRP suppliers. When we do a kit and we get volunteer labor to do it, we can sell kits much cheaper than the commercial guys. We want them to stay in business, because the hobby needs them and they are very valuable.

One option would be for us to just add the same markup as the commercial vendors. That would solve the problem, but create another. What does NorCal do with the money? No, we chose to use the excess to do a good deed, a gesture of friendship. We also feel that the NorCal 20 is still a huge bargain. Try to find a rig with all of its features for the same price. You can't do it. Realize also that 5 years ago the club sold the NorCal 40 for $95. But it was not a 5 Watt rig, it didn't have near the receiver that the NC20 does, it didn't have a keyer, it didn't have a frequency counter, and the case wasn't nearly as solid. Plus the board was not of commercial quality. How can we do it now? Because we have learned so much through the years. We have found contacts, new ways of doing things,better parts sources, and we have just improved on things. It is called progress.

Let me end by saying that no one is required to buy the kit. We put it on 20 meters because that is the best band for our requirements. It is open somewhere, every day. I thank also all of the contributors to the design. Their work is immense and greatly appreciated.

The target date for shipping the kits is late October, perhaps by Pacificon. All of this hinges of course on parts availability and no major problems in the process, which we don't forsee at this time. Remember, only one run of 500 kits. If you want one, order quickly, because we will not be doing another run. Jim will start taking orders Aug. 1st. I am looking to seeing the final product and then using it to work a DX station and hearing him say, rig here is NC20!! What a thrill that will be.

NorCal 20 Block Diagram - Designed by Dave Fifield, AD6AY



Are You Ready for CCW and BPSK?

de Vic Black, AB6SO

There's been a lot of recent press concerning the rebirth of Ham Radio about every 11 years, coinciding with the sunspot cycle. All's gloom and doom during sunspot lows and nothing but DX, happiness and TVI at the peaks. At the 1957 sunspot high, QRM was so great that SSB was developed to save spectrum space. Using SSB was considered almost unsociable because of the racket it created compared to AM, even though there were fewer squeals and squawks from adjacent interfering carriers with SSB. The ensuing upheaval meant we had to upgrade equipment which had worked fine up until then, but in the long run it proved to be the best solution to the challenges of HF voice communications.

During the 1960's FM repeaters were introduced. I was working in Palo Alto at Hewlett-Packard when a PA system announcement was made that Varian had installed an FM repeater on Black Mountain for ham use. This was a revolutionary idea at the time. We now know it as the 147.315 repeater whose trusteeship recently changed to the HP club WW6HP.

Later developments included development and general use of SSTV, satellites and packet radio. During the last cycle, packet gave up ground to Amtor, Pactor, Pactor II, Clover and the Automatic Packet Reporting System (APRS). Predictions for the future are tough since we have no control over the future. Anyhow, I'll stick my neck out and predict that this next cycle will finally see wider acceptance of coherent CW, or variants such as BPSK, as viable digital modes.

Coherent CW (CCW) is a 25 year old Morse code mode that uses tight time and frequency control, very narrow bandwidth signals (less than 10 Hz), perfectly sent code and very tight CW filters to bring weak signals up out of the noise. Amateur Radio CCW inventor Ray Petit, W7GHM also invented the digital mode Clover. The first ham QSO was by Andy McCaskey, WA7ZVC using a Ten-Tec PM-1.

How does it work? First, the basic CW element, a "dit", is established as 100 milliseconds long (equivalent to 12 wpm). The receiving computer can then latch onto a dit and expect another dit, dah or space at multiples of exactly 100 msec. In other words, the more you know about a signal before it arrives, the less information you need to acquire from the signal itself. This is how we copy plain text Morse by ear. A couple of letters into a word is often sufficient to know, from context, what the word is probably going to be. A couple of words into a sentence is often enough to finish up the sentence. The rest is only validation of what we anticipated.

Secondly, if the receiver filter passband is too wide, the filter will pass through a lot of noise along with the desired signal. On the other hand, if the signal bandwidth and the filter passband are extremely narrow, the amount of noise passed through decreases and the ratio of signal-to-noise is increased tremendously. The effect is similar to raising the power at the transmitter.

Until now this hardware based system, which relies on tight frequency control and detection of varying amplitude, has been difficult to achieve by most hams because the infrastructure didn't exist to support it adequately. With the advent of extremely stable VFO's, GPS for time control and inexpensive microprocessors and excellent software to send perfect keyboard code and do the necessary digital signal processing (DSP) we may see the mode flourish.

Why would anyone want to use an "outdated" mode like CW in this day of computers, packet, Pactor, etc.? Mainly because you can work around the world on 40 meters during daylight hours using only a few milliwatts of power with CCW. You may not be able to hear the signals by ear on an ordinary receiver, but the DSP can bring them up out of the noise so you can easily copy the code by ear.

Early CCW proponent Professor "Woody" Woodson W6NEY told me he used to carry a 40 meter QRPp beacon on European lecture trips. A prearranged set of dits and dahs would allow his wife, who was monitoring in Berkeley, to know if he was going to be on time getting home or whether he would be delayed by a day or two. The weak signal wasn't heard by anyone else.

This time around CCW will probably be reincarnated as Binary Phase Shift Keying (BPSK), a form of radio teletype. Several groups are working on kits to build standardized rigs analogous to the Tucson Amateur Packet Radio (TAPR) TNC's that allowed easy packet radio access. Johan Forrer KC7WW, TAPR moderator for the HF special interest group, is involved with BPSK experiments. G3PLX Peter Martinez, who created Amtor by adding error detection and correction to the commercial SITOR, has joined BPSK nets on 20 meters. Incidentally, Amtor is pretty much obsolete now that Pactor and newer modes have replaced it during the past two years.

The original CCW scheme relies heavily on the fact that two signals with the same 100 milliseconds mark length and space length will stay in lock step indefinitely if they both start at the same time. Accurate timing and element length control are extremely critical requiring tight frequency and time control at each end of the path. This hardware dependent system is replaced by DSP software control with BPSK.

Receiving CW depends on differentiating the signal from surrounding noise. We can hear frequency and amplitude changes by ear and use those to receive ordinary CW. We are accustomed to thinking of RF signals as having both a frequency and amplitude, but they also have phase relationships. The human ear cannot differentiate phase differences. In fact, quadrature modulation allows us to modulate one signal starting at zero degrees, for instance, and another at 90 degrees on the same carrier sine wave and then differentially detect, or separate, the two signals at the receiver. When the transmitted and received signals are in phase, or synchronized, we say they are "coherent".

BPSK is a modulation scheme which shifts the phase of an RF carrier with respect to a digital bit stream. It requires a simple transmit interface board which mixes a stable audio reference tone derived from a crystal controlled clock with an 800Hz digital signal through a double balanced mixer or an exclusive-OR gate to produce the binary phase modulation and then inputs the signal into an SSB transceiver audio input. The interface board can be built on perfboard for as little as $10.

The receiver compares the phase of each bit with the phase of the preceding bit to perform the differential coherent (i.e. synchronized) detection. A receive interface board accepts the 800 Hz audio tone from the receiver, performs an analog to digital conversion and feeds the signal to the computer where the software does the rest. A simple 12 MHz AT computer is sufficient to handle the software under DOS control. The shareware, called "Coherent" is used by the low frequency and very low frequency experimenters (LowFERS) all the way up the spectrum to ham use with lasers. Setting up the software is similar to setting the parameters for a computer modem (start and stop bits, parity and baud rate).

LowFERS are especially interested in raising signal-to-noise ratios since they are restricted to low power using antennas only 50 feet long (including feedline!) on a band with a wavelength of 1750 meters. That's the definition of "inefficient".

Results are best with stable frequency control, but this is nowhere as important as with hardware dependent CCW since we're comparing phase, not frequency or amplitude. Receiving requires setting the BFO to exactly 800 Hz, displaying frequency in 1 Hz steps and having a single frequency reference for internal oscillators. The currently preferred transceiver is the ICOM 706, especially with the optional temperature controlled crystal oscillator, although this is not an absolute requirement.

On-air operation is done with the transceiver in the split frequency mode, receiving in CW and transmitting in SSB up 1800 Hz on the lower side band. Note that the transmitted signal is data, not phone. Bill de Carle VE2IQ produces freeware which allows you to compare your receiver's frequency counter to WWV and apply a correction to accurately set your receive frequency to the standard BPSK calling frequencies, if desired. The software also sets the received CW audio sidetone to exactly 800 Hz.

If this mode catches your fancy you can check the progress of cutting edge work by going to the web site in Aitkin, MN of Lyle Koehler K0LR at http://www.qsl.net/k0lr/watsbpsk.html. For schematics, & freeware see Bill de Carle VE2IQ's site http://www.ietc.ca/home/bill/bbs.htm. For a BPSK reflector, subscribe to bpsk@qth.net. Thanks to Andreas Junge KF6NEB for these addresses. Bill de Carle's new program, AFRICA, uses a tracking filter so the signals don't have to be at exactly 800 Hz so long as any drift is at a constant rate. It will run on faster, modern PC's. For PCB's and kits see http://users.aol.com/part15/readccw.txt.

George Heron N2APB of Sparta, NJ reports by e-mail that he and fellow New Jersey QRP members Joe Everhart N2CX and Clark Fishman WA2UNN are working on a modular R2/T2 transceiver with integrated DSP board for audio phasing and CCW processing. George calls this "hot stuff!" and says to expect an important announcement at Dayton Hamvention in May. Jim Mortensen N2HOS of Indian Rock Beach, FL has a nifty newsletter at http://www.n2hos.com/digital/frontpage.html. "Jim's Gazette" is dedicated to digital modes including CCW and BPSK and should appeal to anyone who likes digital communications.

CCW didn't catch on earlier because it was dependent on highly stable standard oscillators and transceivers at both ends. Some early experimenters went so far as burying oscillators underground in order to control temperature and thus frequency drift. Now, only reasonably stable transceivers and frequency standards are required because of modern computer program development, although results are better if highly stable hardware is used. You don't need special equipment to join in if you can hear the CCW stations (listen for "CQ CCW" in perfectly sent code). Daily QSO's are now routine with unmodified rigs such as the ICOM 706.

There is daily activity on 3591, 7081, 10141, 14081 and 18081 kHz. Some of the same weak signal and QRP groups responsible for getting thousands of new users on the air with simple, inexpensive kit radios and on FM packet with inexpensive TNC's are now working on BPSK in conjunction with the LowFERS, or very low frequency fraternity. Time will tell if their efforts will achieve wide spread acceptance of this new (old) binary mode.

The St. Louis Express Antenna

by Dave Gauding, NF0R
nf0r@slacc.com

The St. Louis Express and the St. Louis Vertical antenna projects evolved together. Configured as a base loaded vertical the original SLV seemed much more logical when it came time to focus on one design. The then incomplete SLX sort of went away quietly before coming back on the drawing board a year later.

A few feet of flat computer cable, some specialized radials and a tuner can produce a respectable portable vertical antenna covering 10-40m. Here's the story of a little shade tree engineering and how the design evolved.

Square One

The earliest predecessor to the SLX concept is a simple remotely tuned antenna perfectly described as a "Birdical". This is a stealthy folded vertical suspending a miniature birdhouse in order to disguise its true purpose.

Approximately 34' of stranded rubber (or teflon) coated wire is passed over a small diameter tree branch at a height of 20-25'. The wire drops straight down on the opposite side thus justifying the folded description.

A lightweight birdhouse provides modest tension allowing the radiator to gently follow the tree as it moves in the wind. Depending on the diameter of the chosen limb the continuous element could be separated by a quarter-inch or less for up to half its length.

Coated wire serves two purposes. The rubber keeps the folded element from shorting when blown together by the wind and helps it slide easily across branches. Bare wire or magnet wire tends to cut into the bark a little too quickly and eventually binds.

With radials and a tuner the Birdical functions reasonably well from 10-40m using coax or balanced line. For permanent installations the antenna could be coax fed and pruned in place for a single band.

The design has been tested to 50w output and is difficult to detect when properly installed. For amateurs faced with restrictive covenants it's safe to suggest that the Birdical, while a compromise, is a better option than no antenna at all.

Performance on 40m and 30m is generally good. Signal absorption in foliage seems to diminish performance somewhat on higher HF frequencies. As might be expected the situation improves during late fall and over the winter months.

At this point our portable operators have probably noted that the Birdical is adaptable to their specialized needs in the field. The design has been scaled for 80m though not to 160m. Loading coils can be added to shorten the physical length somewhat. The SLX goes one better on this but I'm getting slightly ahead of myself!

Moving Forward

It only took a few days to develop the Birdical. After several months of casual operating at home and in the field the concept offered enough potential to justify further experiments.

One of the now ubiquitous South Bend SD-20 collapsible fiberglass fishing poles replaced the tree. A single 34' length of #24 stranded hookup wire dropped back down from 20' after passing through the tip eye. The element now hanging in the breeze was more or less a folded quarter-wave radiator on 40m. On air performance was adequate but visually the antenna was an embarrassment. Selling anyone else on the merits of same would not have been easy.

Recalling several successful folded dipole experiments it was worth setting aside a few minutes to investigate that configuration. A folded 40m radial used under an original SLV quickly found temporary work as the SLX radiator.

These 20' long folded radials are fabricated from 300 ohm twinlead. Start by shorting the far end. One side of the twinlead is notched 14' down from the top. This produces a folded 34' wire and a 6' wire. Both sides of the twinlead are terminated in an alligator clip and fed at the base.

The shorter wire serves no useful purpose when pressed into service as a radiator. Performance seemed unaffected so it was left intact during preliminary testing. I fully expected that such closely spaced conductors would interact resulting in a dud design. Surprisingly, despite such proximity, it did not happen. This would prove to be an accidental yet significant discovery!

The twinlead radiator for the SLX radiator loaded on the seven design bands using homebrew and commercial T-match tuners. Both coax and balanced lines were tried successfully. During testing up to eight folded 40m radials were employed in the ground system.

My enthusiasm for pursuing this project jumped after the first contact on 20m at a full five watt output. Then 30m and 40m stations found their way into the log. Eventually, several Caribbean DX stations arrived on 20m. The solar cycle was right at the bottom at that time so this was encouraging.

The SLV concept was evolving quickly at this same time and eventually took precedence. Work on the then incomplete SLX design stalled. In the course of a few days it moved to a back burner and soon was simply overlooked.

About A Year Later

By now the St. Louis Vertical concept was in general use. Antenna enthusiasts N0TFI and W6MMA had come forward with significant improvements for the loading coil. The SLV was evolving into a better antenna.

I started looking around for a new portable project and the SLX came back into focus. The folded 40m twinlead radial used under an original SLV went back on the SD-20 pole and a long postponed experiment resumed.

This interim configuration worked once again but the twinlead's sail area presented stability problems for the SD-20 on windy days. The tuned quarter-wave radiator was changed to #22 stranded speaker wire in an effort to streamline the design. On-air performance remained about the same.

Then, hoping that even smaller wire might work, the radiator was converted to two adjacent conductors of #28 stranded flat computer cable. The antenna was loading and logging stations yet the conductors were separated by only .050" on center. At this point, things started to get real interesting!

The SLX concept would soon emerge from limbo in a slightly modified format but for same good reasons attributed to the original SLV. The newer antenna remains independent of external supports while installing and disassembling quickly. This design is also simple, lightweight, inexpensive and covers 10-40m. Experienced portable operators understand such features very well indeed!

Eureka!

Three parallel conductors of #28 flat computer cable were then configured as a 20' radiator. The overall length was chosen to take full advantage of the SD-20's height. The assembly itself took linear loading to the extreme. This was a classic example of nothing ventured, nothing gained! It turned out to be one of those better shots-in-the-dark!

The final version of the SLX radiator features almost a half-wave of wire on 40m or the lowest design frequency. The arbitrary electrical length seems content on the other bands as well. Resonant points are typically sharp but loading with a wide selection of tuners is straightforward.

The three wire assembly is shorted at the top and fed only through the center conductor at the base. The radiator is cut a little long to provide for a few loose turns along the SD-20. This wrap keeps the wire closer to the pole and helps the antenna fare better in windy conditions. The neat and tidy appearance doesn't hurt at all for stealth or cosmetic considerations.

For those familiar with the recently introduced St. Louis Radials the SLX feedpoint configuration is borrowed from that assembly. The readily-available Radio Shack 270-375 alligator clip (or equivalent) again provides support for the thin ribbon and protects the fragile connection. When the radiator shown in Fig. 1 is properly fabricated it is very durable.

Construction

SD-20-type collapsible poles are hand-made and vary somewhat in length. They can even grow longer in cold weather when the friction joints change diameter slightly. With this in mind builders should expect to adjust radiator length to suit their particular antenna assembly. The following construction technique takes the variables into account:

1. Cut a 21' section of any stranded wire flat computer cable. The life expctancy of solid wire is limited in this application. Peel out three conductors and separate back to 1/2" from the end.

2. Trim the two outboard conductors back to 1/4" from the end. Strip 3/16" of insulation from the center conductor only. These dimensions are approximate. See Fig. 2

3. Discard the terminal screw from a Radio Shack 270-235 alligator clip or equivalent (with crimpable pre-scored base. Carefully slide the prepared wire into the alligator clip.

4. Position the two outboard conductors just past the inner end of the tubular extension. When crimped the wire ends will bend upwards slightly to prevent shorting against the body of the alligator clip.

5. Gently but firmly crimp the tubular extension with a wide-jaw pliers. Do not crush! Too much pressure will distort the wire insulation and may short out the conductors.

6. Carefully solder the exposed center conductor to the body of the alligator clip. The previously crimped tubular extension will serve as a heatsink and minimize melting of the rubber insulation.

7. Attach the alligator clip to the antenna terminal on the mounting base. Lay the fully extended pole on the ground and determine the wire length necessary to comfortably reach the tip-eye.

8. Strip all three conductors. Short and lightly tin the wires. Thread on a small fishing swivel and solder after looping the wire so the attached swivel assembly moves freely.

The completed feedpoint is now secure but can be better protected from moisture with RTV-type sealant, heatshrink tubing or electrical tape. With reasonable care during installation and storage the assembly will give excellent service. When installing an SLX tighten up on the radiator to minimze sail area. Finish with several loose turns along the extended pole including the base section.

Fig. 1

Fig. 2

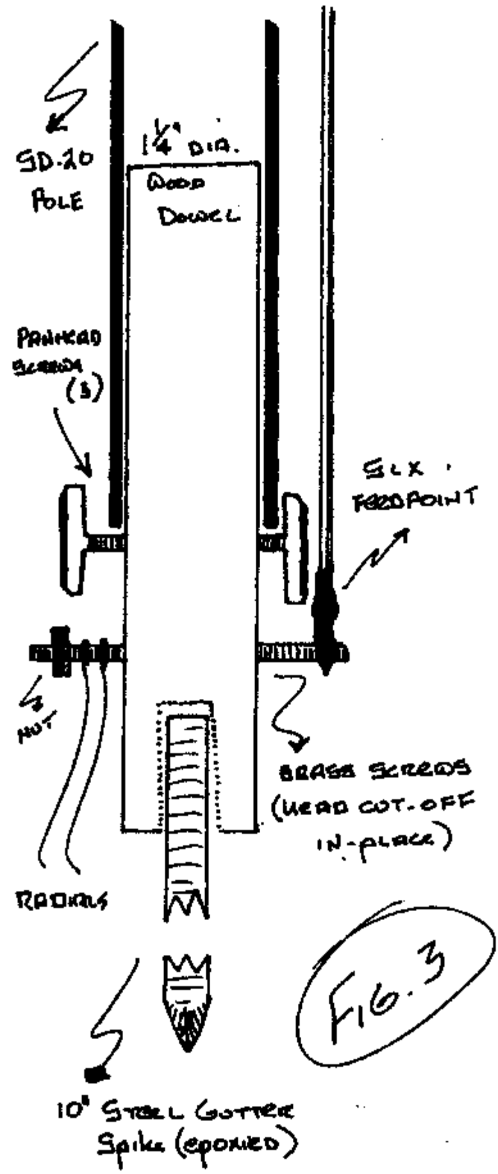


Fig. 3

Armchair Engineering

The SLX places sixty feet of radiator at right angles to the horizon over a ground radial system. Apart from being compressed into only 20' by linear loading that's all there is to it.

The SLX is a remotely tuned multi-band portable vertical. Therefore, SWR and bandwidth are easily managed by the tuner and not major concerns.

The SLX needs an effective ground radial system like any other shortened vertical antenna. Don't even think about squeaking by with just a few wires or a shallow ground rod! You will end up with a portable vertical covering 10-40m. But, it won't be the SLX as depicted in this article.

With the foregoing in mind, St. Louis Radials and the St. Louis Express perform very well together. Three SLR's is a minimum number. Choosing an even number allows a set of two ribbons to be re-rolled at the same time when breaking down the portable station. This places more ground radials under the antenna with about the same amount of effort and simplifies storage.

I use six ribbons under a ground-mounted SLX in portable locations. All seven conductors of the flat computer cable are cut to 16.5'. It is an easily installed and retrieved system. This SLR set provides forty-two radials and about 700' of wire in a compact footprint.

Several spare radiators have been sacrificed in the interest of developing a mono-band SLX. It is certainly possible to do so but the 40m and 30m test antennas typically lost resonance when relocated. Commercial transceivers being broadbanded are better prepared to compensate for such changes. Many simplified homebrew designs expect a good match most of the time and do not adjust quite as easily.

Testing

Field testing of the SLX started at five watts. Power was soon dropped back to three watts and then two watts. On-air results for each test band reflected what should be expected from a simple ground mounted vertical. No contacts were attempted on 17m and 12m due to equipment limitations as well as poor propagation.

The SLX's final testing program consisted of operating CW at one watt output and evaluating an even one hundred contacts subjectively. Activities were split between calling CQ, answering stations and QRP contesting. Past experience shows that consistent performance by a tuned multi-band antenna on its lowest design frequency will generally be repeated on higher frequencies. The SLX is no exception.

Operating Ideas

On-air results seemed about the same when alternating between 50 ohm coax and balanced line. The tuned feeders varied between 450 and an estimated 100 ohms impedance.

For convenience, chose coax such as RG-58 or even RG-174. Backpackers and other users with space/weight considerations may favor the smaller diameter line in spite of higher losses. Twinlead is the lightweight, low-loss and low-cost alternative.

Twinax, speaker-type zipcord and even flat computer cable have been employed as a feedline. The SLX specifications are non-critical so feel free to experiment. The inevitable compromise between performance and convenience will determine feedline choice.

The prototype SLX uses the excellent mounting base that accompanies W6MMA's commercial adjustable loading coils. As this article is written the mounts are not sold separately.

Verne Wright's base assembly for the SD-20-type pole raises the feedpoint slightly off the ground. The radiator is coax-fed through a bulkhead-type BNC connector. This design is simply too good not to use so plan on fabricating your own, if necessary.

A simpler but nevertheless serviceable mount for the SD-20 is depicted in Fig. 3. Like the W6MMA mount this feedpoint configuration can be used with either coax or balanced line. Though not shown either solder lug or alligator clip terminations are suggested for portable feedlines.

The SLX has been tested at 50W output on several bands. More testing is required to define power limitations which may vary with different feedlines.

And More Ideas

Like any other minimalist antenna the SLX should be kept away from trees, shrubs, structures, autos and perhaps even the operator. It doesn't make a lot of sense to give away RF at QRP outputs.

Store the flat cable radiator on a miniature plastic reel. Nest the reel inside a hand-coiled feedline. Place that combination on top of six finger-rolled St. Louis Radials previously packed in a round plastic container. My antenna field kit includes the storage container, SD-20 pole and the W6MMA mount. It is a compact and easily transportable system.

The SLX radiator can also be tree hung using either ground mounted or elevated radials. Depending upon location performance is in the same league as the Birdical described earlier. Once again, RF absorption in foliage at higher HF frequencies should be taken into account when siting the antenna.

The preceding paragraph indirectly underscores the value of portable antennas suspended by collapsible fiberglass fishing poles. Designs such as the St. Louis Express, St. Louis Vertical and other lightweight antennas can be installed quickly almost anywhere, even after dark. The value of trees as antenna supports is somewhat limited under similar circumstances.

The SLX can be modified to operate on 80m. Choose an unshielded balanced feedline. This will normally increase the total available electrical length to a quarter-wave or more on that band.

When using coax add 3' to each of the radiator's three conductors or about nine linear feet to achieve the save effect. Winding a coil will fit the lengthened radiator to the SD-20 pole.

Elevated coil locations minimize ground losses. Position the coil slightly above eye-level but not lower than the top of the pole's base section. Butt the individual turns together and tape in place. The quality of the ground radial system will be a major factor in determining performance on 80m.

Some Reality Checks

Portability, ease of installation and low-cost were objectives for the SLX from the outset. Coverage down to 40m was an absolute must. These very specific targets have been achieved. Application of basic vertical antenna theory took care of the technical side of this project.

The SLX has not been to an antenna range or computer modeled. However, the final design has been field tested in quite a few fields! An extended five month development period provided opportunities for both day and night operations.

The antenna is a good ground-mounted portable vertical now. There has been no effort to optimize since the design was finalized. As always, improvements are officially encouraged.

Down the Road

A follow-up project describing a free-standing backpack version of the SLX is in draft form. Application of the SLX-type radiator to other limited space antennas is underway.

Preliminary testing suggests both the SLX and the older SLV are good low-angle radiators in elevated mountings. A future article will describe simple techniques to get either antenna off the ground easily in portable locations.

The NJ-QRP MicroBeacon*The Design Phase*

The NJ-QRP MicroBeacon

The Design Phase

by: George Heron N2APB, Joe Everhart N2CX and Bob Applegate K2UT

INTRODUCTION

In part 1 of this project series (Spring 1998 QRPp) we presented the Concept and Requirements phases for the New Jersey QRP Club "MicroBeacon." This project is a collaborative effort being done by our club membership to specify, design and construct a low-cost, flexible and completely open keyer/beacon by following the industry-standard techniques of phased development.

By saying that this is an "open project" we refer to the availability and tutorial nature of the software source code used to control the MicroBeacon ... with this software in-hand nearly anyone can easily get into the fascinating world of microcontroller programming.

We'll be describing the Design phase in this article installment by building off the requirements specified last time to detail the actual hardware and software design, parts selection and tradeoff considerations made in getting to our first working prototype of the MicroBeacon. We'll wrap up the project series in the following issue of QRPp by presenting full schematic and software details, prototype construction and review of MicroBeacon field usage.

THE BIG PICTURE

The major components of the design, as specified in the project requirements, consist of: (1) the Microcontroller, (2) the User Interface, and (3) the Attenuator. Refer to the system diagram in Figure 1.

Basically the Microcontroller (with paddle input) keys the transmitter, whose RF output is coupled through a programmable attenuator controlled again by the Microcontroller. All of this is under software control: keyer speed/memories/options, along with power control of the transmitter being used.

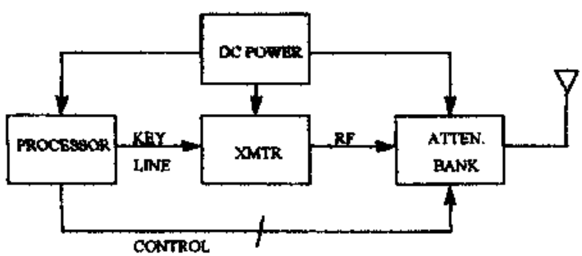


Fig. 1

THE MICROCONTROLLER

Selection of the appropriate microcontroller for this project was a tough and debatable topic. This decision caused the most discussion among our membership on the listerv ... everybody has a favorite controller and desire for one vendor or another. Ultimately we settled on the Microchip PIC family mainly because of its intrinsic ease of programming, for its relative low cost, and for its popularity in many discussion groups and other projects. This educational benefit is of great importance in the project requirements.

Referring to "Figure 1: Detailed Block Diagram", our microcontroller needs to control many devices and serve a variety of demanding functions. We need to have 14-or-so output control lines, be able to read 6 input lines, communicate serially to a host PC, generate a side tone and determine a potentiometer setting through an A/D converter. The microcontroller must be easy to program, reprogram, and reprogram again during the development cycle, for us the design team as well as others who may wish to modify the software later on for their own use, per the source code we provide as a starting point.

We chose the PIC16C74A microcontroller because of its high I/O capacity, its built-in A/D converter port, its built-in serial communications port, it's pulse width modulation (PWM) port capability, and for its simplicity of programming. The microcontroller costs about 10 bucks in single quantities, but for all you get (and for all the parts we don't need because of the PIC's integrated functionality) the price is rather attractive. The '16C74A is an 8-bit CMOS RISC, fully static microcontroller in a 40-pin plastic DIP package containing 4KB of program memory and 192 bytes of RAM for keyer and beacon memories. You can see the full spec sheet (288 pages worth!) at the Microchip website:

http://www.microchip.com.

Programming the PIC16C74A is also very straightforward. All one needs to do is build/buy a simple programmer (we use the EPIC programming board from Jameco, priced at about $75) and connect it up to the serial port of your PC. Using public domain software (i.e., free assembler and downloader!), you can quickly program your own PIC in almost a blink of an eye. Further, a version of the PIC comes with a quartz window in the package allowing for erasure of the program by a UV lamp so you can download your new program to the device and use it again and again. New feature, personalized beacon messages, bug fixes, speed defaults, and many other software customizations become easy as pie to do.

THE USER INTERFACE

Perhaps the most important and visible aspect of a project is the "user interface", or the controls and indicators used by the user while operating the MicroBeacon. We detailed the functional requirements pretty carefully in the last installment, and now we'll take you through just how we realized them all in order to provide a usable unit.

The main way that the MicroBeacon has of communicating with the user is by means of a simple, inexpensive 1-line-by-16-character LCD display. The microcontroller is able to display status (e.g., what memory is playing), prompt the user for input (e.g., "Power level?:") and to display mode, keying speed, and more. We opted for use of the LCD over some less expensive display/feedback alternatives (like LEDs or audible Morse code) because of its inherent greater flexibility. Rock bottom project cost wasn't a high priority requirement, so we selected a flexible display device that was very user friendly.

We decided to use a keypad on the front panel to provide the user with a way to input various parameters and to easily navigate through a myriad of configuration options presented in the MicroBeacon. We considered using a bunch of pushbuttons as in some other popular memory keyers but we felt that a miniature keypad (like those used in tone pads on HT mics) would be more elegant and flexible in the longer run.

Other user interface devices include a pot for conventional speed adjust (much better than entering digits via the keypad!), and a sidetone generated by a digital pulse train off one of the microcontroller's PWM outputs (with a simple LPF to smooth it out).

ATTENUATOR

If the processor selection was the most debatable topic in the design of the MicroBeacon, then the attenuator was certainly the most challenging and most interesting problem to solve.

The current practice in beacon transmitters seems to be the use of no more than a watt as the maximum power level. This is in keeping with the spirit of QRP in using the minimum power necessary. In addition, since the beacons are often used on the more popular amateur bands, it is important that they not generate excessive QRM. With good antennas 40 meter beacons have been received over distances of several hundred miles during daylight and several times that distance at night, down to low milliwatt outputs.

Beacons operated recently by AA4XX and WA3NNA have used power levels which decrease in steps of 10 dB. On HF the minimum easily discernible difference in power levels is about 3 dB, and since one S-unit is 6 dB, it is recommended that the increments (decrements) be no smaller than 6 dB.

Potential Implementation Methods

Given the requirement of interfacing to an existing transmitter, we explored several methods of power control.

1. Switched Attenuator — Benefits here are that the transmitter need not be modified in any way and the conceptual simplicity is elegant. Disadvantages include: (a) the need to dissipate nearly the full output power of the transmitter under some circumstances; (b) the possibility of needing a physically large device, depending on the power dissipation, the type of attenuators used and the means used for switching the attenuator sections; and (c) a potentially high power dissipation for the attenuator switches. Probably the best type of attenuator to use is a "pi" type of attenuator composed of carbon composition or carbon film resistors. 50 ohm attenuator pads are very easy to design and will give reasonably accurate results using inexpensive 5% resistors.

The two easiest types of switches are PIN diodes and relays. PIN diodes seem attractive at first glance, but tend to be fairly complicated in a multi-attenuator configuration. Their microsecond switching speed is not needed in this application. Power dissipation can be on rather high, on the order of 100 mW or more switch. In addition, isolation may be only 30 to 40 dB, requiring special techniques if high-value attenuators are used.

Relays may be a better choice when considering a switched attenuator design. They are relatively small. A candidate is the Omron G6H-2-DC-12, available from Digikey for $4.22 each. It is a dpdt relay that is only 5x14x9mm and has a low operating power requirement of only about 12 ma (1028 ohm coil resistance at 12 volts).

The simplest way of arranging the attenuators to be switched is to put them in cascade, and arrange the dpdt relay to either bypass them individually when powered off, or put the selected one in line when its associated relay is energized. This is identical to the way that manually switched lab type attenuators are built.

A means of reducing operating current for the attenuator even further is to use a latching type relay. This type has two

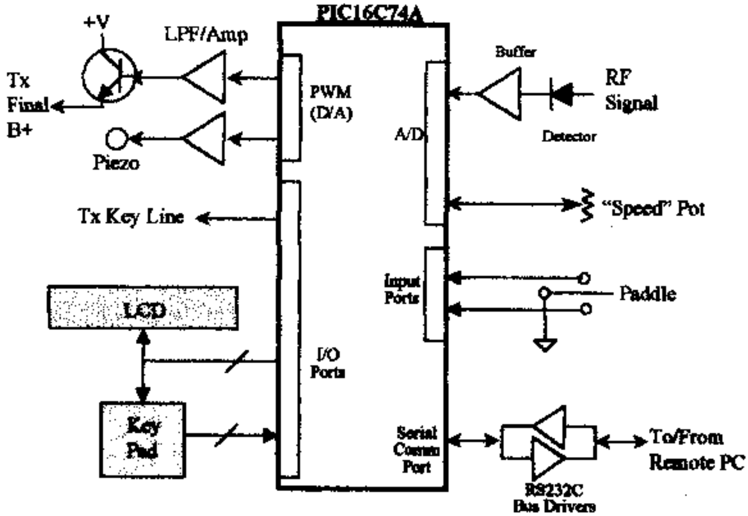


Fig. 2

coils, one to toggle back and forth between the two relay states when pulsed briefly. The disadvantage is additional circuit complexity, but that is minimal. A candidate latching relay is the Omron G6HK-2-DC-12 which has the same dimensions as the non-latching type mentioned above and is also available from Digikey for $5.22.

2. Adjusting Supply Voltage to Set Output Level

RF output power from a class-C amplifier is approximately proportional to the square of the DC supply voltage. Thus an output stage that supplies 5 watts at 12 v DC will produce about 2 watts at 7.6 volts and 1 watt at 5.37 volts.

12V	5W
7.6V	2W
5.37V	1W
3.8V	0.5W (-10 dB)
1.7V	0.1W

For a 5 watt transmitter, pretty good output control can be maintained down to about 100 mW. DC control can be easily accomplished by means of an integrated circuit linear voltage regulator and switched resistors to set the voltage. And power levels can be accurately calibrated for a given transmitter using switched potentiometers and fairly good stability and repeatability are expected.

Another Method: Ingenuity Strikes!

The approach we ultimately settled on for our first prototypes is a creative variant of the pulse-width-modulated technique. We use a built-in capability of the PIC (i.e., its PWM output pulse stream) and filter it to produce a surprisingly clean "D/A" analog voltage which feeds the base of a series pass transistor, which in turn provides a regulated and variable voltage to the final amplified of the transmitter. This "emitter follower" transistor stage is the same technique used for voltage regulation in linear power supplies, but in our case we're providing a computer-controlled variable voltage to the transmitter's power amplifier stage, thus providing computer-controlled power output!

As an added benefit of using a microcontroller in the heart of this system is that we can "close the loop" to ensure that stable and accurate power levels are being transmitted. We added a diode detector to monitor the transmitter output - when buffered/amplified it provides an indication to another of the PIC's A/D inputs regarding transmit power levels ... voila, a built-in and computerized power meter to boot!

Note that by using this technique of power control we infringe on one of the project requirements ("must interface to a standard, unmodified QRP transmitter") by forcing the need to separately control the voltage to the transmitter's power amp. This tradeoff was deemed acceptable by the project manager (K2UD) as it provided an elegant balance to the overall system simplicity, cost and functionality.

NEXT TIME WE MEET ...

Well, that's it for now. We've given a general overview of the MicroBeacon design, major component selection, and some of the specific paths we followed as well as several we could have gone. We felt that these alternative directions would be of much interest as the ultimate design we're providing.

Next time will be the final installment which will delve greatly into the software design, full schematic details and operator usage in the field with prototypes built by a number of club members.

Stay tuned to the NJ-QRP website (http://www.njqrp.org) for periodic detailed updates on the MicroBeacon, as well as to view to complete requirements specification and design documents, additional diagrams and photos of the project prototypes thus far. 72, George Heron N2APB (g.heron@dialogic.com)

Building the KD1JV LED Keyer

By Jerry Henshaw, KR5L
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I purchased one of the LED Keyer kits from Steve Weber, KD1JV at this year's FDIM at Dayton. I had a blast at Dayton this year and am looking forward to next year. However, I made the mistake of walking around the vendor area with Doug Hendricks. He had also purchased a LED Keyer kit and caught me in a moment of weakness and persuaded me to write this article on my method of constructing the kit.

I built the keyer in my room at Days Inn South. The kit went together without a hitch and worked right out of the box. However, there is a typo in the instructions - step 7 C1 should read C3 and in step 8 C3 should read C1. The parts placement drawing is correct.

I didn't want to use the harsh/piercing Radio Shack piezo buzzer as the side tone oscillator as suggested by Steve Weber. Whilst wandering around the Hara Arena I stumbled upon a Rainbow OSC-2 code practice oscillator kit for $4.95. This is a simple NE555 kit with a very thin 8 ohm speaker. The price was right! I had no problem interfacing the OSC-2 to the LED Keyer.

I modified the OSC-2 by adding a 500 ohm pot in series with the speaker lead to serve as a volume control for the side tone. I also paralleled a .01 uf cap across C2 (timing cap) to lower the side tone to a more pleasing note. I shorted the "key" pads together with a cut resistor lead. Instead of keying the oscillator with a key, I wired the + VCC to the "+V" connector on the LED Keyer. The - (ground) terminal connects to the "SD-Tone" terminal on the LED Keyer. The Side Tone circuit of the LED keyer applies power to the OSC-2. That is all there is to it!

I first tried a Radio Shack 6 volt lithium battery and a "N" battery holder to power the keyer and side tone oscillator. The battery only lasted about 3 days in relatively heavy use with the side tone oscillator. I replaced the 6 volt cell with a standard 3 volt lithium camera battery. The volume is lower on the side tone oscillator but adequate. I couldn't find a battery holder locally for the 3 volt battery so I just soldered the power wires directly to the battery used double stick foam tape to hold the battery in place. I suspect this battery will last considerably longer due to its larger size and mah rating. I used a SPST toggle switch to turn the side tone on and off.

I mounted my unit in a custom built ABS plastic sloping panel box (ala Bill Jones). The completed unit fits in the palm of my hand and is very light weight and therefore perfect for field or mobile use. The keyer works as described in the documentation.

Steve uses a clever method of editing characters entered in the two message buffers. As you enter characters into the memories, the display will flash "- -" to indicate proper character spacing and will flash "SP" to indicated a space between words. If you make an error entering a character, simply rotate the speed control counter-clockwise until a "BS" is shown on the display indicating backspace. You can continue rotating the control counter-clockwise as many times as needed to erase the desired number of characters. Simply re-key the errant character and continue with your message. A really nice feature of this keyer is the ability to put either message buffer into loop or beacon mode. Steve has provided a special edit feature to insert multiple spaces (to give more time delay before the loop repeats). Simply rotate the speed control in a clock-wise direction until a "SP" is shown on the display indicating an extra space has been added to the message buffer. You can continue to add spaces in this manner until the desired delay has been reached. There is a total of 86 character memory locations shared between Memory 1 and Memory 2.

The unit can be operated in either Mode "A" or Mode "B". The speed range is 8 to 35 wpm in 1 wpm steps. The speed control is also unique in that Steve uses a mechanical encoder instead of a potentiometer for this function. The control is freewheeling (no stops) thus ensuring absolute linearity in controlling speed and editing functions. The keyer has a user selectable "Training Mode" that will flash either "- -" or "SP" on the displays to aid you in sending correctly timed code. Simply time your sending to the display and bingo — perfect code. You can easily disable this feature to conserve power.

The keyer will automatically go into sleep mode after about 7 minutes of inactivity. The keyer draws only 3 micro amps in this mode. Pressing the Dash paddle will wake the unit. All memory and user settings are maintained during sleep mode. Since the current drain is so low, I didn't bother to put an on/off switch on my unit.

I am very pleased with the keyer and highly recommend it to anyone who sends between 8 and 35 wpm or needs a nifty beacon generator.

72's Jerry KR5L

[Check with Steve Weber, KD1JV, 633 Champlain St., Berlin, NH 03570 for kit availability and information]

The NorCal Dayton Building Contest

by Doug Hendricks, KI6DS
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This years Dayton building contest consisted of three division, the NorCal K8FF Paddle building contest, the K5FO Unlimited contest, and the NorCal 2N2222 Transceiver Contest.

Judging was held on Saturday night at the hospitality room sponsored by ARCI. Judges for this year's contest were Dick Pascoe, G0BPS, Wayne Burdick, N6KR (who came up with the 2N2222 idea), Wayne Smith, K8FF (the designer of the K8FF paddles), and Gary Breed, K9AY, well known author, publisher and designer.

The results of the paddle contest were:
First Prize: KC5FMZ, Robert Sorge
Second Place:KR5L, Jerry Henshaw
Third Place:N8VAR, Ron Doyle
The quality of the work was unbelievable, and the winning entry received a prototype of the K8FF paddles built by Wayne Smith himself, and donated by Wayne. K8FF has now become a very recognizable call and Wayne says that it is a thrill to call CQ and have someone come back to him and say that he is using one of Wayne's paddles. It was an excellent project, and it far, far exceeded my expectations.

The 2N2222 competition was just amazing. I could not believe the craftmanship of the entrants. First prize was won by Jim Kortge for a 20 meter transceiver, and Jim is writing up a very extensive article that will be published in the fall issue of QRPp. He modeled every section of the rig with modeling software, and just did an absolutely beautiful job of building and documenting his work.

Second prize went to Roger Traylor, for his NP0 40 meter CW transceiver. It utilized a phasing method to reject the unwanted sideband, and was a most unique entry. Roger's design is featured elsewhere in this issue.

Third prize went to James Roberts, NC9H for his 20 meter CW/SSB/AM transceiver. James' rig will also be in the fall issue, as I have not had time to redraw the schematic.

Last year Chuck Adams announced that he would sponsor the unlimited building contest. Actually I announced it and named it after Chuck, and then told him that he could pay for the prize, since the contest was named in his honor. We have had an ongoing battle to cost each other money over building contests over the years. I still remember the year that Chuck decided that we had a 7 way tie for third place, and I had to come up with 6 more prizes.

The judges decided that the winner was Roger Traylor's design in the unlimited class and that Jim Kortge's design came in second. I didn't understand the reasoning, but they had an explanation. Third place in the unlimited division went to Howard Kraus for his spy radio. Howard has an article in this issue on the spy radio.

Many of the entries didn't win prizes but were worthy of one. I have included several of the designs in articles, including Robert Freiss' amazing 2 transistor transceiver and his 10 transistor 5 Watt power amp. Also, Sashi Kumar, AD6CR, deserves mention of his entry. Sashi found out about the contest late in April, worked feverishly to finish his design, and even though it was not quite finished, sent it in anyway. He had fun building, and he wanted to share his project with the rest of us. Tha is what QRP is all about.

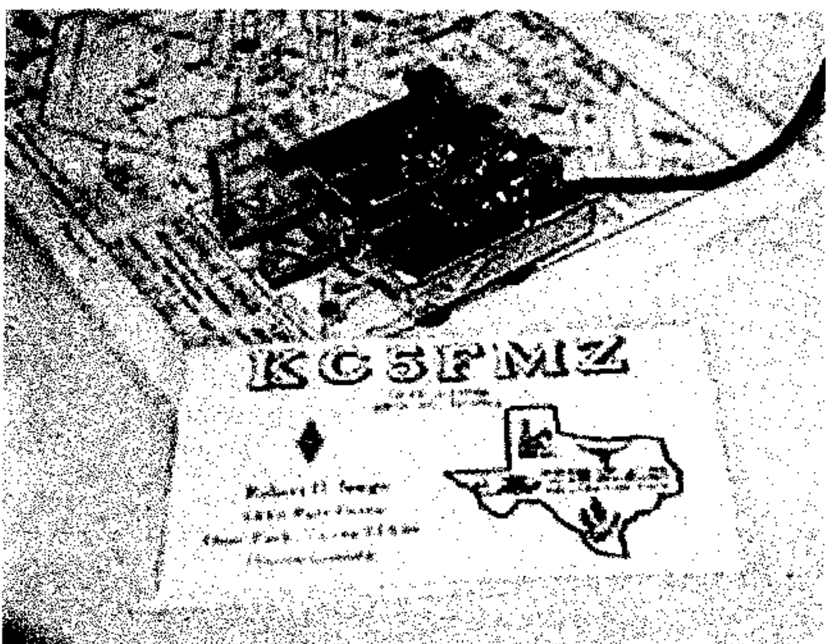
We all benefit from building and design contests, because excellent articles are generated for all of us to read and learn from. Hopefully, you will enter the building contest this fall at Pacifion. There will again be 3 divisions, with some changes in the 2N2222 contest. The 3 divisions at Pacificon are:

K5FO unlimited contest. You may enter anything that is qrp related that you have built since Pacificon of last year.

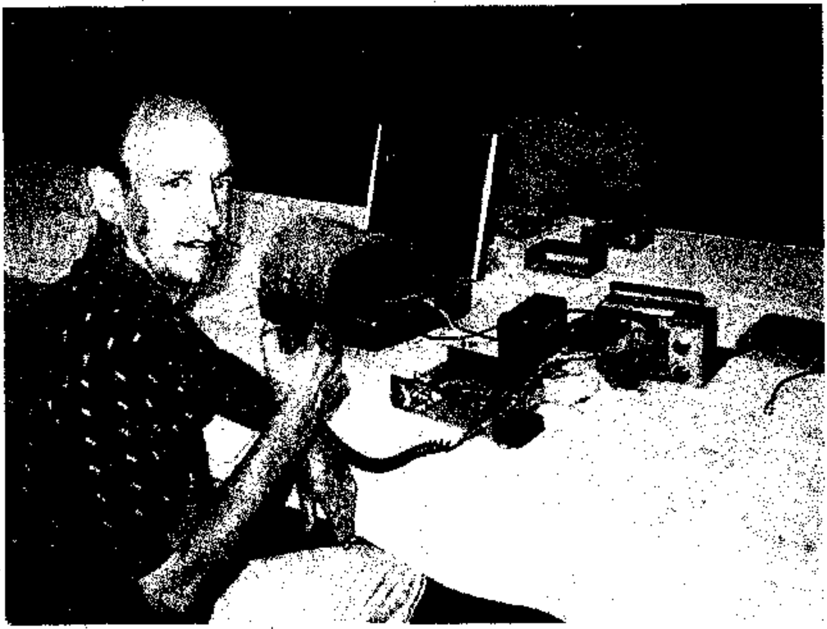
NorCal K8FF Paddle Contest. NorCal K8FF paddle kits that have been put together and finished will be judged on presentation and appearance.

NorCal Transistor Transceiver Contest. The object of this contest is to build a transceiver using only transistors. You may use as many as you wish, and any kind that you wish, as long as it is a transistor. IC's are not allowed. Passive mixers are allowed. TUF-1's, SBL-1's etc are ok. Voltage regulators are allowed, as long as they are the 3 pin variety. In this contest you may use NPN's, PNP's, FET's, MosFet's, etc. The objective is to build a transciever that is not made of little black boxes (IC's). LED's are ok, as are diodes.

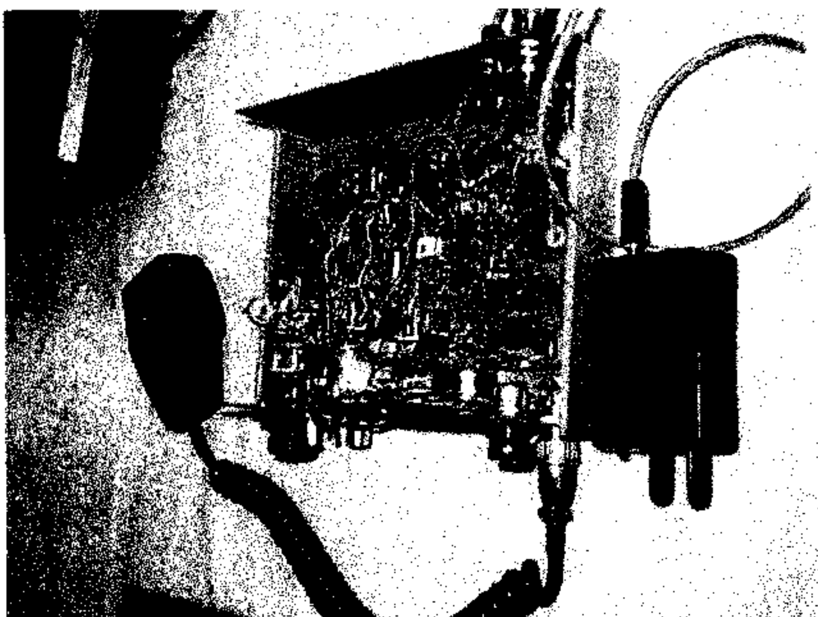
I would like to thank the prize donors: ARCI, Almost All Digital Electronics, American QRP Key Company (Gil Kost), Ade Weiss, Paul Harden, the KnightLights, Wayne Smith, and NorCal. I would also like to say a special thank you to the judges, Wayne Smith, Wayne Burdick, Dick Pascoe, and Gary Breed. The job was immense, and you did a very commendable job. Thank you. And last, I would like to thank everyone who entered, without you we wouldn't have a contest. Keep up the good work, and keep burning solder. 72, Doug, KI6DS



KC5FMZ's winning entry in the NorCal K8FF Paddle Contest

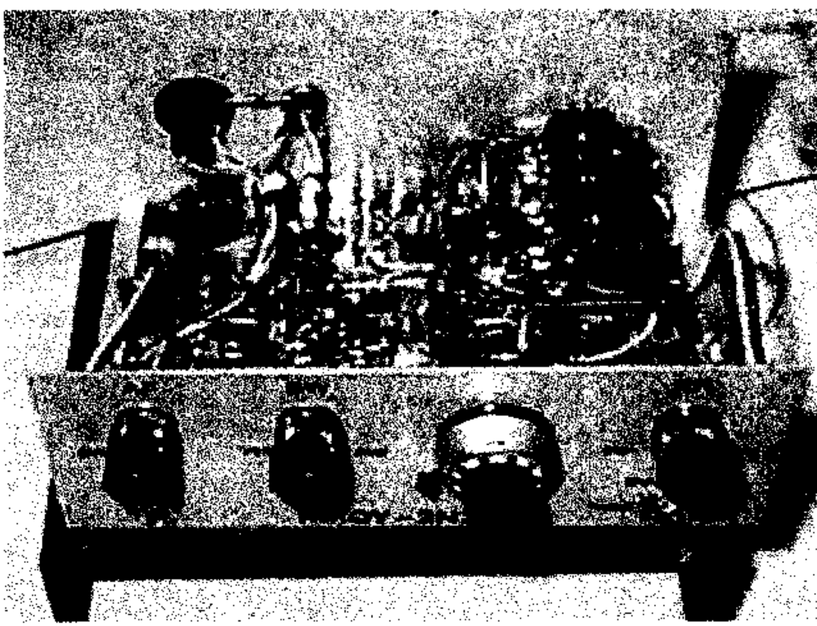


Jim Roberts, NC9H and his third place 2N2222 entry



A closer look at Jim Roberts, NC9H, 20 meter transceiver

The first place entry in the 2N2222 contest by Jim Kortge



Front and Interior view of Jim Kortge's First Place 2N2222 Rig

My 2N2222 Contest Entry, the "NP0"

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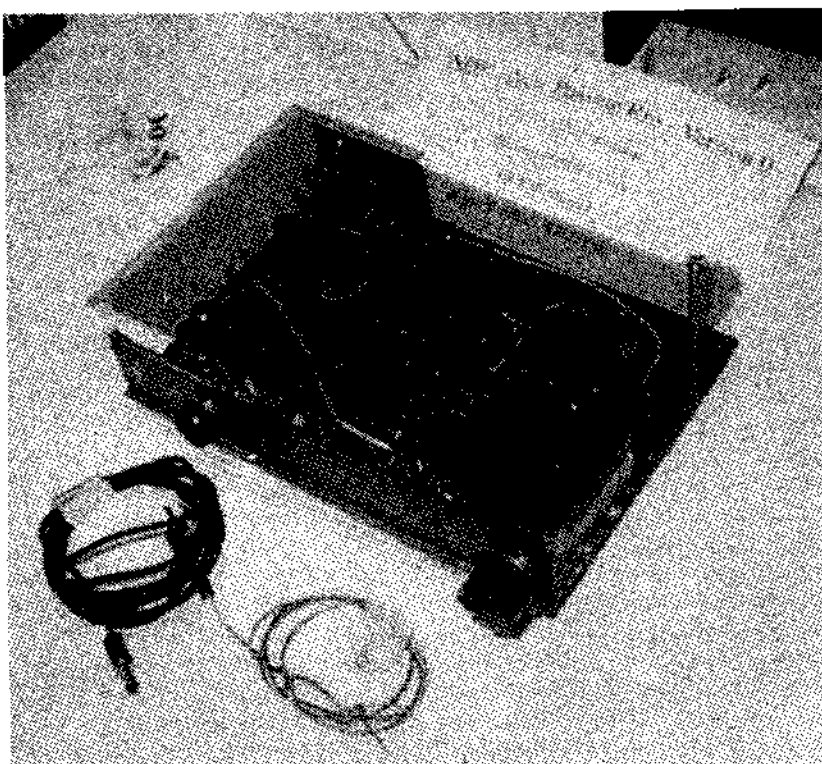
The 2N2222 design contest thought up by Wayne Burdick, N6KR, was the perfect vehicle to try out some phasing rig ideas that had been brewing in my mind for some time. I have been interested in the phasing technique for many years despite their shortcomings and the difficulty in getting adequate opposite sideband rejection. However, my attempts to build these receivers have led me down some unusual paths over which the learning experience was very rich. I suppose its the "road less traveled" effect. I highly recommend taking that path.

While creating this rig, I tried so many ideas that didn't work. Honestly, I completely gave it up for lost 4-5 times. But each time I'd get a 3am wake up call from deep in some brain wrinkle that would bring it back from the grave. My wife would stumble into the kitchen and give me that "what in the heck are you doing at this hour" look and then go back to bed wondering if I had lost my mind.

This rig remains a work in progress. The receiver sounds great as it is. But, as a typical engineer, I still want better performance. I thought I could achieve a 90db



SFDR; missed it by 10db. The QSK still thumps too much for me at full volume. The keying waveform could use some tweaking. So, here is a good place for you to start, and improve what I've done. I already have several plans for it in mind.

"NP0" Description

The "NP0" is a 40 meter CW transceiver. "NP0" is short for New Phasing rig, version 0. The receiver uses the phasing method to reject the unwanted sideband. Maximum power output at 12.6v is approximately 1W. The design uses 21, 2N2222-type transistors. Full break-in operation up to about 30 words per minute is supported.

VFO and Buffer

The VFO design is similar to those described in SSD[1]. A 4.7v zener diode provides voltage regulation for the VFO and varactor tuning circuit. The low operating voltage was used to reduce component heating that would cause drift. The frequency determining capacitors were a mixture of polystyrene and NP0 caps. Tuning is accomplished with a surplus 10-turn pot. Since this is a DC receiver, the VFO must be well shielded from the front end to prevent self-detection(microphonics). Therefore, the VFO is contained in its own brass box fashioned from hobby brass.

The VFO output is buffered by a two transistor amplifier taken from a KK7B[2] design and is modified to provide extra output. The output from this stage was approximately +11dbm.

Power Splitter and Phasing Generator

Following the VFO buffer, a power splitter (T2 and R12) divides the VFO energy between the phasing generator and the PA driver. The power splitter and phasing generator are taken from a KK7B[3] article. Fine tuning of the quadrature phase is provided by variable inductors L2 and L3. This proved to be a much easier way to fine tune the phasing adjustment that by squeezing the turns on a toroid as suggested by KK7B. The null in the opposite sideband is quite sharp. A proper null is attained by alternating the L2/L3 setting and the phase amplitude adjustment pot, R63. Upper sideband is selected so that when transmitting, the VFO is offset down in frequency so that it will be at the zero beat.

Product Detectors

The I and Q channels have separate product detectors. They are singly balanced mixers, formed from a differential pair with the LO injection applied to the constant current source.

A beta measuring circuit was used to match the upper differential transistors. Direct measurement of beta was not required, but simply matching emitter currents in the vicinity of 10ma was adequate. Most of my 2N4401's had betas of 120 to 140. I used 2N4401's in the product detectors because of their lower noise figures at audio.

To achieve higher dynamic range, 4.7 ohm emitter degeneration resistors were added to linearize the differential pairs. A standing current of 9mA in each collector of the differential pairs further reduces distortion. I would have increased this to 15mA or more except for the 70mW power limitation of the audio output transformer. Audio transformers (T9, T10) are used to maximize detector gain and to provide a low driving impedance to the audio phasing networks. The balanced output also helps reject any AC hum or microphonics.

Some folks consider audio transformers to be "large and heavy", "costly", and "hard to find". The transformers I used may be found in Mouser or Digi-Key catalogs, cost about $1.50, are smaller than my thumb nail, and weigh about the same as an SBL-1 mixer.

Audio Phasing Network

A passive audio phase shift network[4] is used. I used 1% tolerance resistors and 2% polyester film capacitors. The 0.028uF value was obtained by paralleling a 0.027uF and a 0.001uF capacitor. No matching of components was performed.

The center tapped output of the product detector transformers provide the 180 degree phase shifted inputs for the networks. A high gain audio amplifier for each channel (Q16, Q17) follows the phasing network to offset its considerable loss. A balanced output is again obtained via a audio transformer. The high impedance primary of the transformer allows for high gain and cancels out any hum on the supply line. I and Q channel amplitude imbalance is adjusted out with R63, a 100 ohm, 10-turn trim pot.

Audio Filter and AGC

Main selectivity is obtained with a 7th order, low pass elliptical filter with 850hz cutoff[5] and high pass filter with 300 hz cutoff. I used hand wound pot core inductors and polyester film capacitors to make the filter. The pot cores are actually easier to wind than a toroid since they have a removable bobbin.

The use of "store bought" TOKO inductors has become popular for audio filters. However, these inductors are quite lossy. I ran a Spice simulation to quantify the loss. The filter was modeled three ways; ideal, ideal with TOKO series resistance included, and ideal with pot core series resistance included. Referenced to the ideal filter, the TOKO equipped filter had 10db additional loss. The pot core equipped filter had about 1db additional loss.

A relay is used to provide receive muting during transmit periods. I settled on this approach after many, many other approaches failed. To correctly mute a DC receiver without thumps or clicks without opamps or FETs is a real challenge. The basic problem is that of DC level shifting. Anywhere I tried to simply clamp the audio with a transistor, a DC level shift would be created. With over 80db of audio amplification, the shift would be translated to a "pop" that would blow the headphones off my head.

I found that clamping the input to the audio filter with a transistor, produced a thumpless mute. No level shift occurs since the input to the filter is at DC ground. However, the attenuation was insufficient because the 0.1V Vce(sat) of the transistor could only limit the amplitude to 0.1V. Oh how I wished I could use a FET! Finally, while in the shower (a fertile thinking place) I though of using a relay.

Audio Amplifier and Sidetone

The audio amplifier is another circuit adapted from SSD[6]. It is followed with a homebrew Class A transformer coupled output driver. Its not running class A for very big signals as the standing current is only about 15mA, but distortion is undetectable up to annoying volume levels.

The sidetone circuit is a phase shift oscillator adapted from the 1995 ARRL Handbook. I really don't like this circuit. I never seems to oscillate at the frequency it should. I wanted to do a LC sidetone oscillator but ran out of time. There has to be a better way.

PA driver, Keying and PA

The PA driver (Q4) is the general purpose gain block described in SSD[7]. The only change to it is that the 3.3k base bias resistor is used to key this stage. The all NPN keying circuit is adapted from a QRPp article[8].

The PA stage is adapted from W7EL's optimized QRP rig[9]. It uses two 2N2222's in parallel (Q5, Q6) as the PA. I added the 1.1 ohm resistors in the emitters to limit thermal runaway. They are made up of two, 2.2 ohm 1/watt resistors.

I was able to get 1.25 Watts of output from only two of these poor little 2N2222s in the TO18 cases and a heatsink. At full output however, I notice that the output power slowly increases as the transistors heat up. I believe this is because the transistor current gain (beta) is increasing with temperature which in turn increases the current which increases the beta. This positive feedback is slowed considerably by the emitter degeneration resistors, but continuous key down at full output would probably destroy the PA transistors within 30 seconds.

Another contributing factor stressing the finals is that the output network that appears as a 50 ohm load. This impedance is consistent for producing a output of about 2 Watts, but is too low for these tiny transistors to operate efficiently . My first rig modification will be to replace the finals with a 2N3053 or equivalent. I have tried this, and the output was a solid and stable 2 Watts.

Construction

The rig was built "ugly" style on a piece of double sided PC board material 6x9 inches. A front and back panel was fashioned out of PC board material and held all the controls (both of them!) and the necessary power, key, antenna and phone jacks. I found a 10 cent piece of tinted plastic at a surplus store and mounted it via 2" standoffs over the circuitry to protect it from my kids, dust and our pet rat "Blaze" who sometimes frequents my radio table.

Other than using Spice to simulate the loss in the filter, I did not use any simulation tools in the design. I don't have anything against these tools, in fact, I make my living maintaining and teaching others how to use Spice and other CAD tools. I relied mostly on pencil and paper, a trusty calculator, a multimeter, and my understanding of how circuits work. I did get to use some fancy test equipment to test my rig, but that was once it was done.

Performance

I'm probably prejudiced, but the receiver sounds great. Its easy on the ears and a pleasure to listen to. It has the good audio quality that good DC receivers have. I have detected no AM breakthrough, and absolutely no hum and microphonics. I attribute this to a well shielded VFO and balanced circuitry. The opposite sideband rejection is quite good considering the simplicity of the circuitry.

The transmitter works fine and is acceptably rugged when the output level is held to about 750 mW. The keyed output signal is sharp on the rising edge and slow on the falling edge. This needs some attention. The frequency stability is adequate but could be improved if VFO was made an "all NP0" design. Besides, it would be consistent with the name. Also, the sidetone is still at an irritating 1200hz. I gotta fix that before it drives me crazy.

Specifications

Receiver:
Sensitivity (MDS): -125dbm
Spurious Free Dynamic Range: 80db (tested with 20khz spacing)
Receiver Audio Bandwidth: 500hz
Peak Audio Response: 600-800hz
Opposite Sideband Rejection: 30-40db (depends upon audio frequency)
Output: 8 Ohm

Transmitter:

Output power: 1W nominal, adjustable down to 0W
Keying: PA driver keyed, shaping applied, 1ms rise, 7 ms fall
Power Amplifier: Two 2N2222 (TO18 case with heatsinks)
PA Efficiency: 50%
Output Purity: All harmonics are 35 db down from fundamental
SWR Tolerance: Don't push it!, Use 50, non-reactive load or run at 500mw

Conclusion

I would like to thank Wayne Burdick and all those who judged, donated prizes, or had a part in this contest. I hope others will realize that you don't have to have a room full of test equipment or CAD tools to design a rig. Basic tools, clear understanding of the fundamentals, and a willingness to try something new is all you need. Now, get to work and make this design better!

References:

1. Wes Hayward, Doug DeMaw, "Solid State Design for the Radio Amateur", 1977, pg. 34

2. Rick Campbell, KK7B, "A Small High-Performance CW Transceiver", QST, 1995, pg. 41

3. Rick Campbell, KK7B, "KK7B SPRAT Technical Cartoon #1, A Passive Phase-Shift Network to Cover the Whole Band", SPRAT, Winter 1994/5, pp20-22

4. G.K Shubert, WA0JYK, "Solid-State Phasing-Type SSB Communications Receiver", Ham Radio, August 1973, pp6-16

5. Ed Pacyna, "QRP Reviews - R1 DC Receiver", QRP-L posting

6. Wes Hayward, Doug DeMaw, "Solid State Design for the Radio Amateur", 1977, pg. 223

7. Ibid, pg. 147

8. Steve Webber, "My 2N2222 Rig Design for the NorCal Dayton Building Contest", QRPp, Winter 1997, pp38-54

9. Roy Lewallen, W7EL, "An Optimized QRP Transceiver", QST, August 1980, pp14-19

[The schematic for this transceiver is in the center foldout section.]

The Spy Rig

By Howard Kraus, K2UD

I had ordered two of the 49er kits in the Summer of 1996. As with many of my projects, they languished on my work bench due to lack of recreational time. My position as an elevator mechanic demands a lot of me, especially after hours. Well time went by and I finally got a chance to put the 49er's together this past year. I did put the toroid mods in place of the molded chokes which tended to clean up the oscillations I was experiencing.

At the Rochester, NY Hamfest, I spotted the miniature keys such as the one I incorporated in my rig. Boy, did they cost me! Each key cost more than the 49er. Danny, K3TKS explained the history of the miniature keys to me at Dayton. The key is a 6B Telegraph Key made by Western Electric. It is one of four keys, numbered 1-4, which are the control keys for the 35D/F Apparatus Test Set made by Western Electric. It was used in just about every central office in the U.S. for setting up and adjusting the wire spring relays for their proper operate and release currents. Dave Ingram, K4TWJ's book "Keys, Keys, Keys" romantically describes them as railroad detective keys! Although not intended for CW use, they are for all the world constructed like a precision key should be. Adjustable contact spacing, tension, even a shorting bar makes this a perfect CW sending device.

With 49ers and miniature keys in hand, I set out to fulfill a penchant of mine to construct a "spy-type" radio! Now if I could only come up with some type of enclosure that would befit such a use. Remembering back to another hamfest where I had spotted some rather nice looking wooden presentation boxes with flip lids, I was able to identify the gentleman who was selling them. Turned out, he was a local. Two hours later and I was measuring and drilling the boxes. Yes, boxe(s): I built two of these "spy radios." One for myself, and one which I will present to my 11 year old son when he passes his Novice license. Really impressed the troops one day when he was 3 years old. "What is G?" His reply, "dah-dah-dit." What a guy!

Soon we will clandestinely gain intelligence on the neighborhood. What flowers are growing in the neighbor's gardens, where is that barking dog, what friend is little sister playing with, when will supper be ready, why are my tools rusting on the lawn. Serious matters of state, these!

I have worked out to 1000 miles with the 49er already. Not shabby, especially when you consider that this was done in the heat of the afternoon when the QRN level on 40M was high. A quarter watt into an end-fed Marconi certainly can go quite a ways.

The wooden boxes (I like to call them coffins for rodents) may still be available from John Kozlowski, 306 Riverside Avenue, Buffalo, NY, 14207, (716) 875-8538. The boxes didn't break the bank as the miniature keys did. As far as locating the keys, good luck! Dayton had some, and the prices were pure Dayton. Where else have you seen HW-7s going for $150?

I hope this provides some interesting color for the spy-rig. It really is as much fun to use as it is to look at. Now I have to call control for my new assignment. Hmm, what will it be, a NorCal 20, Green Mountain, SST? 72, Howard Kraus, K2UD

SWITCHED CAPACITANCE AUDIO FILTER plus CW PEAKING SCAF

by Jim Pepper, W6QIF

For those who were fortunate enough to attend the QRPp meeting at the 1997 Pacificon conference, you one of the speakers talk on the advantages of using audio peaking for CW reception. Using this technique, you will find a great improvement with any type of receiver from a Direct Conversion to a modern day superhet. The noise essentially disappears and all you hear are CW signals standing out from the back ground. The following is a project that you can build that will do just that. In addition, for those who have receivers that lack in audio output, this project will also prove worthwhile.

DESCRIPTION

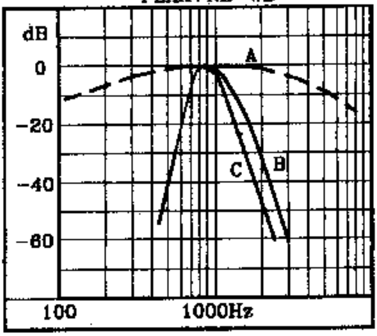
The unit discussed is designed to be used as an outboard module that plugs into the speaker output of your receiver and has an output to connect to a separate speaker or head phones. It is either operated from a 12V source or an internal 9 volt battery. A front panel switch allows either the circuit to be in or bypassed to give normal receiver operation. There are four modes of operation. One, the bypass mode, two, a wide band mode with a corner frequency at 2kHZ, three a narrow band mode with a corner frequency at 1.1kHz and finally, with the filter in the circuit, the peaking circuit can be activated giving further improvement in selectivity. (See curves in figures 1 and 2). The band width selectivity is obtained through the use of a SCAF (Switched Capacitor Audio Filter) circuit. This type of filter is capable of giving very sharp filter skirts with an attenuation ratio of 48dB per octave. A typical RC network will give only 6 dB per octave.

The peaking circuit was derived from a circuit that was originally designed to give a null in the audio range. It turned out that one half of the circuit could be used as a peaking device. The frequency at which peaking takes place can be adjusted from a front panel control and has a range of approximately 5OO to 2kHz.

The filter is built on a PC board obtainable from FAR (1) which in turn is housed in a small instrument cabinet. The front panel mounts three switches, the IN-OUT filter switch, the BANDWIDTH switch and a switch for PEAKING IN or OUT.

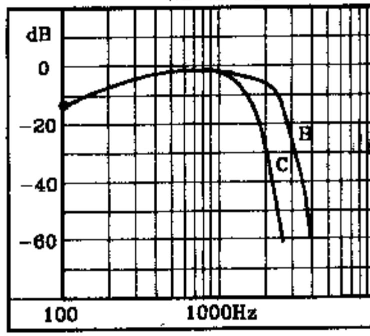
An LED is incorporated to indicate

FIGURE 1
PEAK+NB-WB



A FILTER OUT
B WIDEBAND PEAKING IN
C NARROWBAND PEAKING IN

FIGURE 2
NB vs WB



when the power source is on. In addition, the front panel has a volume control and a control for setting the pitch frequency that best suits your hearing requirements.

CONSTRUCT I ON

First build up the pc board following the layout drawing and the silkscreening on the pc board. The pots are pc type mounting but the switches will have to be wired in. FIG3

The DC power plug is also of the pc mounting type and is mounted at the rear of the board. I find it is best to mount all of the resistors first, then the sockets and then the rest of the components.

(I always like to use pc sockets for the op-amps for ease in trouble shooting when an amplifier can be at fault. It also allows the checking of voltages at the socket before plugging in the amplifiers.) (If the use of a 9 volt battery is contemplated, snap connectors are provided that also hold the battery in place. The switch (S4) on the rear of the cabinet serves a dual purpose, it acts as an ON OFF switch for the 9V battery and if a 12v source is used, the 9v battery is disconnected. To turn off the 12v supply, remove the power plug on the rear.)

Now wire in the switches etc. following the directions in the pcb layout drawing FIG 3. You will have to temporarily wire in the phone plug that goes to the receiver audio output for checking purposes. (NOTE: make sure that the wire to the body of the phone plug goes to the ground point on the pc board.)

When the board is completely assembled, I recommend that it be tested outside of the cabinet in case there is some fault that must be fixed. You can plug it your receiver as the source of audio. As I said before, a separate speaker or head phones must the be plugged into the output connector. Before connecting to a power source, I would check to see if the is no apparent short between plus and ground of the power connector. If you have a source for the 12v, and it is not a battery, you should use it at this time. Otherwise I would use the 9v battery as a source. A battery source can deliver high currents that can wipe out a pc trace if there is a short some where. Do not plug in the IC's at this time but instead check the voltages on each of~the IC sockets to make sure they are the correct value. This is especially important on the Max~95 socket. The voltage on pin 6 be no greater than 9.~volts, and on pin 7, no greater than .6

of 9volts or .6 of 12 volts depending on the power source.

If this check is ok, plug in the IC's and power up the unit. If ok, the LED should turn on.

TESTING

Plug in the phone cable to the receiver and connect the output of the unit to either a speaker or headphones. Turn on the receiver and filter.

With the filter switch in OUT, you should hear the audio coming out of the speaker or phones. Some adjustment of the two volume controls maybe necessary. Proceed to test as indicated below.

OPERATION

Because the circuit has about 3~ dB of gain, the receiver output should be set to a low level and the volume controlled by the units own volume control. This will require a bit of experimenting to get the best results.

I found that, if I set the SCAF volume control at about 1/4 on and the adjust the receiver output level to meet ones audio level requirement, it will give good results. There is essentially no difference in output level between filter in and out.

The peaking circuit has inherently about 20dB of gain, but I have placed an attenuator of about 10 to i to reduce the signal from this stage when it is on. The on state is when the peaking switch is open.

To set the pitch control, first set the control in the full counter clockwise position and the BW position in WIDE. Tune in a cw station to the pitch you normally like for copying purposes. Place the PEAKING sw in the ON position. Now adjust the pitch until you hear the signal increase in volume. The adjustment is quite sharp so it must be done slowly. Switch to the narrow banC position. If you have modern day high selective receiver, you probably won't notice too much difference, but there should be great difference between filter IN and OUT. Tune off to the sideband of the signal and notice the difference in noise between filter in and out. Great results are obtained on Direct Conversion receivers because they lack the selectivity of a superhet.

Now tune in a SSB station and note the effect of the filter in and out. It will be quite noticeable on a DC receiver but not as great on a modern day highly selective receiver but still there will be some improvement.

CIRCUIT DESCRIPTION

The unit contains three integrated circuits. One half of an LF353 or a 1458 (ICi) can used in the peaking circuit. The second half is used to provided a 6 volt output necessary for the peaking circuit as well as one of the voltages for the MAX 295 SCAF IC. The second IC (1C2) is the SCAF IC. The output amplifier (1C3) is an LM38ON-8 with a fixed gain of 50.

(I included pc board component mounting holes for a compensating network on the output of the LM380 but in my case I didn't find it was necessary. If the amplifier has a tendency to oscillate, try an RC network on the output. A 0.luF in series with a 2.7 ohm resistor should work Ok.)

SCAF

The SCAF IC can be set to any corner frequency between 0.1 Hz to 50kHz. I chose 1.1kHz for the narrow band and 2.0 kHz for the wide band. The formula for setting the corner frequency (Fosc) is:

Multiply the desired corner frequency in kHz by 50. This determines the SCAF oscillator frequency

To obtain the required capacitance to set the oscillator C(pF)

C(pF)=100,000/F(osc)x3

Example:

Desired corner frequency is 1.1kHz

1.1x50= 55

C(pF)= 100,000/55x3= 666pf

I chose 500pF plus a 100pF in parallel as a reasonably close value.

It is my feeling that having any other corner frequencies don't buy you much. I have seen some circuits that use the SCAF with a variable selection for the corner frequency but it only leads to more complex circuitry.. However, feel free to try others if you so desire using the above formula.

ASSEMBLY

If the pc board checks out ok, then you are ready to put it in the enclosure. The cabinet requires a number of holes to be drilled. Make two copies of both the front and back panels (Figure 4 and 5) on a copy machine. They should be 1 to 1. Take one copy and lay it on what is to be the front panel and secure it with magic tape for drilling purposes.. Center punch lightly the center points of each of the indicated holes and proceed to drill them to size.

It is best to start with a small drill first to maintain accuracy of the hole positions. Repeat the process for the rear panel. I used a .5" round file to ream out the hole for the 12 volt opening. You can make an effective reamer by rotating the file in a counter clock wise direction. Turn in a clockwise direction and you will lock up the file.

With the panel drilled, you are ready to mount the second set of copies of the panels. First, the panels must be mounted on a laminating sheet to protect its surface. Cut the panels to size with an inch border all around. Hold the panel down on a flat surface with magic tape on the edges. Cut the laminating sheets to the similar size but with about an half inch border all around. Peal off the backing and carefully place the material over the panel starting from one edge.

Next, it is necessary to cut out the required holes for the switches and pots. Use a sharp hobby knife and cut carefully around the outer edge of the marked holes. When completed, cut the panels to size. The panels can be adhered to the panel with an adhesive. I used a product called Elmer's Glue Stick •{R}. Any paste would be ok as long as there are no lumps on the surface. Attach to the box panel.

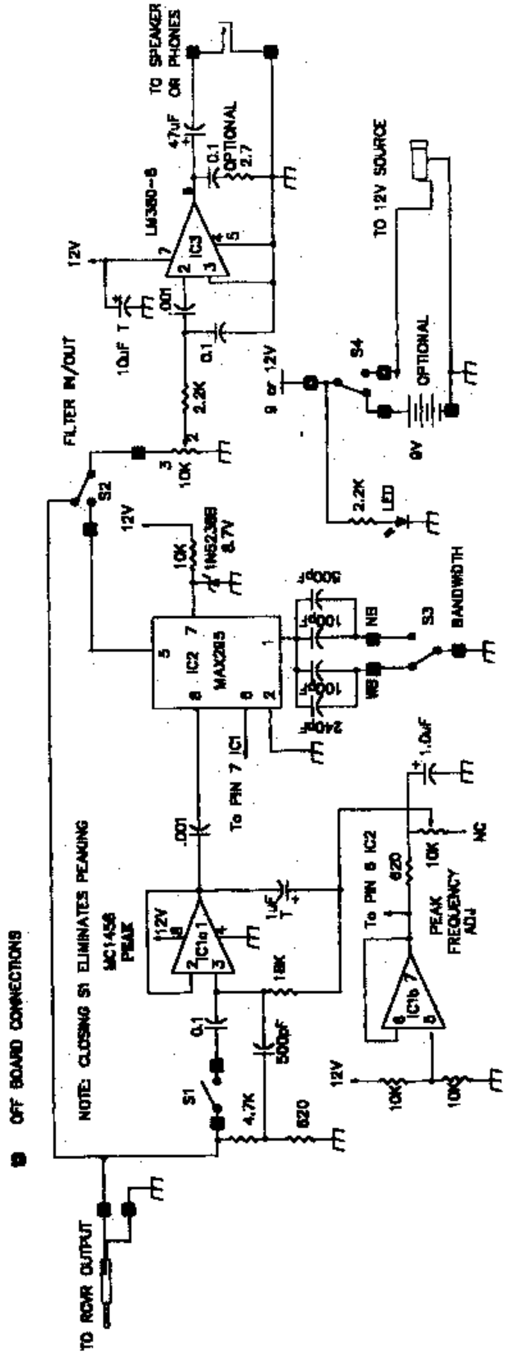
At this time you will have to remove the cable that goes to the phone plug and pass it through the rear panel and reconnect it. Now insert the pc board into the box with the pot shafts going through the front panel. Next mount the wired switches and speaker jack. Later, if you find the switches in the wrong direction, reverse the wiring rather than trying to twist them around to the right direction.

If you have done a good job in drilling the holes, everything should fit properly. You are now ready for the final testing of the unit. Proceed as you previously did and note the panel labeling for the switch action. If everything works, wrap up the project by putting the cover on the box. I think now you can try a 12 volt source if available.

Let me know how this circuit works for you or if you have any questions I will be glad to hear from you.. You can contact me on the internet W6QIF@ix.netcom.com

NOTE: The Max295 is available from only one source that I know of DIGI-KEY. For orders less than $25 dollars there is a charge of $5. The part costs $6.02 If you can get four people together to buy the Max295 plus the other IC's you can waive this fee.

SCAF FILTER, PEAKING and AUDIO AMPLIFIER



SCALE 1" = 1"

FIGURE 4

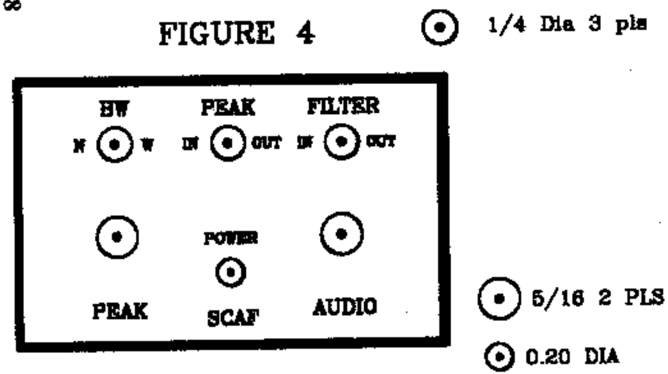
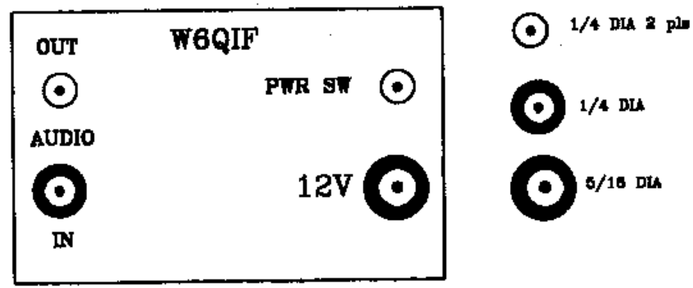
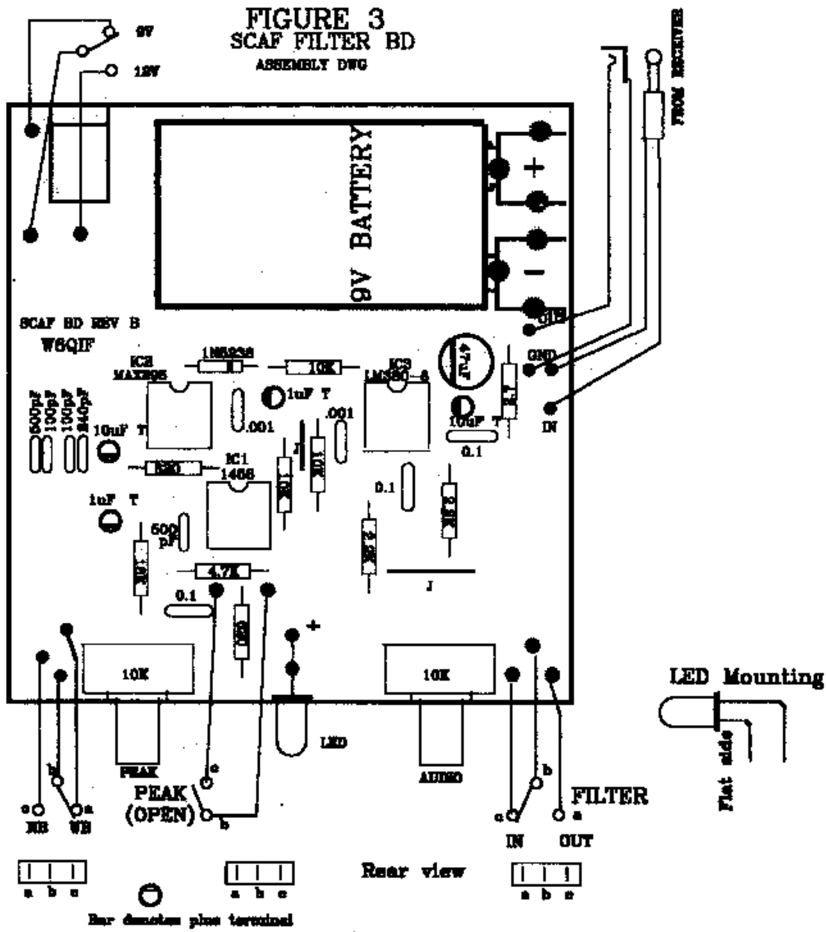


FIGURE 5



PRINT SO SCALE IS 1 to 1
1" = 1"

FIGURE 3
SCAF FILTER BD
ASSEMBLY DWG



Parts List for SCAF

PC Board	$7.00		SCAF Filter Rev B	FAR Circuits
SCAF IC	$6.02		MAX295CPA-ND	DigiKey
Instrument Cabinet	$4.90		4OUB101	DC
Op Amp 1458	$ .49		MC1458CPI	DC
Audio Amp LM380N-8		$1.10	LM380N-8	DC
Zener Diode 8.7V		.20	1N5238B	DC
10K Pot (.99 x 2)		1.98	31CW401	DC
240pf Cer 5%		.15	21CB240	DC
100pF Cer 5% (.15 x 2)		.30	21CB100	DC
500pF Cer 5% (.15 x 2)		.30	21CB500	DC
.001uF Mylar (.10 x 2)		.20	23BK210	DC
0.1uF Mylar (.20 x 2)		.40	23BK410	DC

1uF tant. (.30 x 2)	.60	18EM510	DC
10uF tant. (.55 x 2)	1.10	18EK610	DC
47uF 16V Radial Cap	.15	CM16-0047	DC
SPDT Switch (1.50 x 4)	6.00	SW104	DC
Phone Jack 1/4"	1.10	16PJ022	DC
Phone Plug 1/4"	1.25	ME17-1204	DC
8 pin socket (.07 x 3)	.21	T02-08	DC
9 Volt Battery Holder	1.15	1291	DC
LED red (1.25/10)	.13	LR10	DC
620 ohm 1/4W Res. (.05 x 2)	.10	CF25-620	DC
4.7K 1/4W Res	.05	CF25-4.7K	DC
2.2K 1/4 W Res. (.05 x 2)	.10	CF25-2.2K	DC
10K 1/4 W Res. (.05 x 3)	.15	CF25-10K	DC
18K 1/4W Res.	.05	CF25-18K	DC
9 Volt Battery			
Panel Laminate 65059	1.44	C-Line Product	Bookstore

(1) FAR Circuits 18N640 Field Ct., Dundee, IL 60118 Add $1.50 S&H per 4 boards
DC Electronics, PO Box 3203, Scottsdale, AZ, 85271 $4 S&H
Digi-Key Corp., PO Box 677, Thief River Falls, MN 56701, $5 S&H

Project Cabinets

by Jim Pepper, W6QIF
W6QIF@ix.netcom.com

Many home brewers can build electronic projects but lack the facilities to provide a cabinet for their work. Commercial cabinets are available but they certainly are not reasonable in cost. There is one that is readily available and inexpensive, one made for Radio Shack. 270-253 If you have ever used one of these cabinets you probably have found that the aluminum used for the chassis is very soft and difficult to drill. Other wise, for the price, it can't be beat. ($6.99) I have used them on a number of my projects and on my latest one I feel I have found a solution to making this a very viable unit.

There are two faults that are overcome by applying my modification. The weakness of the aluminum, and the difficulty in trying to drill the panel when its part of the chassis.

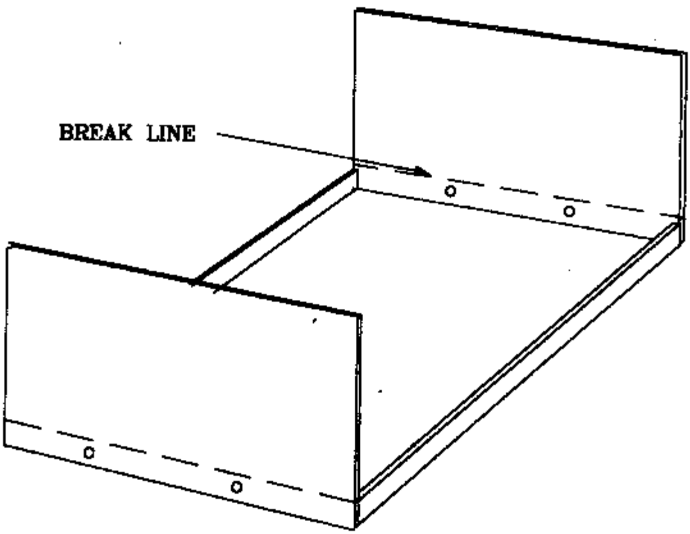
What I did was to remove both the front and rear panels of the chassis This can be easily accomplished by scribing a mark on the panel with a sharp pointed tool (See Figure) to make a break point. Once done, slowly bend the panel back and forth until the panel breaks at the scored point. You probably will have to straighten up the remaining lip and maybe touch up the edge with a file.

The panels will be replaced with 1/16" plexiglass cut to size. This solves the second problem of drilling. The panels are now flat and can be properly clamped for drilling purposes. The panels are mounted to the chassis lips with self tapping screws. A drilling template can be used to mark where the panel holes are to be. Center punch the centers with a very light touch so as to not crack the plexiglass.

You can either spray paint the inside to prevent from seeing into the cabinet (it's best to spray before drilling), or, if you have a panel layout for the panel, you can adhere it to the panel, or you can adhere a sheet of aluminum foil on its back side. I use laminating material to stiffen the layout material so it lays flat against the panel. (One product is called Panel Laminate 65059 a C-Line Product available from stationary stores.) Holes are then cut in the material with a sharp hobby knife. The plexiglass can be obtain from stores that handle plastic materials. They will do the cutting for a nominal fee. The panel dimensions are 5-1/8 x 2-13/16.

If you have any questions about the method you can find me at W6QIF@ix . netcom.com
72 Jim

RADIO SHACK 270-253



In My Post-Apocalyptic World There Were Only Two 2N2222 Transistors

by Robert Freiss, N6CM
16141 Matilija Drive
Los Gatos, CA 95030

This transceiver was designed with the objective of minimizing the number of active devices, in this case the 2N2222 transistor, while achieving usable performance. The resulting 40 meter CW transceiver uses only two 2N2222 transistors, produces about 700 milliwatts of output, is capable of receiving signals well below 1 microvolt, and provides semi-breakin TR switching. One transistor serves as both a receiver RF preamplifier and receiver AF amplifier and the other is used as the receiver local oscillator and as the transmitter. The design is all original with the exception of the idea to use two identical crystals in parallel in the VCXO to increase the tuning range. The origin of this idea is unknown to the author, but it works very well. A more detailed circuit description follows.

Robert Freiss' 2 Transistor 2N2222 40 Meter CW Transceiver

Receive Mode

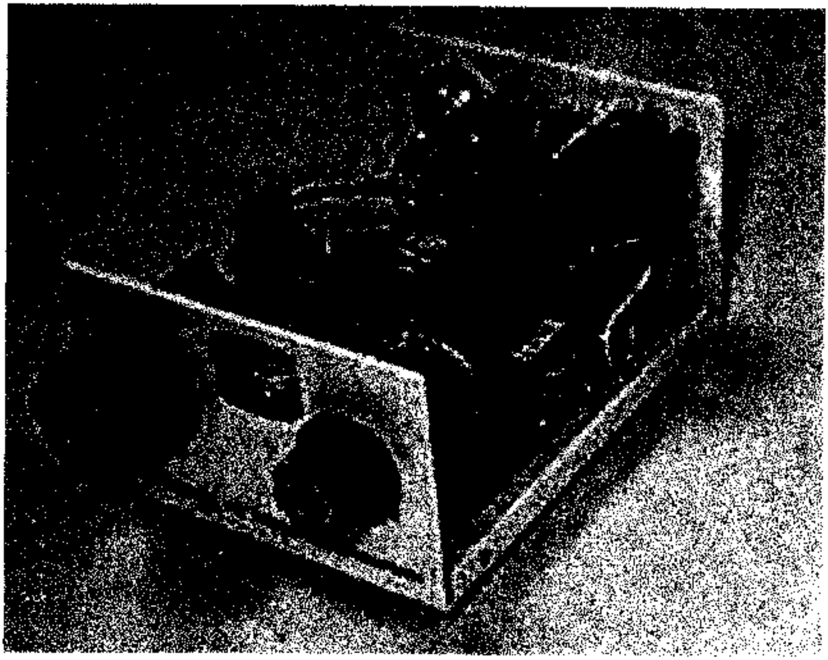
The schematic diagram shows the relays in the receive mode. Signals from the antenna are routed to the base of Q1, the RF amplifier, through a 6 MHz high pass filter (to reduce susceptibility to BC band breakhrough) and a tuned transformer. The amplified receive signal is connected to a diode mixer through a high pass filter that opens a feedback path that otherwise would be present at audio frequencies. The local oscillator signal is coupled to the mixer through the 18 pF capacitor. Recovered audio is connected to the volume control and rerouted through the transistor Q1 again. At audio frequencies output is taken from T2 and connected to the headphone jack. Limiting diodes are provided for comfort when a very strong signal is encountered. The first transistor amplifies the receive signal twice, once at RF and again at AF. Filtering is provided so as not to close a loop at either RF or AF frequencies to assure stability. Selection of coupling and bypass capacitors was made to limit the AF bandwidth. With the component values shown the 3dB audio bandwidth extends from about 300 Hz to 1000 Hz.

In receive mode, Q2, the VCXO, operates at very low power, about 5 milliamps at 2 volts, to reduce radiated power back through Ql to the antenna.

Transformer T2 could be eliminated if high impedance headphones were used, however, low impedance "stereo" headphones are more commonly available so T2 is provided to allow the use of low impedance headsets.

Transmit Mode

To select the transmit mode, the key is closed operating K1 and K2. About 1/2 second of delay is provided after the key is opened before switching back to receive



Interior View of Robert Freiss' 2 Transistor 2N2222 CW Transceiver

mode occurs. In transmit mode, the operating point of Q2 is increased, the feedback is adjusted, RF output is taken from the wideband RF transformer in the collector and Ql is turned off. About 700 milliwatts of output power is achieved with collector current of about 110 ma. In transmit mode Q2 is self-biased by the voltage produced by the current flowing through the diode and 82 ohm resistor connected between the base and ground. Power output can be adjusted over about a 3 dB range by changing the value of the 82 ohm resistor. The output from Q2 is passed through a lowpass filter to attenuate harmonics and is connected to the antenna through the antenna relay. The resulting CW signal is high quality without chirps or clicks. A piezo electric transducer is keyed along with Q2 to produce a sidetone.

An air variable capacitor is used for frequency adjustment in place of a varactor diode in order to maximize the tuning range.

The change in oscillator operating conditions that occurs when switching between receive to transmit also produces a desirable transmit frequency offset. Unfortunately, this offset is not constant across the tuning range. At the high end of the range the ofiset is about -300 Hz and increases to about -1100 Hz at the low end of the tuning range. At the center frequency of 7040 kHz, it is almost ideal at -700 Hz. Not perfect, but not bad considering the simplicity of the design.

The transceiver is switched between receive and transmit mode by the initial closure of the key. Before the relays can operate, the l000uF capacitor provided for delay must be charged through the associated series 22 ohm resistor. The capacitor could have been made much smaller with the addition of another 2N2222, but that would be inconsistant with the minimalist theme of the design. The initial capacitor charging current is approximately 500 milliamperes, consequently, the keying device must be capable of passing this current. It it is not, then the charging of the capacitor may be delayed and the first keyed dot may be significantly shortened or even missed. A mechanical key or a relay or mosfet output keyer is recommended.

Operating Instcuctions

Connect power, antenna, key, and headphones. Turn on, tune, listen and press the key.

Performance Measurements

Power output:

Vcc, volts	Po, milliwatts
12.0	630
12.5	700
13.0	770
13.5	820
14.0	900

RF input for 10 dB s+n/n: -110 dBm

Tuning Range: 7033.6 kHz - 7044.4 kHz

AF Bandwidth: 700 Hz.

Current Consumption:

Receive: 20mA

Transmit: 130mA

Spurious Output < -56 dBc (0-50 MHz)

[Schematics for this transceiver can be found in the centerfold section.]

5 Watts From 10 2N2222 Transistors

by Robert Freiss, N6CM
16141 Matilija Drive
Los Gatos, CA 95030

Although not in conformance with the rules for entry in the NorCal 2N2222 contest, as it is not a transceiver, this amplifier is submitted for interest.

This amplifier was designed to provide higher power for 2N2222 CW transceivers in the 200 to 700 milliwatt output power range. It is automatically switched, all that is needed is to connect it to a 12 Volt supply and insert it between the transceiver and the antenna. Just like an ALPHA.

A fan cooled heatsink intended for Pentium microsprocessors was drilled with ten holes and ten 2N2222 transistors were press fit into the holes. Individual emitter resistors were provided to assure current sharing and the base connections and collectors connections were all connected in parallel. The combination of the emitter resistors and the shunt inductor in the base circuit resulted in an input impedance close to 50 ohms. Without the input attenuator, only about 100 milliwatts drive is required for full power output. The input attenuator is included to allow a drive level of 200 to 700 milliwatts. A collector load impedance of about 12 ohms is provided by the 1:4 bifilar transformer T1. The high impedance point of T1 is connected to the amplifier output through a lowpass filter used to remove harmonics..

Relay K1 is operated by a class B detector connected to the amplifier input. In the absence of a transmit signal, K1 is unenergized and receive signals are passed from the antenna directly to the transceiver. In presence of RF power greater than about 75 milliwatts the relay operates connecting the amplifier into the transmit path. The 470 uF capacitor provides a release delay of about a half a second so that switching does not occur between characters and words. A second detector is connected to the output connector to provide a monitor for output power. This second detector is connected to the front panel meter that has been calibrated in Watts into a 50 ohm load.

Early versions of the amplifier with

smaller emitter resistors and a lower collector load impedance provided by a 9:1 transformer produced more than 10 watts of output. In the end, it was decided that 5 or 6 watts was enought. With the 10 ohm emitter resistors and a 12 ohm collector load impedance the amplifier is very rugged and has been inadvertently operated without load several times without damage.

The described amplifier operates in Class C and is intended for use with CW transmitters. It is not suitable for SSB transmitters.

Performance Measurements:

Pin vs. Pout, Vcc = 13.6

Pin(Watts)	Pout(Watts)
0.1	2.5
0.2	3.6
0.3	4.2
0.37	4.7
0.5	5.0
0.6	6.0

Power required to key relay: 75mW

Output Spectrum Spurius < -55dBc

[Editors note: The schematic for the Power AMP is in the centerfold section of this issue. In order to make the schematics legible, it is necessary to print them in 8.5 x 11" size. I apologize for the inconvence of having to disassemble the journal to read the schematics. Doug, KI6DS]

AD6CR 2N2222 40 Meter CW Transceiver

by Sashi Kumar, AD6CR
41808 Corte Santa Ines
Fremont, CA 94539

I started work on my 2N2222 radio design only in April. so I had to come up with a set of guidelines that would allow me to finish the design in time for the contest. Here is what I came up with.

1. A very simple receiver design for CW (there was no time for anything more elaborate.)
2. Good selectivity and sensitivity
3. Good image rejection (if Superhet or Direct Conversion)
4. Operate on 40 Meters with a spread of about 20 kHz.
5. Sidetone
6. Something new and unique

The receiver stages are as follows:

RF Stage:

This is a two stage buffer amplifier, primarily intended to keep the oscillating detector from leaking signals into the antenna. There is a RF gain control at the input of the first stage to attenuate strong stations. I have attempted to keep the gain of this stage fairly low as all the gain that is needed comes from the detector itself. This stage is inductively coupled to the detector stage.

Oscillating Detector:

This stage gives the receiver the gain, selectivity and CW detection all in one shot. The oscillator itself is a classic Colpitts oscillator. The RF signal from the RF stage is coupled directly into the tuned circuit via inductive coupling on the torroid. There is no regeneration control and strong signals do not pull it out of oscillations. The RF gain control can attenuate strong signals.

Low Pass Filter and Audio Stage:

A RC lowpass filter and two transistor audio stage completes the receiver. The audio amp uses a Radio Shack audio transformer for adequate audio output. A Twin-T audio oscillator gives the transmit side tone.

The Transmitter Stage:

The transmitter picks up RF energy from the oscillating detector and drives a RF buffer stage. The buffer stage drives a pair of parallel connected 2N2222's operating in Class C mode. The output of the final stage is coupled to the antenna via a low pass filter stage. The transmitter is turned on by keying the buffer stage transistors emitter to ground connection. the keying also causes the receive section to be muted and the side tone generator enabled.

Operation:

1. Turn radio On by pluggin in 12 to 13.5 Volts to the power connector.
2. Set RF and Audio gain to a comfortable level.
3. Use Main Tuning dial to receive between 7025 and 7045 kHz.
4. To transmit on the received frequency, tap away on the key.

Bench Test Results:

When the transceiver was completed, I did some quick on the air testing of the receiver and some transmit measurements on the bench.

Receiver:

The receiver is very sensitive and selective. I compared the received signals with my Yaesu FT-920. Most of the stronger CW stations heard on the FT-920 could be copied on the 2N2222 radio. The RF gain is effective only with the very strongest stations and had to be turned up for most other signals to a maximum position. The audio level is high enough, but could be higher. The tuning control runes smoothly between 7025 and 7050 kHz. The receiver is stable and the VFO heard on my FT-920 did not drift more than by about 100Hz. The selectivity is quite remarkable for a radio this simple. I am thrilled with it's performance.

Transmitter:

The transmitter output is not a perfect sine wave coming out of the low pass filter. That was a disappointment. I need to work more on the drive for the final transistor and the low pass filter. I tested the output spectrum on a spectrum analyzer and found that the worst case harmonic was only 14dB below the fundamental. Certainly not good enough. I unfortunately ran out of time since I started the project only in late April. When it comes back from Dayton, I'll fix the output.

Sidetone:

The sidetone on keying seems to be adequate. It does sound a bit raspy. I need to look at the circuit some more.

Keying Circuit:

Works like a charm. The transistor switch scheme seems to work just fine. I need to turn the RF intermediate stages off as well and not just the input. (Again, more work to be done on return of the rig from Dayton.)

Overall Performance:

There is a porobiem with my design. The receiver is slightly detuned by the input loading on the VFO when in receive. When keyed, the RF section is disconnected form the antenna and this causes the VFO to be off from the receive frequency. When using a dummy load, this was not too bad, but with a real antenna, the shift was not acceptable. I believe I have some ideas on how to improve on this, but I have run out of time.

Conclusion:

I have had a wonderful time with this design. I thank Wayne for his wonderful idea and I want to thank Doug Hendricks for allowing me to send this entry in. Thanks guys, I know I don't have a winning entry, but I sure had fun. I would encourage this form of a receiver though. It is quite remarkable.

Acknowledgements:

The RF buffer section and the side tone oscillator are similar to the one in the 1978 ARRL handbook. The rest of the circuit is quite generic. Enjoy. 72, Sashi, AD6CR

[Editors note: The schematic for the AD6CR Transceiver is in the centerfold section of this issue. In order to make the schematics legible, it is necessary to print them in 8.5 x 11" size. I apologize for the inconvence of having to disassemble the journal to read the schematics but it is the best way that we have of doing them. Doug, KI6DS]

Solving a Problem & 2 Mod's for a Wilderness Sierra/KC-2

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When NorCal did the field test edition of the KC-2 keyer/counter/meter module it looked so good that I ordered one for my Sierra immediately. As I already had a KC-1 in my rig the completed KC-2 sat in a drawer for quite some time before I ordered a new matching front panel from Wilderness Radio.

After a while I noticed that there was sometimes a slight warble and a ticking sound on the received signal signals. The repeat rate of the ticking sound depended on the display mode that the KC-2 was in, S-meter or frequency. Wayne Burdick, N6KR, explained that the warble finds its cause in a trick he had to resort to in the design of the KC-2. If you look up the schematic, you can see that the VFO signal is buffered by a two stage amplifier and then fed to TWO pins on the PIC. One of these is used as the input for the counter, but the other is actually an output, whose signal - some kind of square wave, no doubt - not only does its intended job, but also manages to work its way back through the two-stage buffer amp all the way to the VFO itself which it modulates very slightly. It just shows how sensitive a VFO can be to outside disturbances.

At first the warble wasn't all that objectionable, but when I started wondering whether the warble might also be present on my TX signal, I decided it was time to get rid of it. A number of replies to a message on the QRP-L mailing list suggested making the coupling cap (Cv) between Sierra VFO and KC-2 as small as possible. Dave Meacham, W6EMD, pointed out he had published a short article in QRPp of Dec. 1996 (p.59) about fitting a KC-2 to a Cascade that provided me with a further suggestion.

I also had some additional ideas for modifications for the combination of KC-2 and Sierra waiting to be tried out, and I mustered courage to disassemble the rig once more and get rid of the warble.

The VFO coupling cap (called Cv in the KC-2 manual) was still 10 pF as it had been with the original KC-1. To find the lowest possible value for Cv I replaced it temporarily with an 8 pF trimmer cap. Playing with the trimmer cap I found that the value suggested by most respondents (4 pF) would cause the counter to stop counting properly.

As I needed to remove the KC-2 from the front panel to fit two new wires for the two mod's described below, I took the opportunity to do what Dave's suggested in his article. Dave replaced the coupling cap (C8 on the KC-2) between the two stages of the VFO buffer amplifier in the KC-2 with 100 pF. It originally was 22 pF and I made it 82 pF, because that is what I had handy. You'll have to open the 'sandwich' and bend the backside board away from the display board to get at capacitor C8. If you don't have the tools to desolder C8 it would be a sound strategy to add the extra capacitance in parallel with C8 on the bottom side of the board. Then, with the larger

C8, I used the trimmer cap again to find out the lowest value for Cv at which the counter would still work reliably. I settled on a fixed ceramic NP0 capacitor of 4 pF for Cv. No more warble.

In my Sierra the connection from the VFO to the KC-2 consists of a short piece of sturdy hookup wire (stranded, Teflon coated). Some respondents to my QRP-L message had suggested that replacing the connecting hookup wire from the Sierra VFO to the KC-2 with miniature coax might help. However, 10 cm of RG-174 has a capacitance of ca. 10 pF, which together with the 4 pF coupling capacitor will constitute a capacitive divider. This is certain to reduce the effective VFO signal to the input of the KC-2. Because of this consideration and because I had fb results with the hookup wire I actually never tried the coax.

Now to the other modifications.

1. Using the AUX output of the KC-2 to temporarily switch on the side tone oscillator during reception.

The purpose is to provide an accurate reference for tuning. Even if your rig is properly aligned, your hearing may not have a perfect memory of what the signal pitch should be and AGC action makes it hard to locate the peak in the RX bandpass. Accurate tuning is still required if you want the TX to be exactly on the same frequency as (=zero beat with) the other station. This mod makes it possible to beat the detected audio signal against the sidetone. It works best on headphones.

It is necessary that the rig's RX and TX carrier oscillators (the oscillators governed by crystals X6 and X7) and the sidetone oscillator are carefully aligned. This is explained in the Sierra manual in some detail.

Note that the original Sierra by NorCal doesn't have a separate sidetone oscillator, so this mod won't work with that rig.

The modification itself (see figure 1) is very simple to do. A MOSFET 2N7000 (I used the European equivalent BS170) controlled by the AUX output of the KC-2 pulls the lower end of R6C to ground through a series diode. After having drawn the mod into the Sierra circuit schematic it is easy to see that this action of the MOSFET duplicates the key down action as far as the sidetone oscillator is concerned. The two diodes (D3 and the one from fig. 1) form a logical OR gate isolating the key line and the MOSFET switch from eachother. The circuit will also work without the diode, but in that case the sidetone activated by AUX is slightly different from the sound during key down.

R6, a resistor network, sits on the left edge of the PCB in the middle. Locate pin 5 counting from pin 1 which is marked with a square PCB island. Following the tracks on the underside of the board a suitable clear space for the MOSFET and the diode can be found near the threaded support for the band module. A suitable ground point nearby is marked 'G ' on the top of the board. I fixed the MOSFET to the board with hot melt glue to prevent the wire to the KC-2 from pulling the MOSFET away.

NOTE: Holding the MOSFET with the wires towards the viewer, the flattened side of the case up and going from left to

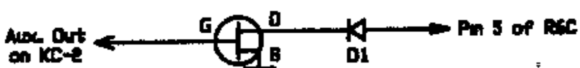

Fig. 1

right, the pin-out is DGS for the BS170 and SGD for the 2N7000 (and the BS170P) SGD.

Disabling the TX during message recording without directly switching an RF signal.

Because this circuit doesn't switch any RF signal directly, there is no potential for affecting the normal operation of the rig. The MOSFET also doesn't need input current like a bipolar junction transistor.

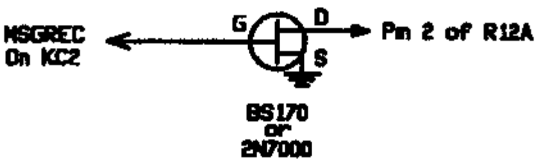

Fig. 2

Figure 2 shows the second modification, which is simplicity itself having a part count of only one. In this case it is the MSG REC signal that is used to control a MOSFET switch. When a message is recorded the MSG REC signal will be 'high'. As long as the gate voltage is 'high' (higher than ca. 3 V) the 2N7000 MOSFET will provide a short to ground for the keying signal at the point between Q8 and Q9 in the keyline buffer amplifier.

This prevents the TX driver stage from being keyed during message recording. Therefore there will be no TX output. The sidetone, however, is still operating as the keying signal for the sidetone oscillator is taken off at a point before the short viz. directly from the keyline input.

See fig. 2 for the circuit. R12, a resistor network like R6, is located near the key connector at the right upper corner. Locate pin 2 counting from pin 1 which is marked with a square PCB island. Follow the track from pin 2 and pick a soldering island to connect the drain of the MOSFET to. Locate a suitable ground point comparing the Sierra schematic with the PCB in that area. I again stuck the MOSFET to the PCB with hot melt glue to prevent the wire to the KC-2 from pulling the MOSFET away.

That's it. I hope you find the additional functions useful. Some the above may be applicable to other rigs that have been equipped with a KC-2. If you have questions, do ask.

FYBO '98

by Joe Gervais, AB7TT
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Howdy Folks,Here it is, the results for FYBO '98! Many thanks to everyone who participated. You guys were great! Condx were tough but it seems like lots of fun was had by all. Wahoo!

Please remember that the goal of FYBO is to have fun with friends and come away with some great stories and/or lies to share around the campfire. To that end, even if you didn't have a huge score or a logsheet full of QSOs, if you got on the air and had a good time then your FYBO mision was accomplished. Bonus points if you've already told your kids/grandkids/nieces/nephews tales of wild rabid ice weasels.

To those of you who managed to rack up logsheets full of QSOs and big scores while battling frozen fingers and iced antennas, many congrats on a great achieve-ment! And a very special thanks to all the home ops who got on the air to join in the fun and send the Frozen Field Critters some RF to keep them warm.

Thanks again to everyone for all of your support and help. As we ScQRPions like to say, we sponsor the event, but it's all of you who actually make it happen.

So, without further ado, grab a Twinkie, Scooter Pie, or other snack of choice and enjoy the stats. Congrats to the MN QRPers at WQ0RP (wait 'til you see...) and everyone else! Cheers de AB7TT,-Joe, , AZ ScQRPions (Phoenix) "If it ain't fun, you ain't doin' it right!" — The AZ ScQRPions

FYBO '98 Trivia

— 80 Logs submitted.

— At least 80 FYBO Ops had FUN!!!

— 7 Ops operated under sub-freezing condx.

— 17 Ops were sub-40F.

— **Coldest Op:** The MN QRP Gang (WQ0RP - MultiOp) at 18F. Now that's some serious B_____-freezin'!

Maybe we can keep N0TU from catching the flu next year and get him back in his snowcave for some serious competition for FYBO '99.

— 6 of Top 10 Coldest Ops were in AZ! C'mon guys, ya let a bunch of sun-baked AZ-NM QRPers out-freeze ya. The sick thing is that after living through 115F summers, we *enjoy* freezing our b_____s off.

— Many congrats to our ex-N/T+ Fox N0GLM for not only being the coldest N/T+ FYBO op, but the third coldest station overall - nice job Preston! And congrats on the upgrade to Advanced! We'll figure out a special award for you! At the very least, you get your own bottle of true Southwest hot sauce.

— 3 of Top 5 scores were QRPp.

— 18 of Top 20 scores were FYBO Field Ops.

— **Highest Score:**

MultiOp - 218,448 for the MN QRP Gang (WQ0RP). WOW! Total FYBO sweep and a new FYBO record! Nearly 3 times the next highest score! Man, Coldest Temp, Most QSOs, Highest Score, WQ0RP did better than Titanic at the Academy Awards. Hats off to you folks! Better yet, keep 'em on for warmth....

SingleOp - 40,128 for Bruce (WB0CGH). Nice one Bruce - nearly double the next closest single op score!

Most Q's

MultiOp: 123 Q's, The MN QRP Gang (WQ0RP)

SingleOp: 66 Q's, Tie between KO7X and NQ7RP

FYBO '98 PRIZES

Worked Most AZ QRP Stations: Winner - Jeff, AC6KW (16 AZ stations). Congrats!Prize - A GM-XX xcvr from Small Wonder Labs, courtesy of Jay WA5WHN and Dave NN1G. Thanks guys!

W7GVN ScQRPion Raffle: Sponsored by the AZ ScQRPions in memory of Rod, W7GVN/SK. All we ask is that you build and use these, or donate them to a "newbie" you can Elmer. Please have fun with 'em!

Winners:

38-Special Xcvr Kit: Joel, WA1QVM

Rainbow Tuner Kit: Bill, W6PRI

Lowest Field Operating Temp: Winner (MultiOp): The MN QRP Gang at WQ0RP - 14F! Yikes!

Winner (Single): Preston, N0GLM/T+ - 24F! Our Frozen Tech+. Prize: Everyone gets a bottle of authentic AZ hot sauce to help keep you warm and toasty through the next cold winter.

Lowest Home Operating Temp: Winner: Kevin, KB9IUA - 33F. Get that man a space heater!Prize: A big package of York Peppermint Patties to help give you that feeling of mushing a sled team across the frozen tundra.

FYBO '98 RESULTS (sorted by temperature)

NOTE: A (*) next to a callsign indicates multi-op.

Callsign	Loc	Q's	SPC	Temp	Power	Score
WQ0RP (*)	F	123	37	18F	5W	218,448
AB7TT	F	41	11	20F	5W	18,040
N0GLM/T+	F	9	7	24F	5W	2,240
KI0II	F/H	14	12	29F	5W	4,720
NA5N/7	F	17	10	31F	5W	5,440
KI7MN	F	15	10	31F	5W	4,800
N7KT	F	21	7	31F	3W	4,704
K5OI/7	F	32	18	33F	5W	18,432
WA5WHN/7	F	28	7	33F	1W	6,272
KB9IUA	H	20	13	33F	5W	1,040
N5ZGT/7	F	22	12	34F	4W	8,448
N0QT	F	11	10	34F	5W	3,520
NF3I (*)	F	69	34	37F	5W	75,072
AB5UA	F	35	19	37F	2W	21,280
N4JS	F	36	18	37F	5W	20,736
KO7X	H	66	31	37F	5W	8,184
W4ED	F	37	17	38F	5W	20,128
WB6JBM/8	F	46	22	40F	2W	24,288
N2TNN	F	28	13	40F	2W	8,736
WV3B	F	10	6	40F	5W	720
AF5Z (*)	F	53	24	44F	4W	20,952
KI0KY (*)	F	12	7	44F	5W	2,016
KN6YD	F	14	6	44F	2W	1,344
WD8RIF	F	29	19	46F	5W	13,224
W8MHV	F	7	3	46F	5W	504
N7CEE (*)	F	45	19	48F	900mW	41,040
WB0CGH	F	38	22	49F	900mW	40,128
NF0R	F	31	24	50F	950mW	23,808
WA1QVM	H	32	22	52F	4W	2,816
AD6AY	H	45	14	52F	2W	2,520
W5VBO	F	25	11	53F	5W	4,400
KX7L	H	40	16	54F	5W	2,560
W6RCL	H	8	5	54F	5W	80
N6WG	H	38	10	55F	5W	1,520
WE6W	H	58	12	55F	5W	1,392
WD6FDD	H	9	2	55F	5W	36
K6PZB	H	12	3	56F	2W	144
AB70A	F	14	7	58F	5W	1,568
N1MVU	H	6	5	59F	5W	60
W5FN	F	16	11	60F	950mW	5,632
AC6KW	H	62	20	60F	5W	4,960
N7XJ	H	56	26	60F	5W	2,916
WZ2T	H	50	22	60F	5W	2,200
WB5QYT	F	14	5	60F	5W	560
N8ET	F	4	4	60F	950mW	256
W6KI	H	16	4	60F	2W	256
VE7CQK	H	8	7	60F	5W	112
AA0SM	H	18	14	62F	950mW	2,016
KJ5CI	F	4	4	62F	1W	128
NA3V	H	17	11	63F	4W	374
N0TU/flu :-)	H	11	8	63F	5w	352
WA2OCG/7	H	17	13	64F	5W	884
KU7Y	H	30	14	65F	200mW	840
AA4RP	H	6	5	65F	5W	30
W6PRI	H	14	4	68F	5W	56
NQ7RP	H	66	30	70F	5W	1,980
KL7JAF	H	41	22	70F	5W	1,804
AA1IK	H	44	23	70F	5W	1,012
VE3ELA	H	17	14	70F	950mW	952
N5JI	H	45	21	70F	5W	945
KA8OKH	H	24	19	70F	4W	456
KW5OK	H	20	13	70F	5W	260
AA9KH	H	15	12	70F	5W	180
K3AS	H	6	5	70F	5W	30
WB6FZH/KH6	H	4	2	70F	5W	8
N4ROA	H	81	26	72F	5W	4,212
AB7TK	H	58	25	72F	5W	1,450
N2CQ	H	38	21	72F	5W	798
K0SU	H	16	11	72F	5W	352
K7GT	H	19	7	72F	2W	266
W3CD	H	14	10	72F	5W	140
K8ZAA	H	13	10	72F	5W	130
KB0SBA	H	13	9	72F	5W	117
KB6FPW	H	18	5	72F	4W	90
KC4MHM	H	9	9	72F	5W	82
N7RI	H	10	8	72F	5W	80
K8CV	H	9	7	72F	5W	63
KJ3V	H	8	7	72F	5W	56
KI6DS	H	13	3	72F	5W	52
W7HQO	H	5	4	72F	5W	20

FYBO '98 RESULTS (sorted by score)

NOTE: A (*) next to a callsign indicates multi-op.

Callsign Loc Q's SPC Temp Power Score

WQ0RP (*) F 123 37 18F 5W 218,448
NF3I (*) F 69 34 37F 5W 75,072
N7CEE (*) F 45 19 48F 900mW 41,040
WB0CGH F 38 22 49F 900mW 40,128
WB6JBM/8 F 46 22 40F 2W 24,288
NF0R F 31 24 50F 950mW 23,808
AB5UA F 35 19 37F 2W 21,280
AF5Z (*) F 53 24 44F 4W 20,952
N4JS F 36 18 37F 5W 20,736
W4ED F 37 17 38F 5W 20,128
K5OI/7 F 32 18 33F 5W 18,432
AB7TT F 41 11 20F 5W 18,040
WD8RIF F 29 19 46F 5W 13,224
N2TNN F 28 13 40F 2W 8,736
N5ZGT F 22 12 34F 4W 8,448
KO7X H 66 31 37F 5W 8,184
WA5WHN/7 F 28 7 33F 1W 6,272
W5FN F 16 11 60F 950mW 5,632
NA5N/7 F 17 10 31F 5W 5,440
AC6KW H 62 20 60F 5W 4,960
KI7MN F 15 10 31F 5W 4,800
KI0II F/H 14 12 29F 5W 4,720
N7KT F 21 7 31F 3W 4,704
W5VBO F 25 11 53F 5W 4,400
N4ROA H 81 26 72F 5W 4,212
N0QT F 11 10 34F 5W 3,520
N7XJ H 56 26 60F 5W 2,916
WA1QVM H 32 22 52F 4W 2,816
KX7L H 40 16 54F 5W 2,560
AD6AY H 45 14 52F 2W 2,520
N0GLM/T+ F 9 7 24F 5W 2,240
WZ2T H 50 22 60F 5W 2,200
AA0SM H 18 14 62F 950mW 2,016
KI0KY (*) F 12 7 44F 5W 2,016
NQ7RP H 66 30 70F 5W 1,980
KL7JAF H 41 22 70F 5W 1,804
AB70A F 14 7 58F 5W 1,568
N6WG H 38 10 55F 5W 1,520
AB7TK H 58 25 72F 5W 1,450
WE6W H 58 12 55F 5W 1,392
KN6YD F 14 6 44F 2W 1,344
KB9IUA H 20 13 33F 5W 1,040
AA1IK H 44 23 70F 5W 1,012
VE3ELA H 17 14 70F 950mW 952
N5JI H 45 21 70F 5W 945
WA2OCG/7 H 17 13 64F 5W 884
KU7Y H 30 14 65F 200mW 840
N2CQ H 38 21 72F 5W 798
WV3B F 10 6 40F 5W 720
WB5QYT F 14 5 60F 5W 560
W8MHV F 7 3 46F 5W 504
KA8OKH H 24 19 70F 4W 456
NA3V H 17 11 63F 4W 374
N0TU/flu H 11 8 63F 5w 352
K0SU H 16 11 72F 5W 352
K7GT H 19 7 72F 2W 266
KW5OK H 20 13 70F 5W 260
N8ET F 4 4 60F 950mW 256
W6KI H 16 4 60F 2W 256
AA9KH H 15 12 70F 5W 180
K6PZB H 12 3 56F 2W 144
W3CD H 14 10 72F 5W 140
K8ZAA H 13 10 72F 5W 130
KJ5CI F 4 4 62F 1W 128
KB0SBA H 13 9 72F 5W 117
VE7CQK H 8 7 60F 5W 112
KB6FPW H 18 5 72F 4W 90
KC4MHM H 9 9 72F 5W 82
W6RCL H 8 5 54F 5W 80
N7RI H 10 8 72F 5W 80
K8CV H 9 7 72F 5W 63
N1MVU H 6 5 59F 5W 60
KJ3V H 8 7 72F 5W 56
W6PRI H 14 4 68F 5W 56
KI6DS H 13 3 72F 5W 52
WD6FDD H 9 2 55F 5W 36
K3AS H 6 5 70F 5W 30
AA4RP H 6 5 65F 5W 30
W7HQO H 5 4 72F 5W 20
WB6FZH/KH6 H 4 2 70F 5W 8

FYBO '98 Soapbox: Fun Fun Fun!! I had a horse, a donkey and three ducks for company. N5LU came by to check on me. He felt sorry for me and took me to town for lunch ... a fantastic contest! It warmed up to 50F with SUN! — Clif, AB5UA

This was my first CW contest. Chris (W0ITG) and I had a blast ... We were assisted by a 12-year-old who is still interested in ham radio. Train them young andthey'll be QRPers forever! — Steve, KI0KY

REALLY enjoyed FYBO. My first ever CW contest! And particularly glad to work you at 2135. — Joe, KW5OK

N6CNY and I had planned on heading up into the Mendocino Nat'l Forest again, but bad wx put a stop to that. I got more than three inches of rain over the weekend. We'll try again next year with a camping trip. — Mitchell, KB6FPW

Perfect day for FYBO, mild but cold enough for x6 multi. Thanks for fun contest. — Jim, N0UR (WQ0RP multi-op)

This was my first FYBO and it won't be my last! — Brian, N5ZGT

20m never opened when I was operating. — Greg, WB6FZH/KH (Manager's Note: Hey Greg, who needs the bands open when you live in paradise!

The practice time I did on sending while wearing mittens sure paid off. The kids thought I was crazy, outside doing the hula and singing "We're Havin' A Heat Wave".... Probably coulda done better if I'd quit running inside to warm up and drink coffee ... Thanks for another round of fun! — Jan (N0QT)

Fun contest! — Bill, K3AS

I missed the first 5 hours during the middle of the contest and then was overwhelmed by the NA Sprint, but had great fun. — Glenn, W6KI

Was looking forward to operating in the field. Had a nice site picked out, but came down with a flu bug ... just played at it for a few hours when I felt up to it ... Thanks for a great contest! — Ken, VE5ELA

My first FYBO Winter QRP FD. Lots of fun. — Bill, W6PRI

20 ft vertical good for coast to coast, not so good for states close in. A lot of fun up to the last hour, that's when the cold got to me. Twice the points of last year - more fun. — Bob, W4ED

Fun contest! Tried the kite antenna for a bit - no wind! Used OHR Spirit and 180 ft counter-fed Zeppup 25 ft. Next year hope to do better! — Tom, WB5QYT

It was fun and a good excuse to get a new antenna up. — Bill, KJ5CI

Great contest! We had fine wx and a pleasant location next to Beaver Creek. — Bruce, N7CEE and Scott, K7ZEN

Great fun! Wish I could have operated more than a few hours. Working AH7R made me smile. How do you freeze anything off in Hawaii? — Charlie, KX7L(Manager's Note: Lots of frozen pina coladas!)

Lots of fun trying to build, operate and align at the same time! — "Kim" Kimura, N1MVU

I had a blast. I can't wait until next year. — Preston, N0GLM

About 3 hours of QRP fun. No time to set up with multipliers but glad to QSO as many as possible. 7 QSOs with AZ, and KL7JAF as best DX. CU next FYBO! — Ken, N2CQ

Great contest, with fairly good turnout of eastern stations. Next year, if I can get an antenna for the high freqs I may go after a big score. HI. — Jim, NA3V

What fun! Not quite as cold as we would like, but for most of us "cliff dwellers" it was a chance to use "real" antennas. Three ops and about ten very interested visitors. Lots of Tech/Tech+s to break in for the next one! Lots of fun to know the names before they were sent. A keeper! — Chris, N3XRV (with Scott NF3I and George K3TKS)

Not a stellar performance, but alot of fun. I always look forward to these events. Maybe next year I'll try for the temperature multi. Thanks to you and everyone who puts this on. — Rick, K0SU

Only able to operate a couple of hours, but enjoyed it very much! — Drew, W8MHV

On and off operation from horrible most unbearable temp of 72F - Had lots of fun. — Dan, N4ROA

About the same time I finished my chores and could sit down and work the contest, the NA Sprint came along and I could hear nothing else. Look forward to next time. — Ronnie, KI0II

Great day and great fun! — Bruce, WB0CGH

When I arrived [at my site], I discovered that I was at the snow line and then the wind started to blow and then the clouds came rushing in, so I strung up my 185 ft longwire and fired up the HW-7 ... the dog was shivering and I couldn't feel my fingers ...Thanks so much for the 2nd FYBO. I hope you had as much fun as I did. — Jeff, KN6YD (Manager's Note: That's the FYBO spirit, Jeff!)

I alternated between hunting for DE, the last state I need for QRP WAS, and FYBO. I got 3 DE stations. Had what I considered a nice run of 11 FYBO stations in an hour on 15 m. Also got some NH and VT QSO Party stations. — Randy, AB7TK

I had fun. The best part, was the eyeball QSOs with the Az. Crew and working everyone on the air. Yahoo !! Will be back next year. — Jay, WA5WHN/7

My company picked one heck of a time to need me in the Netherlands, and I missed the event this year.... maybe in '99.... — Jack, WA8GHZ/5

Antenna certainly wasn't sleet/wind proof :-(Had to piggy-back on NQ7K W5VBO's operation ... good fun and comeraderie, tho. :-) — Kent, AB7OA

Here is my FYBO entry. Thanks for your fine effort and hope you have the energy to do it again. I had a great time right up to the point when my brain turned into a ghost f**t. — Ed, KC4MHM

While I was in the backyard operating, we had just a little rain but a lot of wind and about an eight/nine inch (dia.) limb fell from the tree, missed the house though. Grand kids in and out all day, you know birthday stuff, so it was a very hit and miss operation, mostly miss, but had a good time. — Rich, WD6FDD

It sure was a VERY fun contest and I look forward to it becoming a regular one. I do plan to operate the next one out in the field. I have 2 friends who like QRP work and I am going to try to encourage them to come with me and make a little group effort. — Lynn, KJ3V

Had fun although I didn't operate a lot nor outside my house. But it was the first time I have really tried to run at milliwatt levels in a contest. Also, there seemed to be a lot of noise here and I had to work hard to copy some of the QSOs. That made it a good learning experience. — Tony, AA0SM

Mighty big score.........NOT! — Walt, K8CV (Manager's Note: Heck, as long as ya had fun, you won! Thanks for coming out!)

Thanks to all the AZ ScQRPions for making this event happen... Thanks to all the participants that made it a fun event... Good conditions here in Alaska... Next year we will see if we can work on the temperature multiplier... 72 — Bruce, KL7JAF

Mucho fun! Too damn cold! Can't wait 'till next year. Or at least until BUBBA! — Bob, KI7MN

Ice storm took care of the antenna's. The 80m dipole is in the snowbank and the 40m delta loop is resonant on 6m. — Rich, WZ2T (Manager's Note - We've gotta make a multi for snow-bound antennas!)

I consider this my first *real* contest ... Most notable contact was Zack, W1VT. Heck, he's a celebrity in my mind! The most impressive contact: Scott, N7CEE, showed me what you can do with less than a watt on 40m! And he was loud! ... I'm looking forward to the next FYBO! — Bob, W3CD

Had a grand time! The weather was beautiful, blue skies & 60s. Mebbe next time I'll take less stuff.. glad I didn't have to hikein to the site! — Tim, W5FN

Had Fun!! — Bill, N8ET

I was warm as toast! While staying close to the 'john' (nursing the intestinal flu) and feeding my wood stove I managed to nabbed a few of the lucky ducks who were out there really FYBOing. Next Year... to the Field! And NO FLU! — Steve, N0TU

What a blast! A steady 31 deg with snow falling all day, light wind, and COLD! Gaps in the log are not from poor condx....just got too cold and had to warm up a bit. — Roger, N7KT

My plans for a solo FYBO winter outing fell through at the last minute. ... I opened the outside door to the shack to cool things off a bit ... it was 34 F outside, but it only got down to 60 F in the shack before the family started screaming at me. Next year it's snow caves for sure ... but I need a crazy partner. — Bob, N7XJ (Manager's Note: Plenty of us crazy ones out there, Bob. We'll take care of ya next year!)

Thanks for all the contacts and did manage a new state, NH. Dissapointing that the skip was so short but it was nice to hear the locals. Lets get set for next year and maybe a new mult for the temp. I couldn't get it to go down 1 degree to 39F. maybe with the windchill but no banana!! — Dean, N2TNN (Manager's Note: How about a banana multi?)

I just stumbled into this contest and had real fun! Thanks for it and I'd like to have more connections with you guys. — John, K6PZB

The surprise contact was by far Ade, W0RSP, one of my heroes — glad we finally meet on the air! Got plenty of strange looks from my neighbors and others walking/driving by, but I had a blast ... Thanks for sponsoring the contest! — Kevin, KB9IUA

Lots of fun and thanks to all the ScQRPions who organized it, thanks to the Pinetop gang for drumming up the publicity and thanks to the participants for some great fun! Wait til next year!! — Doug, KI6DS

Didn't spend much time in the contest but did have fun! Anyone who doesn't play around in the FYBO must not be crazy.... — Ron, KU7Y

Couldn't get the *@^%! temp to drop below 20F - ARGH! Next year I'm bringing the liquid helium. — Joe, AB7TT

It was 37 deg as I set up a little after 1600Z. After an hour, it started to sleet. Only place in NJ with weather that lousy! Little FYBO activity heard on 20, although DX was good. 40M was "bread and butter" band. Operated most of time from inside Explorer, but had to have window open both for temperature mumtiplier, and because I was smoking noxious cigars! — John, N4JS

My operation was a bit disjointed, as it felt like I was set up by a stream. We had so much water in the back yard it came in through the back of the garage. I spent a lot of time with a squeegee escorting it out the front into the driveway. Talk about high humidity. — Bob, N6WG

I did not work the whole period, but I did have a blast working all the people we see on the net. — Joel, WA1QVM

A truly great contest. Was planning a field location but the non-stop rain and severe floods in our county made this impossible. — Ed, WE6W

QRP HINTS & KINKS

A NorCal Exclusive

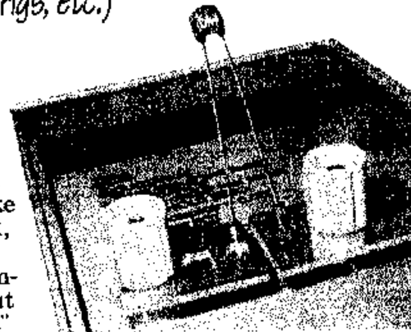
Illustrated by Paul Harden, NA5N

#8 More Build-It-From-Scratch Stuff

(Pixies, 2N2222 rigs, etc.)

An L-C Meter Test Jig

From Chuck Adams, K5FO
Dallas, Texas



AADE L-C Meter sl wn
(Almost All Digital Electronics)

L-C Meters usually come with fairly large binding posts, making it tough to measure small components. Make two small "shelves" from copper clad, soldering on wire wrap socket pins (or similar), for measuring small components as shown. Shelves are about ¾"x1" pieces of copper clad with a ¼" slit cutout with a nibbling tool. The slit slips into the binding post and allows it to be adjusted for the proper "gap" between the two terminals. A close gap can be used for testing small or surface mount components.

Capacitor Value Markings

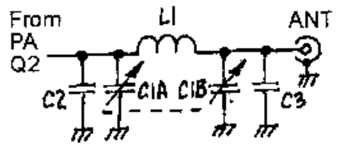
109*	1pF	102	.001uF
100	10pF	103	.01uF
101	100pF	104	.1uF
102	1000pF	105	1uF

*Used by some manufacturers to denote less than 10pF

PIXIE Tunable Output Filter

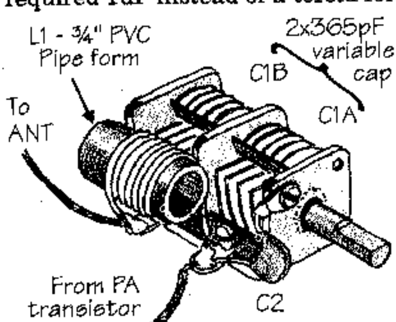
From Arnie Coro, CO2KK
Havana, Cuba

The Cuban's have built the Pixie-2 and achieve better receiver sensitivity by using variable caps in the output filter. Peak for maximum output power, then peak for maximum signal strength on receive. Note that L1 is 8T of #22 solid insulated wire on a PVC form for the required 1uF instead of a toroid form.

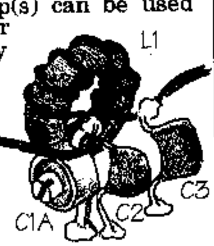


PIXIE values:
80M L1=2.2uH C1A+C2=820pF
40M L1=1.0uH C1B+C3=820pF

Pixie-2 designed by Dave Joseph, WA6BOY. See June 1995 QRPp, p. 45-48



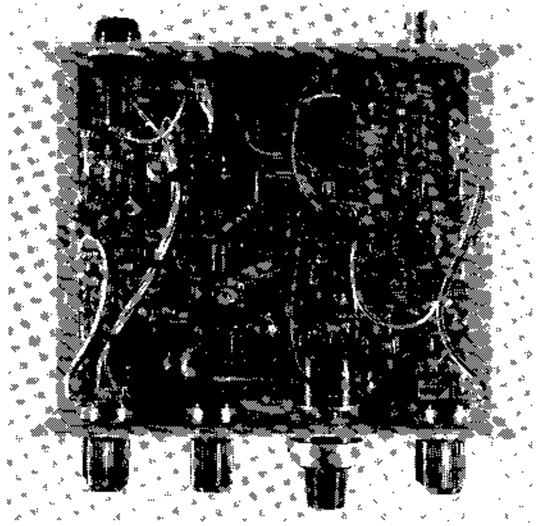
For those who think QRP means *small*, trim cap(s) can be used with a toroid for same effect. Try this on any QRPp rig to peak filter for maximum receiver sensitivity.



Next Issue: more on homebrew coils

Some "Ugly Construction" Practices
(The K8IQY 2N2222 QRP Rig)

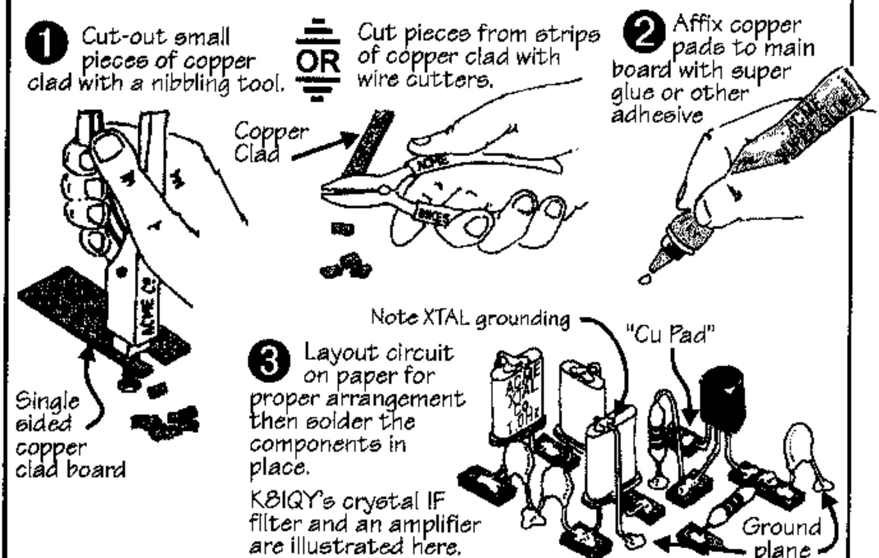
One "ugly construction" method is to use small copper "pads," or "islands," glued to the working surface (usually a solid piece of copper clad) for affixing the components and wiring. This construction technique was excellently executed by Jim Kortge, K8IQY, on his award winning 2N2222 rig (1st place at the NorCal building contest, Dayton, 1998), for which a few examples are detailed here.



Front panel controls:
- RF Gain
- Audio Gain with ON/OFF switch
- RF Pre-amplifier (10dB or 20dB)
- 10-turn TUNE with vernier
- XTAL Filter bandwidth, adjustable 250-750 Hz.
- Phones

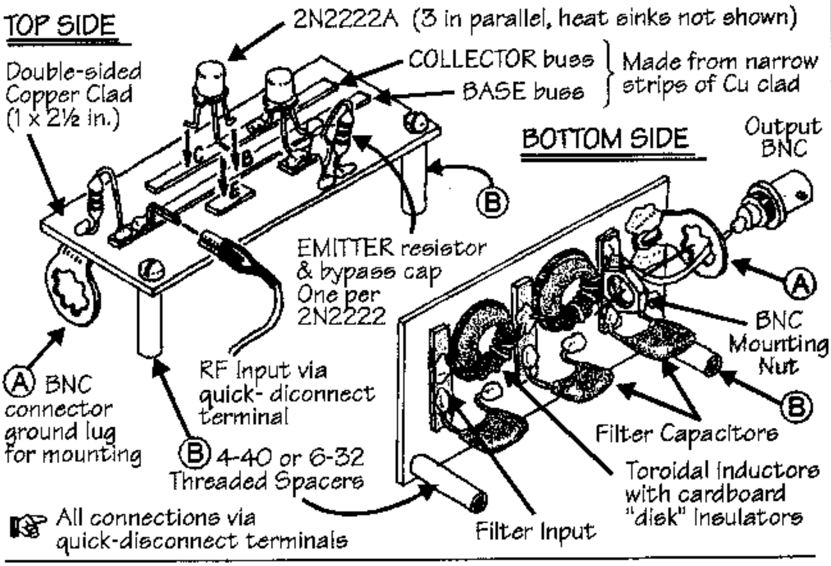
Rear panel controls:
- Antenna BNC
- Fuse holder
- DC input jack
- KEY jack

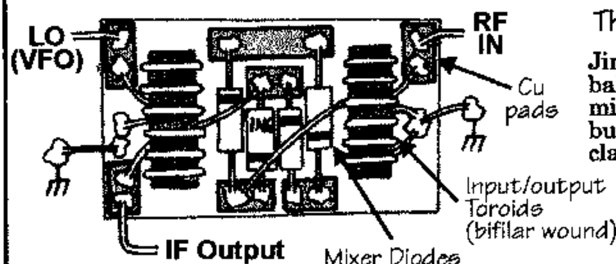
The Copper Clad "Pad" Technique



Stand-alone P.A. Assembly

K8IQY used a clever method of building a 2.5W (three 2N2222A's in parallel) on a separate piece of copper (Cu) clad. This would allow building other P.A.'s, such as with power MOSFET's, to be easily installed in this rig by simply "swapping" P.A. boards.





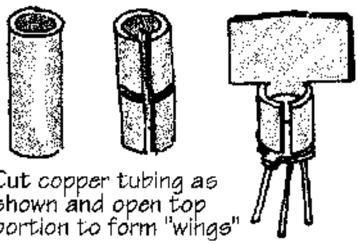
The Receive Mixer

Jim used a double-balanced diode ring mixer with 1N914's, built on a ½"x¾" Cu clad platform. Note efficient placement of parts. MDS is better than -112dBm!

HEAT SINKS GALORE (for TO-18 and TO-39)

Heat sinks for the metal can transistors are less than $1 each, but here's a few techniques for rolling your own. The idea of a heat sink is to transfer heat from the device to the air or other absorber quickly. Also note the metal can is often connected to the emitter or collector!

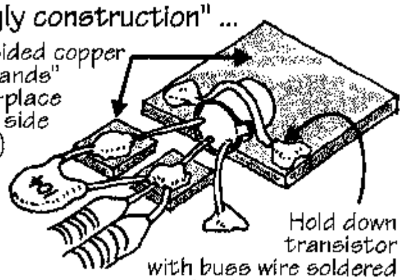
USING COPPER TUBING



Cut copper tubing as shown and open top portion to form "wings"

Use 1/4"dia. for TO-18 • 3/8"dia. for TO-39

For "ugly construction" ...

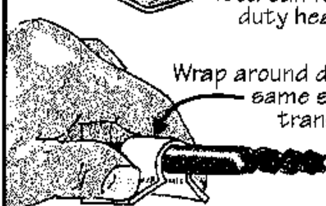


Single-sided copper clad "islands" glued in-place (Copper side on top)

Hold down transistor with buss wire soldered to copper-clad heat sink piece.

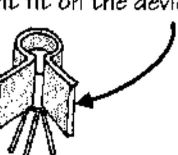
The OLD CLASSIC

Form piece of metal or aluminum as shown. Cut from metal food can for light duty heat sink.



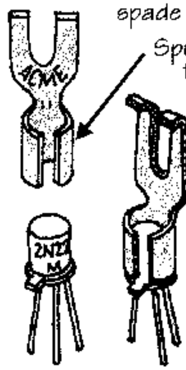
Wrap around drill bit same size as transistor

"Wings" can be squeezed or spead apart for tight fit on the device.



The SPADE LUG SPECIAL

From D.K. Philbin, KD6TK

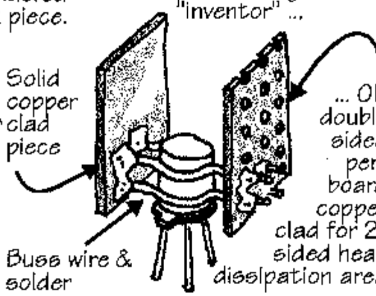


Use large wire spade or ring lug

Spread to fit transistor diameter

The EMPIRE STAR FIGHTER

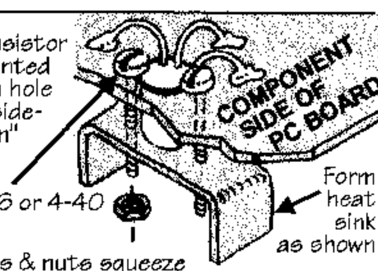
I saw this at a building contest, but forgot the "inventor" ...



Solid copper clad piece

... OR double sided perf board copper clad for 2-sided heat dissipation area

Buss wire & solder



Transistor mounted thru hole "upside-down"

2-56 or 4-40

Form heat sink as shown

Bolts & nuts squeeze heat sink & transistor together. Saw this on a submarine sonar board!

NorCal K8FF Paddle Kits

The NorCal Paddle Kit will consist of all the parts needed to build the kit, including the base, machined brass parts, and all hardware. The kit is unfinished. The machining has been done for you, but it is up to you to finish the kit by polishing the brass parts and painting or plating the base. The cost of the kit is $30 plus $5 shipping and handling in the US, $10 shipping and handling for Western Europe and Canada, and $15 shipping and handling for the Pacific Rim. To order send your check or money order (US Funds Only) to: Jim Cates, 3241 Eastwood Rd., Sacramento, CA 95821, USA Make checks and money orders out to Jim Cates, NOT NorCal.

For those of you in the United Kingdom and Western Europe. You may order your paddle kits from our European agent and pay in English pounds. The cost is 25 UK pounds and includes shipping. Steve Farthing, 38 Duxford Close, Melksham, Wiltshire, SN12 6XN

QRPp Back Issues Pricing:

1993 - $10, 1994 - $15, 1995 - $15, 1996 - $15, 1997 - $15 (Avail. Feb. 1, 1998) Full year sets available. NO individual issues available, sets will not be broken up.

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Shipping: Canada

$3 for 1 issue, $5 for 2 - 3 issues, $7 for 4 -5 issues.

Shipping: DX Europe & South America

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$5 for 1 issue, $10 for 2 issues, $15 for 3 issues, $20 for 4 issues, $25 for 5 issues
All funds US funds only. Make check or money order to Doug Hendricks, NOT NorCal.
Please send orders to: Doug Hendricks , 862 Frank Ave. , Dos Palos, CA 93620, USA

QRP Frequency Crystals

NorCal has available the following crystals in HC49U cases for $3 each postage paid in th e following frequencies: 7.040 MHz, 7.122 MHz., 10.116 MHz. Send your order and payment in US Funds only to: Doug Hendricks , 862 Frank Ave. , Dos Palos, CA 93620, USA. Make check or money order to Doug Hendricks, NOT NorCal.

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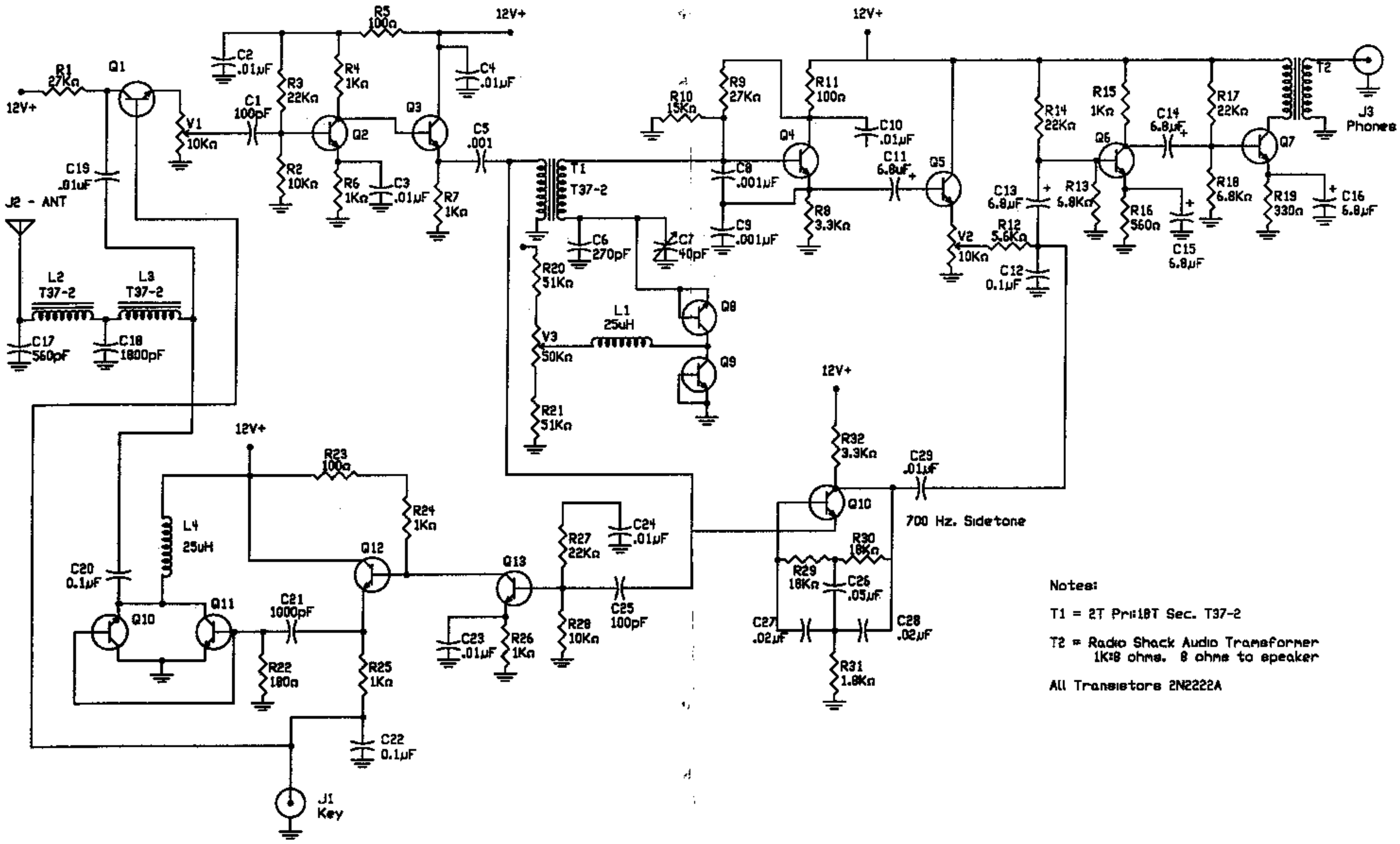
QRPp, Journal of the NorCal QRP Club
862 Frank Ave.
Dos Palos, CA 93620

PRESORT
FIRST-CLASS
Permit #72
Socorro, NM
87801

NorCal members were recently called "Zombies" on QRP-L. Be proud to be a NorCal Zombie! Cutout Zombie badge for hamfest ID, or contact NA5N@Rt66.com for laminated version.

Pre-sort
FIRST CLASS

AD6CR 2N2222 40M Transceiver



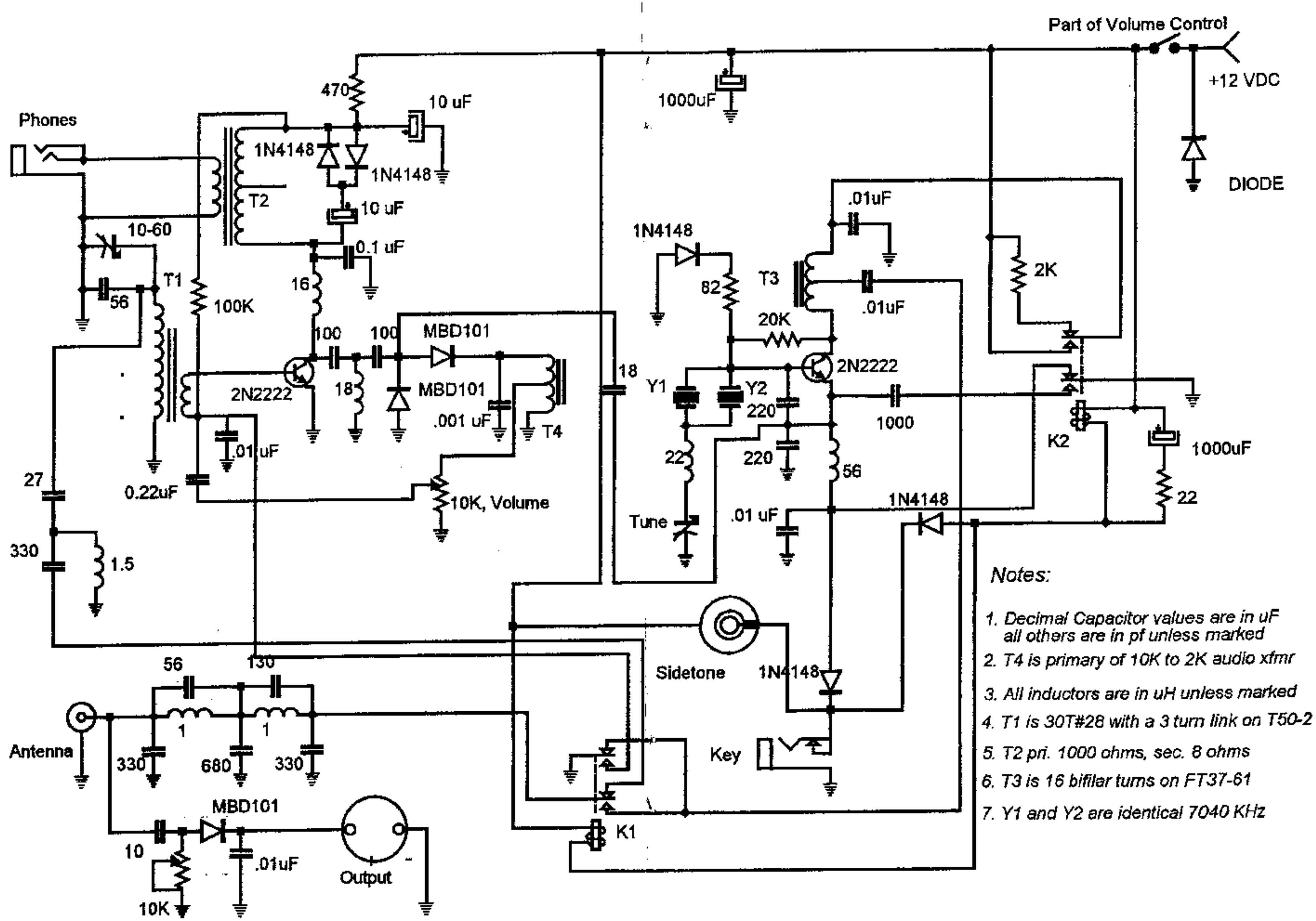
Notes:

T1 = 2T Pri:18T Sec. T37-2

T2 = Radio Shack Audio Transformer 1K:8 ohms. 8 ohms to speaker

All Transistors 2N2222A

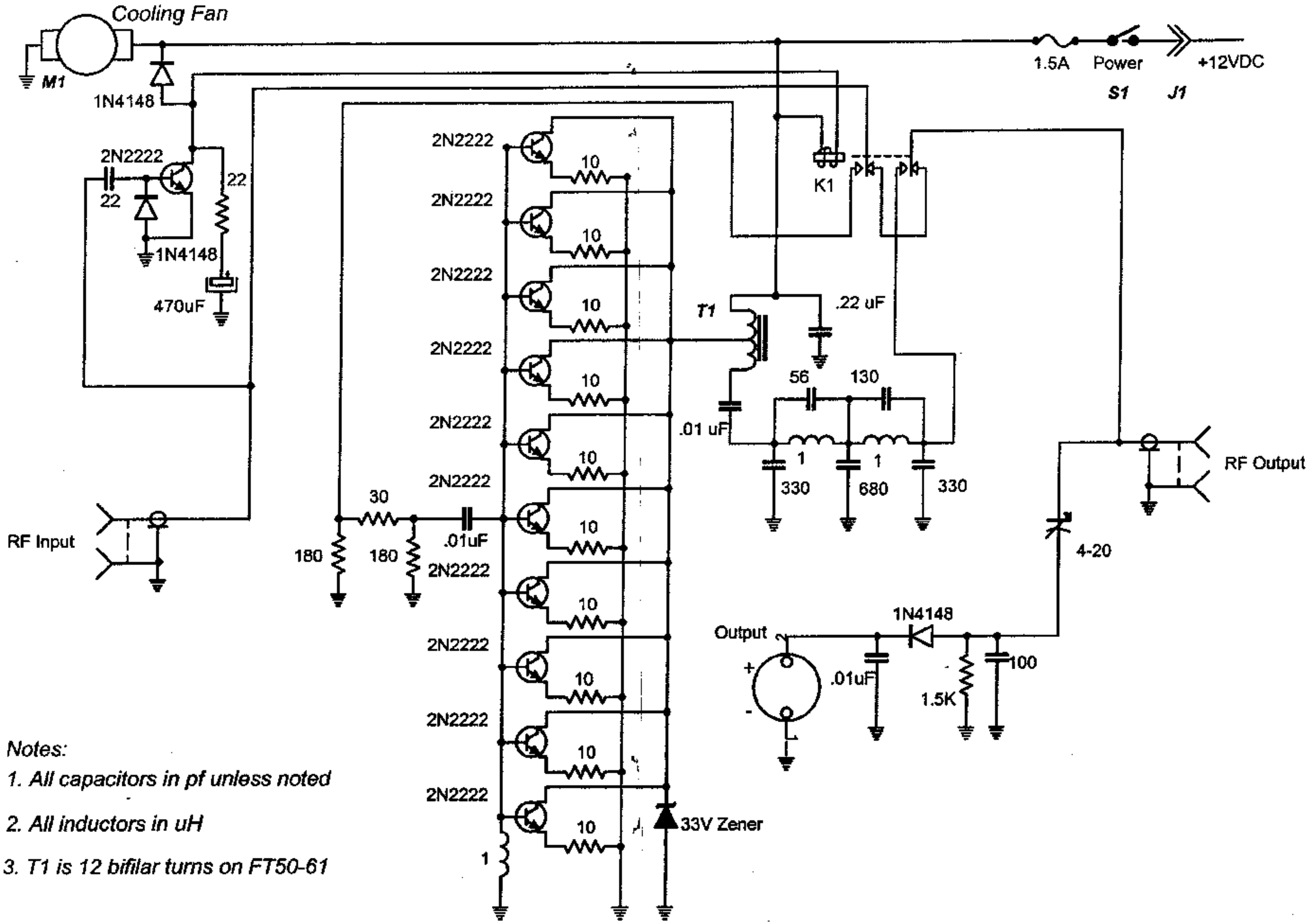
N6CM 2 x 2N2222 40 Meter CW Transceiver



Notes:

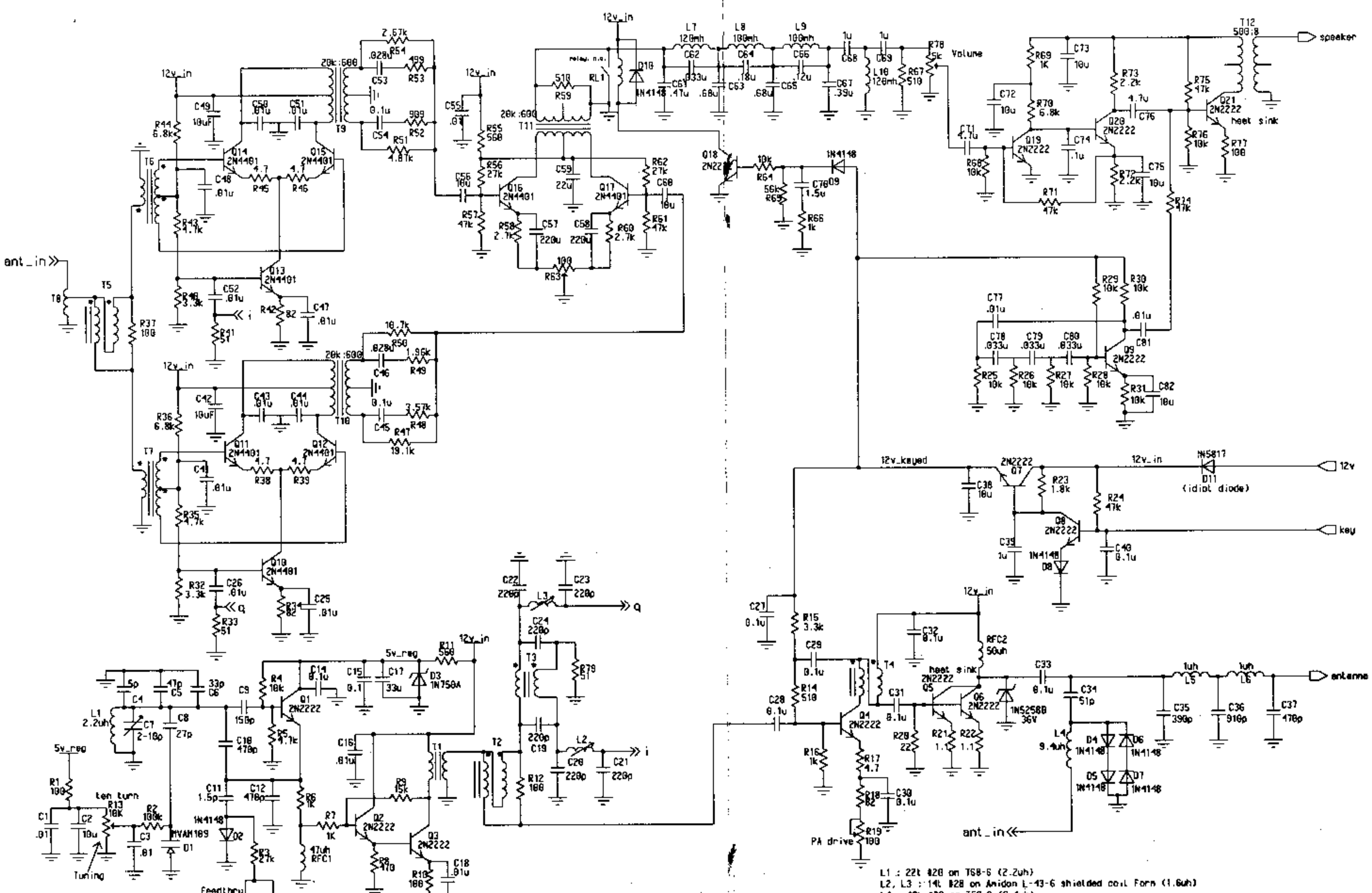
1. *Decimal Capacitor values are in uF all others are in pf unless marked*
2. *T4 is primary of 10K to 2K audio xfmr*
3. *All inductors are in uH unless marked*
4. *T1 is 30T#28 with a 3 turn link on T50-2*
5. *T2 pri. 1000 ohms, sec. 8 ohms*
6. *T3 is 16 bifilar turns on FT37-61*
7. *Y1 and Y2 are identical 7040 KHz*

N6CM 10 x 2N2222 5 Watt Amp



Notes:

1. All capacitors in pf unless noted
2. All inductors in uH
3. T1 is 12 bifilar turns on FT50-61



T1 : Pri - 10t #28 on FT37-43, Sec - 4t #24
T2, T4, T5 : 10t #28 bifilar on FT37-43
T3 : 17t #28 on T37-2, pri and sec wound side by side
T6, T7 : Pri - 10t #28 bifilar on FT37-43, Sec - 2t link over primary
T8 : 4t #28 on FT23-43, taped 3 turns from ground (autotransformer)
T9, T10, T11 : 20K to 600 ohm audio transformer, Mouser 42TL017
T12 : 500 to 8 ohm audio transformer, Mouser 42TL001

L1 : 22t #28 on T50-6 (2.2uh)
L2, L3 : 14t #28 on Amidon L-43-6 shielded coil form (1.6uh)
L4 : 40t #28 on T50-6 (9.4uh)
L5, L6 : 19t #28 on T37-6 (1uh)
L7, L10 : 247t #36 on Amidon PC-1408-77 Pot core (120mh)
L8, L9 : 226t #36 on Amidon PC-1408-77 Pot core (100mh)
RFC1 : Molded RF Choke (47uh)
RFC2 : 10t #28 on FT37-43 (50uh)
RL1 : 12V Reed Relay, Mouser 431-1412

NPO - A New Phasing-type CW rig - Version 0
Roger Traylor WB4TPW 5/9/98

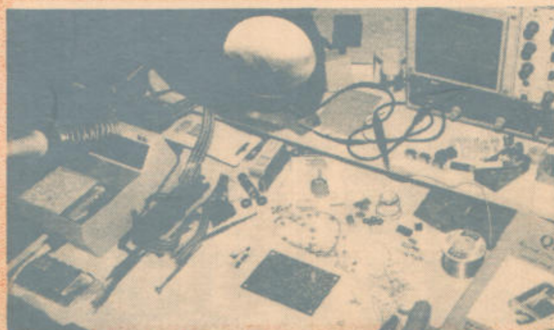
Roger L. Traylor
5/29/98

Vol. VI, No. 3 Autumn 1998

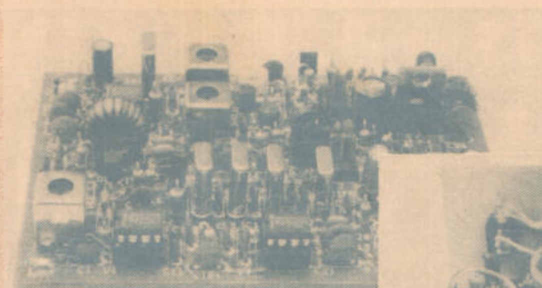
QRPp

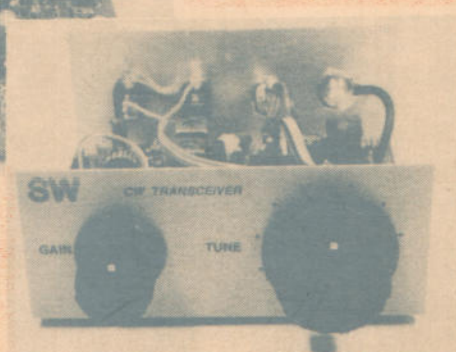
ELMER 101 SPECIAL ISSUE

- Complete Lessons
- Circuit theory and analysis
- Test Bench procedures
- Step-by-step construction
- Build & Learn



Get the Workbench ready!





Featuring the SW-40+ Elmer Kit

Journal of the Northern California QRP Club

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From the Editor

by Doug Hendricks, KI6DS
862 Frank Ave.
Dos Palos, CA 93620
ki6ds@dpol.k12.ca.us 209-392-3522

You will notice something different about this issue. It is devoted entirely to one subject, the Elmer 101 Project. To my knowledge, this has never been done before by any of the QRP journals, or ham radio magazines. I did it because I know that there are a bunch of subscribers to QRPp who don't have internet access, and also to preserve on paper what is now only available from several different sources on the internet. The next issue of QRPp will go back to our regular format, and I hope that you will indulge me this one time.

And speaking of the internet, I have been remiss lately in not mentioning in QRPp the existance of my favorite web site, the NorCal Page, which is run by Jerry Parker, WA6OWR, who puts in hundreds of hours provinding up to date QRP information to NorCal members, and attracting new members to the club. The URL is:

http://www.fix.net/norcal.html

Check the page regularly for the latest up to date information on NorCal projects, reports on monthly meetings, and some great pictures. Jerry also provides links to a ton of QRP information from other sources.

I would like to end by saying thankyou to all who purchased the NorCal 20 kits. They sold out in 18 days. That must be some type of record. If everything goes right with parts aquisition, we should be able to ship the last week or so of October. But that depends on everything going just right. We will take the time necessary to do the rig right. Dave Fifield and all of the NorCal 20 team are burning the midnight oil to ensure that you get the best possible radio. Thanks again for your support. Hope to see all of you at Pacificon 98 for the QRP Forums and Fun. 72, Doug, KI6DS

Elmer 101: How it started

By Doug Hendricks, KI6DS
862 Frank Ave.
Dos Palos, CA 93620

Last January there was a discussion on the internet qrp reflector **qrp-l@lehigh.edu** about the need for a course that would enable the builders of kits to understand just exactly what was going on in the rig, to explain not only what part was being used where, but why.

QRP-L has a history of taking simple subjects and making them horribly complicated, and thus many good ideas die on the vine. I have seen this happen several times when it was suggested that the guys on QRP-L design a radio and kit it. Somthing that I don't believe will ever happen, because there are just as many different ideas as to what the rig should be as there are subscribers to the list. You just can't get 2500 qrpers to agree.

The more that I read, the more that I could see that this was a good idea, and that it should not be allowed to die the horrible deaths that other good ideas on the list had suffered. I thought about it, and decided to post to the net a message that contained the following points that needed to happen for the class to work.

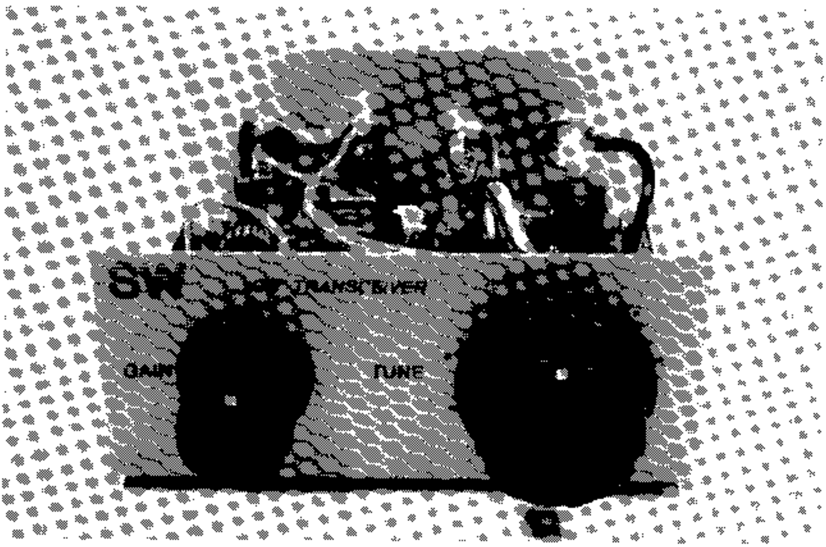
1. Contact Dave Benson and see if he can supply the group with kits for the 40-40 in quantity.

2. We need an instructor to be in charge. He doesn't have to teach the whole class, just be in charge. Qualifications: Knowledge of the subject, ability to communicate, organizational skills, and able to finish the job.

3. The class would consist of going through the schematic part by part,and explaining the purpose of every part. We would build the radio as we go, and the course would be on QRP-L, with someone putting each day's lesson on a web page, so that we will have it later for the newbies. As we go through the schematic, the instructor might have us build a simple oscillator and then try different resistors to see what happens when we change the bias, etc.

4. We have had numerous threads on this list that have died because of lack of action. Here is a plan. Who will step up to the plate? The most important question now is how many people are interested in doing this. I don't have time to take this on, but is there someone who is willing to take private email and keep track of the number on this list who are willing to order the kit from Dave and participate? If so, make yourself known. Post to the list that you will take a list of those who will buy a kit and participate, and be sure to give a deadline, say midnight Wednesday, so those on the digest have a chance to email you. Then report back to the list the number. Maybe there are 100, maybe 5 who knows? Lets get started. When we have a number, then we can ask Dave about delivery times, etc. 72, Doug, KI6DS

This was the extent of my involvement. I made a suggestion and Mike Maiorana stepped up to the plate and volunteered to organize and run the project. He did a wonderful job. Chuck Adams contribution of the idea to use the Small Wonder Lab's 40+ as the radio for the course was brilliant. Dave Benson even updated the design of the 40-40 to the SW40+ so that we could have a better kit. In fact, you can still order the kit, the SW40+ from Small Wonder Labs. See pages 4-5 for ordering information. Now, lets get started on building and understanding a CW transceiver. All of us hope you learn from our efforts.



SW+ Transceiver Series

The SW+ Series is Small Wonder Labs' latest product offering. This CW transceiver board kit is an updated version of the classic '40-40' transceiver first fielded by the New England QRP club. This design was subsequently published in the November '94 issue of QST and serves as a centerpiece in the ARRL's recent anthology, 'QRP Power".

Design features:

1. Single-board transceiver, 2.8 x 4.0" (7 x 10.1 cm)
2. Commercial-quality board, masked and silkscreened
3. True VFO coverage- 35-40 khz
4. Superheterodyne design, with crystal filtering

The SW+ series retains much of the original receiver design, while augmenting the transmitter design for improved stability and output power. The following design changes went into making a classic even better:

Added power supply reverse-polarity diode. The number of toroids to wind drops from 8 (in the orginal) to 5. This pays off in faster and simpler assembly. The diode bridge T-R switch is replaced by a series L-C type. This drops receiver current draw from 22 to 16 mA and improves image rejection.

Better yet, there are several more reasons to consider the new SW+ series:

Improved board- The printed-circuit board is now double-sided and solder-masked both sides. Component silkscreening is improved, and all parts are identified on the silkscreen by both outlines and reference designators.

Upgraded documentation- The manual is expanded to incorporate additional information for beginning builders. The manual now also breaks construction into groups to allow less-experienced builders to proceed in easy stages. The manual itself has undergone a 'facelift, with new figures added.

I've saved the best news for last- The price hasn't changed! I'm able to offer the SW+

at the pre-existing pricing, and plan to do so for some time. This is afforded by the price breaks I can get on larger parts quantities.

The pre-existing SW-40 and its siblings are now being retired. All future orders for this kit will be filled with the new series, and I'm confident that you'll be pleased with the differences.

Price and Schedule:

The SW+ series is currently available for 80M, 40M , 30M or 20M. The SW-40+ and SW-30+ are $55 (postpaid) to US and Canada. Overseas customers please add $5, this includes airmail shipping. (CT residents please add $3 state sales tax)

Enclosure Kit:

An enclosure kit is available for the SW+ series. This resembles the earlier SW-series enclosure with a number of improvements.

1. The kit includes a customized Ten-Tec TG-24 enclosure, which measures 4.1"(W) x 4.0"(D) x 2.0"(H). It's a handsome two-tone (black/grey) finish, and is now silkscreened on both front and rear panels.
2. The rear panel complement has been revised with respect to its predecessor. The phono ('RCA') has been replaced with a 3.5mm (1/8") jack- this facilitates use with lambic paddles should you wish to install a KC-1 (Wilderness) or TiCK (Embedded Research) keyer kit. The pre-existing DC power plug is replaced with a 2.1/5.5mm coaxial connector; this connector is common to other QRP kit designs.
3. As with its predecessor, the SW+ board snaps into 4 mounting posts, so there's no hardware to work loose in the field. Both the new and old board versions may be installed in this enclosure.
4. Interconnect to the connectors and controls comprises a set of .100" locking headers and mating terminal housings. The enclosure kit provides preassembled harnesses to make wiring a snap- you simply cut the harnesses to length and solder to the connectors and controls. The documentation which accompanies the enclosure kit provides illustrations and clear directions for enclosure assembly and final hookup.

Price and Schedule:

The SW+ enclosure kit is $35 plus shipping ($3 US and Canada). Overseas shipping is $10 by airmail. Note: the complete overseas kit price is $100 including shipping.

Technical Support- Each manual contains telephone, US mail and e-mail address information. All requests for assistance are answered promptly. If I can't bring your Small Wonder Labs product to life properly by phone or otherwise, troubleshoot and alignment service is available for a reasonable flat fee. Missing or damaged parts are replaced on a prompt "no-questions asked" basis. When you're ready to order, send personal check or money order (US customers) to Small Wonder Labs at the address below. Canadian customers may use a US dollar account or postal money order. Overseas customers can send an international postal money order, cash (if concealed and sent via registered letter), or contact me for other means of payment. All prices include air mail shipment.

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The Elmer 101 Project: Building the SW 40+

by Mike Maiorana, Glen Leinweber, Chuck Adams, Dave Benson, Mike Gipe, Paul Harden, Bill Jones, Gary Surrency & a class of thousands of QRP-L readers.

First, READ THE MANUAL! Dave has done a great job on the manual and it contains tons of useful information. Don't worry if the "Theory of Operation" stuff goes over your head, that's why we are doing this.

Inventory your kit. If you are missing any parts, double check then contact Dave Benson for a replacement. Don't wait to do this step, it will save you grief in the long run. Also use this opportunity to familiarize yourself with identifying the components. If you have trouble identifying the components after reading the manual, post your question to qrp-l@lehgih.edu (with the Elmer101 subject header)

Get the soldering iron, solder, desoldering braid and sponge ready. Do you have a 12-14 volt power source? It needs to be able to supply at least 500mA to the circuit. You should avoid using switching power supplies (like out of a computer) as they are electrically noisy. A small 12 volt battery should be fine, 8 D cell batteries in series would also work. You can buy a wall transformer that will power the rig, but they are pricy.

There are some parts that you need to complete the rig that you can get from RadioShack listed here:

1) 5k pot RS#271-1714
2) 100k pot RS#271-1716
3) headphone jack RS#274-249
4) key jack RS#274-247
5) antenna jack RS#278-105 (If you want a BNC antenna antenna connection.)
6) power jack RS#274-1569
7) power connector RS#274-1582

The only one of these that you need ASAP is #2 as it will be used in the VFO section (next).

You will need some small hookup wire for testing and final assembly, 20 gauge stranded insulated should work well.

Check your power source output with your volt meter and verify that it is at the proper voltage. First we will build up the power supply on the radio. This is the simplest part of the whole project and a good place to start (no power, no RF).

Also, please, speak up if you need anything! Also feel free to comment on how we may run the class better (be careful, you may be volunteering). All questions are welcome.

Power Supply

This section will cover the DC power supply section of the radio. It has the job of supplying the radio with a useable D.C. power source for the different circuit modules. There are two basic voltage supplies on the rig. There is the unregulated D.C. supply and there is a regulated 8 volt supply.

First find the following components in your kit.

D13 - 1N4001- Diode
C112 - 220uF electrolytic capacitor
C102 - .01uF ceramic capacitor
U2 - 78L08 - 3 terminal voltage regulator

As stated in the manual, many components are polarized. In other words, it matters which direction you install them. Diodes, I.C.'s and some capacitors are examples of polarized components.

Install the above components. PLEASE double check polarity and position before soldering. Reference page 11 of the manual for details on the diode install.

Connect 2 pieces of hookup wire between the power supply connections on the circuit board and your power source. The - supply goes to ground (J4 pin 1) and the + supply goes to the +12 volts (J4 pin 2). You need to be able to easily turn this on and off, so make sure these connections are easily removed. (Don't build with the power on!!!!)

Voltages are measured with reference to ground unless otherwise specified. This means that the black (-) lead of your volt meter should be connected to the board ground, along with the power source (-) connection. You can connect the meter black lead to the power supply (-) connection to make the following measurements.

J4 pin 2 should be the same as the power source + terminal.

Cathode of D13 should measure the Power source voltage (Vps) - D13 dropping voltage (about 0.7 volts). The diode dropping voltage will vary with device and with the amount of current passing through it.

Output of the U2 voltage regulator should be about 8 volts (between 7.7 and 8.3 volts). A convenient place to measure this is at pin 1 of J2.

If you get these readings, you have built the power supply section correctly. Now on to the circuit description.

As you all know, a diode allows electrical current to pass in one direction but not in the reverse direction. When a diode cathode is more negative than the anode, it will conduct current. In this circuit, D13 is in series with the power source as it feeds the rest of the circuit. Its function is to protect the board from damage if the power leads are connected backwards. If the power leads are reversed the diode will be reverse biased and no current will flow into the circuit, saving all those little components from certain death.

The disadvantage to using a series diode for polarity protection is that you lose voltage (and power) in your power supply. There are other methods of polarity protection that don't significantly affect the supply voltage or power, but are significantly more complex or use a fuse. For a simple circuit this is an excellent solution.

C102 and C112 provide decoupling on the power rail. They provide a low impedance path for any AC on the internal power system. This keeps the supply a clean D.C. voltage with a very small A.C. component.

U2 is a low power three terminal voltage regulator. It is there to provide sensitive circuits a constant voltage. The input voltage to the board is not regulated. It can be anywhere between 12 and 15 volts. Lets just say we are using a battery for the power source. All power sources have an internal resistance (usualy small). As more current is drawn from the supply, the voltage drop across the internal resistance increases, decreasing the output voltage. So when we key up the transmit section and the current draw from the power source jumps, the voltage provided drops. There are certain circuit components that require a very stable voltage source. The VFO is one example of this. Imagine what the radio would sound like if the VFO frequency changed depending on how long the key was held down. (We call that chirp). This is a bad thing. So we use a linear voltage regulator to isolate the sensitive circuits from variations in the supply voltage.

The 78L08 device can take anywhere from 10.5 volts to 23 volts at its input and provide an 8 volt output. It provides overcurrent protection, short circuit protection and thermal protection (shut down if it gets too hot).

Remember that these devices are not perfect. We have looked at them up till now as a "perfect" device. They can only supply 100mA maximum. They can only dissipate a total of 700mW assuming the ambient temperature is <25 degees C.

Power dissipated by the device is equal to the voltage dropped by the device (15-8= 7 volts) times the current delivered. Notice that in this design that if the maximum current was drawn out of the device (100mA) at the maximum supply voltage (15 volts), the maximum power dissipation on the device is 700mW. Coincidence? I think not!

Also, variations on the input do appear at the output, although greatly attenuated. The spec is 48dB at 120Hz (full wave rectified line ripple). If my math is correct, a one volt change in input voltage will cause a15.8 microvolt change in the output.

In addition, the device itself uses a certain amount of power. Bias current is about 4mA. At 15 volts that equals 60 mW.

If you are curious, you can view the data sheet if your browser has a PDF reader.

http://www-s.ti.com/sc/psheets/slvs010e/slvs010e.pdf

Next, we build and discuss the VFO. It will probably be done in several separate sections. Stay tuned.

Why these parts?

I've received several emails with questions on the power supply circuit. I don't know if I can answer them completly, but this should serve to start the discussion.

All the questions centered on a theme. WHY did the designer choose this particular component?

Lets also keep in mind that many components are chosen for reasons other than function. There are many parts that could be replaced with a number of parts and function properly. Often the choice comes to economy, availability and stock. Dave may have 10,000 1N4001 diodes in his stock. That would move him to use these components in his designs anywhere possible. Physical size is also a consideration, will it fit on the board? Component choice can also be "designers preference".

D13, why a 1N4001? I think I can answer this one. What characteristics do you need in this particular application? It must be able to carry all of the power supply current through it (up to .5 amps). It must have a reverse voltage rating greater than the supply voltage (15 volts). It does not have to be fast, as it is not a detector or a switching diode. Capacitance really does not matter as it is normally forward biased. It should be inexpensive and readily available.

So, the 1N4001 fits these characteristics perfectly. It handles up to 1 amp forward current, 100 volts reverse voltage, characterized as a rectifier. And they are really cheap.

You could replace this component with any rectifier diode that has a PIV of 30 volts or more(input voltage plus the charged Power supply capacitor) and a forward current rating of 1 amp (0.5 amps plus surge current) or more.

C112 and C102, why these types and values? I think I can answer part of this question. C112 is a 220 microfarad electrolytic. C102 is a .01 microfarad ceramic. C112 is for filtering low frequencies and C102 is for filtering high frequencies (RF). The electrolytic has a low impedance to lower frequencies (120Hz) but has a substantial impedance to high frequencies, due to it's construction. This is why C102 is there. There are lot's of different types of capacitors with widely varying characteristics. Does anyone have a summary of different capacitor types and their characteristics? That would be a good article.

U2 78L08 Why? I believe this one was already answered in the original post. It keeps a steady 8 volts on sensitive circuits even if the supply drops to10.4 volts.

Why this particular part? It is a standard three terminal regulator. They have been around a while. Take a look at the date on the top of the data sheet (January, 1976). From what I understand there are two types, the L series in the TO92 (plastic transistor) case, and the standard series is in a TO-220 (like the final output transistor, Q6). The standard series can supply lots more current. It is also more expensive, larger and has a higher bias current. Since the circuit requirements are for <100mA , the 78L08 is the correct choice. You could "roll your own" regulator with discrete components. However, at $0.25 each, and such a small size, I don't think you can beat the 78Lxx series.

I hope this is a start in the right direction to answer the questions posed. Let's hear from those "in the know" on the details I missed.

More Whys.

Here are the answers to the capacitor selection questions. I got this info from Dave Benson, the designer.

"Why do we use a 220 mF instead of a 100mF to filter the low freq junk?" *The 220 microfarad cap was the largest value available in that size package.*

"Why do we use a .01 mF instead of a .1mF to filter the RF?" *Yes, they'd all work, the .01 is cheapest.- I buy caps in lots of a thousand-the difference between $.02 and .05 fills up my car's gas tank a couple times.*

I do remember someone asking why the bypass caps on U1 and U2 were different values, and I saw some good explanations. The real story is that they would have both been the cheaper .01s but one of the locations was physically too tight and I upgraded to the smaller-package .1 cap!

I hope this clears this all up. Thanks Dave for the feedback. So, it should be clear that often a component choice is not made only on it's function. Economy and size are also a large factor.

Power supply rejection ratio error. The following text is in error in the power supply section. "Also, variations on the input do appear at the output, although greatly attenuated. The spec is 48dB at 120Hz (full wave rectified line ripple). If my math is correct, a one volt change in input voltage will cause a15.8 microvolt change in the output."

Sorry .... the power supply rejection ratio is in units of power, so the power is indeed reduced by 48 db. But, this corresponds to a 4 mV change in voltage. This is one of those famous 'db voltage' vs. 'db power' problems.

10^(-48/20) = 0.004

Schematic error - C102

I recently posted that C102 was at U2's INPUT side. WRONG! I had looked at the schematic to determine where it was, not on the board itself....

On the schematic, C102(0.01uf) is shown at U2's(78L08) INPUT. But how is C102 connected on the board? Its at U2's OUTPUT side. So if you measure the DC voltage across C102, you'll see +8v. Not +12v. Everyone should scratch out C102 on their schematics, and draw in a new C102 at the top of the tuning pot (J2, pin 1). -Glen VE3DNL

Lets get the VFO built.

Some quick theory first. A schematic of the VFO only is shown in Fig. 1. It is also available at
http://reality.sgi.com/adams/vfo.jpg
(Thanks Chuck)

VFO stands for variable frequency oscillator. The VFO determines the frequency at which the radio operates. The vfo signal is mixed with the incoming RF to convert the desired receive frequency to the IF (Intermediate Freq.) of 4MHz. It also determines the transmit frequency by basically the opposite function.

NN1G SW-40+ TRANSCEIVER

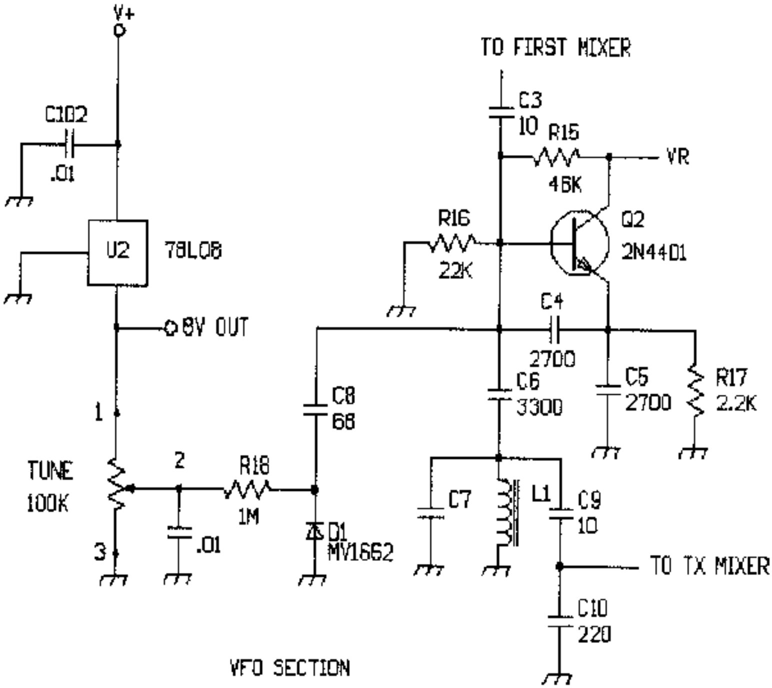


Fig. 1

There are 3 things that you need to make a VFO (or any oscillator) work. You need gain (amplification), feedback from output to input in phase, and a frequency determining device (or network).

Lets get it built. Find and install the following components (with the power off)

C2 47 pF
C3 10 pF
C4 2700 pF
C5 2700 pF
C6 3300 pF
C8 82 pF
C9 10 pF
C10 270 pF
C103 .01 uF
C105 .01 uF
D1 MV1662
D2 1N4148
L1 (You did finish it, right?)
Q2 2N4401
R15 47K
R16 22K
R17 2.2K
R18 1 Meg

Install a jumper between J2 pins 2 and 3. You can use a resistor lead that you trimmed from one of the above components. This temporarily takes the place of the tuning pot, which will be mounted later.

When you finish, double check the component placement. Also check your soldering.

Fire it up! Put your RF probe on the base of Q2. You should see some RF voltage. Those with oscilloscopes or frequency counters should see an approximatly 3 Mhz signal here. The circuit will be calibrated later so don't install C7.

Get this portion built, and stay tuned for a circuit description, spice analysis and some experiments.

A VFO Experiment

Here's an experiment to try on your freshly-minted VFO. It'll show some quirks of oscillators, and how they differ from normal amplifiers in the way they're biased.

Set your meter to "DC volts", and measure the base voltage and emitter voltage of Q2. It gets kinda crowded at the transistor pins, so you might want to measure these voltages across R17(2.2K) and R16(22K) instead.

Here's what I get: Q2's base voltage (R16, 22K)........2.17V Q2's emitter voltage (R17, 2.2K)....2.4 V

Ok, what's strange about this picture? The BASE is lower than the EMITTER!! How the heck can Q2 work when its base to-emitter voltage is reverse biased? In a normally working amplifier, the base must always be about 0.6 volts HIGHER than the emitter!

Now you may get slightly different results, because your meter will "load down" the oscillator differently than mine. But you will still likely see the strange situation where Vb < Ve.

If you want to extend this experiment further, turn off the power and tack-solder a short jumper temporarily across the toroid (L1). This will keep the circuit from oscillating. Now power up and re-measure the DC base voltage and emitter voltage: Q2's DC base voltage.......2.13V Q2's DC emitter voltage....1.5V

OK, that makes sense. The base is now about 0.6 volts higher than the emitter. With 1.5V across the 2.2K emitter resistor, the transistor is biased at 0.68 mA. emitter current. Collector current is about the same. Now its biasing the way an amplifier should...but its not an oscillator anymore. (Unsolder the short jumper now, before you forget)

So what's going on with the oscillator - how can it work when the DC base voltage is less than the emitter? Well, the key here is that there are large AC waveforms (at 3MHz.) at the base and at the emitter too. The AC amplitude at the base (3.8v p-p) is larger than the amplitude at the emitter (1.9v p-p). The base voltage DOES climb 0.6v higher than the emitter, but only during a short part of the cycle: right at the positive peak. For the rest of the cycle, the transistor is biased off, because the emitter voltage is lower than the base. So the transistor conducts current in short pulses, maintaining the oscillations by jamming a current pulse from the emitter into the resonating L-C components every cycle.

You don't see these pulses, because of the "flywheel" effect of the 3 MHz. resonant LC components. All the AC voltages look like sinewaves as a result. All the transistor currents aren't sinewaves but are pulses.

Its also important to realize that AC voltages and DC voltages co-exist in any amplifier: interpreting what your meter is telling you can be tricky (especially when the AC volts are bigger than the DC volts). Glen VE3DNL leinwebe@mcmaster.ca

SW40+ VFO

A 3 Mhz. oscillator supplies a sinewave to both receive mixer and transmit mixer. This note describes how Q2, a Colpitts oscillator is biased, how it begins to oscillate, and discusses some of the component selection. PSPICE is employed to illustrate circuit operation. The coupling circuits into the two mixers are described as well.

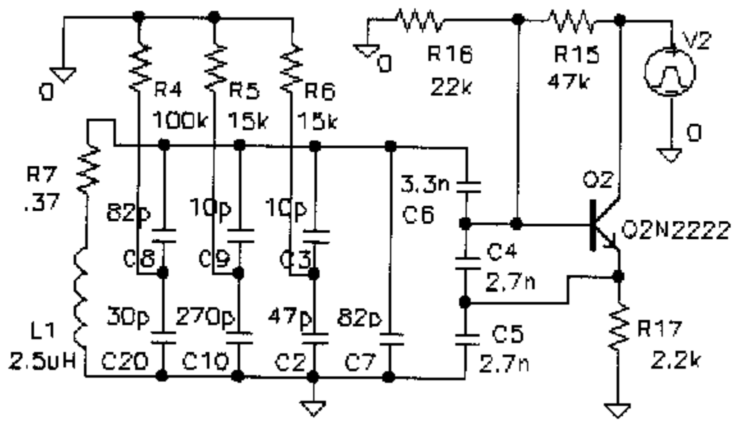
Biasing

Only three resistors are involved in the biasing of Q2: R15(47K), R16(22K), and R17(2.2K). Q2's base-bias point is set by the resistor voltage divider R15, R16. From the 7.4 volt collector supply, you'd expect the base voltage to be 7.4*(22)/(22+47) volts or 2.35v. Instead, Dave shows it to measure 3V (pg.19 of the manual) - why the difference? The answer is that Q2 is oscillating. It is actually operating in a very non-linear way. Should you prevent oscillations (by shorting out L1 with a short jumper), you'd find that the base voltage would settle much closer to the calculated 2.35 volts.

bias resistors. About 30 microseconds later, Q2's base rises to +0.6v and Q2 now begins to conduct current from collector to emitter. The emitter current charges C5(2700pf) slightly faster, and C4 doesn't charge much more because the base-to-emitter voltage track together (a 0.6 volt differen

Somewhere between 35us. and 45us. Q2 starts to oscillate at 3Mhz. The amplitude starts very small from random noise. All the while, the capacitors continue to charge. The 3Mhz. amplitude builds quickly, because Q2 has a lot of gain and pumps up the resonant circuit a little more cycle-by-cycle.

At some time around 50 us., the oscillating amplitude has grown so large that

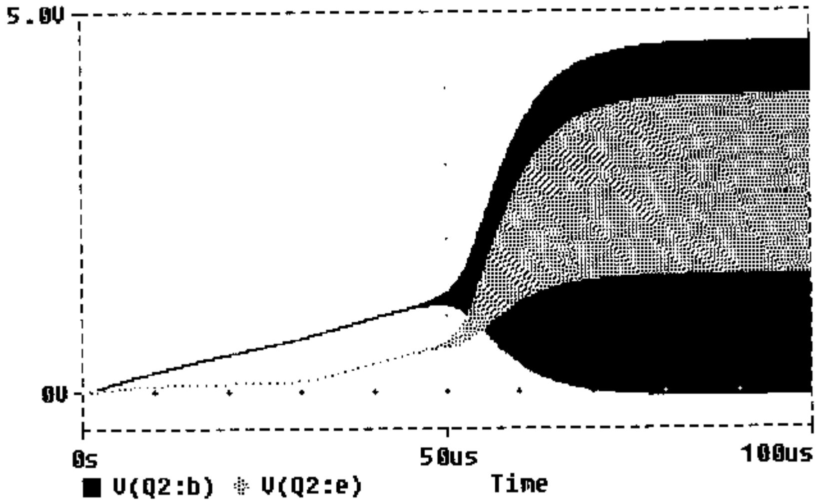


SW - 40 VFO

In a PSPICE simulation, Q2 was started initially with its collector supply at zero volts. It was then raised up quickly to 7.4 volts. The base and emitter voltages were plotted against time (with zero seconds corresponding to the moment that the collector supply was raised). The base voltage starts at zero volts because C4 (2700pF), C5 (2700pF) and C6 (3300pF), are all discharged to zero volts. These capacitors all start to charge through the base-

Q2 begins to operate non-linearly. Up until this time, Q2 has been conducting current from collector to emitter all the time. Now however, on the bottom peaks of the oscillation cycle emitter current zeroes-out. For the fraction of the oscillatory cycle where emitter current is zero, Q2 is not contributing any current to build the amplitude higher.

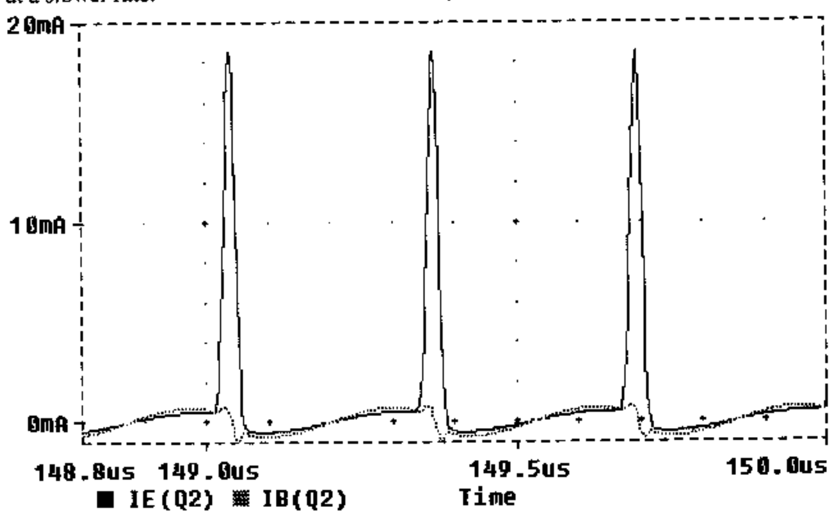
Between 50us. and 80us. Q2's emitter current shifts from a more-or- less sinusoidal



PSpice Simulation of VFO Envelope

waveshape to a pulse waveshape. The fraction of a cycle where Q2's emitter current is zero grows longer and longer. But Q2 still conducts enough (and has enough gain) to continue to add to the oscillation amplitude. So amplitude still builds, but at a slower rate.

Now we come to a fine balancing act. Q2 is cut-off for most of the 3Mhz. sine-wave cycle. For the short time it is conducting, it contributes enough of an emitter-current "pulse" to maintain the oscillation amplitude. Here, the energy lost every cycle (dissipated in lossy components, and delivered



PSpice Graph of Current on the emitter and base of Q2

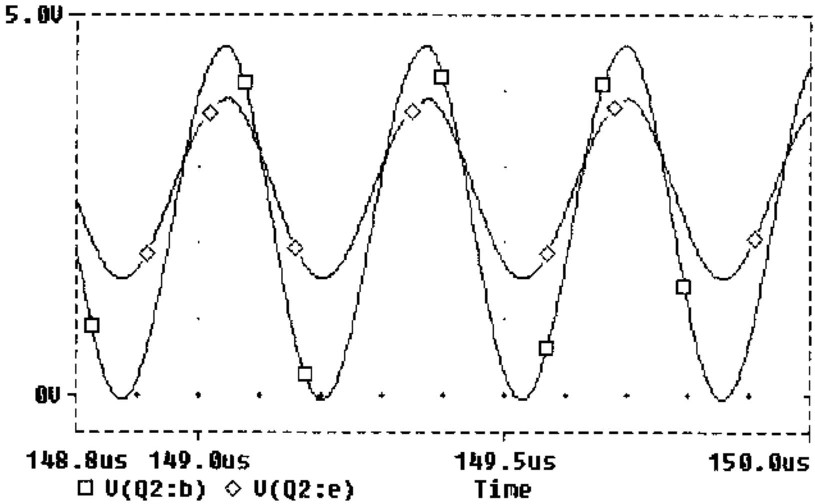
to the two mixers) is exactly replaced by the emitter current pulse.

After about 80 us., this balancing act is in equilibrium. According to the PSPICE simulation, the emitter conducts only 14% of the time, at the positive peak of the AC waveform (on the base). The rest of the time Q2 is off - very little current flows either into the base, or between collector and emitter. While the emitter current looks like a string of short, sharp "spikes", the base voltage and the resonant voltage at L1 are clean sinusoidal waveshapes.

Which components form the 3MHz. resonant circuit? The only inductance in the circuit is L1 - it is the inductive reactance of the resonant circuit. The associated capacitive reactance is distributed among capacitors C2 to C10, plus the capacitive reactance of the varactor, D1. Much of the resonant current flows through C4(2700pF), C5(2700pF) and C6(3300pF). The reactances of the other capacitors are relatively higher, and they contribute less to the resonant energy.

L1 has about 2.5uH inductance. To resonate at 3 Mhz. a parallel capacitance of 1126pF is required. To get to 3.04Mhz, a parallel capacitance of 1096pF is required. The varactor diode must supply the difference of 30 pF.

Dave "taps-off" some energy of the



PSpice Simulation of the Voltage on the emitter and base of Q2

resonant circuit to feed 3MHz. signals into mixer U1 and mixer U5. He does so with a capacitive voltage divider. C3(10pF) and C2(47pF) feed about 1V p-p into the U1, the receive mixer. The RF voltage across C2 will have a sinusoidal waveshape. This voltage divider allows U1's internal biasing to set the DC voltage point of its oscillator input, without disturbing Q2's own DC bias setup.

U5 (the transmit mixer) requires a much smaller 3Mhz. signal, because it is injected into the high-gain port rather than the oscillator port (as is done for U1). The small reactance of C10(270pF) only allows 0.2V p-p into U5.

Mike Gipe, K1MG, talks about capacitors and varactor diodes.

In theory, all hams are slim, handsome, great conversationalists at any cocktail party, and have over-achieving kids. In practice, ...

In theory, all capacitors are pure and stable, strictly obeying the impedance formula, x = 1/2piFC. In practice, they change value with temperature, they have lossy dielectrics, they have resistive contacts, and they also have a bit of inductance in the leads and plates.

If you remember the impedance formulas from your ham exam, you will recall that the impedance of a fixed value of capacitance decreases as you increase the frequency of the signal you are passing through it. The impedance of a fixed value of inductance increases with frequency. What happens, as you increase the frequency of the signal, to the impedance of a typical ceramic capacitor which has a little bit of stray inductance? At low frequencies, the inductive part contributes very little impedance, so the capacitive impedance predominates — that is, it behaves like a capacitor! As you increase the frequency, the capacitive impedance decreases and the inductive impedance increases.

Would there be a particular frequency at which the capacitive impedance equals the inductive impedance? Absolutely! And if you increase the frequency still further, the inductive impedance becomes higher than the capacitive impedance, and your poor capacitor behaves just like an inductor! The frequency at which both impedances are equal is known as the self-resonant frequency. This frequency is set by the materials used and the construction of the capacitor. It can also be affected by how the capacitor is installed, which is why all the kit instructions tell you to mount the cap very close to the board, with the minimum lead length necessary. In general, for capacitors of the same type and general construction, the larger value cap will have a lower self-resonant frequency.

The ideal bypass component would have infinite resistance at DC, and zero impedance everywhere else. Unfortunately, this component is not yet available, but a capacitor comes close. It has very high impedance at DC and decreasing impedance at higher and higher AC frequencies — this is, until you hit its self-resonant frequency. At that point and beyond, it becomes less and less effective as a bypass component because its impedance is becoming larger. The capacitor is a very effective bypass at some frequencies but useless at frequencies somewhat above its self-resonant frequency.

How do we handle this problem? If we use a large value cap which is a good bypass at low frequencies but useless at high frequencies, and put a small value cap in parallel with it, the small cap will not be very effective at the low frequencies, but since its self-resonant frequency is much higher, it will be effective at the high frequencies where the big cap is useless. Simple!

If you pull out some data sheets for capacitors, you will often find graphs of this and other characteristics of the component (impedance vs. frequency showing the self-resonant point, equivalent series resistance, etc). Keeping all these practical limitations of real components in mind and adapting the design to accommodate them is part of the engineering process.

Incidentally, this is also the reason why you won't find a cell phone built with anything other than surface mount components. The self-resonant frequency of chip caps is much higher than leaded caps.

BTW - inductors have similar flaws. The latest QRPp has an interesting article about the RF choke used in the Back-to-the-Future project. It's an interesting education in the real impedance of an inductor at HF frequencies.

Smaller caps drift in proportionately smaller steps and are somewhat self compensating. I.e.., A 10% 10pF cap will drift up/down by 1pF. A 10% 100pF cap will drift up/down by 10pF. The ultimate result of 10x10pF caps to equal 100pF may seem the same however, 5 of the 10pF caps may drift up and 5 of the 10pF caps may drift down resulting in a net change of zero whereas a single 100pF cap will always drift in one direction by the tolerance spec. Of course, it is improbable that you will get symmetrical results like 5 up and 5 down however, the odds are that you will NOT get 10, 10pF caps that all drift in the same direction. (You thought this was a science?)

I did not mention Silver Micas that are commonly used in VFO's. The Silver Mica film tends to be more rigid than ceramic film and are less likely to flex with the same intensity under the same proportionate degree of heat however, when they do flex, they flex at a higher ratio than ceramics. Plus, the drift direction is unpredictable. In tightly controlled temperature environments, they *can be* more stable than an NPO ceramic. In the real word this generally does not hold true.

On the topic of Varactors, they are virtually all 'good' BUT they are not the same as a variable capacitor. You cannot substitute them directly and achieve equivalent performance, but you can nearly always incorporate a varactor into a circuit and achieve good performance if you take all the effects into account.

These different effects include:

- temp coefficient
- junction conductance
- non-linearities with respect to instantaneous voltage, that is the sum of both the tuning voltage and the RF voltage at any time but especially the peak
- V.tune impeadance

Others have already addressed the different temperature coefficient, so I'll leave well enough alone.

All solid state juntions suffer from one significant difference from a 'real capacitor'. IF the RF voltage is large enough the diode junction will conduct during that portion of the cycle that exceeds the diode 'on' voltage. This introduction of non-linear effects includes changing the RF impeadance of the circuit, changing bias if the circuit is designed wrong, and changing the instantaneous capacitance and hence the tuning. This is to be avoided at all costs. sometimes you will see two varactor diodes in series with opposite polarity. the tune voltage will be feed to the junction of the cathodes. this is to eliminate conduction in the circuit. (one will always be non-conducting..) Preferably, the designer accounts for the peak voltages and ensures that the diode is not going to go into conduction.

In the same vein. A varactor diode (ALL!!!) exhibit non-linear relationships between V and C. This is still true with respect to the instantaneous voltage we talked about above. The C you really get is based on the sum of both the tuning voltage and the RF voltage at any instant of time. This results in spurious modulation, oscillators which will start and run for a few cycles, stop for some small portion of the RF cycle, and then restart (this is the voice of experience, and a REAL pain to find at Ghz freq's!!), and many other nasty behavior. Good designs will ensure that the instanteous variation does not substantatially deviate from the tuning point.

Although not a function of the Varactor, another potential problem introduced by the use of a varactor is the impeadance of the tuning voltage connection. this should be very high to ensure that no extraneous effects (circuit loading, stray rf/audio coupling, etc) will be introduced to the VFO. VFO's can make great mixers, product detectors, etc under the right conditions conditions. This line (V.tune) is generally a 100k resistor to each tuned point for this reason. Mike Gipe, K1MG

Questions Generated by Mike's Article

Q: Mike, I am probably wrong but aren't D2 and C105 really part of the 2nd mixer circuit and not the VFO? Are they essential for the VFO to work or were they included in your list because you were following Dave's order of building?

A: D2 and C105 are part of the DC supply for the mixer chips and the VFO. Current flows from the DC power source through D2. It is filtered by C105 and supplied to the other parts from there. If you don't load these parts your VFO will get no DC power. As I understand it, D2 drops 8v to 7.4v. Also adds a little RF isolation for U1, U3.

Q: After stuffing the VFO parts, there seems to be an extra hole on my SW30+ pcb. Extra hole is connected to ground. (It is also on the SW-40+)

A: This is provided so you can solder a ground lead across the top of the three crystals in the IF filter (to be installed later). Grounding the filter cases prevents "blow by" which is strong external signals effecting the IF filter section.

Q: I would like to know the effect of using the 50K variable resistor in place of the 100K one that is used in the VFO section. As I recall the Radio Shack part number given for this was the number for the 50K pot. The schematic calls for a 100K pot. I have the 50K linear taper pot and the only 100K pot I could find at the local RS was an audio taper one.

Does using the 50K decrease, increase, or have no effect on the tuning range? And would one notice an appreciable difference in using the 100K pot that is an audio taper vs. one that has a linear taper?

A: A question came up about the tuning pot. The only function that the tuning pot, listed as 100K, has is to act as a voltage divider and provide the voltage to set the bias voltage on the MV1662 varactor diode. This in turn sets the VFO frequency. With 8V applied to the pot, 50K will give you 0.16mA and 100K will give you 0.08mA of current, so in the big scheme of things it doesn't make much difference. I used the 50K myself. BTW this is the current through the tuning pot only and just adds to the total current required for the rig.

Q: Now, many years ago, I learned all about Colpitts oscillators, but now I have forgotten.The function of C5 has me stumped. QRP Notebook says it is a feedback cap, but I don't see how that can be. Can either of you shed some light on this?

A: Let's first examine the 3MHz. resonant components. L1 is the resonant inductance, but resonant capacitance is due to a number of capacitances:

-C6 in series with C4 in series with C5
-C8 in series with varicap capacitance (d1)
-C7-C9 in series with C10
-C3 in series with C2.

These strings of capacitance all add up to resonate with L1 at 3MHz. A lot of the resonant current flows down the C6/C4/C5 string, since this string of capacitances represent the lowest reactance path of the bunch listed above. Now you could say that Q2 senses the resonant voltage at its base and injects pulses of current from its emitter into the resonant circuit in order to keep the oscillation amplitude up. So the junction of C4 and C5 is where Q2's emitter "pumps-up" the oscillations. That's the feedback point. Of course, Q2's emitter pulses are timed to re-inforce the sinewave shape that the resonant circuit naturally follows.

Q: Can somebody please help me understand what's going on by perhaps redrawing the circuit so all the series/parallel caps are more obvious, and then work through all the calculations that eventually lead to the value of the resonant circuit (near 3

MHz)?

A: OK, you've got the inductance right. Here's the string of capacitances redrawn. They're still kinda messy because there's so many. I'm assuming the varicap diode is 50pF. And I'm assuming that C7 (which is selected to get the VFO on the right frequency) is 68pF.

So let's do the math now. Start at the end, working out the series combination of C2 and C3:

10*47/(10+47) = 8.25pF, call this "Ca"

Do the same with C8 and D1:

82*50/(82+50) = 31.06pF, call this "Cb"

Do the same with C4 and C5:

2700*2700/(2700+2700)=1350pF

call this "Cc"

Now we'll add Ca, Cb, and Cc together since they're all in parallel:

8.25 + 31.06 + 1350 = 1389.31pF

This capacitance is in series with C6, so let's combine the two:

1389.31*3300/(1389.31+3300) = 977.70pF

call this "Cd"

Let's work out the series combination of C9 and C10:

10*270/(10+270) = 9.64pF

call this "Ce"

To finish off, we've got C7, Ce, and Cd all in parallel, so we add 'em:

68 + 9.64 + 977.7 = 1055.34pF

This is the capacitance that resonantes with L1, so we can work out the resonant frequency:

F = 1/(2*PI*SQRT(2.5e-6 * 1055.34e-12) = 3.0985 MHz. Pretty close.

3. How would I go about calculating the efficiency (Pout / Pin) for the oscillator circuit?

May I suggest that this isn't the kind of circuit where efficiency is important. Its not a power oscillator. The two loads (U1 mixer and U5 mixer) are both pretty high impedance and don't draw significant power from this VFO. And the DC power drawn by the VFO is *a very small fraction* of total transmitter power. According to Dave's DC voltage chart, emitter voltage is 2.5v DC. That's across the emitter resistor (R17) of 2.2K. So the VFO draws 1.14mA DC current from the supply. That's still a fraction of the 16mA receiver current. So you might think, "why can't we draw more power from the VFO, so that we don't need as much gain in the transmitter chain?". There's a good reason: U5 (the transmit mixer) can't handle big signals. It sets the limit on how much 7MHz. energy is available.

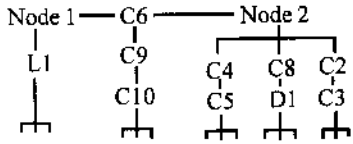
Q: More Math questions answered.

lets see if we can walk back through this.... first lets agree on a couple of conventions...

a) lets represent the series capacitance operation, 1/(1/c+1/c+...) as the operator (||), note that this is the same as resistors in parallel. Also two forms of exponential notation will help in ascii, 10 pf = 10E-12 =10*10^-12

b) since my ascii art is miserable to say the least, lets redraw the schematic in words the same way it would be done in a spice or ARD simulation, that is by series and parallel connections to numbered nodes. You'll probably want to do this w/ pencil and paper... To do this we'll agree that node 1 is the first node and we'll connect the inductor L1 there. A node is simply a point in the circuit where things are connected together. Node 0 is usually ground. The other numbers will fall out shortly. Since we're redrawing this to see the VFO LC pieces we'll ignore all others for just a minute....

L1 is connected from node 1 to node 0, or "IND 1 0 <value>; L1" C9 is in series with C10, connected from node 1 to 0 C6 is in series from node 1 to node 2 C4 is in series with C5, connected from node 2 to 0 C8 is in series with D1, connected from node 2 to 0 C2 is in series with C3, connected from node
2 to 0



we could also designate nodes between each series cap element (and would need to for any simulation input. Also, the note that the series combination of C9-C10, C4-C5, and C2-C3 are used to match impeadance by a technique called a capacitive split. A capacitive split works analagous to a tapped transformer. more on that later...

Now, the total capacitance can be written (remember the || notation) as:
Ct=(C9||C10)+C6||((C4||C5)+(C8||D1)+(C2||C3))
Using circuit values for the SW30+, and assuming
D1=120pF Ct(pf)=(9.64)+3300||(1650+60+8.25) = 1140 pf, or 1140E-12
F=1/(2*pi*f)(L*C)^1/2 and L= 1/ (2*pi*f)^2*C
So for 10.12 Mhz w/ IF = 7.68 Mhz, LO = 10.12 - 7.68 = 2.44 Mhz
L = 1/ ((2*3.14*2.44E6)^2*1140E-12) = 3.736E-6 or 3.736 uh

A VFO Quiz

1. Why is the diode capacitance a max with 0V at J2-2?

A. With no bias on the diode, there is a minimum thickness of the depletion layer between the P and N material. As reverse bias increases the depletion layer spreads, and like the plates of a capacitor, the farther away they are the lower the capacitance.

2. Why is the diode capacitance decreasing as voltage at J2-2 (pin 2 of J2) increases?

A. See above

3. Why is the diode reversed biased?

A. If it were forward biased it would have very little capacitance. Varicaps work in reverse bias mode.

4. What is C103 doing?

A. Preventing RF from the VFO from getting back into the 8 volt power supply.

5. Why is the voltage to J2 provided by the 78L08?

A. It is regulated to remove any variation from the power supply from changing the voltage thereby changing the vfo frequency. Ever heard a CW tone that chirped?

6. When rig is powered up, 8V is applied to the pot. Since we have R and we have I, then we have power applied to the 50K or 100K pot. It must thermally heat up and slightly change its resistance value. Why does this not affect the rest of the circuit, i.e. the voltage at J2-2 does not change over time?

A. Very little current leaves the pot at the center tap. A reverse biased diode in series with a 1 meg resistor draws very little current. That tells me that power is dissapated evenly across the whole wiper surface of the pot. This way both sides change together with a net change in the voltage divider is zero

******DANGEROUS QUESTION ******
Do not try this at home.

7. Why must one be careful when using the clip lead and not connect it between pins 1 and 3 of J2?

A. This will short out the +8 supply to ground. In theory the regulator should shut down without being damaged, but I won't try it.

8. On some rigs, you might see a small trimmer cap in the Y5, RFC2, C28, and C29 part of the circuit. Why?

A. To tune out any deviation in the provided crystals. This circuit oscilates and mixes with the VFO to produce the transmitted carrier. It would fine tune the output frequency as it relates to VFO frequency.

PART 4: Keying Circuit and Transmit Mixer

Gather the following components.

U5 NE612 8 pin IC

PLEASE REFER TO DAVES INSTRUCTIONS FOR INSTALLING THIS PART. IT CAN BE INSTALLED BACKWARDS AND THIS WILL DAMAGE IT!!!

Socket for U5
Q3 2n3906 pnp transistor
D11 1n5236 7.5 volt zener diode
C28 47pf
C29 150pf (the round "ceramic" one, not the oblong one)
C108 .01mf
C109 .01mf
C110 3.3mf Electrolytic

ATTENTION, THE ABOVE PART IS POLARIZED AND CAN BE INSTALLED BACKWARDS IF YOU ARE NOT CAREFUL. ELECTROLYTIC CAPS HAVE A + AND A - SIDE. THE CAP HAS A STRIPE ON THE - SIDE.

C111 .01uF
R19 1K
R20 22K
R21 10K
RFC2 22 microhenry RF choke
Y5 4 Mhz crystal

Install all the above components after you double check the values. Install a small wire (3") with the end striped to J3-3. This is your test key. Double check your soldering and component placement. (Really, you should)

Ok, power it up. You should measure 0 volts DC on pin 8 of U5. Temporarily connect the wire from J3-3 to J3-1. This simulates a key down condition. You should measure about 7.5 volts DC on pin 8 of U5. Also, using your RF probe or oscilloscope, you should see RF on pin 4 or U5. Disconnect the wire from J3-1 and power down the rig.

Here is a quick theory of the circuit you just built. The transistor Q3 controls the power to the transmitter. When you ground J3-3 you turn on Q3 and allow power to flow to the transmitter circuit. In this case we only have the transmit mixer installed.

R19 and D11 form a voltage regulator for U5 which I think isolates it's power from the rest of the transmit chain. When power is applied to U5 it mixes it's own oscillator frequency (determined by Y5, RF32, C28 and C29) with the VFO signal on pin 2. The resulting output is the sum and difference products, plus lot's of other "unwanted" mixer products. The unwanted signals will be filtered out later. If you are looking at the output of U5 on a scope you will probably see a very messy signal, not a nice pretty sine wave.

What we are doing in this part of the circuit is deriving the transmit frequency from the VFO by mixing it with the equivilant of the IF frequency. Remember that in this radio the VFO freq (3 Mhz) plus the IF frequency (4 Mhz) equals the receiver frequency (7 Mhz). The same thing is done to derrive the transmit frequency. The VFO (3 Mhz) plus the Y5 freq (4 Mhz) equals the transmit frequency. As our VFO frequency changes and our receive freq. changes we want our transmit to also change along with them. (Wouldn't be much of a radio if it didn't).

I'm sure this section will bring forth lots of questions on the venerable NE612 mixer chip. Glen Leinweber has provided a ton of good information on this little beauty.

If you would like to view the data sheet for this part it can be found here: http://
www. us.semiconductors.philips.com/acrobat/datasheets/SA612A.pdf

You need a pdf viewer to see it.

SE612 Integrated-Circuit Double-balanced Mixer

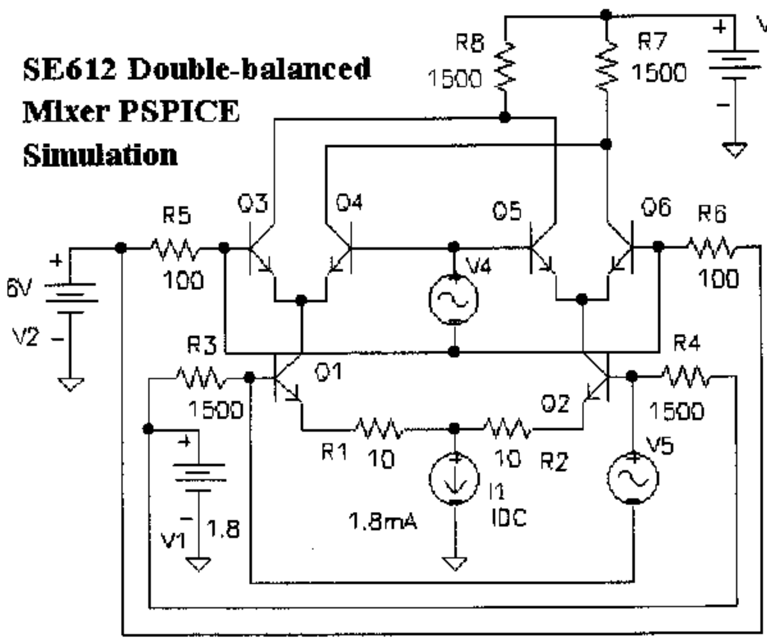
by Glen Leinweber VE3DNL

The SW-40+ radio employs three of these chips: one to heterodyne the incoming small-signal (7MHz.) RF down to the I.F. frequency of 4.0 Mhz., another to heterodyne the 4.0 MHz. I.F. down to audio, and another to heterodyne the VFO frequency of 3.0 MHz. up to 7 MHz. for the transmitting amplifier.

This note uses a PSPICE simulation to illustrate the mixing function of this chip. As an example, the transmitting mixer is examined to show how the 3.0 MHz. VFO is mixed with 4.0 Mhz. to get the desired 7.0 Mhz signal.

The term "heterodyne" refers to the mixing function, where two different frequencies are combined in a non-linear way

SE612 Double-balanced Mixer PSPICE Simulation



to generate an output waveform of a different frequency. Keep in mind that the process is non- linear: there is no way to linearly add two frequencies to get a third. An audio "mixer" is an entirely different animal: it simply **adds** signals together linearly. If it *did* output other frequencies, an audio mixer would be considered faulty, and in need of repair.

In the case of U5 (a SE612 chip), one sinewave input signal from the VFO at 3MHz. comes into pin 2, while the chip generates the other input signal at 4MHz. internally. The output waveform is available at pin 4 and/or pin 5. An internal Colpitts crystal oscillator generates the 4.0 Mhz sinewave (the crystal oscillator connections involve pin 6 and pin 7).

The heart of the mixer uses a circuit known as a *Gilbert Cell*. The output of this circuit is taken from R7 and/or R8. Inputs are represented as voltage sources V4 and V5:

A simple Gilbert Cell requires six identical transistors. Q1 and Q2 accept one of the mixer's input - in our case 3Mhz. from the VFO. The upper four transistors accept the other mixer input - in our case it is from the internal 4 MHz. Colpitts oscillator connected to pins 6,7.

V4 represents a 4 MHz. voltage source, simulating the Colpitts crystal oscillator connected thru SE612 pins 6, 7. V5 represents a 3 MHz. voltage source, simulating the 3MHz. input from the VFO. I1 is a DC current source, inside the SE612. If V5 were zero amplitude, half of I1's current would flow into Q1's emitter, and half into Q2. V5's input voltage unbalances current so that it flip-flops back and forth between the two transistors at a 3MHz. rate. Another way of looking at it is that Q1 and Q2's collector currents have equal amplitude, but opposite phase.

The real mixing action occurs at Q3, Q4, Q5, and Q6. The 4 MHz. signal drives the bases of these four transistors. Their collectors connect directly to SE612 output pins 4 and 5. Two internal 1500 ohm resistors provide a path to the +7.5v power supply. Notice how their collectors are cross-coupled together - part of the magic of double-balancing.

A simplifying assumption will show how mixing works: think of Q3, Q4, Q5 and Q6 as switches. In our case, Q3 and Q5 are "closed" when Q4 and Q6 are "open". Then the role reverses, with Q3 and Q5 "open" while Q4 and Q6 are "closed". The switching flip-flops back and forth at a rate determined by the 4 MHz. oscillator: each switch is "open" for 125ns., and "closed" for 125ns.

These switches direct the 3MHz. AC currents from Q1 and Q2 to the output pins, half the time to one, half the time to the other. The simple switching action described above is a VERY non-linear process, throwing chunks of the 3MHz. signals to one output or the other. The math is rather nasty, but in this process, other frequencies appear that are not simply harmonics of either the 3MHz. or 4MHz. input signals. We are entirely interested in one of these: at 7 Mhz. All others are unwanted.

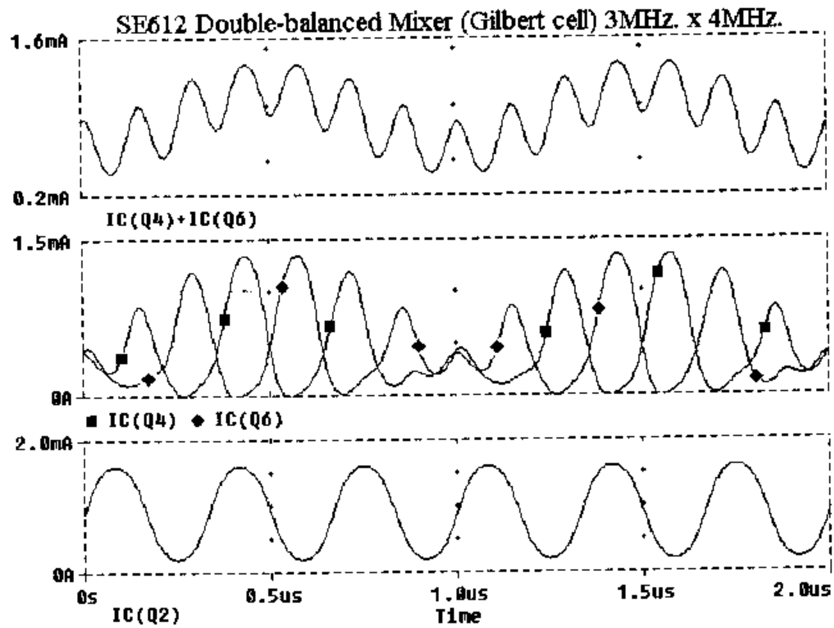
A superb feature of the Gilbert-cell mixer is that neither 3 Mhz. nor 4 Mhz. signals appear at the output, provided that switching action is seamless, and the 3 Mhz. signals at Q1 and Q2 collectors are properly balanced. Ideally, only two frequency components will appear at the output: one at the difference frequency (4MHz - 3MHz = 1MHz) and one at the sum (4MHz + 3MHz = 7 MHz). That's the best we can hope for. Usually, these two dominate over a mess of other mixing products of lower amplitude.

The mixer still performs its task if Q3, Q4, Q5 and Q6 DON'T act as switches. Output will be smaller, but all we really require of these four transistors is that they direct more current during their 125ns. "window" and less during the alternalte 125ns. "window".

Now let's look at the PSPICE simulation, showing two microseconds of the Gilbert-cell mixing action. Only currents of one branch of the cell are shown for simplicity. You can see that Q2's collector current is almost a sinewave (the peaks are compressed a little) of 3MHz(bottom).

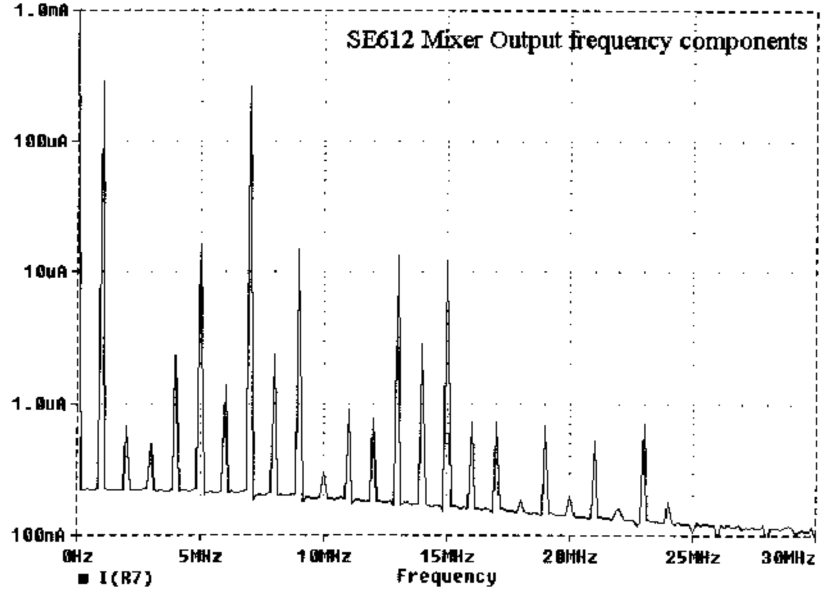
You can't easily see much 3MHz. waveshapes at Q4 or Q6(middle), but the 4MHz. waveform is quite apparent, as is dissapear(top)? A really close, critical look at the output (top) will reveal some waveform compression. The output waveshape appears to be a combination of 1MHz. and 7 Mhz. sinewaves. The other output would appear similar, but out of phase. These output currents are translated directly into voltages by the 1500-ohm collector load resistors.

"Get OUT", you say, "there's nothing else there besides those two signals!". Oh yeah? PSPICE can do a fourier transform of those outputs, showing the amplitudes of any and all frequency components



the longer 1MHz. wave. Note that Q4 and Q6 waveforms bottom out at zero current. These transistors are operating partly into the "switching" region. Even so, the combined collector waveform looks surprisingly good. Isn't it marvelous how when the collector currents of Q4 and Q6 are combined, 3MHz. and 4 MHz. that are there.

Yes, the 7MHz. and 1MHz. signals are the biggest, but there's a murmuring mess of others too: many different combinations of 3MHz, 6MHz, 9MHz, 12MHz., and 4MHz, 8MHz, 12MHz, 16MHz. Of these we should be most concerned with



high-amplitude mixing products close to our desired 7 MHz. output, because these will be most difficult to knock down with a bandpass filter. For this example, the undesired freqeuacies at 5MHz. and 9 MHz. will determine the extent of post-mixer filtering.

If we hit the mixer's input ports with smaller signals, these unwanted extras would die away to insignificance. But we'd have less output at 7 MHz. too. The SE612 mixer was really meant for low-signal receiver mixing, not high-level transmitter mixing. The result is puny output power, in need of amplification and/or filtering.

Don't expect the output waveshape from U5 to look as clean as this simulation. Balance is perfect here, not in real-life.

Part 4 Questions and Answers by Glen Leinweber

Q1. What is the significance of introducing the concepts of voltage source and current source in the analysis of this circuitry? I am more familiar with the concept of a voltage source...at least I think I know the "characteristics" of a voltage source.

A. Since Philips isn't very forthcoming about how the NE612 chip is internally biased, I've had to make assumptions about DC biasing of the chip. One assumption is that they use a DC current source to feed Q1 and Q2 (I1 in the schematic). Current-source biasing is very common inside integrated circuits since transistors can take less room and allow better and more stable performance than resistors. You could replace I1 with a resistor of about 660 ohms and get very similar results. This is a DC source. V4 and V5 are both AC voltage sources.

Q2. If V4 was based upon a 3MHZ voltage source, would the peak current through Q6 and minimal current flow through Q4 coincide with the timing of the peak current flow through Q2? I notice that the peak current flow through Q6 and minimal current flow through Q4 slowly change their relative positions over time with regard to the peak current flow of Q2.

A. Yes, with both V4 and V5 at the same frequency, peak current would always be the same amplitude, and wouldn't shift with time. Let me expand on your suggestion: what happens when you mix 3 MHz with 3 MHz? You should get frequency components at sum & difference: at 0Hz and 6MHz. And indeed, if you make the one stipulation that V5 is 90 degrees out of phase with V4, you'll see a 6 MHz sinewave coming out the top. The peak/ minimum current flow thru Q4 & Q6 changes with time because the phase of 3MHz with-respect-to 4MHz changes with time. That's mixing at work.

Q3. "The mixer still performs its task if Q3, Q4, Q5 and Q6 don't act as switches. Output will be smaller, but all we really require of these four transistors is that they direct more current during their 125 ns "window" and less during the alternative 125 ns "window." (Quote from simulation) When I view the current traces for Q4 and Q6, is the minimum referred to in the quote from the analysis, when these traces "cross?" Likewise, the maximum referred to in the quote occurs when either Q4 or Q6 are at their respective peak values? I assume that it is no accident that the pattern of current flow for combined would reflect such a (summing strategy).

A. Perhaps its unfortunate that I've chosen signals levels part-way between "switching" action and the more linear "multiplying" action. Q4 and Q6 (Q3 and Q5 as well) "bottom out" at zero current on negative peaks. With V4 smaller, you'd see Q4 and Q6 display more symmetrical currents for +ve and -ve peaks - that's in the "multiplying" region. As shown, they're into the "switching" region partly.

Q4. The functioning of both Q4 and Q5 in their respective roles in the process is confusing when I consider the relationship of Q3/Q5 and Q4/Q6 to each of "their" respective 3MHZ transistors. Even though Q2 is permitting maximum current flow through Q6, do I assume that at the same instant Q1 (minimal current—180 degrees out of phase with Q2) is permitting "some" current flow through Q4? (although the analysis reveals very small amounts of current flow in Q4).

A. Ok, you're getting into the heart of mixing action with this question - you're close to seeing it all. But its hard to see the whole thing working at once. At the moment when Q6's current is maximum, you also see Q2 current peaks as well. So all of Q2's current goes up thru Q6 rather than Q5. Q5 is "off" Over on the other side (at this same moment) Q1 is suppling a meager current. Q3 is directing all of it up to R7, and Q4 is off. It'd likely help you to see the Q3/Q5 currents laid over those Q4/ Q6 currents. I had a look at this plot but it was too complex to follow, so threw out the Q3/Q5 currents. Keep in mind that I(q1) + I(q2) = 1.8ma DC (at every moment) Also I(q3) + I(q4) + I(q5) + I(q6) = 1.8 ma DC as well...at every moment. How these are distributed depends on the relative phase of the 3MHz and 4MHz signals. Its magical that you don't see any 3MHz or 4MHz stuff at either output - the magic of double balancing.

Q5. What is happening during the approximately .5 us, centered on 1.0 us with regard to current flow in Q4/Q6? It appears much different than the periods of time between 1.0 us.

A. There are moments (at 1us intervals) where everything is balanced. Naturally, because the phase of 3MHz and 4MHz sources is constantly changing these moments are fleeting. But at the moment of 0us, 1.0us, 2.0us...etc, Iq3, Iq4, Iq5 and Iq6 are all equal, 1/4 of 1.8ma. each. And Q1/Q2 are balanced too: Iq1=Iq2=.9ma.

Q6. Is the presence of 1 MHZ detected through the slowly changing amplitude of the current flows in of Q4/Q6? Likewise the slowly changing amplitudes (?) of the combined IC?

A. Well, I'd say that the combined (Iq4 + Iq6) current shows the 1MHz presence very clearly. A little harder to see in the separate Iq4 or Iq6 waves, but its there.

Q7. The schematic reveals the bandpass filter is connected to each of the outputs of the mixer. Maybe this is to come, but what are the advantages of using both of the outputs from this mixer? Are these advantages part of the rationale for the use of a doubly balanced mixer?

A. Pin 4 and pin 5 of the NE612 have very similar wavshapes. You could use either one. But this chip suffers from having output signals that are rather small - they need a lot of power amplification to get up to 1.5 watts of 7 MHz out the antenna. Hey, its a "low-power mixer". So we should squeeze as much output juice as we can. Its easy to do: we simply take the output as a differential signal, amplifying the difference in voltage between pin 5 and pin 4. Its fortunate that the 7MHz signal is out-of-phase between these two pins. So we've doubled the output voltage - that's worthwhile. That's the only advantage - more signal.

May I suggest that it might help to view the four transistors q3, q4, q5, q6 as a bridge or ring. They're actually arranged in a similar fashion to the diode-ring balanced mixers. But they're rarely drawn that way.

The double-balancing trick is very similar in both circuits: With the diode ring, out-of-phase input signals are made with the multi-winding input transformer. In the gilbert-cell, its done with the Q1/Q2 differential amplifier. Then the mixing action is done by four devices in a ring: be they 4 diodes or 4 transistors. Perhaps the diode ring collects output signals in a more orderly manner (a single-ended output). Only two of these ring devices are "on" (dominant) at any moment. Great questions. Keep at it - its beautiful when you can see how the whole thing works.

I guess it's time for my 2 cents worth. I have worked for a leading manufacturer of mixers and have been exposed to their care and feeding.

1. Double balanced diode mixers.

There are many falvors of these depending on the need and your bank account. The difference in their performance is mosly a function of the diodes used and the local oscillator drive power necessary to have them function correctly. The most common variety uses +7 dbm (that is 5 milliwatts) of local oscillator (LO) drive. The Miniciruits SBL-1 is such a mixer.

The next LO drive level is usually +17 dbm (50 Milliwatts) or +10 dbm (10 milliwatts).....these guys cost about 3 or 4 times the +7 units.....Next comes the +23 to +27 dbm (200 to 500 milliwatt....yes that's a 1/2 watt) of local oscillator drive. These guys cost in the ball park from about 50 to 100 bucks each in small quantities. The difference in these mixers is their ability to handle signals without generating spurious responses. A company called Watkins Johnson makes many mixers and if you contact them they can provide excellent articles on mixer selection,

For average ham use say in a QRP rig's receiver, the SBL-1 mixer will provide very good performance.....If you spend about 10 or12 bucks more the SBL-1H using a +17 dbm (50 milliwatt) local oscillator drive mixer really work fine.

Time for a reality check....these mixers must be used properly for you to get the stated performance.....that is...all 3 ports (RF, LO, and IF) of the mixer want to see 50 ohm terminations.....The IF port especially is the most important. The LO port is easy....if you have some extra drive available padded it with a resistive pad and then into the LO port. The RF port can be driven by a diplrxer which passes the frequencies you want and terminates all others in 50 ohms. The IF port can be terminated in a 50 ohm input impedance amplifier or a diplexer like the RF port.....I prefer a diplexer most of the time because it terminates the IF port in 50 ohms at all frequencies and dumpss the image freqs into the 50 ohm load.

I realize that many QRP rigs are offen powered from batteries and that receiver drain is a concern.....but if conditions are tough its nice to have a good mixer in the receiver front end.

Q. Can anyone please explain the details of the oscillator circuit connected to Pins 6/7 of mixer U5?

A. There's a transistor inside U5: base comes out at pin 6 and emitter comes out at pin 7. All the biasing is inside the chip. So you've got a Colpitts oscillator, similar to the VFO (Q2). In case you don't see it, here are the analogous parts:

C5 is analogous to C29

C4 is analogous to C28

These are the two critical parts to this Colpitts configuration, providing the positive-feedback path required by any oscillator. There's no single part that is analogous to the crystal. It is the resonating element, containing both inductive equivalent and capacitive equivalent of a resonant circuit. But what may be confusing is that 22uH choke. Let's take a closer look at its purpose. The short explanation is that its there to pull the crystal to a lower resonating frequency.

A little background: we need about an 800Hz offset between RX and TX. That's the "sweet spot" CW note that most folks like to hear. This offset is done by having U3's 4MHz. BFO crystal run at a frequency that is 800 Hz. higher than U5's 4MHz. crystal. The 22uH choke pulls Y5's resonating frequency lower by adding some inductive reactance to the crystal's own. Now 22uH is a lotta inductance. If it only pulls the crystal by 800 Hz. then Y5's own internal inductance must be absolutely HUGE. And it is. Inductive reactance inside the crystal is a fraction of a HENRY. That's astronomically big compared to Q2's resonating inductance of 2.5 MICROhenry. So you can see that pulling a crystal's frequency is really difficult. Now C28 and C29 also affect U5's oscillating frequency. You'll notice that C29(150pf) is much larger than U3's equivalent: C18(47pf). This was done to keep U5's oscillating amplitude low, in an effort to reduce U5's spurious frequency output at pins 4, 5. Having C29 large also helps lower the resonating frequency of Y5. But not enough. Adding 22uH to the crystal pulls Y5 down some more.

If you've got a working rig, with working RX and TX, you can try this experiment to explore the resonating frequency of U5's 4MHz. oscillator. Since some may be following the construction sequence on QRP-L (and not have U3 wired yet) I'll come back to this experiment later on.... Short out the 22uH choke (RFC2). This will raise the oscillating frequency of U5, much closer to the oscillating frequency of U3. You should either hear no sidetone, or a very low-frequency sidetone. This experiment demonstrates that the rig's TX/RX offset is set by the frequency difference between U3 and U5 oscillators.

One small detail on 602 type mixers... The biasing internal to the chip is sufficient for most applications. Occasionally you may find a resistor from the output (emitter) pin to ground. This is done to increase the bias current by lowering the effective emitter resistance by parralleling the internal resistance with the external resistor. (R.effective = R.internal || R.external) A second effect is to extend the oscillator range or increase oscillator output, so you may also see this technique used when someone is using the mixer chip close to the specified freq. limits or in a tx mixer application. Glen VE3DNL leinwebe@mcmaster.ca

Part 5

As promised here is the next section of the Elmer 101 project. This is a short one and fairly simple so we should get through it quickly. Anyway, where we left off we had a hodgepodge of frequencies coming out of the NE612 mixer chip. Only one of the frequencies is the one we want to transmit, so we need to filter it out and stop the other unwanted signals from reaching our final amplifier. Dave uses a bandpass filter implemented with 10.7 Mhz IF transformers and some caps.

Gather the following components.

C30 47pF
C31 220pF
C32 47pF
C33 .01uF
T2 IF transformer
T3 IF transformer

Install these components in the appropriate places on the circuit board. Be sure to solder the "tabs" of the transformers to the board as they act as a shield and need to be grounded. Double check your component values and parts placement (Really, you should do this

You will need your RF probe, or an oscilloscope for the adjustment of this section. Connect your RF probe to pad of the base of Q4 (not installed yet). Turn on the power to the board and connect your temporary wire key between J3-1 and J3-3. You should see a reading on your RF probe. First adjust T3 for maximum reading on the RF probe. After you peak T3, adjust T2 for maximum reading. Go back and forth a few times to get the highest reading possible.

If you have an oscilloscope you should see a nice clean sine wave at about 7 MHz. Mine was 3 volts peak to peak at 7.111.42 MHz.

Here is what is happening in the circuit. The outputs of the NE612 (pins 4 and 5) are the differential outputs of the mixer. Remember the mixer discussion? You have the VFO signal at about 3 MHz and the internal BFO signal at 4 MHz being mixed at U5. The two main frequency components on the output are 7 MHz (desired signal) and 1 MHz (difference mixer component). Look at the mixer output frequency components at http://www.qsl.net/kf4trd/ne602.html . Notice that there are frequency components from the mixer as high as 25 MHz. We have to get rid of all of them except the 7 MHz one.

T2 and T3 are configured as a band pass filter, tuned with C30 and C32 for 7 MHz. The fine tuning is done by turning the slugs in the transformers. These IF transformers are designed to resonate at 10.7 MHz and contain internal capacitors, but the resonant frequency is lowered to 7 MHz by paralleling C30 and C32.

Also, when you finish up and adjust T2 and T3, you can prepare the primary of T4 as per the instructions on page 13. Don't install it in the board yet and don't install the secondary winding. We will need this for the next step.

Q: I'd like to hear more about Step 5. What are the advantages of the balanced vs. single-ended output configurations for the NE612? Whichever sort of output is used, is there an optimal termination for the mixer?

A: Using both outputs has the advantage of supplying double the signal for the next stage. The output impedance of the mixer is 3k ohms (from the data sheet).

Q: This is an exchange regarding the bandpass filter after the transmit mixer.

The original questions begin with
I'll start my questions on the Tx bandpass filter by quoting a section from the introduction in the rig's manual:

"Changed the Tx bandpass filter to use IF transformers. This configuration makes use of the differential outputs of the NE612. Filter bandwidth is increased considerably over the original configuration."

Is using the mixer in the differential mode any better? Why?

A. The outputs of pins 4 and 5 of the mixer are out of phase with respect to one.another. By using them both, as opposed to a single-ended configuration, there's twice as much signal to work with.

Q. I understand that in this filter we want a relatively broad bandwidth so any signal in the 40m band passes through unattenuated. I checked out the schematic for the original version (as seen in **QRP Power**), and he at first used an LC filter design. What was wrong with its bandwidth that it needed improved?

A. The original design was a little too sharp- it couldn't be modified much beyond the original bandspread with falloff becoming noticeable. I've simply broadened it a bit to make that adjustment a little less critical. Yes, a resistor could have been added to swamp the response. On the new version, the TX mixer source impedances (1500 ohms nominal at pins 4 and 5) as well as the emitter follower stage, establish loading on that filter. The value of coupling capacitor C31 also affects the filter response.

Q. I checked the Mouser catalog and see that one of these IF transformers sell for $0.65 in hundreds. So Dave probably saved a lot of real estate and maybe even cut the rig's cost by going to the transformers. But why are two transformers necessary; wouldn't one be sufficient? Don't two stages in the filter sharpen its frequency response, whereas the original idea is to broaden it?

Here were the key design considerations:

- Real estate
- Cost
- Easier asembly

It's possible to use a single tuned circuit and still meet the FCC requirements for spectral purity. Doing so, though, requires some pretty high impedances, which should avoided as a general rule with transmitter design- there's an increased susceptibility to unwanted feedback due to ground-loop problems. I didn't have the luxury of unlimited ground plane, although I was cognizant of ground paths, and elected for 'safe' over 'sorry'. Keeping the impedances reasonable and still retaining a good bandpass characteristic (good rejection away from the passband) calls for more parts.

Q. Also, very puzzling to me: the IF transformers are resonant at 10.7 MHz. But without knowing the values of the internal coil and cap, what's the process for determining that a 47 pF cap in parallel brings resonance down to 7 MHz?

A. The internal characteristics are easily inferred with a signal generator and scope. Once the resonance peak is found, extra capacitance is added in parallel and the new peak is located.

The resonance formula is
F(mhz)**2= 25,330 / LC
where L is in microhenries and C is in pF.

Doubling the capacitance (adding a parallel external capacitance replicating the internal one) moves the resonance to .707 of the original frequency. For these transformers, it's approximately 5 uH and 50 pF.

Q: Does the circuit following the mixer provide something like a 3K termination for the mixer? If so, how can we see this?

A. First, C33(0.01uF) has a very low impedance, so that T3 is coupled very tightly to Q4 base. Whatever Q4's input Z is, that's what T3's going to see. Ditto with C34(0.01uF). Next, take a look at Q4's biasing resistors, R23(22K) and R22(10K). Their parallel combination is 6800 ohms. So T3 isn't going to see a load any higher than this.

Now comes the trickier part: determining the actual base input impedance of Q4. Whatever it is, it'll be in parallel with the bias resistors above, lowering the 6.8K load Z we have so far. Q4 is an "emitter follower". The impedance that we'll see (looking into its base terminal) is hie + hfe * Re where Re is the impedance from emitter to ground and hie is the base-to-emitter impedance of the transistor and hfe is the transistor's current gain (at 7 MHz.).

I'm going to make a guess at hie of about 300 - 1000 ohms. And I'm going to guess that hfe is about 25. If you look up the 2N4401 data sheet, you'll think I'm way off. They list hie=700 ohms (at 6ma. Ic). But they list hfe=150

The difference arises because these small-signal h-parameters were measured at 1KHz, not at 7MHz. At high frequencies, current gain drops off. At about 200MHz, it has no current gain at all.

What is Re? Maximum value is 500ohms due to R24. But in parallel with R24 is Q5 and its bias resistors. Bias resistors R25(2.2K) and R26(470) work out to 387 ohms. I'd estimate that Q5 has about the same Z as its bias resistors. So in parallel with R24 is 387 ohms, in parallel with another 387 ohms. So total Re is 500||387||387 = 140 ohms

So in summary, for Q4 we have:
hie = approx 700 ohms
hfe = 25
Re = 140 ohms
And its input Z is 700 + 25 * 140 = 4200 ohms.

This is in parallel with the bias resistors of 6.8K So the total Z that T3 sees is 6800||4200 = 2600 ohms

Now this is a minimum estimate, because I've assumed that the wiper of R24 is right up at the top. If its down lower, the total Z figure above will be higher, because Re will be larger. Dave has chosen bias resistors on the low side. This provides temperature stability, and also means that the load that T3 sees doesn't change wildly as you turn the R24 trimpot.

Q: Summary of transmit mixer problem.

I am building the SW30+ and have run into a problem. When I completed Lesson 4, I observed that Q3 was switching properly and that there was a complex waveform on pins 4 and 5 of U5. Feeling confident that all was well, I moved on to Lesson 5 and installed T2 and T3 and related components. The complex waveform observed on pins 4 and 5 of U5 are also present on the input of T2 but the output of T2 is flat. After checking all component values, orientation, solder joints etc. I finally concluded that T2 was probably working as designed, ie the input signal was outside of the bandpass of T2.

With that in mind I started backtracking and taking a closer look at the waveforms on U5 and made the following observations.

1) LO as measured at the base of Q2 is about 2.439 Mhz and 2.6V p-p.
2) LO as measured at pin 2 of U5 is about 0.16 V p-p.
3) Pin 7 of U5 is a beautiful modulated sinewave (NOT WHAT I EXPECTED). P-P voltage is about .05 V and it appears to be a signal of about 24-25 Mhz moduled by at about a 2.4-2.5 mhz rate. I was expecting to see a 7.68 mhz sinewave here. I have rechecked Y5, RFC2, C28, and C29. All values are proper, connections look good, etc.

What should I be seeing on Pin 7 of

U5? Assuming that what I am observing is not right, any ideas of what might be wrong?

TURNED OUT THAT THE CRYSTAL (Y5) WAS BAD. UP AND RUNNING NOW.......

Q: When I tweak T3 and T2 (while observing waveform on scope) I find the setting for T3 that gives me the largest amplitude to be with the slug turned all the way CCW (to the stop). T2's peak is roughly mid-way between the stops. T3 never really shows a peak - just gets larger as I go CCW. Is this okay?

Glen, VE3DNL, suggested that perhaps my scope probe was adding enough capacitance to the circuit to cause this problem. Following his suggestion, I went ahead and installed the Q4 buffer (and related resistors) and redid the alignment with my scope probe at the emitter of Q4 rather than the base. This effectively isolated the probe from the bandpass filters. The results proved to be quite interesting. There is now a definate peak about midrange in T3. What is kind of weird is that as soon as I go slightly past the peak (CCW) the signal degenerates into a real mess. Dave Benson suggested a different solution which was to add 10-22pf capacitance across T3 (ie C32).

More on this problem

The procedural problem (measuring the waveform at Q4's base rather than at the emitter) did not result from any ambiquity in your manual. The Elmer 101 Part 5 had us stop prior to installing Q4 or any of its biasing resistors and then instructed us to measure the waveform specifically at the base of Q4 (no signal at emitter until buffer components are added in subsequent lesson).

I went ahead and put the buffer section in and while that helped it did not totally solve the problem. I was then seeing a peak more toward the middle of T3's range but when I hit the peak (going CCW) rather than seeing a reduction in amplitude what I saw was a degeneration of the waveform which required I unkey and rekey the transmit section.

I took your advice and put 22pf in C32 and found that threw T3 all the way to the CW stop. Reduced it to 10pf and found a nice solid peak near mid-range. That, however then caused T2 to hit its stop. I then put 10pf in for C30 and am pleased to say that I now have both transformers showing nice solid peaks near mid-range.

Even more....

Dave Benson suggested a different solution which was to add 10-22pF capacitance across T3 (ie C32). I will try that this evening and report the results. I'm betting that the two solutions togther solve the problem.

I assumed that you were looking at Q4's emitter, thus isolating the probe capacitance from the tuned circuit. As I look back, though, I didn't expressly say that anywhere in the manual- an oversight on my part. Scope probe capacitance will indeed upset the operation of that bandpass filter, and what you reported makes sense in light of the presence of probe capacitance. I'd recommend moving the measurement point to Q4's emitter and repeaking T2/T3- the extra capacitance I suggested earlier shouldn't be necessary. 73, Dave- NN1G

Part 6

We will build this up in two stages. First the RF buffer, then the driver. For the first section gather and install the following components.

R22 10K
R23 22K
R24 500 ohm trim pot
C34 .01uF ceramic (103)
Q4 2N4401

Follow all the standard installation

steps and check your work before proceeding!

Turn on the rig and connect your temporary key. You should see a nice RF sine wave at the base of Q5 (not installed yet). Remember that adjusting R24 will change the voltage from 0 volts to maximum. Make sure it is adjusted up. If you measured the output of the bandpass filter this reading may be a little lower. That's ok.

Just a side note. Any time you make a measurement of an electronic circuit you will effect it in some way, guaranteed. We try to minimize the effect by using the correct measuring device. Case and point, there were a few folks who had trouble adjusting T2 and T3 for a peak in the rf output. The reason for this was that the O-scope probe was changing the characteristics of the circuit and changing resonance due to added capacitance and resistance. So, as we move forward keep in mind that the bandpass circuit is easily effected by circuit changes.

So we have this nice pretty 7MHz sine wave at the output of T3. The problem is that it is sensitive to circuit changes. So we must isolate it from the following sections. This is the job of Q4. It is configured as a common collector amplifier with voltage divider bias. The bias on the base of Q4 is set in the linear region of the transistor by R22 and R23. With a 12 volt supply this makes the DC bias on the base of Q4 3.75 volts. Vr2=(12 * r2)/(r1 + r2)

For information and an excellent explanation of bipolar transistor biasing please refer to chapter 8 page 20 of the 1998 ARRL handbook. It is a must read section!

In brief, the common collector amplifier (a.k.a. emitter follower) has some interesting characteristics. It has a gain of less than one (Hmmmm), a very high input impedance and a very low output impedance. So it does not provide any voltage gain, but it does isolate the bandpass filter and the RF driver section (next section).

If you tweeked T2 and T3 in the last section, put your probe on the hole for the base of Q5 (not installed yet). Now key up and see if you can tweek up the voltage with T2 and T3. I went through it again and was quite a bit off. This is because my scope probe changed the resonance of T3 and bumped the whole circuit a bit. My scope probe is rated at 10 meg ohms and 11.8 picofarads of capacitance.

Now while trying to peak T2 and T3 again I accidently bumped the ground shield on my scope probe to the top part of R20 (the side not connected to V+). Can you guess which component I fried when I keyed up, and why?

Ok, now on to part 2. First wind the primary of T4. Please follow the directions on page 13 of the manual. My experience was that 3" of wire was not enough for my coil. I would use 3.5" (I had to rewind mine, yuck). Install it and the secondary as per the instructions.

Gather the following components and install them:

R25 2.2K
R26 470
R27 10
R28 51
R29 51 (the books parts layout drawing has this incorrectly labled as 100)
C114 .1uF (104)
C35 .01uF (103)
D6 1N4148
Q5 2N4401

Check your work before continuing, paying special attention to T4. Put your scope probe on the base pin of Q6 (not installed yet). Key up and you should see your 7Mhz wave. Mine was distorted severly until I turned R24 down a little (I had it cranked all the way up). If you have an O-scope you will notice that the bottom half of the wave is distorted. D6 clamps the negative half of the waveform at -0.7 volts. This part of the circuit has several things I don't understand but I'll try to explain what is obvious. The purpose of Q5 is to drive the final amplifier Q6 (not installed yet).

The final amplifier Q6 is a class C amplifier, which means the active device (the transistor) conducts for less than 180 degrees of the signal. The signal is kept going by the resonant circuit in the collector. Q6 just gives it a "kick" every cycle to keep it going. More on this when we put in the final amp.

R25 and R26 set the DC voltage on the base of Q5 at about 2.1 volts. This sets the DC emitter voltage at about 1.4 volts (2.1 - 0.7 base emitter diode drop). This sets the DC emitter current at 23 milliamps (1.4 / (51+10)). C114 bypasses R28 at RF frequencies so the effective emitter resistance at AC is 10 ohms which changes the AC operating characteristics (and increases AC gain??). Again refer to the ARRL handbook for details.

The load for this amplifier is the primary of T4 which is in the collector circuit. The manual describes it as an 8:1 transformer. I'm guessing that this ratio provides more current drive to the base of the final Q6.

Q: So what is accomplished by clamping the negative portion of the drive signal? It would seem that we're wasting valuable signal by shunting it to ground!

A. It's not really shunted to ground. The combination of C35 and D6 is a 'clamp' circuit. When the voltage at the base of Q6 goes very far negative, D6 begins conducting, and as such, it's charging up the .01 coupling capacitor. This negative side of the voltage swing normally contributes nothing to driving the class C stage, so there's no signal loss per se. On the positive side of the input signal excursion, the presence of this stored charge on C35 actually drives the base of Q6 a bit harder. The improvement is about 2 dB in terms of making the final easier to drive. You can verify this by setting the output power around 1.5 watts and removing the diode- you'll see output power drop.

The signal at the base of Q6 (without the diode) is about a volt positive (and noticeably "squashed") on the positive half-cycle of the input waveform. This is because conduction on the PA starts when the base is about one diode-drop above ground and doesn't vary much in voltage as the drive is further increased. Without the diode, the negative signal swing can be quite large- it's not unusual to see a few volts of negative signal swing. With the clamp diode in place, the negative swing is constrained to near ground, the DC average is pushed upward, and the base of Q6 is driven harder. For the curious, the presence of this added diode appeared to have no adverse effect on spectral purity.

Q: Paul (AA1MI) and I had a recent private discussion of the SW40+ circuitry involving Q5, and its collector load thru T4, the ferrite 8:1 transformer. We both agree that it may be useful to others. Glen VE3DNL

Original posting from Paul (AA1MI) to QRP-L:

I've been looking over and playing with the latest installment (RF buffer/driver) and have a few questions for our online sages...

1. The design consists of a 3-transistor output stage (Q4, Q5 and Q6). Why is it necessary to have three stages? Wouldn't just two suffice — one to buffer the mixer output/filter, in turn driving the PA transistor (here, Q6)?

2. I think I understand the purpose of T4 (improving gain on a Class A amp?), but I sure would appreciate it if somebody could walk me through the process of determin-

ing how many turns on what kind of core are needed — and *why*. Thanks, Paul, AA1MI

Response from Glen (VE3DNL)

1. Good question. Dave has designed the RF amp stages very conservatively. Good approach. Consider that these transistors are CHEAP!!! like about ten cents each. If adding one extra makes your design more stable or reproduceable then its money well spent. You COULD do it with two, but you'd have to push'em to the limit.

2. I went thru the design of this stage and found that Dave pushed the collector EXACTLY right...beautiful job. Its a class-A amp. To get max power out of it, you want the collector current to swing from its quiescent value (I recall its something like 20 - 30 ma) down close to zero ma., and up to twice quiescent. At the same time, collector voltage should swing from +12v down close to the emitter voltage, and up to +24 v on the overshoot. For both current and voltage swing to reach these limits simultaneously requires a specific collector load Z. That's where the turns-ratio of T4 comes in. If quiescent Ic = 25mA, and collector voltage swing is 10v (some is taken up by the emitter resistors), then Rc for best efficiency is 10v/.025 ohms, or 400 ohms.

With a turns ratio of 8:1, the impedance ratio is 64:1 This means that the base circuit must be around 400/64 ohms (about 6 ohms). This load is mighty non-linear and can't be measured easily. (and remember that these numbers are from memory, and might not be exact). To choose the turns ratio requires you to know what impedance Q6's base circuit presents to the 1-turn winding of T4.

So you've gotta choose a core that gives an inductive impedance of much greater than 6 ohms per turn^2. A rule of thumb is to design for between 5 to 10 times the 6-ohm load. So at 7MHz you want about 50 ohms minimum inductance. That's an inductance of 1uh per turn. Choose a core using the "AL" winding value (units of henries-per-turn-squared) sometimes they spec AL in mH/t^2 or nH/t^2. I'd expect that the FT37-43 core has an AL value exceeding 1uH/t^2 (more is OK, less isn't).

A few follow-up questions:

Q. Why do you say the load is highly non-linear? And how does somebody go about estimating it in order to size T4?

A. Q5 is the last linear stage: all the active devices beyond are "ON" during part of the (7MHz) cycle, and "OFF" during other parts of the cycle. This includes D6 and Q6, D7-D10. (D12 should never conduct in normal operation). When "ON", the base of Q6 is VERY low impedance. When "OFF" it is very high impedance. Trying to figure out the average impedance isn't easy. Same with D6. I suppose you could say that Q5 has an input Z that varies with instantaneous input signal, but it varies only slightly. When we say that Q5 is linear, we assume that input Z and output Z DON'T vary with input signal, and its a pretty fair approximation. We can't make the same approximation with D6 and Q6 because their input Z and output Z vary WILDLY with instantaneous input signal level.

Q. So you've gotta choose a core that gives an inductive impedance of much greater than 6 ohms per turn. Why? I only need 6 ohms, right, so one turn does the trick? A rule of thumb is to design for between 5 to 10 times the 6-ohm load. Rule of thumb for what? I'm not sure what you're referring to here...

A. Well, we don't want the inductive reactance of the transformer to load down Q5's collector. Q5 should be seeing mostly a resistive load, consisting of the (transformed) impedance of Q6's base circuit. Since T4's inductive reactance is in parallel with Q5's collector, and in parallel with (transformed) load of Q6, it should be much larger than the resistive load that Q5 sees. This will assure that most of Q5's collector current goes into the load, and not into T4's inductive reactance. This is an important thing to see.

Q. So at 7MHz you want about 50 ohms minimum inductance. That's an inductance of 1uh per turn. How did you arrive at that figure (1 uH/turn)?

A. What inductance gives 50 ohms at 7 MHz? It is 50/(2*PI*7e6). That works out to a little more than 1e-6 henry (1uH). Since T4's secondary winding is 1 turn, then AL is 1uH/turn^2

Q. I noticed that many example circuits use a tuned tank at the output, putting a cap across the transformer. Why not here?

A. Yes, a tuned collector load could work. It'd be pretty low Q because of the low impedances involved. But still, the tuned circuit might require a trim-capacitor to resonate at 7MHz. Costs more, and its another tuning stage that builders can misalign. The broad-band transformer that Dave uses is cheap, requires no tuning, and has about the same performance.

Q. You say, "since T4's inductive reactance is in parallel with Q5's collector..." Hold on!! The transformer is in series with Q5's collector, not in parallel, right? Even looking at the Handbook's equivalent circuit for a transformer, all the elements are series (except for stray capacitances).

A. Didn't mean to add confusion. I've pulled out the only Handbook available,(1978) and am referring to their audio transformer modelling discussion... The Handbook talks about a few different loss mechanisms in their transformer: due to magnetizing current, leakage current, and winding resistance losses, and core losses. In the '78 book, they show the transformer model you've described:

It shows Rc (core losses) in parallel with the primary.

It shows Rp (primary wire resistance) in series

It shows Xp (leakage inductance loss) in series

Then it shows an ideal transformer labelled "PRI" and "SEC"

On the secondary side:

It shows Xs (leakage inductance loss) in series

It shows Rs (winding resistance loss) in series

Then the transformer model's output Es.

I looked for a more RF specific model that included some stray capacitances but didn't find any. In our application (T4) this model is OK because the coupling coefficient between primary and secondary is almost 1.0. However, the model shown doesn't discuss the path for magnetizing current. Since coupling is tight, Xp and Xs are small. And Rp and Rs are small too, since we have so few turns. Consider what happens in the extreme case where we disconnect the load. Secondary current goes to zero. Its a pretty good approximation to assume the whole secondary part of the transformer disappears. So you're left with Rc, Rp, Xp and the primary winding "PRI".

What isn't discussed in the '78 Handbook clearly is that in this model, some current still flows thru the primary side in this case. It flows around thru PRI, and is mostly inductive in nature (meaning that the primary voltage leads primary current by close-to-90-degrees). This is the magnetizing current. And we'd like this current to be small, compared to the primary current that flows when the load IS connected. To accomplish this, we need to have the inductance of PRI to be much larger than the transformed load resistance. This is where the "rule-of-thumb" of *5 to *10 comes in, to make magnetizing current 5 to 10 times lower than transformed load current.

OK, now back to the T4 being in parallel with the collector. I consider that the collector output voltage is measured with-respect-to ground. For RF purposes, the top end of T4 is at ground too, because of the bypassing effect of C111 and C110. So in my mind, T4 is actually in parallel with Q5's collector. Most times, the supply voltage and ground are the same for AC signals. Make SURE you see this...its REALLY important.

Q. You then again say that T4's reactance is also "...in parallel with (transformed) load of Q6..." Again, I don't see any parallel circuit here; the secondary of T4 is in series with the base of Q6, which presents the load.

A. The secondary winding of T4 is in PARALLEL with its load. I think we'd both agree that D6 is in parallel with R29. Can you see that the base of Q6 is in parallel as well? If so, then you'll have to agree that the secondary winding of T4 is in parallel as well. I'm mentally shorting out C35, because its a very low impedance for RF.

Q: My interest has been "peaked" while reading the first chapter of "The Art of Electronics," a text recommended on QRP-L. I have been reading a section on Thevin's equivalent circuit which the author's use as a basis for understanding impedance matching between circuits.

A. Thevenin and Norton equivalents are VERY powerful analytical tools. Used extensively to simplifiy linear circuits. Learn 'em well.

Q. What are the input-output impedances associated with the circuitry associated with Q4 and Q5? I would appreciate the logic supporting the answer. I am comfortable with only resistance and DC circuits at this time, but I am not quite certain how to incorporate active devices and reactance components in the computations.

A. You need to learn a little more about active circuits before you can work out Q4's input Z. But you can find an upper limit by calculating the equivalent resistance of Q4's bias resistors, R23(22K) and R24(10K). You should be able to see that Q4's base will be in parallel with these resistors, and can only reduce the result of the above calculation. Since we're dealing with AC signals, consider the top of R23 to be at AC ground potential. So for AC, R23 and R24 are in parallel.

Q. C114 by-passes only a part of the Q5 emitter resistance. Why? I "thought" good practice dictated a by-passing of the total emitter resistance was necessary to assure a "stable" circuit, that is, to avoid oscillation. Obviously, I have missed something in my past study/reading.

A. Actually, the circuit is more stable with some of the emitter resistance un-by-passed. The gain is lower as a result. And Q5's input impedance is higher too. Q5 becomes a more linear amplifier as well. A good, conservative design.

Q. The directions for peaking T2 and T3 do not exclude the use of a metallic tool. I used both a metal small screwdriver and a homebrewed plastic "screwdriver" with no discernible difference in adjustment. However, I have some other kit building experiences with the adjustment of coil/capacitor/ferrite which required the use of a plastic tuning tool. What gives?

A. T2 and T3 are cup-cores. The screwdriver slot is mostly out of the flux path. This design is mostly self-shielding. And T2, T3 tune fairly broadly too, so you don't notice much de-tuning. I'd still use a plastic tool though. A slug-tuned threaded core with a hex-hole is a different story. Here, the flux-path is terribly distorted by a metal tool.

Here is the short quiz from part 6 with an answer. Most of those who responded had the correct answer. Some did not, but I think it was because they did not read the question carefully.

Q. Now while trying to peak T2 and T3 again I accidently bumped the ground shield on my scope probe to the top part of R20 (the side not connected to V+). Can anyone guess which component I fried when I keyed up, and why? (This is homework.)

A. 12V (or 13.8) from emitter to base of Q3 would fry the junction - almost certainly open, unless your supply has a quick current fold-back, in which case the junction might wind up shorted. Not likely though. Also - it wouldn't matter if the rig was keyed or not.

Scope waveforms of the SW-40+

Some oscilloscope waveforms of the keying process have been taken to show how the radio switches from receive-to-transmit and back. The oscilloscope is particularly useful here. Waveforms of the final amplifier base and collector voltage are shown as well.

Equipment setup:

A TDS210 digital oscilloscope with two x10 attenuator probes was used to capture the waveforms. A function generator was used to "key" the rig in a predictable way: the transmitter was activated for a time period of 0.18 seconds, and then the receiver was allowed to operate for another 0.80 seconds. Keying was repeated continuously this way. Antenna connection went to a 50-ohm dummy load. No headphone was connected (open-circuit). DC power came from a regulated bench supply at 12.3V.

For the keying waveforms, the 'scope was triggered "externally", directly from the function generator that was keying the radio. An analog 'scope usually displays waveforms that start the sweep at the left coincident with the triggering event. With a digital 'scope like the TDS210, you can see stuff that happens *before* the trigger event. So some waveforms would be very difficult to duplicate exactly if you're using an older-style scope.

Oscilloscope waveform data was transferred to a PC computer over a serial port. Data was imported to a spreadsheet where it was graphed. WINDOWS **Paintbrush** was used to cut-n-paste some graphs together, and annotate and title them.

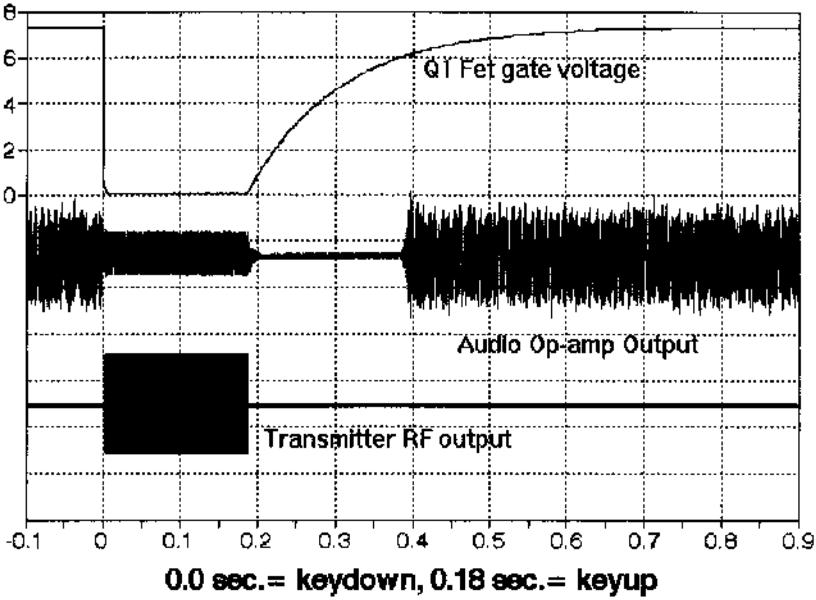
Waveforms explained, scope triggering

The first graph shows one keying event, lasting 0.18 seconds. The trace actually starts at the left 0.10 seconds BEFORE the key activates. The timescale is shown so that 0.0 seconds corresponds to the moment when the key is activated.

If you're setting up a 'scope to view these waveforms, you might want to connect one channel to the keyline, say channel 1. You'd set the 'scope to trigger from channel 1, negative slope (falling edge), and DC coupled. Many scopes will require that you switch to "normal" triggering rather than "auto" at these slow sweep speeds. Adjust the trigger level while keying the radio till you see that hitting the key initiates a sweep. The scope screen should be blank if you don't key the rig.

Now you can use the other channel (channel 2) to probe around the radio and view various parts of the radio that only change when keying is activated. Of interest are the FET gate (Q1), the transmit supply switch (Q3), RF amplifier (Q4, Q5) and perhaps the transmit mixer (U5).

During the first 0.1s at the left, you can see audio (noise) output from U4, pin 7 up until the key is hit. The sweep here is so slow that you can't see the waveform going up and down, but you can see its "noisy" envelope. Very soon after the key is activated, the FET switch opens up, and the rig starts transmitting. During this time, audio consists of a constant-amplitude sidetone of about 800 Hz. When the key is



These waveforms represent Q1's gate voltage (top), the audio output at pin 7 of U4 (middle) and the 7 MHz. RF transmitter output at the antenna (bottom).

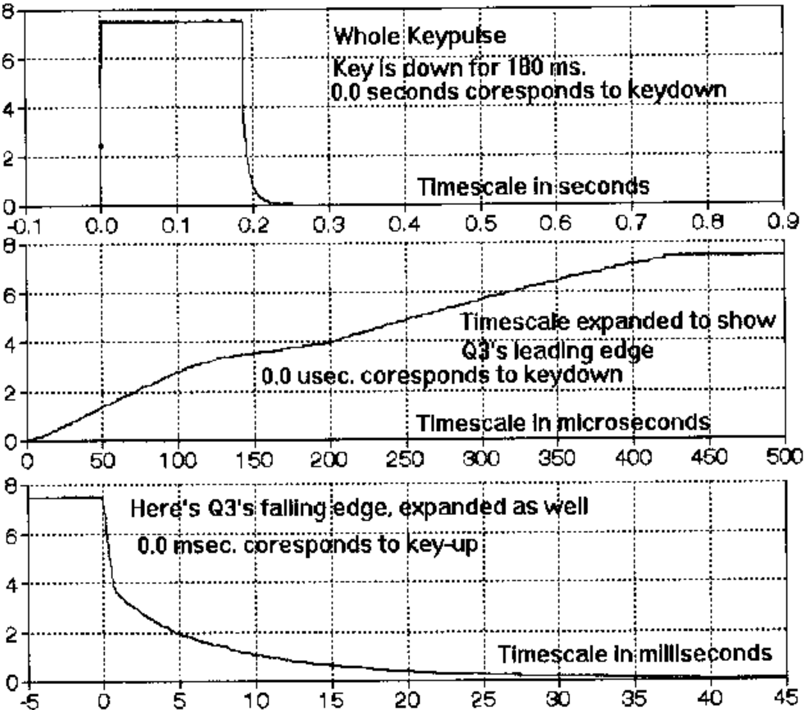
released, both the transmitted waveform and the sidetone stop.

After that, the audio output is silent for a while, till the FET gate charges back up. Then the FET switches back ON and audio noise re-appears for the rest of the trace. The keyline not only opens up the FET gate, but it turns ON the transmitter amplifer supply via Q3. The next set of three traces explores the keying timing involved with raising, and lowering the supply to U5. Voltage rises up to 7.5 volts, where zener diode D11 conducts. Q3's collector continues all the way up to +12v.

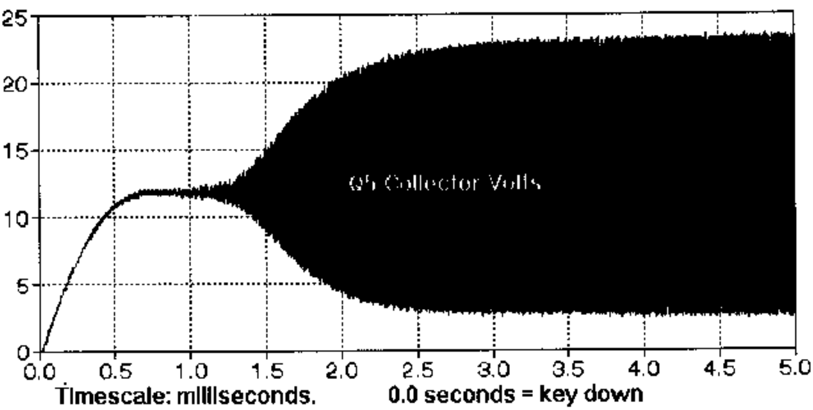
The top trace shows U5's supply at the same timescale as the previous traces: key is activated at 0.0s and de-activated at 0.18s. Q3 pulls up to nearly 12v very quickly after the key it activated. The middle trace examines its rising edge in more detail - notice that the sweepspeed is much faster than the top trace, and that the keydown event occurs at the extreme left edge of the sweep. U5's supply ramps up to 7.5 volts about 430 microseconds after the key is activated.

The bottom trace examines Q3's falling edge, showing how it falls from 7.5v back to zero. Here, 0.0 seconds corresponds to the key-up event. Q3 actually turns off quickly, but charge on C110 takes time to bleed away.

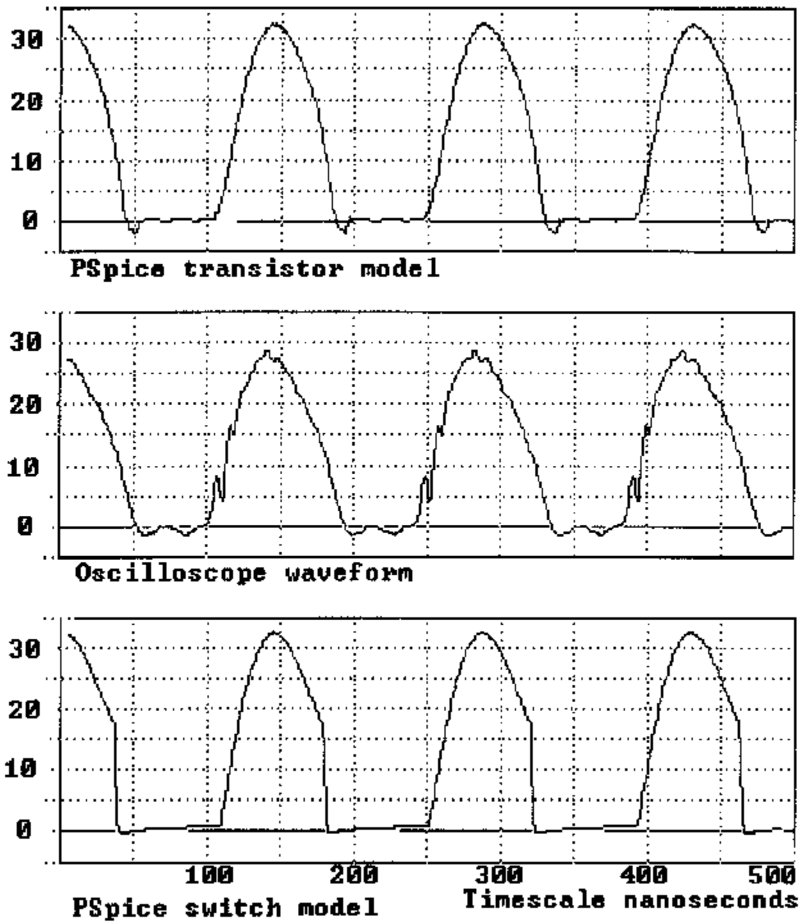
Well, its fine to see the supply voltage going up and down, but does the RF waveform follow it in a similar fashion? No, it lags a bit, as the next trace shows. Q5's collector voltage is shown as the key is activated. You can see that it exponentially rises up to +12v when Q3 turns on, but RF doesn't come out immediately



Q3 collector voltage shown at three different timescales



The RF envelope (at 7 MHz) starts to come out about 1 millisecond after keying, and only rises to full amplitude after about 3 milliseconds. Although U5's supply is up to 7.5v after only 0.43 ms., its 4 MHz. crystal oscillator (connected to pin 6, and pin 7) takes some time to build up. U5's output at 7 MHz. depends on the oscillator, and doesn't come up right away. The laggard RF goes thru the buffer at Q4 and into Q5.



The last waveform here hasn't anything to do with keying. It shows the 7 MHz. voltage waveforms around Q6, the final RF amplifier. RF drive was a little high, so that two watts output was sent to the 50-ohm dummy load. The collector waveform's average voltage is +12v. It swings down to ground (Q6 is conducting a lot of current at this time). But when Q6 is not conducting, its collector voltage swings high above the supply voltage on the rebound - up to 28v. This transistor is working somewhat beyond class C, since it is saturated when ON.

Base voltage is limited by D6 on the negative swing, and by the base-emiter of Q6 on its positive swing. Its the positive swing that turns Q6 ON - while the base voltage swings negative, Q6 is OFF

Part 7.

In the transmit chain we left off without installing the final amplifier transistor. This was done on purpose. With the final out we don't have to worry about frying the final because we forgot to connect the dummy load. We will install it last before the final calibration.

The reason for building the transmit circuit first was to provide us with a signal source for testing the different sections of the receiver. This should make trouble-shooting the receiver easier for those who don't have an RF signal generator.

Gather the following parts:
T1 IF can (the last one in the kit)
C1 47 pF
C40 47 pF
C101 .1 uF
D7 1N4148 diode
D8 1N4148
D9 1N4148
D10 1n4148
RFC3 10uH inductor (brn blk blk) in the "misc" bag of parts
8 pin socket for U1
U1 NE612 mixer IC

Install the above components using the same caution as in the previous lessons. CHECK YOUR WORK!

Now we are going to cheat a little. We are going to "borrow" some signal from the output of the transmit mixer so that we can get a nice strong signal for the receive sections.

Two TEMPORARY jumpers are needed for this. I used two of the trimmed leads from one of the capacitors that I just installed. Solder them lightly, as they will need to be removed later. I soldered mine on the top of the board. All references are looking at the front of the board, with T1 in the lower left hand corner. Connect the first jumper from J1 between pins 2 and 3 (Those are the top two). The second jumper is from the base hole for Q6 (left most hole) and and the top hole for C36. Remember that all references to "top" and "left" are with you looking at the top of the board with T1 at the lower left hand corner.

What these jumpers do is bypass Q6 (which is not installed yet) and bypass the RF Gain potentiometer. This feeds the transmit signal from the base of Q6 into the input of T1.

Set T1 to mid range. This will be tweeked later. Turn on the rig and check for smoke ;-) None? Good. Ok, put your RF volt meter or o-scope on pin 5 of U1. An easy place to measure this is at the top pad of C11. The o-scope users will see a little (millivolt) signal leaking through from the VFO. Key up the rig. You should see RF at pin 5. O-scope users should see a complex waveform at pin 5. Mine was several volts peak to peak. This waveform should look similar to the one we saw at the output of U5, the transmit mixer, before the bandpass filter.

Here is a little theory. From the antenna the receive signal first passes through the first bandpass filter consisting of L3, L4, C37-39 (not installed). This cleans up the transmitted signal during transmitting and preselects the 7Mhz band during receive. The signal is coupled through C40 to the four diodes whos function is to limit the signal reaching the receiver by clamping it to ground if it is over 1.4 volts. The only time that it will reach that level should be during transmit. The signal from the transmit that reaches the receiver provides sidetone during key down.

The RF gain pot (not installed) is used to reduce the RF from the antenna while receiving a strong signal. The connection of this part is a little unusual and it took me a while to figure it out. In other instances where control of a signal is required, you see the signal injected into the "top" of the pot, the bottom of the pot grounded, and the output signal taken from the wiper. The problem with this setup is that as the wiper postion is changed the output impedance is changed also. In Dave's configuration the impedance is relativly steady across the wiper postions. This is important as changes in this impedance will effect the resonant circuit of

T1.

T1, which is set to resonance at the receive frequency, couples the RF into U1. Here it is mixed with the VFO signal and is available at pin 5. This signal will contain two major components and several minor components. The major components are RF+VFO and RF-VFO. At 7 Mhz with a 3 Mhz VFO, there will be 10 Mhz and 4 Mhz. The 4 Mhz is the one that we are interested in as it is our IF frequency. All these unwanted "nasties" will be removed by the next section (part 8) the crystal filter. More detailed info on the mixer can be found in part 5, the transmit mixer.

Remember that our transmit mixer oscillator (Y5) was "pulled" lower in frequency by RFC2 and C29. This gives us the proper offset for receiving on the proper side of the signal. At a receive frequency of 7.040 Mhz the VFO will be at 3.040 Mhz and the transmit frequency should be about 800Hz lower, or 7.0392 Mhz.

SW40+ Receiver Front End

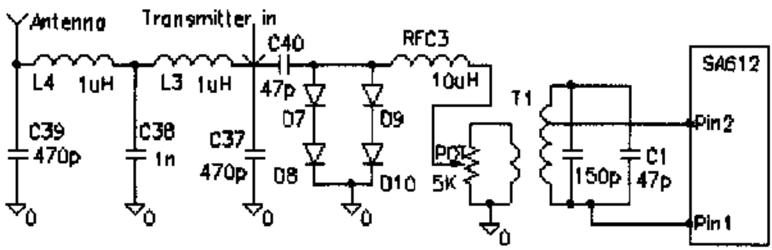
This note describes the circuits between antenna and mixer U1(SA612). Circuit operation during receive as well as during transmit is described since the very large transmit signal modifies circuit operation. The circuitry is divided into functional blocks: a good way of separating function for debugging. Each module serves a different purpose.

PI Filter: The first circuit "module" is the five-element low-pass filter involving **C39**(470pF), **L4**(1uH), **C38**(1000pF), **L3**(1uH), and **C37**(470pF). You should see that this circuit is symmetrical: it looks the same from either end. Indeed, the transmitter propagates its signal from right-to-left out to the antenna, while the receiver uses the same circuit in the other direction. In any case, it is a low-Q filter that attenuates signals above 7MHz, while passing all below 7MHz. Ideally, this filter should be terminated in a 50-ohm resistance. Due to its low-Q, this requirement is somewhat relaxed, and we shall see that the receiver doesn't comply here. Circuit function is more appropriate to the transmitter, to attenuate harmonic output. But why not take advantage of its filtering action for the receiver?

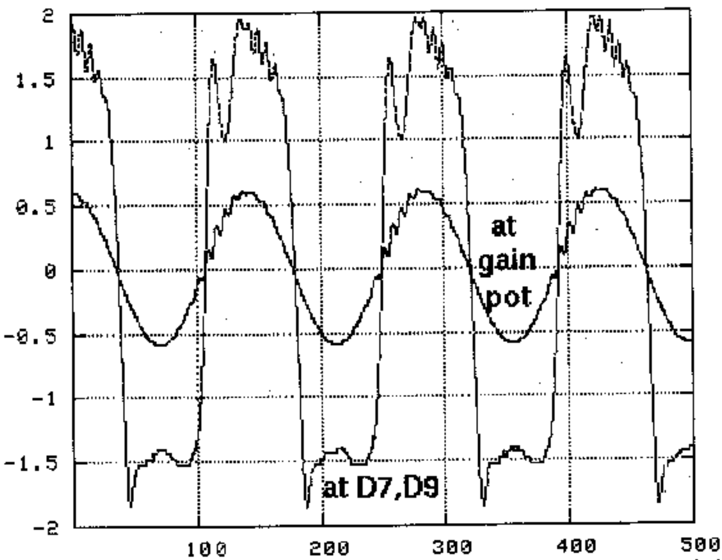
T/R switch

The next circuit "module" blocks most of the transmitter power from overpowering (and destroying) **U1**. We want most of the transmitted power to go out the antenna, not into the receiver. Yet we want *all* the received signal to pass through this circuit with little attenuation, into **U1**. Circuit components here include **C40**(47pF), **D7 - D10**, and **RFC3**(10uH).

Consider what happens while transmitting. A very large amplitude waveshape (not a sinewave) appears at **C40.** This point is common to both receiver and transmitter. That is, when not transmitting, the very small received signal must pass this



SW 40+ Receiver Front End Schematic



T/R switch during transmit (volts vs. nanoseconds)

same point on its way into **U1**.

The transmitted signal is of such large amplitude, that **D7- D10** conduct 7MHz. current to ground. Current is limited by the impedance of **C40**...480 ohms at 7MHz. While conducting, these diodes look like low-impedance to ground. However, their forward-bias voltage of 0.6v each mean that there is still a 7MHz. signal across them. But instead of 30v p-p it is clipped to about 3.3v p-p (**"at gain pot**"scope trace). The **RFC3** choke further attenuates the transmitted signal so that the **R.F. GAIN** pot sees even less (**"at D7,D9"** scope trace). However, from there, the voltage amplitude is boosted by **T1** (tuned to 7 MHz.) on its way into the mixer due to its step-up turns ratio.

The critical parameter of the mixer's input transistors is their reverse breakdown voltage between base and emitter. For R.F. transistors, this voltage limit is about three to five volts. Anything less won't cause damage.

While receiving, the transmitter is idle, and looks like a very small capacitance in parallel with **C37**. At 7 MHz., antenna signals pass through the PI filter unmodified and appear at **C40** with no attenuation. Since the amplitude of received signals is so small, **D7-D10** do not conduct, and they appear as a tiny (insignificant) capacitance to ground. This allows **C40** and **RFC3** to work in concert as a series-tuned circuit resonant at 7 MHz.

The series resonant circuit sees about 50 ohms on its antenna side (**C40**) and about 100 ohms on the mixer side (**RFC3**). So its loaded Q is low: about 3. For such a low Q, exact trimming is unnecessary: resonance is "close enough" to 7MHz. At this frequency, reactance of **C40** and **RFC3** cancel, leaving an almost direct connection between **C37** and the **R.F. Gain** pot (and to the link winding of **T1** too).

You might ask how large an antenna signal would have to be before **D7-D10** began conducting? If amplitude across each diode rises to perhaps 0.6v, diode resistance may start to load the series-tuned circuit of **C40/RFC3**. A Q of three means that the diodes see three times the antenna amplitude. So that reduces the diode conduction limit to 0.2v. With two diodes in series, maximum peak voltage would double to 0.4v, and we could withstand a 0.8v p-p antenna signal before conduction begins.

7MHz. tuned Transformer (T1)

The PI filter, and the series-tuned T/R switch provide inadequate selectivity to reject unwanted mixer input signals (particularly at the image of 1.0Mhz). **T1** is a tuned bandpass filter that attenuates signals both above and below the 40M band. In addition, it also steps up the low antenna impedance to more closely match mixer input resistance of 3000 ohms. Here are the turns ratio of windings and taps:

- Link winding: 2 turns
- Tuned winding: 17 turns, tapped 11 turns up

Let's see how the mixer impedance matching works out... First, what's the **SA612** input impedance? The data sheet says "unbalanced: 1500 ohms". However you should note that neither input (pin 1 nor pin 2) are bypassed to ground. So the input tends to be balanced at twice this value, and the 11-turn winding section of **T1** sees 3000 ohms. Assuming that flux linkage within **T1** between the 2-turn link and the 11-turn winding is 100%, then the impedance ratio is $(11/2)^2$ or 30.25. So the 3000-ohm mixer load looks like 99 ohms at the link winding.

Since the series-tuned T/R switch has nearly zero impedance at 7MHz., the PI filter sees 99 ohms as well. And so does the antenna. Measuring with a noise bridge verifies that at **T1**'s 7MHz. resonance, input Z is indeed 100 ohms. Now this is not a very good match to a 50-ohm antenna system. Why did Dave not use the full 17-turn winding instead? This would give about a 41-ohm impedance at the link...a closer match to a 50-ohm system.

There are a number of possible reasons:

- The full 17-turn could present too high peak voltage to the SA612's input transistors during transmit
- The loaded Q of T1 would be lower, resulting in poor image and spurious rejection
- Overload (intermodulation IP3) is worse, resulting from bigger input voltages.

As a matter of fact, you could improve the robustness of the front-end by changing to the 6-turn link section rather than the 11-turn section: connect **SA612's** pin 1 to the other end of the transformer (requires cutting a P.C. trace). The price you pay is poorer sensitivity: if you have a good antenna, it is a reasonable price to pay.

Part 7 Questions and Answers:

Q. C40 and RFC3 form a series resonant circuit at the input of the receiver. My calculations show that it is resonant at 7.34 Mhz. This is outside the 40 meter cw band. How does this effect receiver performance?

A. But did you calculate the Q? Very low. There's about 50 ohms at the antenna-side. And on the receiver side, at LEAST 50 ohms more. So Q is MAXIMUM 5. That covers the whole band. And if there IS any left-over reactance, T1 can tune some of it out.

Q. The diodes D7-D10 are meant to limit input signal. Why are they in the middle of the series resonant circuit made up of C40 and RFC3?

A. If the diodes weren't there, the voltage at this point would be Q6's collector voltage (25v p-p) MULTIPLIED by the Q calculated above And U1 (or the RFgain pot) would certainly get fried by all that QRP power. Not only do the diodes clip it down to about 2.6vp-p, but they destroy the Q of the series-resonant circuit of C40-RFC3, since while conducting, they're very low-

Z devices. So while transmitting, RFC3 is acting as a proper choke, with 440 ohms inductive reactance in series with the receiver. But while receiving, this reactance is tuned out by C40, because the diodes are NOT conducting.

Q. Explain what is happening impedance-wise with the RF gain pot, T1 and U1. Why is C1 150 pf instead of 47 pf like in the transmit mixer?

A. C1 is a goof. It IS 47pf. T1 is tuned to 7Mhz. Don't know what the turns-ratio is, but i'll bet it steps up the 50 ohm antenna Z to something higher for U1's input of 1500 ohms.

Q. Why is the signal for U1 taken from the center tap of T1, not across the whole thing? I thought we would need as much signal as possible from the antenna to make it to the receive mixer.

A. I intend to find the turns ratio of T1 (don't know it yet). The tap could be anywhere, not necessarily at center. Using the tap instead of the top means the loaded Q of T1 is high. These canned tuned transformers usually have unloaded Q's approaching 100. With only ONE tuned circuit at the front end, we need a high Q to reject spurs, and images. Tapping U1 down maintains the Q reasonably high. Its also a good idea to tap-down too low rather than too high. This'll improve U1's large-signal handling.

You had some good questions about T1. I just measured its turns ratio (roughly). If you take the full tuned winding length as 100%: the link is about 13% the tap-point is at about 68%. So if U1's input Z is 1500 ohms, then the turns ratio of (.68/.13)^2 transforms down to about 54 ohms. Not a bad match to the antenna. Loaded Q isn't very high. Something like 10

Part 8

Gather the following components:

C11 47pF
C12 150pF
C13 150pF
C14 150pF
C15 150pF
C104 .01uF
R1 470 ohm
RFC1 22 microhenry
Y1 4 Mhz crystal
Y2 4 Mhz crystal
Y3 4 Mhz crystal

Install the above components into the board. Use caution while installing the crystals Y1-Y3. If they are mounted flush to the board the cases could short out the solder pads underneath. I mounted mine about 1mm above the board surface using a temporary spacer while soldering. I know that you can get insulators that fit over the bottom of the crystals but I had none. Use whatever method you would like to prevent the crystal cases from touching the solder pads on the top of the board.

You can ground the cases of the crystals now by soldering a solid wire across the top of the 3 crystals. DON'T OVERHEAT THE CRYSTAL CASES AS DAMAGE CAN RESULT! Now attach the wire to the solder pad on the left side of the crystals. It should be the only open solder hole on the left side of the 3 crystals. When you are done you should see a single wire going from the right most crystal, soldered across the top of all 3 crystals, then down to the solder pad on the left side. This grounds the cases of the crystals preventing interferance from strong stations from getting past the filter.

Ok, check your soldering, parts placement and parts value. Got it all right? Good. Now apply power and check for smoke. Place your scope probe or RF probe on the solder pad for U3 (not installed yet). Key up the rig with your temporary jumper. You should see a nice pretty 4Mhz sine wave. On my scope it was about 0.5 volts peak to peak. That should be enough of a voltage to tickle those RF probes. What happened to all those nasty mixer components that we had at the output of U1? Well, thanks to the crystal filter they are all gone!

So now you have to ask the simple question "how does it work?" For me, this part of the circuit is shrouded in mystery. Please try to stay with me and lets see if we can get some discussion going on the subject of crystal filters.

Remember, the basis of a superhet receiver is that it converts the desired incoming signal to some "standard" frequency. In our radio that frequency happens to be 4Mhz. This is done because it is easier to design a filter that operates on one specific frequency than one that operates over a range of frequencies. It also allows you to reject the other sideband, unlike Direct conversion receivers. So the purpose of the receive mixer is to convert the desired receive signal to the IF frequency (4Mhz). The crystal filters job is to make sure that only the IF frequency makes it from the receive mixer to the product detector.

In the last section we completed the receive mixer that was centered around U1. This mixed our incoming signal from the antenna with the VFO and presented the mixed signals at it's output. Let's pick some round numbers.... Receive signal=7Mhz VFO=3Mhz The output of the mixer will contain many mixer products, the major ones being 4Mhz and 10Mhz. This circuit will filter out all but the 4Mhz signal.

I did a bunch of reading on crystal filters and came away even more confused then when I started. Most of the descriptions that I read either were emperical designs, or the design was referenced as being covered by one of the books in the bibliography. "Just build it this way and it should work" was a common phrase in these writings.

Here is what I do know. The crystals must be closely matched, within 10 to 20 Hz of each other. Dave at Small Wonder Labs was kind enough to do this for us. If the crystals are not matched the performance will be poor. All of the capacitors are the same, 150pf. The value of the capacitors has an effect on the bandwidth of the filter. It is important to match the input and output impedance of the filter to minimize the loss. I have no earthly idea on how to calculate this, but I do know what parts in the circuit are performing the impedance matching. C11 and RFC1 form an "L" filter to match the output impedance of U1 with the input impedance of the filter. The filter is terminated into R1 (470 ohms) before reaching U3.

The crystal filter is the core of nearly every QRP rig out there. I think it is important to understand what is happening here. Lets start a discussion on the function and characteristics of this filter and see what we can learn.

Mike,

I can sympathize. But handwaving explanations don't hack it when describing these multi-coupled circuits. So where does that leave us? It leaves us with the "black-box" situation that you describe. Don't knock black-boxes too much - it's a very powerful analytical tool in breaking down circuits. Xtal-filter is just one of those black-boxes where peeking inside reveals a lotta nasty math. Do you really wanna know where all those coupling coefficients come from?

Me - I'm math-adverse. After peeking inside, I'm content to use the design-tables But it IS useful to play about: What happens if you design for a wider bandwidth? Coupling caps go down. Terminations go up. What happens if you use low-Q crystals? In-band attenuation goes up. Passband edges become rounded. What happens if your termina-

tions are too low-Z? Passband ripple looks like a rollercoaster. What happens when your terminations are reactive? Passband gets skewed. SPICE simulations can help a lot to show this kinda stuff: use the book designs as a starting point, then play-about with SPICE. - Glen VE3DNL

Q. The thing I am having trouble with is this - why doesn't RFC1 effect the filter's shape and why doesn't C12 effect the impedance matching in this "swapped" position? Or is it that they do, but not significantly? I am intrigued by this because, as a neophyte designer, it isn't intuitive to me when one can "get away" with this.

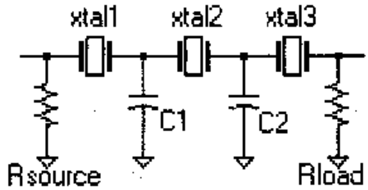
A. These components DO affect impedance match (and therefore filter shape as well). RFC1 and C11 form a "L-network" to match U1's output Z of 1500 ohms down to the filter's required impedance of about 350 ohms. However C12 is in there to modify Y1's series-resonant-frequency up a little higher (by 106 Hz) than Y2. It is not part of the impedance matching network.

We'll look through xtal filter design. - Glen, VE3DNL

SW40+ I.F. Crystal Filter

This note proceeds through the design of a Cohn-type crystal ladder filter. Starting with fixed crystal specs and desired bandwidth, a simple generic filter is designed. The generic filter is then modified to accommodate source and load impedances found in the SW40+ receiver. Component values work out close to those in the rig.

The simplest form of the ladder-type Cohn filter requires at least two crystals, but any number can be cascaded. Between pairs of crystals and ground must appear a coupling reactance. Source resistance and load resistance must also be defined. A two-crystal filter would result in inadequate sideband suppression. Four or more crystals require extreme care in selecting



crystal frequencies, coupling capacitors and termination resistances.

Crystal Model

From the Handbook you should review the electrical equivalent of a quartz crystal. By far, the two most important crystal parameters are the motional inductance Ls and motional capacitance Cs. From my junk-box a number of 4.0 Mhz. HC-18 microprocessor crystals were characterized. These should be *hopefully* similar to those in the SW40+ kit:

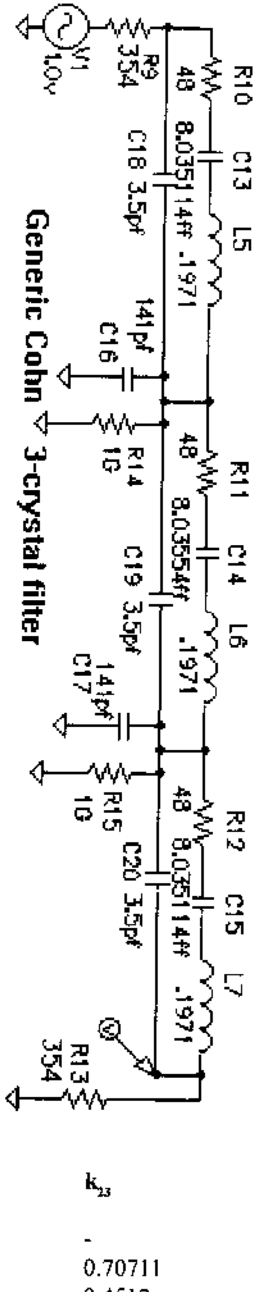
- Fs = 3999165 Hz. **Series resonant frequency**
- Ls = 0.1971 H Motional Inductance
- Cs = 8.03554x10-15 F Motional Capacitance
- Rs = 48 ohms Motional Resistance
- Cp = 3.5 pF Parallel plate capacitance

Besides crystal parameters, we must choose a desired filter passband width (BW). I choose 300 Hz. because I know from experience that component values will come out about right.

We can also choose from Butterworth, Chebychev, Gaussian, or Bessel responses. Each is optimized for different applications. One has minimum ringing, another has best shape factor. Butterworth response is reasonable for listening to CW.

Generic Ladder Design

I have followed the ladder design process as described in Handbook of Filter Synthesis by Zverev[2]. His ladder designs are exhaustively complete and unfortunately complex. The result is shown in the schematic "Generic Cohn 3-crystal Filter"



Generic Cohn 3-crystal filter

N	q	k_{12}	k_{23}	k_{34}	k_{45}
2	1.4141	0.70711	-	-	-
3	1.0	0.70711	0.70711	-	-
4	0.7654	0.8409	0.4512	0.8409	-
5	0.618	1.0	0.5559	0.5559	1.0

below. All Butterworth filters share coupling coefficients which determine the reactances of C1 and C2 of the generic filter above. For a Butterworth response, Rsource and Rload are scaled by another coefficient called "q" which is related to loaded filter Q (Fs / BW). Here is a table of Butterworth coefficients for ladder filters of N crystals:

For our 3-crystal generic filter, both coupling capacitors (C1 and C2) will have the same value, because k_{12} and k_{23} have the value of 0.70711. Their capacitance is roughly:

$C1 = Cm \times Fo / (BW \times k_{12}) = 8.03554 \times 10^{-15} \times 4000000 / (300 \times 0.70711) = 152$ pF

$C2 = Cm \times Fo / (BW \times k_{23}) = 8.03554 \times 10^{-15} \times 4000000 / (300 \times 0.70711) = 152$ pF

Since each of these capacitors sees Cp from two adjacent crystals, we should subtract off 2 x Cp from these values leaving us with 145pF. In any case, these are close to the values Dave chose for C13 and C14 in the SW40+ schematic.

Now let's try a simplified equation for Rsource and Rload. Our generic filter is symmetrical, so these will have the same value:

$Rend = 2PI \times Ls \times BW / q = 6.2832 \times 0.1971 \times 300 / 1.0 = 372$ ohms

These simplified values are close to those derived from the complex methods of Zverev[2]. PSPICE's requirement that all nodes not "float". There is one more aspect of this filter that we haven't addressed: frequency matching of the three crystals. For proper tuning, the two end crystals should have a series-resonant frequency 106 Hz. higher than the center crystal (from Zverev's design process). In the Generic Cohn filter shown, C13 and C15 have been decreased to reflect this frequency offset. In practice, we cannot modify our sealed crystals, and must execute the offset a different way so that three crystals of identical Fo can be used.

The frequency response of this filter is plotted below (Generic). Were the filter lossless, output voltage would be 500 mv.

This generic filter will now be adapted to make it work using three identical crystals. Since the SA612 source and load resistances are different from the generic design, matching networks must be added as well.

Compensating for 106 Hz. Offset

We can raise the series resonant frequency of the two end crystals by adding a capacitor in series with each. Currently, series resonance is:

$Fs = 1 / (2 * PI * SQRT(0.1971 * 8.03554 \times 10^{-15})) = 3999164.7$ Hz.

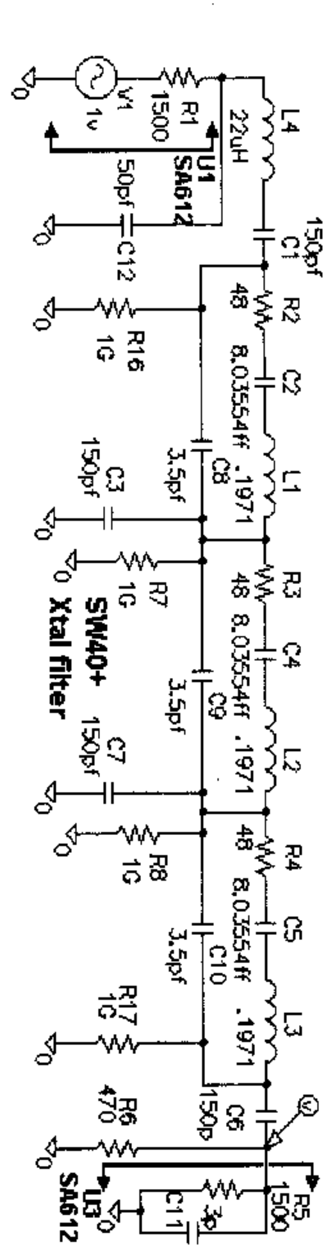
What capacitance would raise Fs to (Fs + 106) ?

$Cs(new) = 1 / ((2PI \times (Fs+106))^2 \times 0.1971) = 8.035114 \times 10^{-15}$ farad

Cs(new) is the total capacitance of two in series: our original crystal motional capacitance (Cs) of 8.03554 fF and our externally added modifying capacitor. Knowing Cs and Cs(new), we can find the value of the external capacitor:

$Cexternal = (Cs * Cs(new)) / (Cs - Cs(new)) = 151.56$ pF.

By adding this capacitance in series with Xtal 1 and Xtal 3, the 106 Hz. offset is accommodated - and all three crystals can be frequency-matched to within about 30 Hz. These capacitors appear in Dave's SW40+ schematic as C12 and C15. Is it coincidental that the coupling capacitors are the same as these frequency-tuning


L4
22uH
R1
1500
V1
1v
U1
SA612
50pf
C12
150pf
C1
R2
48
R16
1G
C2
8.03554ff
L1
.1971
C8
3.5pf
C3
150pf
R3
48
R7
1G
SW40+
Xtal filter
C4
8.03554ff
L2
.1971
C9
3.5pf
C7
150pf
R4
48
R8
1G
C5
8.03554ff
L3
.1971
C10
3.5pf
R17
1G
C6
150p
R6
470
R5
1500
C11
3p
U3
SA612

capacitors? For this filter (and *only* for 3-crystal types) this will always be the case.

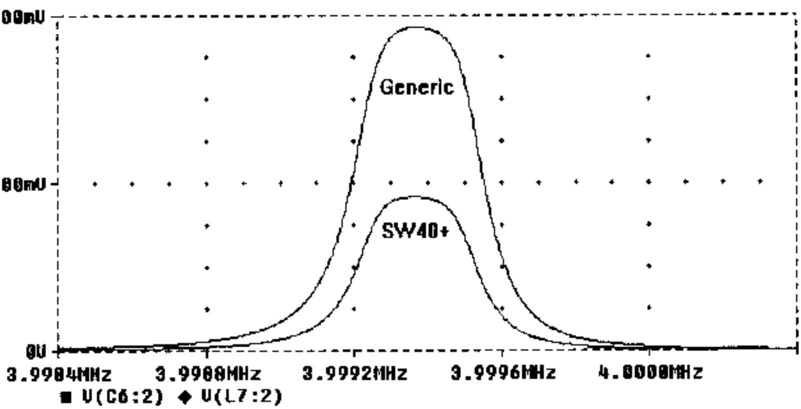
Matching to SA612 source and load

Driving the filter is a SA612 chip (U1), with 1500 ohm source impedance. The filters' load is also a SA612 (U3) whose input impedance is also 1500 ohms. Our filter would like to see terminations of 354 ohms.

Dave has chosen to simply load down the filter's output with a 470 ohm resistor (R1). This resistor, in parallel with the chip's 1500 ohms works out very close to the required 354 ohms. At the filter's input, Dave has chosen to add an L-matching network consisting of a 22uH choke (RFC1) and a 47pf capacitor (C11). Let's see how well these component values do in matching the required 354 ohms to SA612's 1500 ohm source:

At 4 MHz., the choke's reactance is +j553 ohms. C11's reactance (added to the SA612's 3pf output capacitance) is -j796 ohms. What's the parallel equivalent of 354+j553? It is 1218 ohms in parallel with inductive reactance of 780 ohms. C11's reactance nulls out this equivalent parallel reactance quite well, leaving 1218 ohms resistance - nearly matching to SA612's 1500 ohms. Here's the PSPICE circuit showing the SA612 equivalents at both ends of the filter:

This filter's response is overlaid ("SW40+") in the frequency plot above. Let's take a quick look at filter attenuation. Each crystal has a series resistance of 48 ohms. For the generic filter, if we assume that all filter reactances cancel somewhere close to the filter's center frequency, we have left 3 * 48 ohms series resistance dumping signal into a 354 ohm load. That's a simple voltage divider that delivers 0.713 of input voltage to the output.



For the SW40+ filter, additional losses are incurred because of the 470 ohm loading at the output. That's why the amplitude response is lower than the generic filter. The input side is matched, the output isn't.

References:
1 Hayward, Wes A Unified Approach to the Design of Crystal Ladder Filters QST May, 1982.
2 Zverev A.I. Handbook of Filter Synthesis Wiley 1967.

Part 9

The section we are going to build next is the product detector. Remember where we last left off, we had mixed the receive signal with the VFO down to the IF frequency. From there it is "magically" filtered by the IF crystal filter. Now we want to take that signal and turn it into something we can hear with our ears. This is the job of the product detector. It mixes the filtered IF with it's own oscillator that is running at the IF frequency. In this case, if the VFO frequency is 3Mhz, the transmit frequency is 6.9992Mhz (VFO + xmit mixer freq 3.9992Mhz). Remember that the crystal frequency in the oscillator of U5 is pulled 800 Hz lower by the addition of RFC2. This provides the proper xmit signal offset of 800Hz on the upper sideband. Remember that we are using a small part of the transmit signal as our receiver source, so the receive signal frequency is 6.9992Mhz. Once it is mixed with the VFO we get VFO - receive=3.9992Mhz (look familiar?). This is within the 500 hz bandwidth of the IF filter so this 3.9992 Mhz signal is presented to the product detector. The product detector mixes this signal with its own internal oscillator running at the IF frequency of 4Mhz. The resulting signals are 7.9992Mhz and 800Hz. The 800Hz signal is in the audible range for our ears to hear.

So far in the receiver we have been able to tune a signal with our VFO that was 6.9992 Mhz and turn it into an 800Hz tone on the receive end.

Gather the following components.
U3 NE612 mixer chip
C16 68pF
C17 47pF
C18 47pF
Y4 4Mhz xtal (the case of this one is not grounded)

Install on the board and check your work. Those of you with a scope can look at the output of U3 on pin 4 or 5. You should see an interesting mix of high frequencies (7.9992Mhz) and a low audio frequency (800 Hz).

For those without a scope, or if you just want to "hear" your receiver work, try this. Power off the rig. Get one of the 47uF caps left that has not yet been installed. Don't cut the leads! Tack solder the + lead to the C19 pad that is closest to U3. Now using clip leads connect one side of a speaker to the - lead of the capacitor and the other side of the speaker to ground. Make sure the room is really quiet. Power up the rig and hit the key. You should hear a very faint 800Hz tone coming out of the speaker. That is your superhet receiver at work! Cool, Huh?

Once you hear the tone, shut down the rig and remove the capacitor and put it back in the parts bag (you need it later).

There is not much to describe in this portion of the circuit. Just a standard implementation of an NE612 mixer.

Part 10

Up to now we have a functioning receiver. We have audio coming out of U3, but it needs filtering and lots of amplification. Let's build the first section. Gather the following components:
U4 NE5532 and socket
C19 .033uF
C20 .1uF
C21 .01uF

C22 150 pF
C23 150 pF
R2 10K
R3 10K
R4 510K
R7 510K
D3 1N4148
D4 1N4148

Install the components and check your work.

Turn on the rig and look at pin one of U4 with a scope when you key up. Hey, what's wrong here? I had much more signal at the output of U3 than I have here. What gives? Well, U4 is an amplifier, but it also has some limiting diodes in the feedback circuit, D3 and D4. These limit the output swing of the amplifier as to not saturate Q1, the mute FET (not installed).

Remember that up till now we are cheating with the receiver. We are using the transmit signal as a signal source to test our receiver. In the real world we would never have such a large signal on our antenna.

This section provides 30db gain and is differentially driven (like T2 at the output of U5) to take advantage of the greater signal voltage. It also acts as a low pass filter, rolling off frequencies that are over 1500 Hz.

R4 DC biases pin 3 of U4. C23 and C22 lower the gain of the stage as the frequency rises. Lets get a DC and AC analysis of this stage.

Part 10 Questions and Answers

Q. How can we calculate the DC voltages of this stage. Opamps should be easy, right?

A. Ok, it all starts with the +8v feeding in thru R4(510K)...that's the biasing reference voltage going into U4 pin 3. Since U4's bias current is so small, there'll be a very small D.C. voltage drop across R4, and pin 3 will end up with almost +8V too. Now at 0Hz (D.C. voltage), U4 has INCREDIBLE gain. That is, if there's ANY voltage difference between the two input pins (pin 2 and pin 3), the output D.C. voltage (at pin 1) will saturate: if pin 2 is ABOVE pin 3, the output will saturate down near zero volts... if pin 2 is BELOW pin 3, the output will saturate up near +12v.

Notice that there's a DC path from the output (pin 1) back to the "-" input (pin 2) through R7(510K). Once again, the D.C. current drawn into pin 2 through this resistor is tiny (insignificant). So to keep pin 2 = pin 3, the output will have to sit very close to +8V. So all three pins sit close to +8V. If you were to drag pin 3 down to +6V, the other two pins would follow. Isn't negative feedback wonderful?

Q. How do we calculate the gain of this stage. The manual says 30db. What is the voltage gain?

A. This is AC gain (DC gain is zero since C20 and C21 block DC voltages). AC gain is set mostly by the ratio of R7(510K) to R2(10K). This gives a gain of about 50. Actually, source impedance is a little higher than 10k, since we should add U3's output resistance of 1500 ohms (reducing gain a little). That's where the 30 dB comes from. But you can consider that gain is actually twice that, since BOTH output signals from U3 pin 4 and U3 pin 5 are used to drive U4 (each have the same AC amplitude). This is a differential amplifier configuration.

Q. Why is C21 smaller than C20?

A. To find the answer, you should look at the input impedance going into each input to U4 (this gets tricky): Input Z looking into R2 is 5K, not 10K as you might expect. Consider that when the input side of R2 is going UP, its output side is going DOWN by about the same amount. Remember, pin 2's voltage tracks pin 3's voltage...and pin 3 is driven from U3 with a signal of similar amplitude, but opposite polarity. Input Z looking into R3 is very very high, since each end of R3 has the same AC voltage on it....except for the effect of C22(150pf) and R4(510K). R4 actually sets the upper limit on input Z here.

So C20 sees 1500 ohms on one side (from U3) and 5K on the other side (from R2). This works out to be a high-pass filter, letting through everything above about 350 Hz. But C21 can be a LOT smaller because impedance levels approach 510K. C21(0.01uF) just happens to be a handy value that is used elsewhere.

Q. What is the purpose of C19? Is this a terminator of some kind?

A. Remember that U3 is a double-balanced mixer. It gives about equal output at two frequencies:

L.O. + I.F. (4.0008 Mhz + 4.0Mhz = 8.0008 MHz)

L.O. - I.F. (4.0008 MHz - 4.0Mhz = 800 Hz)

We want the 800 Hz. stuff, but we DON'T want the 8MHz. stuff since it could cause U4 trouble (wasn't made to handle R.F.). So C19 "terminates" the R.F., leaving audio alone.

BTW: C19 and C20 and C21 were all ceramic capacitors in my kit. These are prone to generating "microphonics". And since they're ahead of a LOT of audio gain, they are the prime suspects for replacement if you have microphonic trouble. Check for microphonics: once audio is coming out the headphones, tap the board and listen for "boink" aftereffects. If you hear any, try tapping or scraping along these three caps to see if its worse. If you can run a fingernail along the face of these caps, and hear it in your headphones, then you might consider replacing them with mylar, or polyester or any plastic film-type caps of the same value. Should help reduce microphonics a lot.

Q. Will Q1 turn on without C24 installed? Is C24 just to add a delay in turn on?

A. Yes, you've got it completely right. R8 willdrag Q1's gate up to +8V, which turns the FET into a low-value resistor. Previously we mentioned about C24 "charging". It is R8 that does the charging, via the +8V available at U4a's output at pin 1. Time constant is 0.1seconds (1MEGohm x 0.1uf)

When the FET acutally turns ON depends on its pinch-off voltage (different for many kinds of FETs)...may not be exactly 0.1seconds. A neat experiment would be to short out R9 temporarily, to see how really LOUD the sidetone actually is (blow your ears off). And you'd hear the T/R thump too, although the sidetone may cover it up.

An Experiment

The best way to see what Q1 (the mute gate FET) actually does is to disable it and listen. Before proceeding, be aware that audio from headphones may end up being mighty loud...

Tack-solder a temporary jumper across R9(4.7MEG) on the bottom of the board. This will effectively "bypass" audio directly into the headphone amplifer, disabling the FET from its mute function. It won't hurt the FET. You should notice no difference while receiving; the FET is normally about 0.1Kohms while the key is up. 100 ohms is as good as a short-circuit compared with the 22K of R10.

But now when you hit the key, be prepared for a monster sidetone. The FET becomes a very high resistance once the key is down, but audio just shoots thru the short-circuit you've added instead. See how far back you have to turn the RF GAIN pot to cut the sidetone level. With the short-circuit removed, a little audio gets past the FET through R9, providing a reasonably comfortable sidetone level. R8 and C24 are only in the circuit to provide some delay on key-up before the FET turns "on" and the receiver's audio comes back up. They have nothing to do with audio level, only timing. However R8 is required to drag Q1's gate up to the same voltage as its source. Vgs=0 volts is required for the FET to be "on".

Part 11: VFO Adjustment

Since we are close to getting our receiver finished, let's quickly adjust our VFO for operation in the amateur bands.

First, remove the temporary jumper that we installed before from Q6 to C36. This will remove our "cheat" and stop feeding xmit signal directly into the receiver.

You can use a frequency counter for this or a calibrated receiver. Using a frequency counter, connect the probe to the top of R29 or the cathode of D6. Turn on and key the rig, note the frequency. It should be around 7 Mhz. With a receiver, connect a clip lead to the top of R29 or the cathode of D6 as a small antenna. Turn on the rig and your receiver. Start at 7Mhz on your main rig and key the SW-40+. Tune the main rig up until you hear the transmitted tone. It helps to key it on and off so the carrier will be distinctive. Zero beat the receiver (tune it down until the receive tone gets so low you can't hear it, 0 Hz). The receiver is reading your transmit frequency.

Now, go to the manual page 16. Look up your frequency on the chart and find what capacitor that you will need for C7. Make sure you use the correct chart for Novice operation. Mine required a 68pF capacitor for C7. Install C7.

Next remove the temporary jumper at J2. Install the off board tuning pot (not included with kit) as per page 15 of the instructions. Now you can tune your xceiver. I built mine for the general+ segment. My freqency coverage is from 7.015 Mhz to 7.050 Mhz, perfect for me. Without C7 mine tunes from 7.111 to 7.149. Maybe I can install a switch on C7 to switch between General and Novice operation.

I don't remember if we covered this in the VFO section, but you can change the range of tuning by changing C8. Increasing C8 widens the tuning range and decreasing it decreases the tuning range. The manual states that the practical upper limit of C8 is 1000pF, and at the larger values capacitor and varicap thermal stability become crucial. Use NPO/C0G caps if you replace C8. Now that our VFO is set we are ready to finish the receiver and listen for some stations!

Part 12: Final Audio Amplifier

Ok folks, let's make this thing hear! We are going to complete the last section of the receiver that consists of the mute circuit and the final audio amp/bandpass filter.

During key down we want to reduce the signal to the final audio amp. Remember that a portion of our transmit signal is fed into the receiver to give us a side tone. We want to reduce the level to a comfortable listning level. On key down Q1 acts like an open circuit, so the only audio getting through is that through R9. This is why if you reduce the value of R9 that the side tone gets louder.

The second part of the circuit that consists of the other half of U4 is an amplifier / bandpass filter. It has approximatly 30db of gain and a center frequency near 800Hz. It also provides the power to directly drive headphones without needing and additional audio power amp. Those LM386s are noisy

The parts gathering should be getting easier as the contents of the parts bags dwindle.

R6 10 ohms

R8 1Meg
R9 4.7Meg
R10 22K
R11 510K
R12 1Meg
R13 1Meg
R14 10 ohms
D5 1N4148
Q1 MPF102
C24 .1uF
C25 820pF
C26 .0022uF
C27 47uF
C106 47uF
C107 .1uF

Install the above components. Be aware of the polarity of C27, C106 and Q1. Connect a set of low impedance headphones or a small speaker (good headphones are MUCH better) to J3 pins 1 and 2. Connect a temporary antenna to the side of C40 that does not connect to the 4 diodes D7-D10. The antenna should be long enough to pick up a strong signal, maybe 10 or more feet. Remember that we don't have the RF gain connected yet, so watch out for strong signals. This receiver is VERY sensitive. When signals are too high remember that they are clipped in the first audio stage by D3 and D4, so it shouldn't blow your ears out.

Try this in the evening when 40 meters is usually very active. Power up the rig. You should hear some hiss from the headphones. Tune around and listen for some CW signals. Cool, It hears! Glen Leinweber has done an outstanding circuit description of the audio sections. It is a detailed analysis of both the first and second stage audio circuits.

SW40+ Audio Circuits

A general-purpose dual operational amplifier (NE5532) is used to amplify audio to drive headphones. Most of the rig's gain occurs here. These audio circuits are detailed in many texts of op-amp applications. This note concentrates on aspects unique to the SW40+ application of these common circuits. Once again, circuitry is described in blocks: separated into power amp, mute gate and differential preamp.

Audio Output Amplifier

One of the two NE5532 op-amps is configured as a band-pass filter, and can drive headphones to a fairly high sound level. Its highest gain of 33 occurs at a frequency of 816 Hertz. Q is about three, giving a bandwidth of 270 Hertz. This bandwidth complements that of the crystal filter. It also reduces wideband hiss resulting from high audio gain that might be otherwise irksome. The components that determine frequency response and gain are **R10**(22K), **R13**(1MEG), **C25**(820pF) and **C26**(.0022uF).

Because the output at pin 7 is at a DC potential of +8v, audio must be coupled to headphones through a capacitor, **C27**(47uf). A "ballast" resistor is included, **R14**(10 ohms), to prevent strange reactive headphones from giving the op-amp a hard time.

This amplifier has a very low output driving impedance (less than one ohm), and will try to pump current into low-Z phones (or an inadvertent short-circuit) until internal current-limiting circuits kick in (maximum load current is 38 ma). Current limiting "clips" the positive-going and negative-going audio peaks, resulting in distorted, harsh audio.

The RF Gain control should be set so that audio level is below the current-limiting threshold. Set this way, current-limiting acts very nicely to clip the odd noise peak. You could call this a poor man's noise limiter.

With no feedback, this amplifier would have very high gain (over 10,000). The four feedback components mentioned above limit the maximum gain to 33. Don't think that the extra gain is "thrown away",it is diverted to other purposes:

- distortion is reduced
- output is very low resistance, able to drive any load
- input impedance is linear and predictable
- gain & frequency response is determined by passive (external) components
- operation is independent of supply voltage, bias voltage and temperature

Reducing excess gain with feedback is a powerful way to improve desired amplifier characteristics - most of the amplifiers in this rig (RF as well as audio) use this technique. You can thank feedback for making sure the theoretical and measured frequency response shown above agree so closely.

The Mute Gate

Q1 is a switch. When it is "open", its impedance from source to drain is very high (many megohms). A small fraction of audio is allowed to leak from U4a to U4b through **R9**(4.7MEG) so that a "sidetone" can be heard. When it is "closed", the FET appears as a small resistance (roughly 100 ohms from drain to source), and audio is conducted through it from U4a(pin 7) to **R10**. You should be able to see that **R9** and FET switch are effectively in parallel for audio signals.

Why is this FET *not* an amplifier? Its drain and source are at the same DC voltage. This means that there is no standing DC bias current: the only current passing through this FET is due to AC signals. But doesn't the AC signal appear between source and gate, as in an amplifier? Consider the DC potential there as well... When the FET is "open" a full -8 volt DC potential on the gate overpowers any small AC signal on the source -nothing gets through. When the FET is "closed", the gate and source are connected together through **R8**(1MEG) keeping the gate at the same DC potential as the source. However, **C24**(0.1uf) bypasses the gate, so yes, audio signals on the source could affect the FET-switch operation. However, as long as AC signals are small (less than a few hundred millivolts), resistance between source and drain remains linear, and insignificantly small. You can't use a gate like this at high audio levels (at headphone levels, for instance) because of the requirement of small drain-to-source AC voltage.

The capacitor **C24**(0.1uf) is required to keep the FET gate in its open state after transmitting for a few hundred milliseconds to allow the receiver to "recover" and not pass an audible thump on key-release. C24's voltage is dumped very quickly through **D5** to cut off audio very quickly, preventing an audible thump on key-down. Sequencing transmit/receive switch over this way is critical for seamless audio with no clicks or thumps.

Audio Preamp, U4a

U4a is configured as a differential amplifier. A regular amplifier's input uses ground as its voltage reference. A differential amplifier has two inputs (neither one grounded): output is proportional to the difference between these two inputs. A good differential amplifier ignores any signals that are common to the two inputs, only amplifying differences. In this case, differential inputs are at **R2**(10K) and **R3**(10K).

This kind of amplifier is more complex, requiring more parts than a simple amplifier. Why did Dave choose it? The product detector **U3** provides two opposing-polarity outputs ideally suited for differential amplification. This means that audio amplitude is effectively twice as big. With so much audio gain following, audio hiss due to op-amp noise is significant. We should take advantage of all the signal available: a single-ended amplifier could only use one or the other output of **U3**, not both.

There is a more subtle reason for using the differential configuration that also involves noise. **U2** is a rather noisy voltage regulator - while its output is a constant +8v, AC variations (at 800Hz) are significant. So **U3's** supply (pin 8) contains audio noise that propagates through internal 1500 ohm resistors to its outputs at pin 4 and pin 5. Since this noise is common to both outputs, a differential amplifier will ignore it as a common-mode signal. Remember, **U4a** will only amplify *differences between* the two outputs of **U3**.

Gain of **U4a** is mostly set by the ratio of two resistors (**R7** / **R2**). That's 510K/ 10K or a gain of 51. Differential gain is twice this value (102). **U4a** is also a simple low-pass filter, with **R7**(510K) and **C23**(150pF) providing a roll-off frequency of 2080 Hertz. Diodes **D3** and **D4** clip large amplitude signals, keeping output signals small enough that the mute gate can handle them. These diodes also help keep U4a stably biased, even for very large input signals.

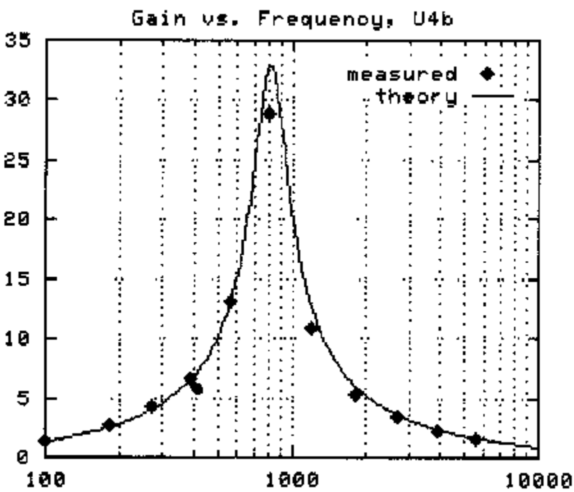
Audio from the product detector is fed into the differential amplifier through coupling capacitors **C20**(0.1uF) and **C21**(0.01uF). **C20** and **R2** act as a high-pass filter with cutoff frequency of about 350 Hz. **C21's** effect on frequency response is insignificant since U4a's input resistance on this leg is so high.

Glen has done some excellent work here. Please read through it and be prepared, bring your thinking cap. All we have left is the power amp and output filter.

Part 12 Questions and Answers

Q. I rewired my phone jack so that the headphones would be in series rather than parallel as suggested in "QRP Power", page 3-22. The Op amp seems to drive my phones louder before clipping. It really seems to work for me. I gotta wonder why it wasn't designed this way, is there a draw back that I'm not aware of?

A. I agree, that's the way to wire headphones, especially when driven from a feeble driver like an op-amp. But there IS a catch. You must be careful not to ground the headphone jack. The shell of the jack is the common-point between the two headphone elements. When you wire each



element in series, then one "hot" element-end ends up going to the ground-plane on the printed circuit board. The headphone jack shell is now at a half-voltage point.

If you try to wire the jack in a series-connected way, and find you only get audio out of one side of your phones, the cause could be a grounded shell. Insulating the jack from ground should solve the problem. Or using a plastic (insulating) case to mount everything solves the problem too.

Audio Experiments

Here are some experiments to try on your SW40+ receiver to help determine noise sources in the rig. Just how much audio noise is internally generated, and how much is due to RF noise coming in the antenna?

Experiment #1. Pull out U3(SA612) with the power off. With the rig powered back up, you'll hear low-level audio hiss. Take a mental note of its level, or measure its amplitude on your scope. This hiss is entirely due to noise being generated within the high-gain audio op-amp stages of U4. It isn't very loud. Power off, replace U3 (careful to place pin 1 correctly) and power up. Compare the "hiss" level: significantly louder. Even though the bulk of this rig's gain is in audio stages, most noise you hear is RF noise. Good.

You could do this experiment as well by carefully jumpering pin 4 to pin 5 of U3. I did this with power on, holding a short insulated wire. Be careful not to short adjacent to pins.

Experiment 2: Take an electrolytic capacitor (I had a 47uF/16V handy) and bypass U3 pin 4 to ground. GET THE CAP'S POLARITY RIGHT! Try bypassing pin 5 to ground too. Since half the audio signal comes from pin 4, and the other half from pin 5, you'd expect noise level to drop by 3dB. But I hear noise level go up! Careful listening revealed that noise BANDWIDTH went up too. What's going on?

This is tricky (hope I've got it right). If you listen carefully, you'll hear the narrowband noise (400Hz wide) drop in level, as expected. But wider bandwidth noise is introduced that brings the apparent overall noise level up. Where did this noise come from? I believe that it comes from U2, the 78L08 regulator. It sends wideband noise into U3's power supply pin 8. This noise shoots thru a 1500-ohm resistor (inside the chip) into the audio amp. When you DON'T short one of U3's outputs to ground, this noise appears IDENTICALLY at BOTH outputs of U3. Since U4a is a differential amplifier, it rejects U2's noise as a common-mode signal. U4a only amplifies difference-signals between pin 4 and pin 5 of U3.

Experiment #3. Listen to the noise level while you unplug your antenna. Noise should drop. This is a quick-n-dirty test to determine if a receiver has enough "sensitivity". With no antenna, you're listening to noise generated entirely within the receiver.

Here are some other "safe" points in the receiver that you could try shorting to ground with a short insulated jumper:
-link winding of T1 (J1 pin 3)
-either end of RFC1
-Junction of Y3(4MHz) and C15(150pF)

Glen VE3DNL leinwebe@mcmaster.ca

If you are having trouble peaking T1 for max audio out:

My rig would not peak. The slug in T1 was all the way out and I did not reach a "peak" in the signal. I soldered a 22pf capacitor in parallel with C1, which took the total capacitance to 69pf. I got a nice peak at about mid range of the slug.

If you are having trouble peaking and the slug is all the way out, try adding capacitance. If the slug is all the way in, try reducing C1.

Part 13:Final RF Amplifier and Filter

This is the last construction section The last part of the kit is the final RF amp and output filter.

FROM THIS POINT ON MAKE SURE YOU HAVE A SUITABLE ANTENNA OR DUMMY LOAD CONNECTED TO THE ANT PAD ON THE CIRCUIT BOARD. Transmitting without a resonant antenna or dummy load will cause high SWR and can damage the final transistor. This is why we saved this section for last. An outstanding description of this amplifier and it's function was done by Glen, VE3DNL.

SW40+ Final Power Amplifier (Q6)

QRP power amps are not complex: you'll see from this note that modeling the transistor as a SPST switch gives accurate results. A PSpice switch model is compared with a full-blown PSpice transistor model, and then compared with oscilloscope waveforms taken from a working SW40+.

Q6 substituted with a switch?

Yes, let's try this simplifying model first. Q6's collector/emitter is substituted with a SPST switch. PSPICE controls the on/off state of the switch from a control voltage. So our simple switch actually looks like a four-terminal device: two terminals are the actual switch, while two terminals accept the control voltage. In our case, the control voltage **V1** is a 7MHz. square wave so that the switch **S1** is *on* for a time period of 71.4 ns. and *off* for another 71.4ns. **V2** is the +12v D.C. power source. **Rantenna** represents a 50-ohm dummy load. All other components show their SW40+ schematic designations. Remember, **S1** substitutes for the collector-to-emitter connections of **Q6**.

The PSpice waveforms show voltages at the switch [**V(L4:2)**] and at the 50-ohm dummy load [**V(C36:1)**]. It should be clear that when the switch is on (short-circuit), its voltage is clamped to zero. When off (open-circuit) switch current is zero, and voltage at the switch terminal can float wherever it wishes. The floating voltage is constrained by choke **L2** and the following PI network components to look like a half-sinewave, swinging up over the +12v supply voltage, before the switch turns *on* again. Note that the average voltage at the switch must be equal to the supply voltage of 12v. The inductor **L2** requires this to be true. When the switch is on, it temporarily drags **L2** (and **C36**) down to ground. Then the switch opens: voltage must soar above the supply in order to keep **L2**'s average voltage at 12v. That's why peak voltage rises to about 34v. The combination of **C36** and the 50-ohm dummy load resistor must result in average voltage at the load of zero. So the dummy load voltage swings about zero volts: rising to +17v and dipping to -17v. The five-section PI filter consisting of **C37**, **L3**, **C38**, **L4** and **C39** accepts only the 7MHz energy and rejects most of the higher harmonics. The result is a clean sinewave at the dummy load shown as **V(C36:1)**.

PSpice transistor modeling

How accurate could the simple SPST switch model be? Let's do a more complete SPICE model that includes not only a transistor for **Q6**, but a proper driving circuit too. The final amp is actually a 2N4401 transistorscaled up in size. Q2's collector drives the primary of a transformer. Coupling between L3 and L4 is tight (99%) as a ferrite toroid should be. An attempt was made to simulated lead inductance at Q1 with 5 nh inductors (L6 & L8). This model is very close to the SW40+ schematic, however, the parts numbering is different. Now let's compare the three cases: the collector voltage of the final amp from the PSpice model above, the actual waveform as measured on an oscilloscope, and the simple switch model. The switch model (bottom) is very similar in amplitude and shape to the more complex transistor model (top). The oscilloscope trace (middle) has slightly lower amplitude, is a bit more jagged, but maintains the same shape. Note that peak voltage rises up to nearly 30v. The zener diode **D12** would clip anything more than 33v, protecting **Q6** from overvoltage. Should you decide to raise the supply voltage, **D12** should be swapped for one of higher voltage. **D12** should never conduct during normal operation: normally, it only contributes a small capacitance. Note that circuit operation depends almost entirely on passive component values, not on transistor characteristics. The PI filter is nearly symmetrical so that (at 7MHz.) the transistor "switch" sees a 50-ohm non-reactive load. If the transistor switches efficiently, and component losses are ignored, then we'd have a 12-volt peak square wave applied to the filter. With harmonics rejected, that works out to 1.44w RMS out the antenna.

Is Q6 a class C amplifier? Here are some "classic" definitions of class C operation:

- With no input drive, no collector (plate) current flows
- Collector (plate) current flows for less than one-half cycle
- Collector (plate) voltage shouldn't saturate

The SW40+ final amp only satisfies the first point. Collector current flows for close to half-a-cycle (perhaps a little more). Collector voltage saturates down to zero volts. Some folks use the term saturation in slightly different context: if input power is increased, the amplifier is said to be saturated when power output no longer increases. At this point, the amplifier has long before hit ground on the negative-going swing (voltage saturation). When cranked up, the SW40+ still has a little more to offer before power saturation, but not much. I'd hesitate to use the "class A/B/C/D" criteria of operation. Dave has attempted to make the final amp run as efficiently as possible. You can get an idea of how little power is wasted by feeling how cool **Q6** is, and by the fact that no heatsink is required. Half-cycle conduction, nearly full saturation, and operating into a high load impedance all contribute to high efficiency. Following the "class-C rules" above would result in wasted power.

Q6 base drive

What's it take to drive **Q6**'s base? It is very low impedance. Voltage here never gets very large because **Q6**'s base clamps to about +1v, and diode **D6** clamps to -1v. You might think that **R29**(51 ohms) establishes the base drive impedance, but it is nearly ten times larger than actual impedance of about six ohms. The one-turn link winding on **T4** provides a low driving impedance for Q6's base.

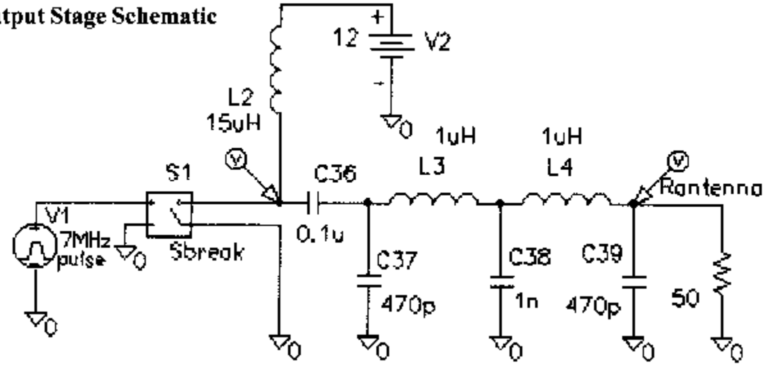
Before I read that page, I would have described Q6 as a class C amplifier. Glen shows that the lines are a little blurry when defining an amplifier in a class. Glen modeled Q6 as a simple switch, on for one half cycle of the 7 MHz and off for the other. As you will see the model comes really close to what was actually measured.

I'm not sure about this, but it seems to me that with Q6 either full on or full off that it's power dissipation must be fairly low. This is also reflected in the fact that Q6 has no heat sink. Operating my SW-40+ in a normal QSO, Q6 barely got warm to the touch.

As for the output filters, they are described as a "5 element Chebyshev" filter. Back in March Chuck posted and excellent tech. description that I am going to include here. The following was done by Chuck Adams with parts by Paul Harden.

A March 26th posting by Paul Harden on low pass filters prompted this posting. C36 is a 0.1uF and is a simple coupling cap, that is, blocks DC from the final transistor (PA) from the filter components.

Output Stage Schematic



L3,L4 and caps C37, C38 and C39 for the output filter, which is basically TWO low pass filters glued together (hopefully with solder!). The values are:

L3, L4 = 1uH (16 turns on a T37-2 toroid)

C37,C39 = 470pF

and C38 = 1000pF

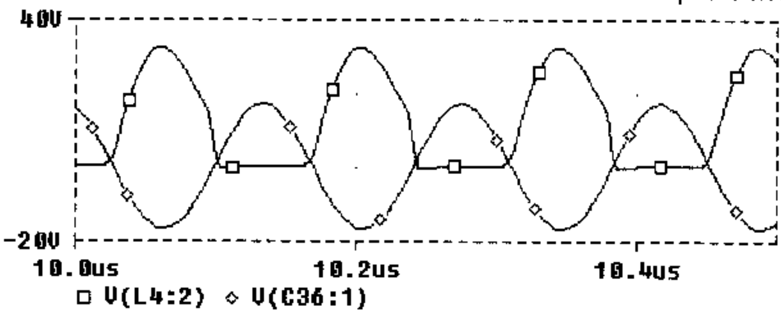
At the desired frequency of operation, if you will make the impedance's XC (37) = XC (39) = 50ohms, XL(L3) = XL(L4) = 50 ohms, and XC (38) =25 ohms to get 50 ohms to 50 ohms impedance match. You can see why C38 has twice the capacitance of C37 or C39.

Here is a table for L and C values that will give you 50 ohm reactance at each of the most popular QRP frequencies.

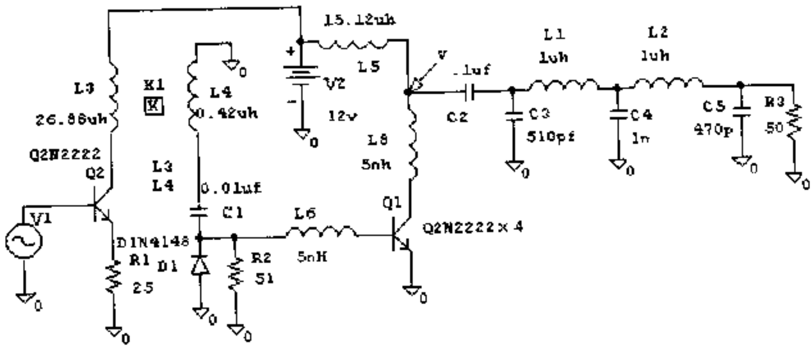
Freq [MHz]	L [uH]	C [pF]
3.560	2.23	894.1
3.710	2.14	857.9
3.579	2.22	889.3
7.040	1.13	452.1
7.110	1.11	447.7
10.106	0.78	315.0
10.116	0.78	314.6
14.060	0.56	226.4
18.080	0.44	176.0
21.060	0.37	151.1
24.910	0.31	127.8
28.060	0.28	113.4

*C = capacitance for end caps. Double value for center cap.

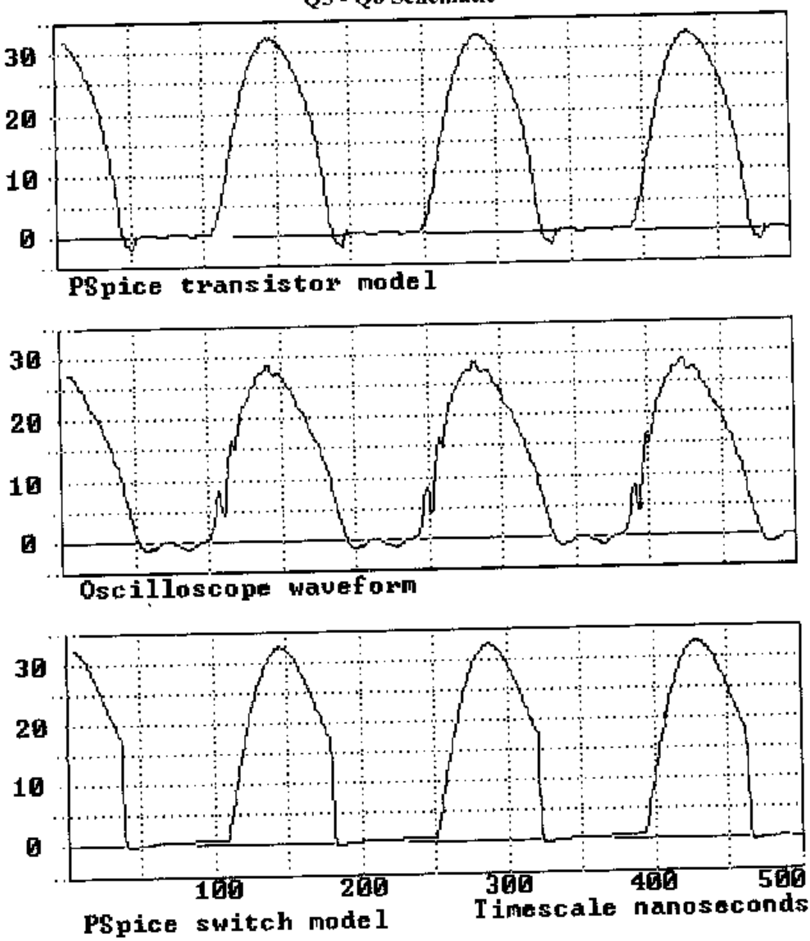
Now the C values are not exactly off the shelf standard values, so you try for the closest you can get. Let's use the 40 meter frequency of 7.040MHz for an example. Dave chose 470pF for C37 and C39 and 1000pF or 0.001uF for C38 and L3=L4=1.02uH. This because 390pF is close on the low end and 470pF is closer to the desired value of 452pF and 0.001uF



PSpice Switch Simulation Waveforms



Q5 - Q6 Schematic



Comparison of PSpice Transistor Model, Scope Waveform & PSpice Switch Model is closer than 820pF for C38. See Paul Harden's book for the standard capacitor values. These values are also the same values recommended by Wes Hayward in the SSD book. (Solid State Design for the Radio Amateur an ARRL book)

For the inductors, we get for the two popular toroid sizes used in QRP work and the two most popular cores:

	T37-2	T37-6	T50-2	T50-6
# turns	[uH]	[uH]	[uH]	[uH]
1	0.00	0.00	0.00	0.00
2	0.02	0.01	0.02	0.02
3	0.04	0.03	0.04	0.04
4	0.06	0.05	0.08	0.06
5	0.10	0.08	0.12	0.10
6	0.14	0.11	0.18	0.14
7	0.20	0.15	0.24	0.20
8	0.26	0.19	0.31	0.26
9	0.32	0.24	0.40	0.32
10	0.40	0.30	0.49	0.40
11	0.48	0.36	0.59	0.48
12	0.58	0.43	0.71	0.58
13	0.68	0.51	0.83	0.68
14	0.78	0.59	0.96	0.78
15	0.90	0.67	1.10	0.90
16	1.02	0.77	1.25	1.02
17	1.16	0.87	1.42	1.16
18	1.30	0.97	1.59	1.30
19	1.44	1.08	1.77	1.44
20	1.60	1.20	1.96	1.60
21	1.76	1.32	2.16	1.76
22	1.94	1.45	2.37	1.94
23	2.12	1.59	2.59	2.12
24	2.30	1.73	2.82	2.30
25	2.50	1.88	3.06	2.50
26	2.70	2.03	3.31	2.70
27	2.92	2.19	3.57	2.92
28	3.14	2.35	3.84	3.14
29	3.36	2.52	4.12	3.36
30	3.60	2.70	4.41	3.60

Dave went for the 16T on a T37-2 for a value of 1.02uH. He uses 1.00uH in print and that is close enough due to variations from core to core on the A(L) value.

I did a quick SPICE simulation and here is my first recommendation for a SW-40+ mod. You knew the mods were coming, didn't you????? Add one more turn to L3 and L4, thus 17T, and this will increase the second order attenuation by an additional 4dB without significant penalty at the fundamental. And I even modeled in some additional distributed capacitance due to packed turns and it seems to be for the good in this case. I get 34.85dB down at 14.080MHz for 17T vs 30.79dB down for 16T. Now as soon as some of the people get theirs built and can get them to a lab with a high-dollar spectrum analyzer they might take the time to try it both ways and tell me if their is any difference. Probably not enough to worry about, but it would be interesting to look at theory vs real data. The SW-40+ etc. all work great as designed and built from the instructions, so this recommendation may be ignored. Due to other factors yet to be studied (see below) the input impedance of the final PA may influence this effect.

Now those that are going to move their SW-40+ rigs to the Novice frequencies on 40M will start to ask questions on what mods do they need to do? The answer is none, as the filter is not critical for the small change from the low end of 40M to the higher end.

In the latest issue of QRP ARCI Quarterly you will see a graph of attenuation curves from a bunch of filter values that I took from all the W1FB books and Dave's filter. NN1G's is the solid curve. The only one that beat it was the theoretical maximum. Good job Dave.

Those of you that went to the trouble of getting SPICE up and running on the computer can check out what happens when you vary some of the values.

One more thing to look at is relative to postings that I see where people 'squeeze' the windings together for these type filters and see power output increase

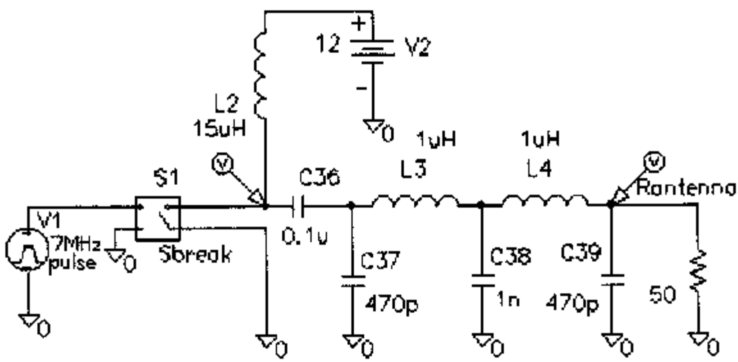
from a rig into a dummy load. Personally, in my opinion, this is a dangerous practice. Into a dummy load, the second and third harmonics (which may increase) contribute to the forward energy detected by the SWR bridge and or power meter. BUT, into a real antenna you may see the reflected power increase at the same time, thus showing that the effect is not what you really want. Again, this is something else to experiment on. Remember, mileage may vary. You have to take lots of data and that's what makes it all interesting and challenging. For those that like to read:
"Ferromagnetic-Core Design & Application Handbook" by Doug DeMaw, W1FB, published by MFJ Publishing Company, Inc. Starkville, MS 39759, MFJ-3506, $19.95
"Simplified Practical Filter Design" by Irving Gottlieb, published by TAB Books, Blue Ridge Summit, PA 17294-0850, ISBN 0-8306-3355-3, $16.95. and of course the ARRL HB and Paul Harden's book.

Now back to building. Wind L2, L3 and L4 torroids as per the instructions in the manual. Remove the temporary jumper from J1 and install the proper 5K RF gain pot. Gather and install the following components:

L2 as per instructions
L3 as per instructions
L4 as per instructions
C36 .1uF
C37 470pF
C38 .001uF
C39 470pF
C113 .1uF
D12 33 V zener diode
Q6 2SC2078

You will have some capacitors left over. That's ok. They were included by Dave for the VFO calibration. Check your work. Be aware of the polarity of D12 and Q6. Don't install them backwards.

Connect a 50 ohm dummy load to the ANT connection and ground. I just soldered some wire to an SO-239 connector and soldered the other ends into the ANT and ground holes. The antenna connection should go to the center conductor and the ground should go to the shield. I then connected the SO-239 connector to the dummy load in the shack. If you have a QRP watt meter you can put it between the rig and the dummy load to check your RF power out. If you don't have a watt meter, con-



Output Stage Schematic

nect your RF probe or oscilloscope across the dummy load to view the output.

Turn it on. You should hear static from the headphones. Turn your RF gain to maximum. Key the rig. You should see your watt meter move to about 2 watts and hear a nice side-tone. O-scope users should see about 30 volts peak to peak of RF. You can adjust the R24 potentiometer to vary the power out. I turned mine up all the way and the waveform got distorted. I backed it off until it looked clean and then turned it down some more. Now I'm measuring 30 volts p-p which is about 2.25 watts out. Remember that peaking the power into a dummy load is not the best way to get the most power. You may be increasing one of the harmonics and the actual useable power may go down. Also your rig may not be in FCC spec for spurious emissions. If I had a spectrum analyzer I'd like to see how the harmonic output changes with R24 position. Well, that's it. If your power out looks good, put it on your 40 meter antenna and make a contact. My first two contacts were Texas, then Cuba. Not bad for 2 watts.

I put my board in the case from a computer A/B switch box. I mounted the RF gain, tune pot, phones and key jacks in the front. On the back I put the antenna SO-239 and the DC power jack. Right now I don't have an on/off switch but I think I may add one to the RF gain pot. I used a 10 turn Spectrol linear pot for tuning. I also got one of those small 10 turn indicators. I thought it would be easy to calibrate, but it seems that the varactor response is not linear. The frequency difference between major divisions is 2kHz on the ends and 5kHz in the middle. So all I did was make a little chart on the front of the rig that had the operating frequency for every one of the 10 major divisions. Enough to get me close. I can tune between 7.015 and 7.050 Mhz. I think the first addition to this rig will be a Small Wonder Labs "Freq mite" for a CW frequency indicator. This radio is a joy to use. It is small and uses very little power, yet the receiver is very sensitive.

Part 13 Questions and Answers

Q. I'm not sure about this, but it seems to me that with Q6 either full on or full off that it's power dissipation must be fairly low. This is also reflected in the fact that Q6 has no heat sink. Operating my SW-40+ in a normal QSO, Q6 barely got warm to the touch.

A. Absolutely right. Only reason Q6 gets warm is that it doesn't switch "on" instantly and "off" instantly. Dave has designed the final for very high efficiency: Driving with 50% duty-cycle helps. Saturating Q6 helps too. Keeping the load (that Q6 sees) as large as possible helps too. Dave gets maximum power out using minimum DC current. This is very important for QRP rigs that might run from batteries. A Class C amp that followed all the "class C" rules wouldn't do as well.

Final Questions, Answers and some Troubleshooting Tips

I traced the low sensitivity problem I was having with the SW40+ to Q1. Good audio on the source and low audio on the drain. Had some MPF102's on hand and replaced same. Problem solved! Now, no matter where I put the probe around the bench, I have to turn my signal generator off to not hear it. The keying thump also went away. Guess that was the clue all along.

I tacked an 8.2pf NPO (had one) to the board, across C1 and can now tune T1 for a peak.(K8IQY changed C1 to 68pf to get a peak and Glen Leinweber mentioned that he gets T1 to peak with core turned near the end.)

Q. I am building a SW-40+ (with the QRP-L Elmer 101 project). I got the transmitter working with your help. Thanks! It puts out a nice, clean 2+ watts. About 30 V peak-to-peak. Very nice signal.

Then I couldn't wait any longer, and went ahead and finished the kit! I have a problem. Now when I transmit, I get very little power out of the transmitter. (I haven't even tried to see if the receiver works yet.) I only get about 150mv peak-to-peak out when keying the transmitter. I am trying to understand the TR switch circuitry, and the 4 diodes (D7 - D10). It almost looks like the diodes will limit the voltage. Then I calculated the impedance of C40 to be 500 ohms at 7MHz, so I guess if I can get enough current flow through RFC3, the combined IR drop across C40 and the voltage drops from the two diodes should still be OK.

It isn't. Do you have any ideas what could be wrong? I did install the potentiometer at J1 and peaking T1 does affect the transmitter output very slightly. RFC3 is not "open". I have not installed the tuning potentiometer at J2 yet. but still have the jumper from pin 2 to 3.

A. C40 and RFC3 form a series-resonant tuned circuit, which resonates around 7MHz. Its low-Q, so doesn't need to be trimmed. So even though you calculate 500ohms for C40, the actual impedance between the antenna PI filter and the RX input (T1) is very low. With a properly working transmitter, D7-D10 will conduct on the transmitted peaks, limiting the >30v to about 2.6v p-p. When the diodes conduct (while transmitting), their impedance is VERY low. This destroys the Q of C40/RFC3, and you can't think of these two components as a series- resonant circuit anymore. Now RFC3 acts as a choke of 440 ohms impedance going into the receiver.

What does the transmitter see? It mostly sees a 47pf capacitor going to ground - the diodes provide a ground-path for a large portion of the 7MHz cycle. You could ground the diode-end of C40 and the transmitter wouldn't notice (but then the receiver wouldn't get any signal).

In troubleshooting your transmitter, I'd look elsewhere for the trouble, not at this part of the TR circuit. I'd be looking around Q6... at D12, D6. I'd want to know if Q6 is getting a good base-drive signal. That'd tell me if the trouble is before the final. If there IS a good 7MHz signal at the base, I'd be taking a close look around Q6, D12, L2, and the PI-network to the antenna. Hope you've got a dummy load on, while testing.- Glen

Q. Thanks for the help! Here is the latest in the saga. First of all, yes, I do have a dummy load connected. I checked the voltage at the base of Q6 and get a nice, solid 2 V p-p at 7MHz. The voltage at the collector of Q6 remains a meager 150 mv p-p. This pointed me to suspect D12. I lifted one end of this diode so I could check it with my Ohm meter. I get about ~74 ohms(??) in one direction and "infinite" in the other direction. I think this indicates that it is OK, but it may still be the culprit. I don't have an easy way to test the reverse "zenner" action that this diode is supposed to provide. I don't have another 33V zenner handy, but will get one if you think that is still a prime suspect. I haven't tried transmitting with D12 lifted. I don't think it would hurt anything, and didn't dare!

I tried grounding the diode end of C40, and the transmitter output still remains the same. I have checked all the DC voltages that are indicated on Dave's schematic, and all are good. L2 appears to be good; the 150mv p-p is found on both sides of L2.

The thing that is so confusing to me is that the transmitter WAS WORKING FINE until I added the receiver and TR circuitry. This makes me suspect a component that was ADDED. Not necessarily, I know. Is it correct that I should see about

30v p-p from the collector of Q6 to ground? (Same as the output of the PI network.)

A. Since you've got D12 lifted, try the transmitter. Just be sure your dummy load is connected: the purpose of D12 is to protect the final amp from rouge loads. 74 ohms seems a little low for measuring the impedance of the zener. But some ohmmeters display strange stuff when measuring diodes, depending on their current source, and voltage scaling. Since it DOES measure infinite resistance the other way, I'm with you - I think it's probably OK.

Looks like you've got good base drive on the final. Its looking more and more to me like the final amp (Q6) is cooked somehow. Before pulling it out, do a really careful visual inspection on top of the board, and on the bottom of the board around Q6, L2, D12, C36, C37, C40 and L3. Look for open circuits and shorts. I'd do this check under a really bright light and a magnifying glass. I've found more than a few faults this way: things like hair-line cracks in traces, or lifted pads or filamentary shorts between traces. Measure the DC voltage on the heat-sink tab of Q6: should be +12V DC. Measure the base drive right at the base lead of Q6: you may have measured it elsewhere, and somehow its not getting into Q6. Also, make sure the emitter lead is well-grounded too - its not a check that Dave has asked for, but the final amp sure won't work if Q6's emitter isn't at ground.

Yes, the peak-to-peak voltage at Q6's collector should be in the range of 20-30 volts, unless you've got the drive pot turned way down.

The next step after doing all these checks is to pull Q6, and test it with your ohmmeter. De-soldering a three-legged transistor like this is tricky: the printed circuit pads take a beating. Its an area where currents are high, so you don't want to beat-up these pads too much. Sometimes its better to cut Q6 out rather than de-soldering it. Then you can clear the three holes one-by-one. Good luck, and keep in touch.-Glen

Q. YES! It works! The bad guy was Q6. I changed it, and now the transmitter is putting out a nice, clean 2+ watts again. Getting almost 30V p-p on output! Now on to testing the receiver. Glen, thanks so much for your time and your patience. In retrospect, debugging a problem like this has helped me understand the circuit more, and that is why I am building this. I really was confused though, and I really appreciate your depth of knowledge and willingness to help.

Q. My sw-40+ tunes from 7.0010 to about 7.036. When I tune in the low part(7.0010-7.0017), I hear a high frequency whine. It is now very loud, simply a bit over the background noise. What is causing it? Where does it comes from?

A. If the whine is tunable, and is at its lowest pitch at the low end of the band. It's a 'birdy', or spurious mixing product. The product detector is sensitive not only to its 4 Mhz LO, but to oddharmonics of that LO signal as well. As you tune to 7.000, the 4th harmonic of the (3.000 mhz) LO beats with that spurious 12 Mhz product detector response to produce an audio output. If the pitch of the whine isn't tunable, it may be an intermod (IMD) product and can be eliminated by backing down the 'gain' control a bit. If that doesn't take care of it, it's an IF response, and can be minimized by 1) grounding the crystal cases ans 2) buttoning up the board in an enclosure. The diagnostic for this involves touching the crystal cases with a fingertip to see if this makes the whine louder.

Q. I will reverse the tuning pot wires... Right now, it is set in a reverse way (increasing freq. by going counterclockwise). I will probably do the same for the gain. Louder counterclockwise...Did Dave reverse things on his drawing coming with his enclosure? Or did I simply reversed the pots? (solder posts up instead of down...)

A. My original hookup illustration was incorrect- it's been fixed. (That presumes that 'clockwise' should correspond to 'increasing frequency', of course.)

Q. I had to play around with L1 to get the desired range. Any suggestions on how to "cast it in concrete" to make sure it doesn't drift due to shock and vibration? What material do you people use, and how do you go about pouring/installing it without getting goop all over the rest of the components? Second, on receive I've got considerable hum in the background even with the volume control all the way down. Any way to get rid of it? Third, when I turn off the power, the rig gives a loud squeal through the headphones — loud enough to be quite uncomfortable if you're wearing the phones. Again, any way to get rid of this electronic flatulence?

A. Use clear finger nail polish on the toroid(s). Cheap and it works great. On the hum. You did not say what you were using for P/S. Battery? Otherwise check the DC output from other P/S's. P/S = Power Supply. The "I'm turning off patented NN1G feature" of the SWL-XX and SW-XX+ series is due to the audio section becoming an oscillator as the voltages and currents wind down.

Q. In Mike's final Elmer101 installment, he warns against keying the rig with a poor SWR at the antenna connector, indicating it could wipe out the final transistor. I've seen this same warning many times before. Could somebody please explain to me the mechanics of what's going on? Why should the transistor care what kind of SWR is out there? What happens in terms of emitter/collector voltages and currents that destroys the device?

A. Going to take a crack at answering. Haven't smoked a rig this way myself, so am going to apply some theory. When you've got a 50ohm resistive load at the antenna jack, then Q6 sees close to 50 ohm NON-REACTIVE as well. This is because the PI-filter consisting of C37, L3, C38, L4, C39 transforms the 50-ohm antenna into a 50-ohm impedance at its other end (at the transistor). This is true only at one frequency...7MHz. Everything runs great this way.

Now suppose you pull the antenna off. The PI network was designed for 50 ohm load. Now the load is infinite. Q6 sees a whack of reactance now, when it used to see about 50 ohms. Or suppose you short the antenna out. You've STILL got a whack of reactance at Q6's collector, although it's value will be different than the case where load is infinite. I modeled Q6 as a SPST switch (to ground) that opens and closes at a 7 MHz. rate. What's the switch see on its collector? A whack of reactance...perhaps inductive reactance from L2. This would look like a flyback switch (like a car's spark-plug coil and distributor):

During the time that Q6 is ON, current climbs (linearly) in L2, as current passes thru L2, thru Q6 to ground. Then Q6 turns OFF. L2's current goes to zero, and the voltage across L2 swings w-a-y above the supply voltage. Bad news for Q6, which can't take a big over- voltage on its collector. D12 saves the day by clipping voltage excursions on Q6's collector to +33 volts.

I once saw +160 volt spikes on the collector of a transistor operating in a circuit like this (with a 12v DC supply). The circuit became unstable because of the high (and reactive) load impedance, and turned into a low-frequency oscillator with these huge, sharp spikes. Luckily, the device survived.

When you've got a proper antenna load, the load resistance "damps" the wild voltage swing, so that it doesn't even get high enough to cause D12 to conduct. In this case SWR is low, because you've got a load close to 50 ohms.

Well, that's it folks. Thanks for sticking with me. I can say personally that I've learned a TON of stuff about this radio and QRP rigs in general.

Blue Printing the SW40+ and the SW30+

by Gary Surrency, AB7MY
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None of thesechanges by themselves add that much to the output level, but when they are all added together the increased output level is significant. I hope this info is useful to those who are seeking the full QRP "gallon". If less output is desired, the drive level control R24 may simply be usedto reduce the output level and current consumption, as when operatingportable and using battery power. The stability and output spectrumremains clean at any power level up to maximum, and the PA transistorbarely warms up using the smallest heat sink that fits the TO-220 2SC2078package.

I changed D13 from a 1N4001 to a 1N5819 schottky to reduce power supply drop. I changed Q3 from a 2N3906 to a 2N4403 for less Vce drop. Keying looks better on the scope too, and it is the complement to the 2N4401, with higher hfe and Ic rating. I used a MPS2222a from R/S for Q5. A very nice, low input pf, high gain version of the 2N2222A. Many of my QRP rigs have benefited from using this excellent device that is widely available from Radio Shack and consistently a good part.

I added one turn of wire to L4 to alter the low-pass filter slightly.ChuckAdams mentioned something about this in a SPICE posting. Adding a turn toL3 didn't help the output or spectral purity. L3's 16 turns are evenly distributed around the entire core just like L4's 17 turns.

Used original 2SC2078 for the PA, as the MRF476's I tried produced no increased output. Used small heat sink on the PA, as the increased output did result inmore heat to be dissipated. A very small one will fit without modifyingthe PA's placement or orientation, as Dave mentions in the manual.

Used a NTE5087A 43V zener for D12, since the stock 33V zener shunts too much power when running 4-5 watts.

Used a 105 pF S/M cap at C8 to get 7.000 to 7.050 Mhz frequency coverage. C7is 10pF. I also used a quality .001 uF 100 V disc for C38 in place of the small monolythic that was supplied in the kit. I checked all the caps in the low-pass filter with a AADE LCIIB L/C meter to insure they were withinspec. There were no other changes, except I picked the highest gain 2N4401 that was in thekit and used it for Q4 following the TX bandpass filter for maximum output.

A lot of tweaking of the bandpass filters will achieve almost 6 watts into a 50 ohm dummy load as indicated on a OHR WM-1 wattmeter when powered from 13.8 volts DC. I notice some heating of the collector choke, L2, so there is probably some room for improvement there also. Not sure if it is core heating or merely heating of the small diameter enamelled wire. Still have toinvestigate this. Obviously some power is being wasted if heat is present. The rig has a very clean output signal and is less sensitive to antenna load changes than my NC40A is. Smooth QSK from the lil bugger too.

For those of you who want more output than the standard 2-3 watts the SW30+ is capable of stock as it comes from Dave, I have succeeded in eeking out an additional couple of watts. Not only that, the rig actually became more stable with the mods that I came up with.

Now for a little history:

After I built the kit, I could get maybe 3-4 watts when increasing the drive pot before the output got dirty, and the collector choke in the PA stage became pretty warm. After an earlier posting, several great guys on this list offered some suggestions. While some of them helped a little, the instability was still there when approaching 4.5 to 5 watts.

I was able to get up to the threshold of 5 watts by using a selected 2N3904 for Q4, and a selected PN2222A for Q5. Along with the other small mods that follow, fairly stable operation at ~5 watts was possible. But if the antenna was reactive at all, or when not using a dummy load for testing puposes,or if I went even a smidge above 4.95 watts - the output spectrum began to deteriorate, and parasitic oscillations in the rig popped the output suddenly to 7-9 watts of crud. I had some limited success with higher bias on Q4 / Q5, and by reducing the lead lengths of these two transistors, but it basically wanted to "take off" on it own right before 5 watts occured on the wattmeter. Heck.

Upon very close scrutiny, and some help from Dave Benson, I found that Miller effects were to blame, and that the succeeding stages after Q4 were not directly the cause of the instability and spurious products. Rather, the source of the instability was Q4 itself. If ground loops, or RF feedback, or poor decoupling at higher power levels are the source for this instability - I can't be sure. As with the Norcal 38 Special, a lot of speculation is in effect here, but no single true solution was evident.

Onward I searched for a solution that would not require a lot of modifications to the circuit design or the PCB. I began to study some of the other designs of the rig's I own. In the S&S Tac-1, gain in the transmitter driver stages is distributed across 4 stages of amplification. One amplifier follows the NE602 mixer, and three more stages of amplification follow the TX bandpass filter before the final PA stage. This way, no single stage or pair of driver stages needs to have a lot of power gain and gain instability is avoided without such high amplification. Total TX driver gain is spread across more devices and the result is good stability and linearity.

In the Norcal Sierra and NC40A, a post-mixer FET amplifier is used to maintain high unloaded Q of the bandpass filter(s), yet adequate power gain is achieved with a single following driver stage without the loss of stability. I thought perhaps substitution of a FET transistor for the post-bandpass filter stage in the SW30-- might be worth a look.

It turns out that by using a J310 in place of Q4, normally a 2N4401 transistor, better stability was possible when running higher levels of drive to the PA stage. In fact, this was a two-fold improvement, since the FET permits much higher input impedance to appear at the output of bandpass filter T3 in the SW30+, maintaing higher loaded Q, and that allows a greater amount of low-level RF to be present at the input of the new FET predriver stage, Q4.

At first the higher input impedance possible as a result of using a FET instead of a bipolar device might seem to be the last thing you would want in an driver stage that was already unstable at high PA output levels. But the N-channel FET is inherently more stable, since it can be used at zero bias versus the positive bias needed for the bipolar stage. And, Miller effects tend to be less with a junction FET, since the inter-electrode capacitances are typically lower, and there are fewer biasing resistors required for the FET stage. At least that is how I understand it after doing some reseach of Miller effect. Somebody correct me if I have it wrong.

For whatever reason, the FET allowed much greater PA output, with absolutely no instability detected by me at any time during my experiments. No combination of power and / or devices following the FET ever caused any instability in my SW30+. It is indeed rock-stable at any and all power levels and antenna loads. Heck, even with no antenna at all attached to the PA stage, I never have seen any hash on the output signal when viewed on the monitor scope. I like it.

So for those of you who want more power from your SW30+, or if your rig isn't as stable at various antenna loads and power levels as you think it should (could) be, read on.

Note: No traces are cut; some rather simple part sustitutions are made; and one less resistor is needed! These are the kind of mods I like to perform.

As in my SW40+, several incremental small gains in power output are achieved in the following manner:

MODIFICATIONS

1. Replace D13 (1N4001) with a 1N5819 or 1N5820 diode. This reduces the DC supply voltage drop. Remove the diode altogether and use a jumper in its place if you use some other form of polarity protection, such as a series fuse and reverse-biased diode from B+ to ground. Just be sure to use something to protect against reverse polarity and short circuits.

2. Replace Q3 (2N3906) with a good 2N4403 PNP or NTE159. Either of these transistors has much lower saturated ON voltage drop, and will help increase the supply voltage to Q4 and Q5. If your keying with the stock 2N3906 is too soft, or has a "tail" on it as someone recently mentioned, this change may correct that problem as well. Note that C110 (3.3uf) may need to be increased in value, since the keyed supply to U5, Q4, and Q5 is now switched "harder" and probably faster as well. I had to do this on my SW40+, and the SW30+ definitely needed a bigger cap for C110. I used a 4.7uF 16V tantalum cap for both rigs.

3. D12 (a 33V zener) has to be changed to a 36V (NTE5085A) or even a 43V (NTE5087A) zener to prevent it from shunting the higher output voltage of the PA stage, and overheating itself into destruction. Besides, since higher output is desired, we certainly don't want some of that power dissipated as heat in the protective zener!

4. As power levels approach 3-4 watts, L2 in the collector lead of Q6 starts to saturate and get warm. At 5 watts, it gets downright HOT. This power should be going to the antenna instead of heating the collector choke. I pulled out the six turn toroid and measured its value at 15 uH on an AADE L/C II meter. A careful inspection of the junk box turned up a cylindrical ferrite RF choke of the same value. I mounted it standing vertically in place of the original L2 toroid choke. No further heating was noticed, and the output also increased. If you also do this, be sure to get an RF choke that has low DC resistance and can handle the required current of the PA stage. The one I used was not epoxy coated, and was about ½ inch long and had decent sized wire windings over a iron core. It was of "unknown" origin, but possibly came out of some old Heath gear.

5. The turns on L4 were increased by one turn from 15 to 16 turns. This improved the load matching of the low-pass filter to the PA stage and further increased the output. The spectral purity does not seem to degrade - I noticed no increase in SWR on my resonant 30m dipole. The monitor scope waveform also looks nice, but it will take someone with a spectrum analyzer to determine this concretely. Check the other

componets in your low-pass filter if the output is still low. Some ceramic disc caps I tried in place of C38 got warm and reduced output. The little monolythic cap Dave supplies performs well - better than several ceramic disks I tried. Surprising!

6. R23 (22k) is removed. It is no longer required.

7. R22 (10k) is replaced with a 1M ¼ watt resistor. This just keeps the gate of the FET at zero bias with no signal. Without it, the FET's conduction drifts all over the place at low drive settings, and if the original 10k is left in, the input impedance is un-necessarily reduced and will lower the Q of the bandpass filter. The resulting filter bandwidth is more than adequate for the small 35 khz of tuning range on 30m.

8. Q4 is replaced with a J310 FET. A J309 works almost as well if that's all you can find. A MPF102 was not adequate in drive. Other N-channel junction FET's of sufficient transconductance and current rating may also work. The pinout of the PCB is not correct for the FET, therefore some lead bending or re-orientation of the FET package is required for proper connection. If you turn the flat of the J310 so that it is facing Q5, the leads can go into the PCB pads in a similar fashion to the original 2N4401. The gate goes where the base used to go, the drain goes to the collector pad, and the source goes to the emitter pad of the original EBC pad layout. Check the lead identification of your FET if in doubt. It's pretty hard to blow up the FET even if you put it in wrong, but it probably can be done! ;-)

9. Get a small TO-220 heat sink for Q6. With 5 watts of output, it has to be heatsinked. Dave Benson mentions a suitable h/s in the manual. The typical TO-220 h/s commonly available is much too large, unecessary for this power level, and it won't fit into the available space. It may be possible to bend the 2SC2078 over a little to make something else fit, but I would get the correct fiiting h/s if I were you. Or make up your own as shown in the current QRPp, as Paul Harden illustrated. His artwork is too cool !

10. Check your work; attach a 50 ohm dummy and QRP wattmeter; then apply power and key the rig. Set the drive pot for <1 watt of output, and carefully peak T2 and T3 in the bandpass filter. Reduce drive as necessary to stay below 1 watt, since this protects the PA from overheating and also seems to indicate the best peaking. Repeat this alignment several times until no further peaking is obtainable. Be sure to use a proper tool so as to not crack the slug in T2 and T3.

11. The output power and the RF envelope should be clean and pure from zero output to near 5 watts or more. You will note the drive pot has greater useful range, indicating the FET is performing very well, and it is more sensitive to the low level RF voltage coming out of the TX bandpass filter. Cool!

12. If your rig still seems anemic, and is short of 5 watts output at 13.8 to 14 volts DC supply, here are some suggestions:

Remove Q5 (2N4401) and try several 2N3904, PN2222A, MPS2222A (available from Radio Shack, pn. 276-2009 , $0.59 each). One of these devices should get you that extra 200-300 mW you may need to achieve 5 Watts. I wound up with a NTE123AP as the preferred device in my rig, but several MPS2222A and 2N3904 devices were nearly as good. Nearly 6 watts is possible with my rig.

13. If you are looking for less receive current demand, install a LMC662CN CMOS op-amp for U4 as recently discussed and offered as a group purchase on the QRP-L. A savings of 6 or 7 milliamps has been reported with this mod. Be sure to wire the stereo headphone jack with the left and right channels in series to make better use

of the CMOS op-amp's performance. Enlarge the hole in the aluminum back panel for the headphone jack to clear the plastic shoulder of the stereo 3.5mm jack, then use a flat fiber washer under the knurled nut to insulate the metal jack from the back panel.

SUMMARY

On my rig, I can get a nice solid 5 watts output with the drive pot less than full on. I have never seen any spurious output at any drive level or with any antenna load condition. The rig is very stable at all power levels and loads. Keying is great, and the transmitter behaves as you really want it to. Even if you don't run it at the full output possible, it is nice to know the potential is there (operation on battery power can now have more possible output) and the stability and alignment is certainly better than before these mods. If you have any questions or feedback on these mods, please let me know by email. Thanks to Dave Benson, Glen Leinweber, and others for their suggestions. Their inputs helped me to zero in on the solution I was looking for. Thanks guys!

This 30m SWL rig was the result of a door prize at the Ft. Tuthill hamfest in July, and I would like to thank everyone who made that possible, especially Dave Benson who graciously made it possible and offered to swap the 40m kit I won for the 30m kit that is the subject of this article. I, of course, had already purchased a 40m kit earlier in the Elmer101 project.

PS. One change I still need to make to the SW40+, is to replace the collector choke on it, since it also heats at power levels approaching 5 watts, though not as much as the SW30+ did. ;-)

72 and good luck, Gary Surrency AB7MY
Chandler, AZ (near Phoenix)

A Homebrew Enclosure for your Elmer 101 Rig

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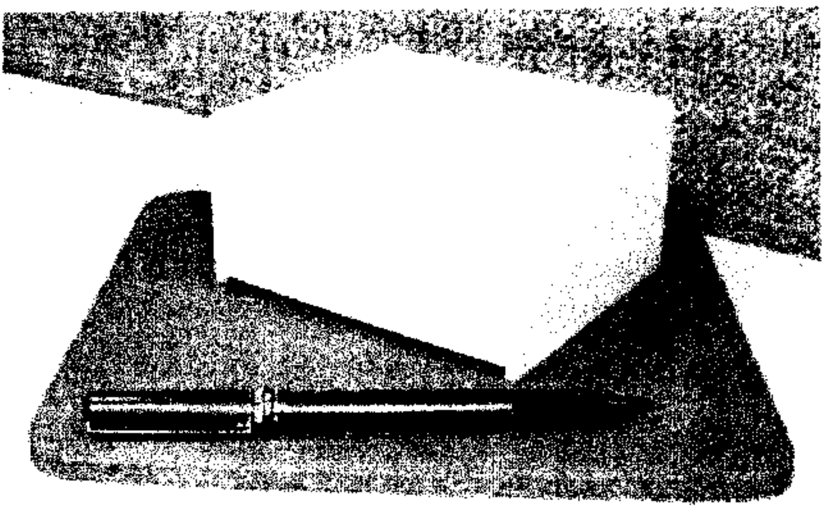
This is a series of step-by-step instructions on how to build custom cabinets for popular board kits. This project is designed around the Small Wonder Labs SW+ transceiver made popular by the qrp-l Elmer 101 tutorial series.

This cabinet is unique in that it requires no fasteners to hold it together.
Instead, it use a "tongue and groove" design. That is, the base of the enclosure slides into grooves cut in the sides. Likewise, the front and rear panels are seated in grooves cut in the sides and base. The pieces lock together to form a rock solid, "hardwareless" enclosure. Trying to remove a rusted screw from a conventional box with a butter knife may be a thing of the past.

If you haven't already done so, please read the section, Learn how to make homebrew enclosures. Here is where you will find the basics on how to layout, cut, weld and finish ABS plastic.

Some fine print. Just so there is no misunderstanding, I received written permission from Dave Benson, NN1G, to target the SW+ transceiver. You may already know that Dave sells a matching hardware package which includes cabinet. However, according to Dave the hardware pack is offered mainly as a courtesy to the builder. If you elect to build an enclosure from the design information presented here, please be careful. I recommend the use of a table saw to cut the plastic and a highly flammable liquid as a bonding agent. I cannot be responsible for any accidents resulting from their use.

This design is Copyright © 1998 by me, William B. Jones - KD7S. You are



hereby authorized to duplicate it for personal use only. That means you don't have the right to make a dozen cabinets and sell them at the next ham club meeting. If you do, you are breaking the law and things like that make me really cranky.

Be your own Cabinet Maker

How to build custom electronic enclosures from scrap plastic:

Anybody who has built a piece of electronic equipment has faced the problem of finding a suitable enclosure. Commercially made boxes never seem to be the right size, assuming you can find one in the first place. Even if you do locate what you need, prices are often outrageous.

If you think this is just another problem you have to live with, think again. With a few square inches of sheet plastic and some time at your workbench you can roll your own custom cabinets. You can build them any shape or size you need using common shop tools. The best part is that the finished product will rival commercial enclosures in both looks and functionality, but at a fraction of the cost.

The two-piece, clamshell enclosure shown above was custom made to house a Small Wonders Labs SW40+ transceiver kit. The top and bottom pieces are held together with a pair of "NorCal 40" plastic latches. The front and rear panels slide into grooves cut in the side pieces and are recessed 1/8 inch. All that remains is to drill the end panels to accommodate the controls and connectors and add some stick-on rubber feet. The end result is a rugged, attractive homebrew cabinet that cost less than $2.00 to build.

Follow the steps below for instructions on how to make your own enclosures.

ABS plastic - The "Volkswagen" of cabinet making.

The heart of homebrew enclosures is a type of rigid thermoplastic known as ABS (Acrylonitrile-Butadiene-Styrene). ABS can be sawed, drilled, sanded, machined and painted. When heated to around 250 degrees Fahrenheit, ABS can be bent or even vacuum-formed. It is rugged, light weight and cheap. ABS is available in several different colors including white, black, beige and gray. Scraps of ABS can be found at plastic supply houses or sign shops for a dollar or two per pound. A pound of 1/8" sheet will make a lot of small cabinets. Check your telephone book's yellow pages for suppliers.

Other types of sheet plastic can also be used. An article describing the use of acrylics and polycarbonates can be found in the August, 1988 issue of QST magazine.

Drawing a design and cutting the pieces to size

In its simplest form an electronics enclosure may consist of nothing more than a few pieces of plastic, welded and screwed together, to form a box.

The best way to learn about ABS is to start with a basic enclosure. Begin by drawing the outline for the top, bottom, sides and end panels on a sheet of paper. Use a sharp pencil or fine line permanent marker and a steel ruler. A T-square or carpenter's framing square will help considerably. When the layout and dimensions are correct, transfer the pattern to some plastic stock. Make sure all lines are parallel. If not, your project will not be square.

Cutting the panels is best done with a tablesaw fitted with a fine toothed blade. If you don't have a table saw, don't dismay. A hacksaw or other type of finishing saw will work just fine. It will just take longer, that's all. Whatever tool you use, cut slowly and make sure your blade doesn't wander back and forth across the line.

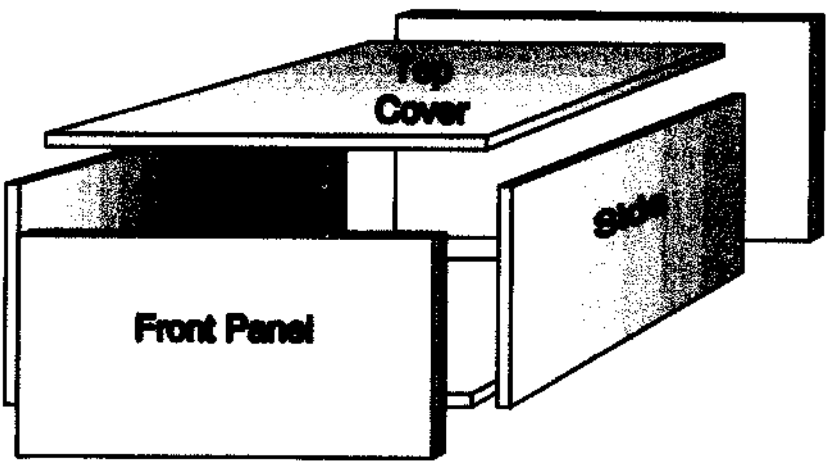
If the saw blade gums up in the plastic, change the blade speed. It doesn't take much friction to heat the plastic to its melting point. When you find the right setting you can slice through sheet plastic just like the professionals.

Welding the Pieces Together

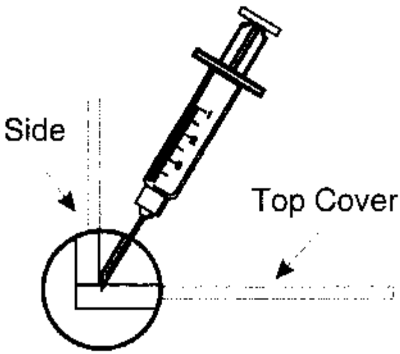
With wood you glue - with plastic you weld

Once the pieces are cut to size you're ready to weld the box together. You can weld ABS using common PCV pipe cement from your local hardware store. If you want to get fancy, there are special, water-thin bonding agents available from plastic supply houses. While you're there you can pick up a special syringe dispenser that makes it much easier and neater to apply. Far from being just another type of glue, these bonding agents actually melt the plastic pieces to be joined. When the solvents evaporate you end up with a chemically bonded joint that is almost as strong as the original material.

WARNING! Be absolutely sure you have adequate ventilation while working with these chemicals. They are extremely flamable and can be harmful if inhaled.



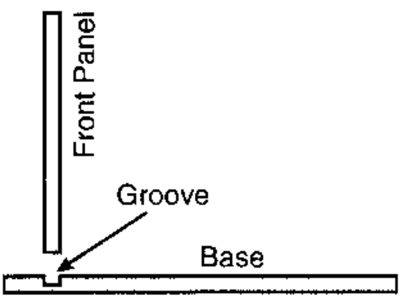
Assembly begins by welding the two sides, one at a time, to the top. Coat both surfaces to be joined with a light application of solvent. A toothpick makes a good application tool. Immediately press the pieces together and apply moderate pressure for one or two minutes. Check for



proper alignment—make sure the parts are square. Set everything aside for an hour or so to allow the the solvents to evaporate. Repeat this step for the other side.

If you're using a syringe and the liquid solvent, simply press the pieces together (clamp them in place if you can) and run a bead of solvent between the parts to be joined as shown in the drawing. The liquid will immediately be drawn into the joint area by capillary action.

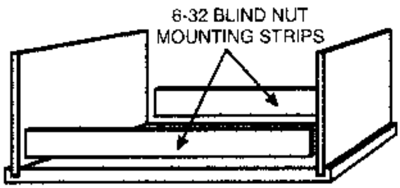
Next, join the two end panels to the base. If you want to make absolutely sure the panels are aligned properly, use your table saw to cut a pair of shallow grooves in the base. Then slip the panels into the



grooves before welding. Again, if you don't have a tablesaw, make a series of shallow, parallel cuts with a hacksaw. Then use the edge of a file to even up the cuts to a uniform depth.

Keep in mind that it is much easier to drill holes in these panels for controls, connectors, meters, dials and such before they are welded into place.

Next, cut and weld two rectangular strips of scrap to the base. These will be used to mount four 6-32 blind nuts which will hold the cover in place. Give the solvent plenty of time to evaporate so as to form a strong bond. Then temporarily position the cover over the base and drill four pilot holes through both the cover and the rectangular mounting strips. Next, apply



a thin coat of solvent around the insides of the holes in the strips and press the blind nuts into place. Use a pair of pliers to embed the tabs into the plastic for added strength.

All that remains is to add any finishing touches such as paint or decals. See the next section for a discussion on sanding and painting.

Sanding and painting

If it doesn't look quite perfect, here's how to fix it.

You will probably discover a few rough edges, nicks and scratches or other anomalies that need to be smoothed out. ABS sands very nicely so it is a simple task to erase any slight imperfections.

Tape a whole sheet of medium grade sandpaper to a flat, smooth surface. Run the assembled box back and forth over the sandpaper using light pressure. Turn the box in your hand from time to time to make sure you don't remove too much material from any given area. Repeat the process with a finer grade of sandpaper. You can finish the job by hand rubbing the enclosure with some fine-mesh steel wool.

ABS will accept spray paint very well. A coat or two of primer will help the paint adhere better. Read and follow the directions on the paint can for best results. And, as always, two light coats of paint are better than one heavy coat.

Building the Elmer 101 Enclosure

Measuring and cutting the pieces

The following instructions will show you, one step at a time, how to cut and prepare the six pieces of ABS plastic that go into making up the Elmer 101 cabinet. Please note that a table saw fitted with a plywood or plastic cutting blade is almost essential.

As each piece is cut, label it with a piece of masking tape as shown in the photograph in Fig. 2. All pieces are cut from 1/8" thick sheet

Instructions

1. Cut a piece 4 3/8" by 3 7/8" and label it TOP.

2. Cut another piece 4 1/4" by 3 7/8" and label it BASE.

3. Cut two pieces 2 1/8" by 3 7/8" and label them LEFT END and RIGHT END respectively.

4. Cut two more pieces 4 1/4" by 1 15/16" and label them FRONT PANEL and REAR PANEL respectively.

In the following steps you will cut grooves in the LEFT and RIGHT ENDS and the BASE.

Raise the table so that the top of the blade is exactly 1/16" above the table surface. Using a piece of scrap, make a few test cuts to insure the groove depth is precisely half the thickness of your sheet plastic stock. Next, position your rip fence so that the outer edge of the kerf is 1/8" away from the edge of the stock being cut.

There will be a total of eight grooves to cut—three in the RIGHT END, three in the LEFT END and two in the BASE. It will probably be necessary to move the rip fence slightly (after the initial cuts have been made) in order to widen the cuts to a uniform 1/8" width. Just be sure to make all eight cuts before you move the fence.

5. Select the BASE to make the first cuts. Position the long edge (4 1/4") against the rip fence and cut the first groove. Make a couple passes to insure a clean, smooth cut. Then, turn the BASE around and make a similar cut on the opposite side.

6. Select one of the ENDS. Place the long edge (3 7/8") against the rip fence and cut a groove. As with the BASE, make a couple passes. Next, place the short edge (2 1/8") against the rip fence and make a cut. Finally, make a third cut on the opposite end.

7. Repeat step 6 using the other END.

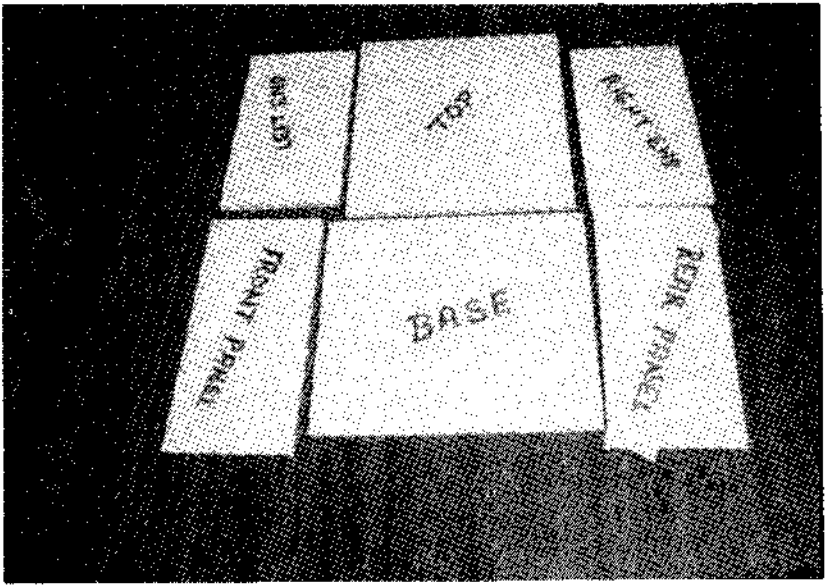
8. Now, using a piece of scrap, make a test cut. Then move the rip fence away from the blade very slightly and make a second pass. Take another piece of scrap and see if the edge will fit (snugly) into the groove you just cut. If it is too narrow, move the rip fence again and make another cut. Keep this up until you have a groove that is a tight fit with the edge of your sheet plastic stock.

9. Go back over all eight grooves with the current settings of your rip fence.

10. Use your fingernail to remove any burrs or rough edges. You're now ready to proceed to the assembly step.

Assembly - Getting it together, at last

The hard part (cutting the pieces to size and forming the grooves) is behind you. All you need do now is weld the RIGHT END and LEFT END to the TOP. Still, don't get in a hurry. Do the job right and you will be very pleased with your

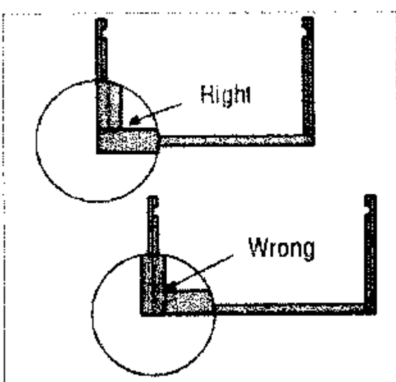


handiwork.

1. Select the cabinet TOP and remove any burrs from the edges.

2. Repeat step 1 with the LEFT and RIGHT ENDS. You want to make sure the pieces are smooth and clean.

In the following steps you will weld the LEFT and RIGHT ENDS to the TOP. Make absolutely sure that you put the END on top of the TOP, not beside it. See the illustration at the bottom of the page if you're confused.

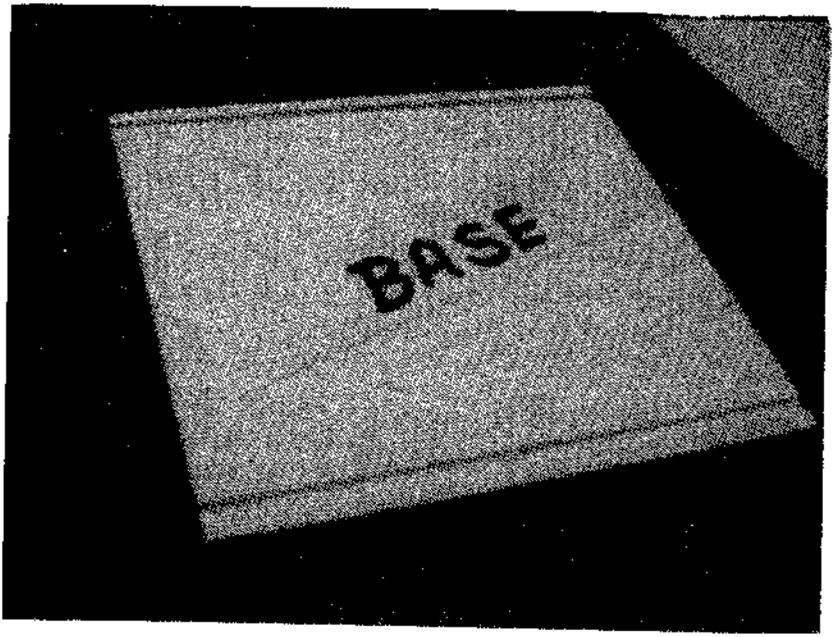


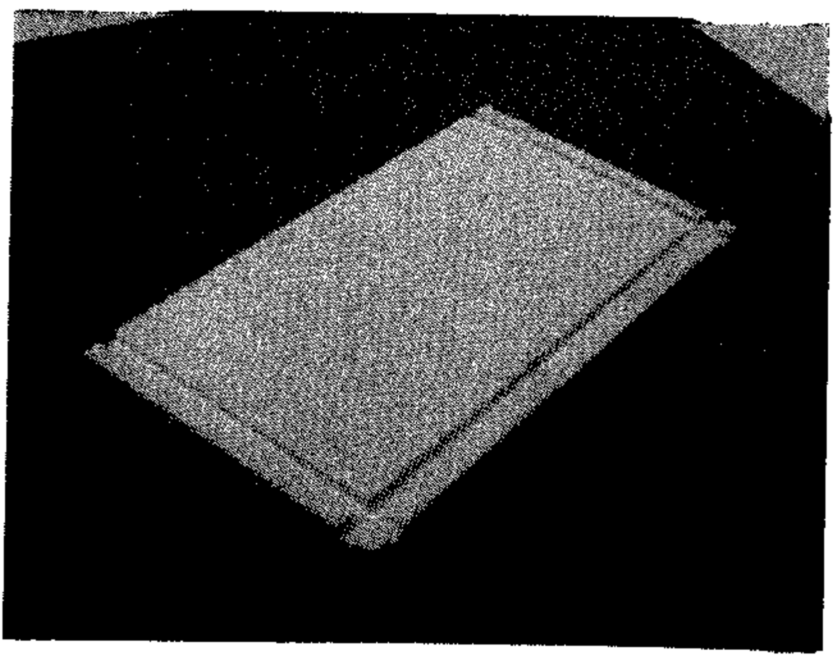
Keep in mind that you will be welding the pieces one at a time. Allow the first joint to cure completely before attaching the opposite END. Depending upon the type of solvent you use, this shouldn't take more than a half hour or so.

IMPORTANT:

Check the fit of the END panels to the TOP before applying solvent. Make sure they will fit together tightly. Also, when you do apply the solvent, angle the free ends of the ENDS toward the center of the cabinet very slightly. This will put tension on the BASE, FRONT and REAR PANELS when the completed box is snapped together.

Weld each END, one at a time, to the top. Apply moderate pressure to the parts being joined for at least 30 seconds. Confirm that the edges match up properly and there is no offset or misalignment except


BASE



for a slight "lean" toward the center. After both joints have cured, apply a light fillet of solvent to the inside of each joint to fill in any possible gaps. Set the assembly aside for a couple hours to cure. You will most likely have a few rough spots on the outside where the ENDS were joined to the TOP. These can be removed with the edge of a metal ruler used as a scraper.

Finish Work

Cleaning up the loose ends

All that remains is to check the FRONT and REAR PANELS and the BASE for proper fit. You will probably have to touch them up slightly.

1. Insert the BASE into the grooves in LEFT and RIGHT ENDs. The ENDs of the box should be parallel with one another. If not, the BASE may have to be trimmed slightly. Successive passes through your table saw should do the job. Just make sure you don't take off too much material.

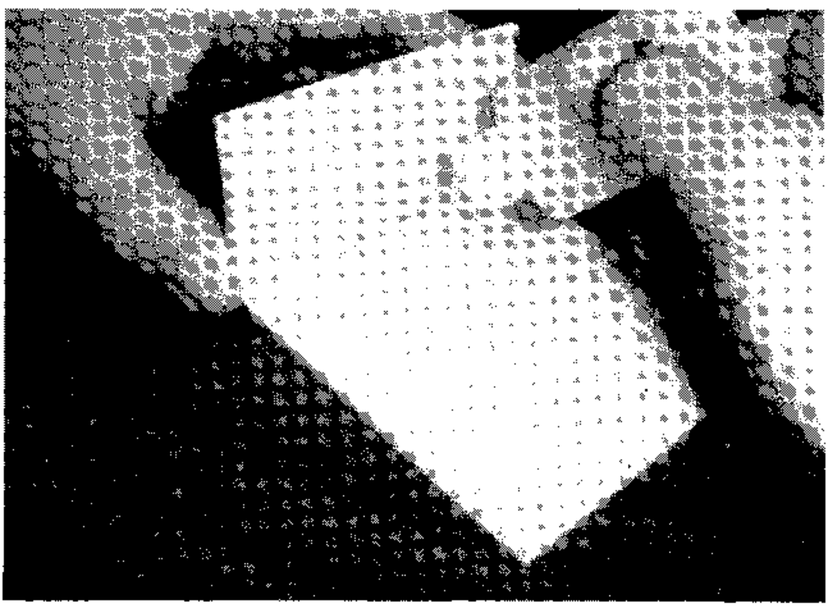
2. Check the FRONT and REAR PANELS for fit. It is likely they will not slide far enough up to make contact with the TOP. If that's the case, round the corners of the FRONT and REAR PANELS slightly by dragging them across a sheet of medium grit sandpaper taped to a flat surface.

3. Once all the pieces fit together smoothly, assemble the cabinet by sliding the FRONT and REAR PANELS into place. Then spread the LEFT and RIGHT ENDs just enough to accept the BASE. Push everything together so the parts lock into place in the grooves. Hey! It looks pretty good, doesn't it?

You can remove any imperfections (like saw marks) from the edges of the panels by running the assembled enclosure over a sheet of fine grit sandpaper taped to a flat surface. You may want to round the corners where the ENDs are attached to the TOP with a sanding block while you're at. Finish the cabinet by attaching some stick-on rubber feet to the BASE.

Some Additional Thoughts

There are some excellent computer based drawing programs available that can make it easy to generate custom artwork for your homebrew projects. Likewise,



color printers seem to be everywhere nowadays.

For a small investment in time you can create professional looking paper overlays that transform your homebrew projects into a true work of art.

Imagine the reaction you will get from your fellow hams when you show them your homebrew transceiver, housed in a homebrew cabinet, with homebrew panel markings. You're gonna' love it.

NorCal QRP Club Web Page

Jerry Parker, WA0OWR
Webmeister

http://www.fix.net/norcal.html

The place to go on the web for the latest up-to-date information on NorCal. Jerry has monthly reports of NorCal meetings, complete with pictures, details on the latest club project, articles of interest to QRPers, and information on how to order an official NorCal T-Shirt.

NorCal's T-Shirts

NorCal offers two shirts:The NorCal T-Shirt and The NorCal Zombie T-Shirt (Limited Edition) The price is $15 each plus $3 shipping and handling in the US, $5 shipping for DX. The shirts are the recognizable NorCal "GOLD" and high quality and heavy duty. The NorCal shirt is imprinted with the NorCal logo and the NorCal Zombie shirt is imprinted with the NorCal Zombie 'Toon. The shirts are gold with the NorCal Logos in black and the Zombie 'Toon is multicolor. To order Send $15 + $3 postage ($5 DX) to: Jerry Parker,
426 Tanglewood Ct.
Paso Robles, CA 93446

Don't forget to specify your size: M, L, XL, XXL (Note XXL shirts are $3 additional) Please make check or money order out to Jerry Parker, NOT NORCAL, US Funds Only.

QRPp Back Issues Pricing:

1993 - $10, 1994 - $15, 1995 - $15, 1996 - $15, 1997 - $15 (Avail. Feb. 1, 1998) Full year sets available. NO individual issues available, sets will not be broken up.

Shipping: US

$3 for 1 - 3 issues, $5 for 4 - 5 issues.

Shipping: Canada

$3 for 1 issue, $5 for 2 - 3 issues, $7 for 4 -5 issues.

Shipping: DX Europe & South America

$5 for 1 issue, $7 for 2 - 3 issues, $10 for 4 - 5 issues

Shipping: DX Pacific Rim, Australia & New Zealand

$5 for 1 issue, $10 for 2 issues, $15 for 3 issues, $20 for 4 issues, $25 for 5 issues
All funds US funds only. Make check or money order to Doug Hendricks, NOT NorCal. Please send orders to: Doug Hendricks , 862 Frank Ave. , Dos Palos, CA 93620, USA

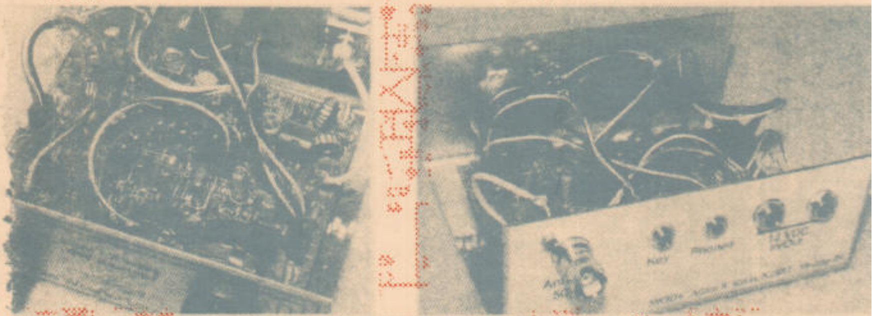
QRP Frequency Crystals

NorCal has available the following crystals in HC49U cases for $3 each postage paid in th e following frequencies: 7.040 MHz, 7.122 MHz., 10.116 MHz. Send your order and payment in US Funds only to: Doug Hendricks , 862 Frank Ave. , Dos Palos, CA 93620, USA. Make check or money order to Doug Hendricks, NOT NorCal.

QRPp Subscriptions

QRPp is printed 4 times per year with Spring, Summer, Fall and Winter issues. The cost of subscriptions is as follows: US and Canadian addresses: $15 per year, issues sent first class mail. All DX subscriptions are $20 per year, issues sent via air mail. To subscribe send your check or money order made out to Jim Cates, NOT NorCal to: Jim Cates, 3241 Eastwood Rd., Sacramento, CA 95821. US Funds only. Subscriptions will start with the first available issue and will not be taken for more than 2 years. Membership in NorCal is free. The subscription fee is only for the journal, QRPp. Note that all articles in QRPp are copyrighted and may not be reprinted in any form without permission of the author. Permission is granted for non-profit club publications of a a non-commercial nature to reprint articles as long as the author and QRPp are given proper credit. The articles have not been tested and no guarantee of success is implied. If you build circuits from QRPp, you should use safe practices and know that you assume all risks.

LJM 127

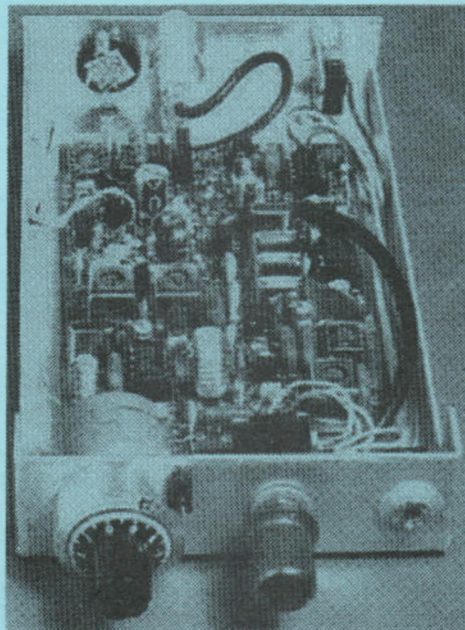


Front and rear panel views of the SW 30+ built into a
...n-Tec enclosure by Adam Kanis, N2BRT, Iowa City, IA.
...p://genome33.ped-gen.uiowa.edu/hamradio/SW30+.html

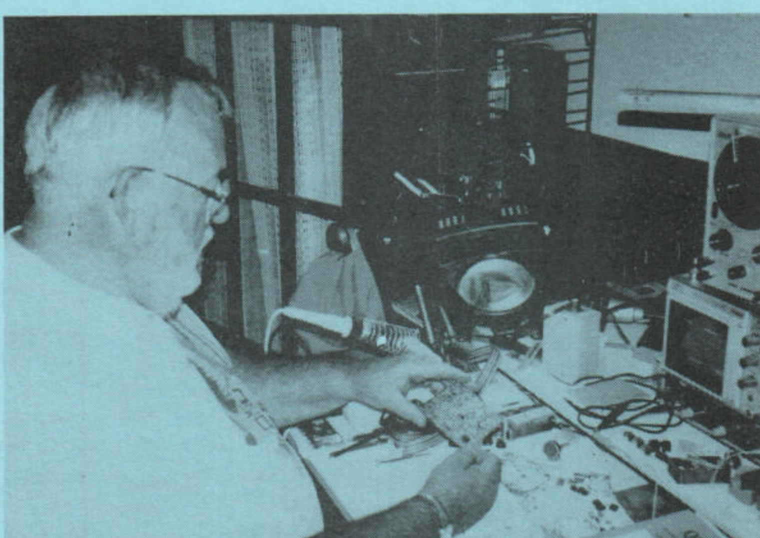
The original SW 40+
built by the designer,
Dave Benson, NN1G,
Newington, CT

The ultimate "smoke test" --
Bruce Rattray, VE5RC/VE5QRP,
Regina, Saskatchewan,
making his first QSO
with the SW 40+ he built

The SW 40+
...ilt into a custom
...closure by Glen
...er, VE3DNL

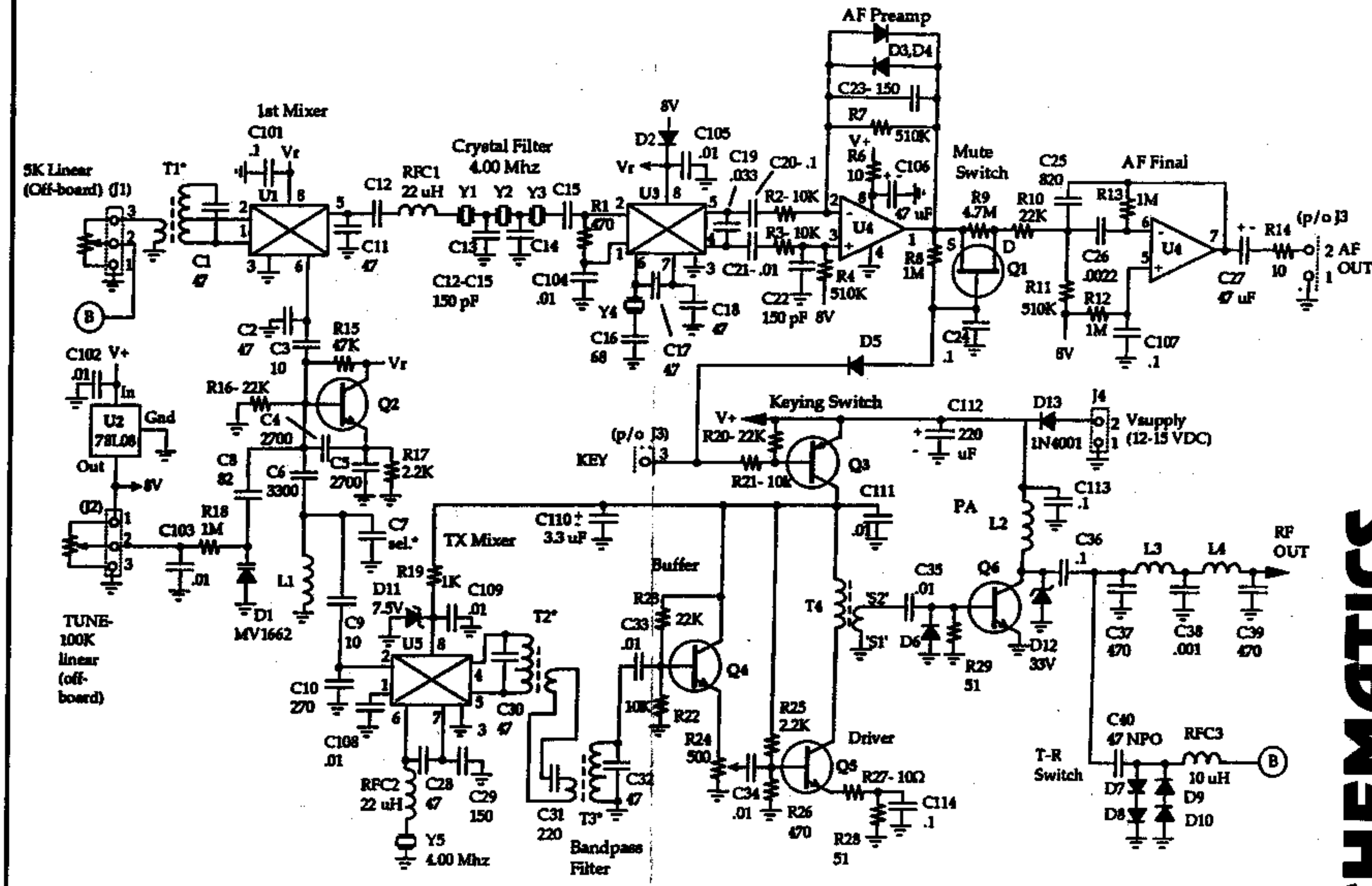


Glen Leinweber's (VE3DNL) completed kit and the SW-40+ upon which his excellent test data in this issue was based.



Bruce Rattray, VE5RC/VE5QRP, checking his work following Lesson 1. Note signal generator and O-scope, helpful aids. Bruce's SW-40 is now completed and making QSO's.

SCHEMATICS

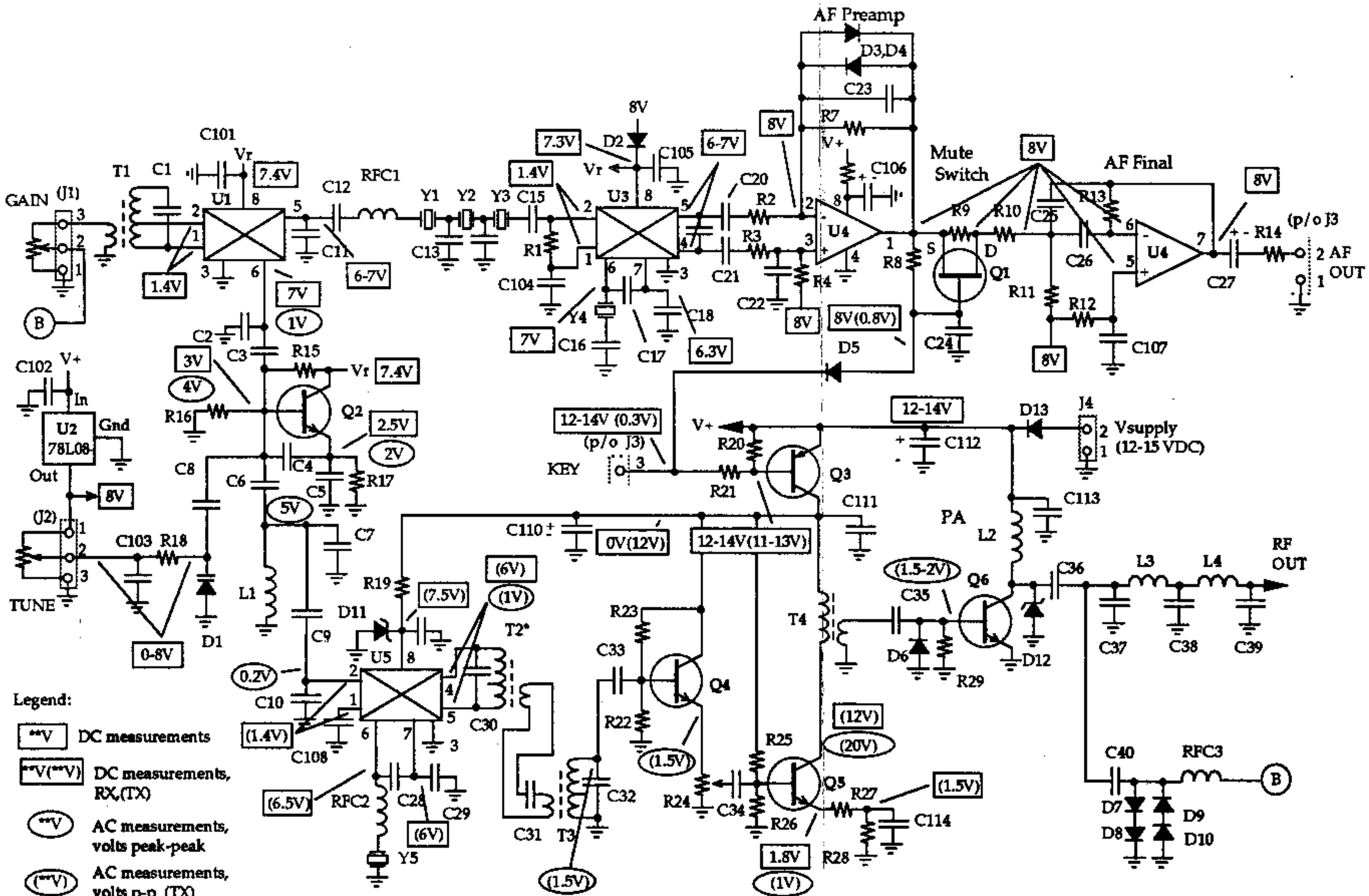


The "SW-40+" Transceiver

SMALL WONDER LABS™

3/18/98

* T1-T3
C-internal not shown, leave intact.



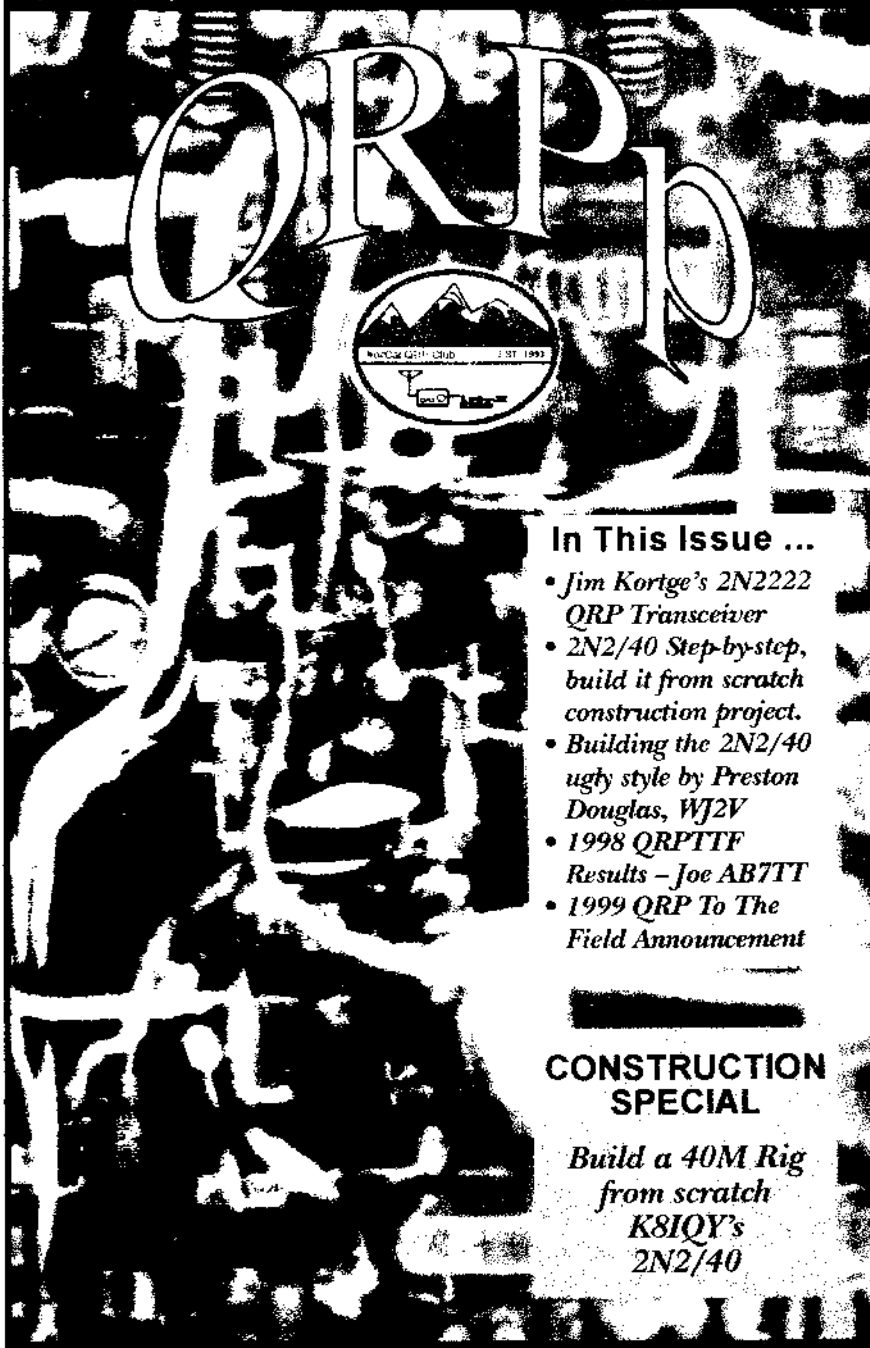
Troubleshooting the "SW-XX+" Transceiver

SMALL WONDER LABS™

3/10/98

Vol. VI, No. 4 Winter 1998

QRPp



In This Issue ...

- *Jim Kortge's 2N2222 QRP Transceiver*
- *2N2/40 Step-by-step, build it from scratch construction project.*
- *Building the 2N2/40 ugly style by Preston Douglas, WJ2V*
- *1998 QRPTTF Results – Joe AB7TT*
- *1999 QRP To The Field Announcement*

CONSTRUCTION SPECIAL

Build a 40M Rig from scratch K8IQY's 2N2/40

Journal of the Northern California QRP Club

Table of Contents

From the Editor

by Doug Hendricks, KI6DS
862 Frank Ave.
Dos Palos, CA 93620
209-392-3522 ki6ds@dpol.k12.ca.us

Wow, another year has come and gone, and we have the final issue for 1998. This one is special, because I did not do most of the work in this issue. Paul Harden layed out the fantastic article by Jim Kortge, and did the wonderful illustrations for it. The reason? I was absolutely tied up with the kitting of the NorCal 20 kits which shipped in late January. I want to publicly thank Paul Harden, NA5N, who saved me on the winter issue. It would not have been out until late March if not for Paul's efforts.

The NorCal 20 as mentioned above, shipped in late Jan. and were we ever glad to see it finally get out the door. But the wait was worth it, as Dave Fifield, the designer, and the whole NC20 team of Dave Meacham, Mike Gipe, Gary Surrency, Doug Hauff, Jerry Parker, Brad Mitchell, Rich Fisher, Gary Diana, Bill Jones, Dave Adams, Jim Cates, George Dobbs, Jim Smith, Lee Johnson, Dave Gauding, and I apologize for leaving anyone out, all worked their fingers to the bone to assure a high quality kit that worked right out of the box. This radio kit has 350 parts, we built 5 rounds of prototypes, spent several thousand dollars on R&D, and even tested every board on a test bed at the board house. The VFO took 4 members, Dave F., Gary, Mike and Dave M. 5 weeks of testing to insure a stable VFO with minimum drift.

We hope that the members enjoy our efforts. Kitting of the 3rd world kits will begin in March, after a 30 day period of rest for me, and also to allow any problems to surface before we mail the kits.

Included in this issue are plans to build the 2N2/40 rig that was the winner of the NorCal 2N2222 design contest held last year. Jim Kortge's design is wonderful. I urge all of you who have ever wanted to build a rig from scratch to do so. Use Paul Harden's wonderful drawings. You can't go wrong. When you finish, I think you will be amazed at the quality of the radio that you have just built.

As with the NC20 project, the 2N2/40 project was not rushed. Jim, Preston Douglas, and Paul worked many, many hours to assure all of us a quality article that will fast become one of the classics.

There is also a flyer in this issue that advertises the Atlanticon QRP Event to be held on March 27th in conjunction with the Timoneum Hamfest. It is being sponsored entirely by the NJ QRP Club. There is NO charge to attend the QRP Forum, which features 7 World Class QRP Speakers, and NO charge for the wonderful compendium that goes to the attendees.

I want to congratulate George Heron and the rest of the NJ QRP Club crew for doing this forum in the true spirit of ham radio and QRP. They are giving back to QRP and helping others, which is what it is all about. We now have major QRP Events on both coasts, and both of them are very similar. World Class speakers, no charge for admission, evening open houses, no host meals at a local restaurant, free compendium, building contests, and most of all, fun.

The NJ QRP Club also has a neat new kit out, the Jersey Fireball 40. The best thing is that the price is only $10 delivered to your door!! The information is also on the flyer and it is a blast to build. Proceeds from the kit are used to support Atlanticon.

If you are anywhere near Atlanticon, I sincerely urge you to attend. It will be a wonderful time, and one that you won't ever forget. QRPers are the best people in ham radio, and they sure know how to have the most fun.

Also, don't forget that the annual NorCal QRP Club Contest, QRP to the Field will be held again on the last Saturday in April. The theme for this year's contest is the same as last year, Run For the Border. Be sure and check out Joe Gervais announcement at the end of the results of last year's contest. By the way, the New England QRP Club started the "To the Field" QRP events. They held one in the fall. I contacted Jim Fitton and urged him to have another one in the spring. He declined, but suggested that NorCal sponsor one in the spring, which we did and have since that time. Paul Harden, NA5N was the first to suggest a theme for the contest, and he started something that has certainly increased the participation. Thanks to Paul and Jim for their support.

I will be attending the Ft. Smith, Arkansas hamfest to give a talk on QRP on March 13th. Hope to see many of you in the area there. This is the second year for a QRP forum there, and Jay Bromely, W5JAY is doing a lot of work getting it organized.

The next issue of QRPp will be an exciting one. Dave Fifield will have an article on the NorCal 20, The NJ QRP Club has another project to announce, plus there will be a full construction article on the Fireball 40.

The back issues for 1998 will be available March 1. The price is going up to $20 per year for the 98 issues, as we are using a wire binding, and costs are going up. Postage and handling have also increased. See the inside back cover for ordering information.

Thanks again to all of you who participated in the NorCal 20 project. I was amazed at your patience with the whole process. You are to be commended. We only had 2 complaints out of all of the orders, an astounding fact. We tried to do the best job possible, but that takes time. Certain things happened that caused delays, parts procurement, delays in the production of the boards, etc. all part of the game. But the end result is worth it. Enjoy QRP. 72, Doug, KI6DS

K8IQY's "2N2/40" Forty Meter CW Transceiver

by Jim Kortge, K8IQY
P.O. Box 108
Fenton, MI 48430

Introduction.
The beginning of the 2N2/40 came about when Wayne Burdick, N6KR, proposed his "post apocalyptic" design contest for Dayton 1998. The premise of the contest was that "no matter what happens to us or the planet, you'll still be able to find them (2N2222's) in huge quantities." It is as Wayne termed it, "The cockroach of the transistor world." The contest challenge was to design a system, capable of transmitting and receiving, using only 2N2222 transistors as the active device, and using no more than 22 of them. A corollary to the constraints was that only other "cockroach parts" could be used, such as 1N914 diodes, but not three terminal regulators, PNP transistors, ICs, or anything of that ilk!

My interest in accepting this challenge was to design and build a transceiver from the ground up, something that I had always wanted to do, but never set aside the time to accomplish. Here was the "golden opportunity", if one ever existed. Along with this, I had been experimenting with MicroSim's PSPICE off and on for several months, but didn't feel that I had a very good understanding of its capabilities, nor how to use it very well. Combining the two elements, design and computer circuit simulation, would provide a valuable learning experience, provide a robust design assuming I was successful, and maximize the "fun" that could be derived from such a project. With those thoughts in mind, it was time to get serious and design and build a rig.

Design Criteria
At the onset, I struggled with some basic questions: "What will I design and build?" "Should it be on CW, and if so, what band?" "Maybe it ought to be something for SSB, then I could use it for bicycle mobile, if it works well." However, reality set in, and the recognition that I had never done this before, so keeping it relatively simple was most appropriate. Forty meters seemed like a good band for a CW rig, as I didn't have a QRP rig for that band, and kept missing out on the Fox Hunts. Sure, I would listen to the gang on my FT990, but the desire to put it on the air wasn't there; it just didn't fit my notion of what that contest is all about.

Another self imposed constraint was to not just lift circuits or designs from various books, but attempt to design the rig from the knowledge gained over many years of reading, listening, experimenting, observing, and operating. That sounds like re-inventing the wheel a bit, and to some degree it is, but it also frees the mind to consider other approaches. Some of that thinking shows up in the rig, and I'll discuss it later in detail.

So 40 meters got the nod for the band, and CW was the mode selected, mostly because of ease of design and construction. A number of the other issues that one would consider resolving at the beginning of a project were left, because I didn't know how difficult it might be to implement various sections sections of the rig, and how many of the 22 transistors would get used in each section.

However, there were some desired basic features in the rig that did not impact the transistor count. These included an r.f. gain control, and a variable bandwidth filter. Features that did depend on transistor count included having an r.f. amplifier to make up for input filter losses, power output of 1-2 watts, and the ability to drive a speaker. All of these were "desirable", but would be reconsidered if all the transistors got used up elsewhere.

Another criterion was to build the rig as small as practical, so that it could go into a QRP-size cabinet. However, at the onset, I had no idea how large or small that might be. The building approach would be to start out with a fairly large piece of single-sided PC board material and begin building in the middle of it. As the design and construction progressed, the circuitry would be built outward, toward the edges. If all of the room wasn't needed when the rig was finished, then a quick trip to the band saw would remove the unused and unneeded board material.

The anticipated approach to use was to design a particular section, build the computer model for that design, optimize the computer model, build and test the section, and finally, compare the test results with those predicted by the modeling. This approach had been used once before on a two band SSB rig that was started for bicycle mobile use, but never finished. For much of that rig, I didn't know enough about modeling to build the models of the ICs that were being used. However, the approach had been used for the antenna T/R switch and the receiver input filter, and it was amazing how closely the actual circuit matched the frequency response predicted by the modeling. What wasn't known was whether this approach would work for a complete rig, and how many design iterations would be required before getting it to work satisfactorily.

As it turned out, the approach worked very well. There were a few iterations on one or two circuits, but for the most part, circuits were built with the component values shown by the modeling to be optimal. The total time to do the design and construction was considerable. I started around the middle of November 1997, a short time after the contest was announced and some 2N2222 transistors had been acquired. It wasn't until nearly the end of April 1998 that the job was done. A good portion of that time was spent doing the actual construction. My building speed could best be described "slow and precise", spending far longer on thinking about and visualizing how a section should be done than most builders would. However, the finished product is quite nice; almost "art like" in its appearance. The first part of May 1998 was spent feverishly getting the rig into a case and assembling the documentation package so that I could take it to Dayton.

Construction Background.

Over the past five or so years, many small projects have been built using a method that I was told years ago is called "Manhattan Style Construction". It's also called "Paddyboard" in some circles. The "Manhattan" name I believe comes from the fact that the little pads and parts that are used look a lot like a city in miniature, when they're all on the substrate. The substrate is usually a piece of single sided PC board material, copper side up. The pads are glued to the surface of the substrate, copper side up, and become the junction points for the circuitry that requires support. The copper ground plane is available for soldering all component leads that go to ground.

Editors Note: This special construction feature is intended to encourage anyone to build a QRP rig from scratch. The following construction practices were written by Jim Kortge, K8IQY, and illustrated by Paul Harden, NA5N, as a step-by-step guide on the techniques required to properly build the 2N2 rig, or most any homebrew project from scratch.

1. Construction Practices & Techniques

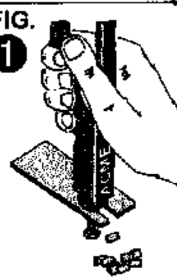
The mounting pads - are made of single-sided copper clad PC material, cut into small pieces and glued to the main ground, or substrate board (a 5x7 inch pieice of solid copper clad for the 2N2/40).

My favorite method of making the small pads is through the use of an ADEL nibbling tool. This is a tool designed for cutting thin sheet metal, but can handle 1/16 inch thick PC board material quite well. The resulting pads that are produced by this tool are about 3/32 inch wide by 1/4 inch in length. (See **Fig. 1**) While that might seem a bit small to most, there is ample room on one pad to solder the ends of 3 or 4 components.

Other alternatives for making the pads is cutting the copper clad PC material into small strips in a mitre box or bench vise as illustrated in **Fig. 2**. The strips can then be cut with wire cutters into the small pads.

Making the "Pads"

FIG. 1



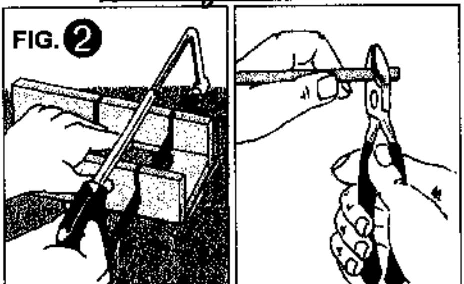
The primary way of making the pads is using a nibbling tool to cut small pieces out of single-sided copper clad board. This also ensures "pads" of uniform size and shape, and fairly fast to perform.

Nibbling tools are available from many tool suppliers and at many Radio Shack stores for about $15.

The copper clad board with holes on 0.1" spacing can also be used. Cutting along the holes with wire cutters tends to break them off 2-holes at a time for a 0.1x0.2 pad with an "octagon" look, shown in **Fig. 3**. File or sand the rougher cuts of this method if desired. A round hole punch from Harbor Freight has also been used by many QRPers for making round pads 3/16 to 1/4" dia.

Making the "Pads"

FIG. 2

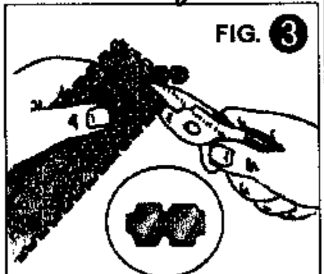


Copper clad strips for the pads can be cut with a sharp saw and mitre box.

Pads are then cut to desired length with wire cutters or tin snips.

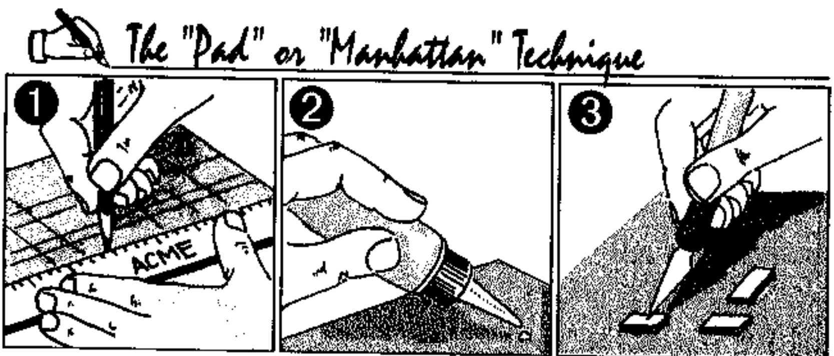
Making the "Pads"

FIG. 3

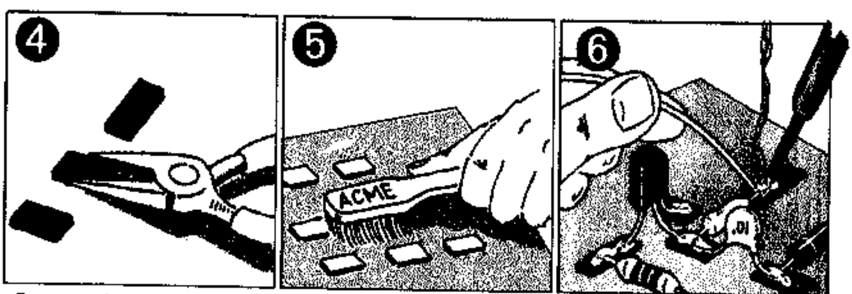


Copper clad with the pre-punched holes on 0.1 inch centers makes good pads also.

Mounting the Pads.
I use common Cyanoacrylate adhesives, (DURO Super Glue) although any of the available, thin adhesives of this type should work. My method for attaching a pad is to hold it in place and put a very small drop against the bottom edge of the pad and the substrate. The thin glue will wick under the pad and attach it in about 5 seconds. Others have tried this method and have had problems and prefer to apply a drop of glue to the board, then mount the pad. The secret is to make sure the surface of the substrate is very clean, and devoid of any sensitizing films, grease, or other contaminants. I scrub my board material with soap and water and a piece of 3M Scotch Bright pad until the copper is shiny. It is then wiped with lacquer thinner to remove any remaining contaminants. When this method is successful, removing a glued down pad requires twisting it off with a pair of pliers as illustrated in **Fig. 4**. Each pad is also wiped across a piece of 400 grit wet and dry sandpaper several times on the copper side before gluing to the substrate. This cleans it and makes soldering to it very easy. Cleaning with a mild solvent or alcohol and brush can also be used to "clean up" the pads before soldering as shown in **Fig. 5**.



1. Draw footprints of each section and guidelines with pencil on the copper clad board. Planning ahead is important!
2. Apply drop of Super Glue or other adhesive to the main board where pad is to be placed. (Glue 1 or 2 at a time!)
3. Drop pads in place over glue and position with exacto knife or other sharp object.



4. Super glue affixes the pads quite well! To remove or reposition a pad, snap-off by a twist with needle-nose pliers.
5. Board and pads can be cleaned with brush and alcohol, mild solvent or water. Excess glue may have to scraped off.
6. Solder the components to the proper pads by following the detailed assembly drawings that follow.

Mounting the Components.
Mounting the various parts to the pads is mostly what could be called a "common sense" approach. I let the "geometry of the environment" guide how a part will be mounted, since there is no standard or accepted way of soldering a part into the circuit.

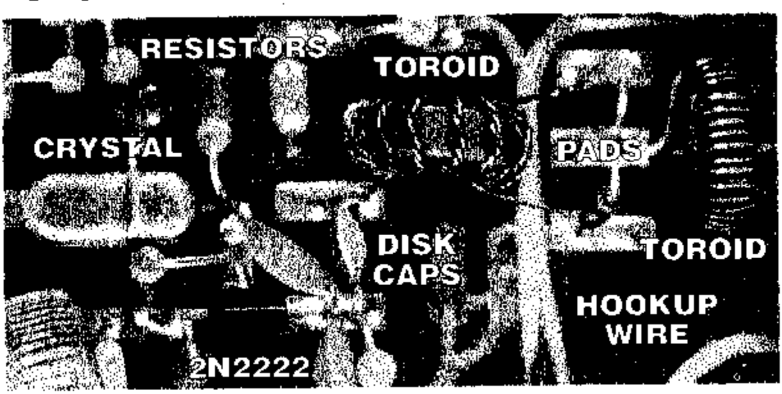
Resistors are generally mounted vertically, for two reasons. First, I think they take up less space that way, allowing one to build more compactly. Second, the higher end also makes a convenient test point; that's why a small loop is put in the higher end lead. It is nice to install resistors with the color codes running from the higher end to the lower end, for easier readability, just in case a mistake is made in building. Occasionally, resistors should be mounted horizontally, either to better span the distances involved, or maybe fit under another component. That's done in several places in the 2N2/40, especially in the audio amplifier section.

Capacitors. There is not a lot to discuss regarding capacitor mounting, since the predominant type used has radial leads. When capacitors are mounted, I try to orient them so that their value can still be read. With components going to ground, one lead needs to be approximately 1/16 inch longer than the other to be soldered vertically to the substrate (ground plane). For leads that are soldered to the substrate, I bend the lead at a right angle at the appropriate length, and leave about 3/16 inch of length for soldering. Leads that will attach to a pad are bent at a right angle also, and have about 3/32 inch of length for soldering.

Transistor and diode leads should be bent about 1/4 to 3/8 inch away from the body. One additional comment is that component leads are prepared one at a time to ensure they fit to their respective pads.

Toroidal coils seem to be troublesome for many. There are detailed winding steps on the next page.

A typical mounting scheme is illustrated in Fig. 6 on the previous page, and of course, as illustrated in the step-by-step assembly drawings that follow. On the 2N2 drawings, special components, such as toroidal coils, crystals, varicap diodes, etc. are well illustrated and detailed to show the recommended mounting scheme. There is nothing critical about the parts placements in the following assembly drawings, should you decide to add your own "flair" or arrangement.



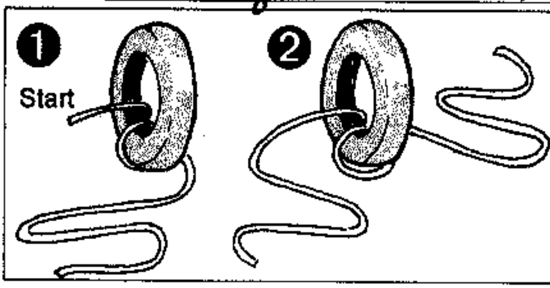
A small portion of Jim's 2N2/40 rig showing a few typical components mounted (soldered) onto the pads

The 2N2 rig, like many QRP rigs today, use toroidal transformers and coils that you must wind yourself. Toroids are cheap, easy to wind, have relatively high-Q's, and "self shielding." Follow these step-by-step instructions, and you will have no problems. Each toroid in the 2N2 is illustrated in detail on the assembly drawing pages to make things easy.

Each time the wire passes through the ***inside*** *of the toroid, it is* ***one turn***. Thus, there are 2-turns in Fig. 1, 3 turns in Fig. 3, and 12 turns shown in Fig. 4.

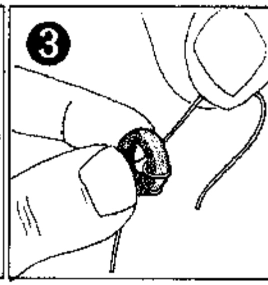
HINTS for Toroids:
- Estimate wire length needed by:
  For T37 - 0.6 inch per turn
  For T50 - 0.8 inch per turn
  Add 2-3 inches for leads, safety
- It doesn't matter which way you wind the toroid, but in the case of a transformer, ensure primary and secondary are wound in the same direction for proper phasing
- Use #24-28 enamel covered *coil wire*, or as specified
- PVC/mylar covered #24-#30 wire-wrap can also be used, although inductance may vary slightly over coil wire.

Winding Toroidal Coils

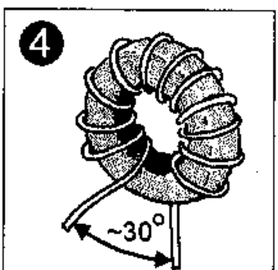


For about a dozen turns or less, start coil wire through toroid as shown, leaving 1-2 inches on start end.

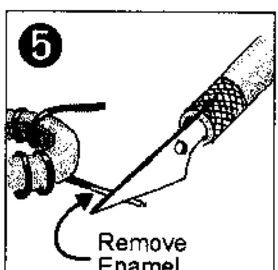
For 12 turns or more, start at half-way point of the coil wire, winding one-half first, then finish with the second half.



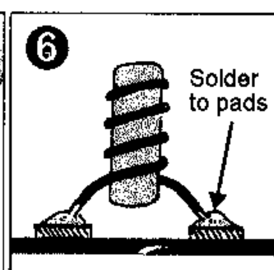
Hold toroid and starting turns with one hand, loop wire with the other, keeping the wire snug against the toroidal core.



When done, windings should be evenly spaced around toroidal core with a gap at the bottom. Trim leads to ½ in. long.



Scrape off enamel from lead ends with a knife. Tin with solder to ensure all coating is removed for a good connection.



Form leads and solder to the mounting pads, with toroid mounted vertically as shown. That's it!

3. 2N2/40 Specifications

RECEIVER

Narrow front end: 150 KHz bandwidth
Sensitivity: -122 dBm MDS (~0.2 uV)
Diode DBM first mixer
Very low noise
VFO: 100 KHz band coverage
 200 Hz maximum drift
 Linear varicap diode tuning
3 pole VBW crystal filter: 300-700 Hz
Push-pull audio output
 for speaker operation

TRANSMITTER

1.5 watts output using
 three 2N2222A's in parallel
Excellent r.f. stability
QSK keying
Meets FCC requirements for
 harmonic rejection (-36dBC)

Overall.

- 22 - 2N2222 transistors; four are 2N2222A metal case types
- All circuits modeled with MicroSim DesignLab or Electronics Workbench
- Built from "scratch" - Manhattan style construction
- 5 inch by 7 inch total footprint size
- Easily fits in many ready-made enclosures

Note from NA5N:
I had the pleasure of having Jim's 2N2/40 in my possession for some time for the purposes of performing lab tests, doing the illustrations contained herein, and making a few QSO's with it. I returned the rig and had the priviledge of working Jim a week later, with him using the 2N2/40, during the Zombie Shuffle *contest on Halloween.*

The 2N2/40 is a serious, high-performance QRP transceiver. *It has very good sensitivity (MDS <-120dBm), selectivity (300-700Hz variable IF filtering), very stable VFO (<200Hz drift first 5 minutes) and surprisingly good audio fidelity (and plenty of it). The "pads" form 3-8pF to ground, and being built over a solid ground from the copper clad board (and not using I.C.'s) lends itself for a very quiet receiver. You'll be impressed with the signal-to-noise ratio, inspite of the nominal -120dBm sensitivity.*

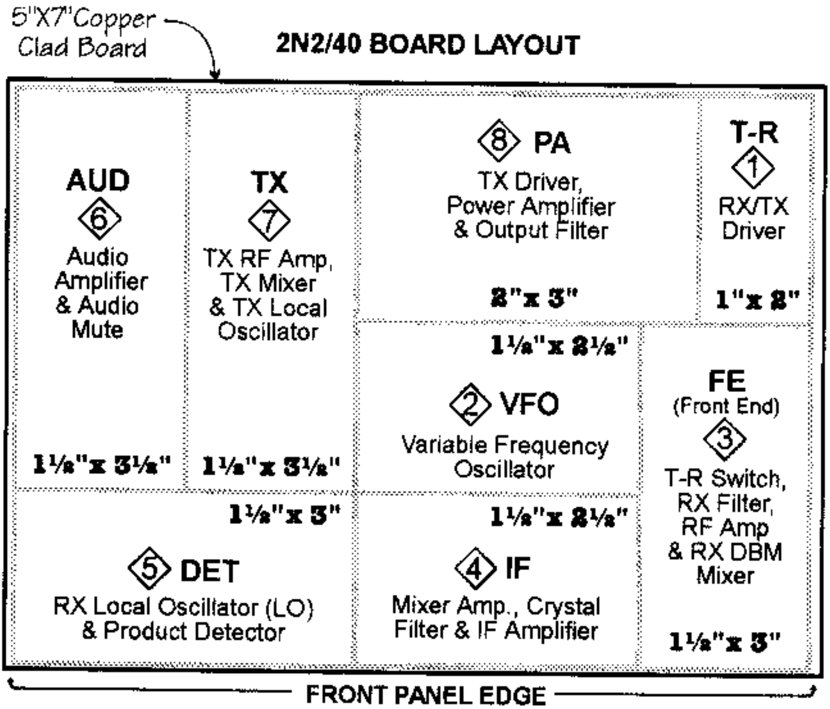
If you've ever wanted to build a QRP rig from scratch, I highly recommend building Jim's 2N2/40. It's a great performer, and why we worked so hard to document it to make it easy to build. I started building mine for the 1999 PacifiCon Building Contest!

4. Physical Layout & Assembly Sequence

Let's talk a bit about the layout used in the 2N2/40 and some of the thoughts and ideas that drove the design. We'll start with the RX/TX driver, only because it is very simple to let you develop your "technique" for making and mounting the pads. Then onto the VFO, since it's shared by both the receiver and transmitter. Then we will do the receiver, starting at the input, and ending at the audio amplifier. And finally, we'll tackle the transmitter. By the way, that's exactly the order in which the prototype rig was designed and built! As each section is highlighted, I'll also try to impart some insight into the various layouts that I've prepared, as an aid in reproducing the rig. While these layouts aren't exactly as the prototype rig was built, they are quite close. However, the size was opened up to 5 inches by 7 inches for this construction article so that there is significantly more room, hopefully making it easier for the first time builder to construct. However, it can be built in a smaller area if you wish with a little forethought.

Layout. The overall layout for the 2N2/40 is shown below, based on using a 5"x7" copper clad board for the ground substrate. It closely follows how the prototype was built. Each block is numbered with the **sequence number (SEQ#)**, the suggested order for building each block, and the order for which this article is based. All drawings are based on the SEQ# for easy reference. Each block also shows the circuit functions it contains and the **footprint** ... the size of each block, which should be pencilled out on the board before mounting the pads to ensure proper fit.

2N2/40 BOARD LAYOUT



The original T/R switch, input filter, r.f. amplifier, and double balanced mixer (usually called the receiver "front end", SEQ#3) were built along the right edge of the board, toward the VFO output transformer. When I got the DBM finished and mounted, (more on that later), it seemed like a good place to "turn the corner", so that was done. Before continuing on though, some testing of the existing circuitry seemed appropriate. Using my FT990 tuned to 4.915 MHz, the 2N2/40's intended i.f. frequency, I connected a test lead from the 990's antenna connector to the output of the receiver DBM. I connected a short antenna to the 2N2/40 input filter and powered it up. I could hear 40 meter signals, and they tuned with the VFO pot! Eureka.....it was working.

Building again started with the mixer amplifier (SEQ#4). Next came the crystal filter, the i.f.

amplifier, and the local oscillator for the product detector (SEQ#5) across the front panel edge of the board. This brought construction to a point near the left edge of the board. It was necessary to make another right turn. That allowed construction of the product detector (SEQ#5), mute switch, and audio amplifier (SEQ#6) along the left-hand edge, going from bottom to top.

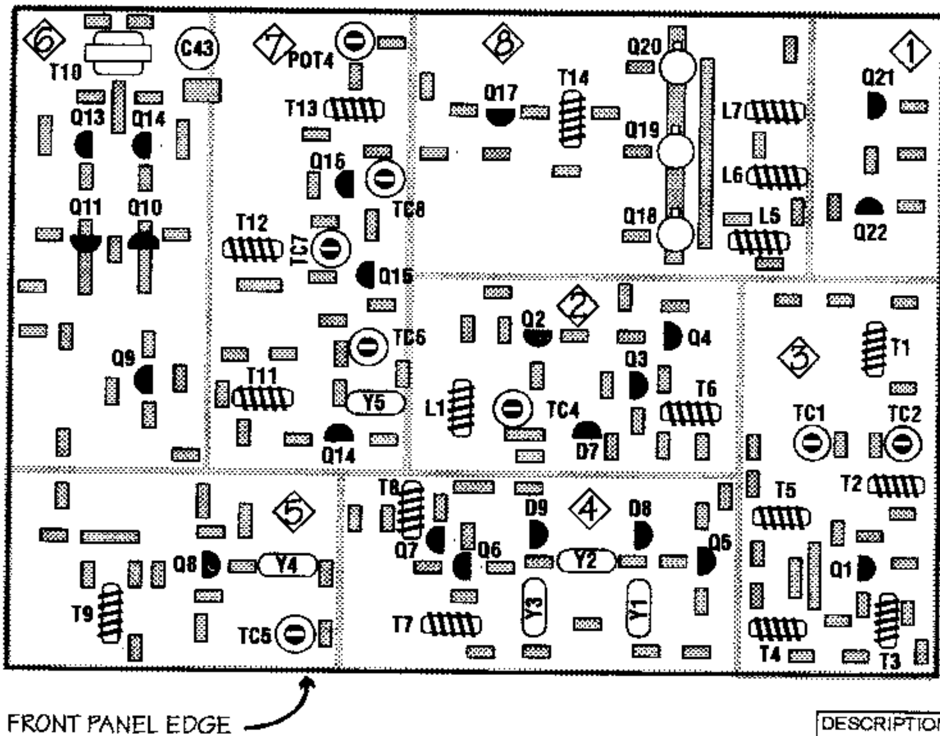
At this point, the receiver portion was essentially done, and I spent about a week just listening to it, and marveling that it actually worked. In fact, it worked very well, far better than I had expected for just 2N2222 transistors. Spurred on by the success of the receiver, I was anxious to see how the transmitter might fare.

Looking over the remaining unpopulated areas of the substrate, it was pretty clear that the transmitter would need to be placed adjacent to the receiver mute switch and the audio amplifier. That also placed the transmit single balanced mixer reasonably close to the VFO, so that getting drive for it would be easy. I built the transmitter local oscillator, the single balanced mixer, and finally the cascode r.f. amplifier. At this point, there was no more room in the direction of the bottom of the substrate. Time to turn yet another corner, and start building toward the right.

However, I started to get a bit uneasy. The buildup of the transmitter r.f. driver (SEQ#7), the final amplifier output section, and the low pass filter (SEQ#8), was yet to be completed, and not much space was left. It was then that the decision was made to go to a "second story" if the rig was all to fit within the substrate footprint. The details at that point were unclear, but it was certain the final amplifier(s) were not going on the main board, but it was certain the final amplifier(s) were not going to fit on the main board, but somewhere else. After building the r.f. driver section, as expected, most of the space was used up.

On the prototype rig, the three 2N2222A transistors used in the final amplifier are located on a 1¼ by 2½ inch piece of double sided PC board material. The transistors are on the top side, and the low pass filter components are on the bottom side. The whole affair is mounted on two 1 inch standoffs. Details of that construction are also shown in the Summer 1998 QRPp. As Paul Harden, NA5N pointed out, building the output final amplifier and low pass filter as a separate structure allows it to be replaced easily with another unit, maybe using a different bipolar or a MOSFET PA. The layout I've suggested, based on my second built 2N2/40, leaves ample room to put the three PA transistors and the output filter on the board. However, you could build the driver, PA, and LP filter on a separate 2x3 inch piece of material, just so you have the option of replacing it some time in the future with a different PA.

That completes the rig in terms of overall physical layout. Let's now move on to the various circuits and circuit sections and discuss them in more detail. Before leaving the layout diagram, one additional comment is appropriate. As a building aid on a 5 X 7 inch substrate, use a ruler and black marking pen with permanent ink and layout the lines as shown. When you build, don't put any component closer to a line than 1/8 inch. This will leave 1/4 inch "gutters" between each section which can be used for routing power and various signal lines. That approach worked really well on the second rig I built using the documentation from this article.

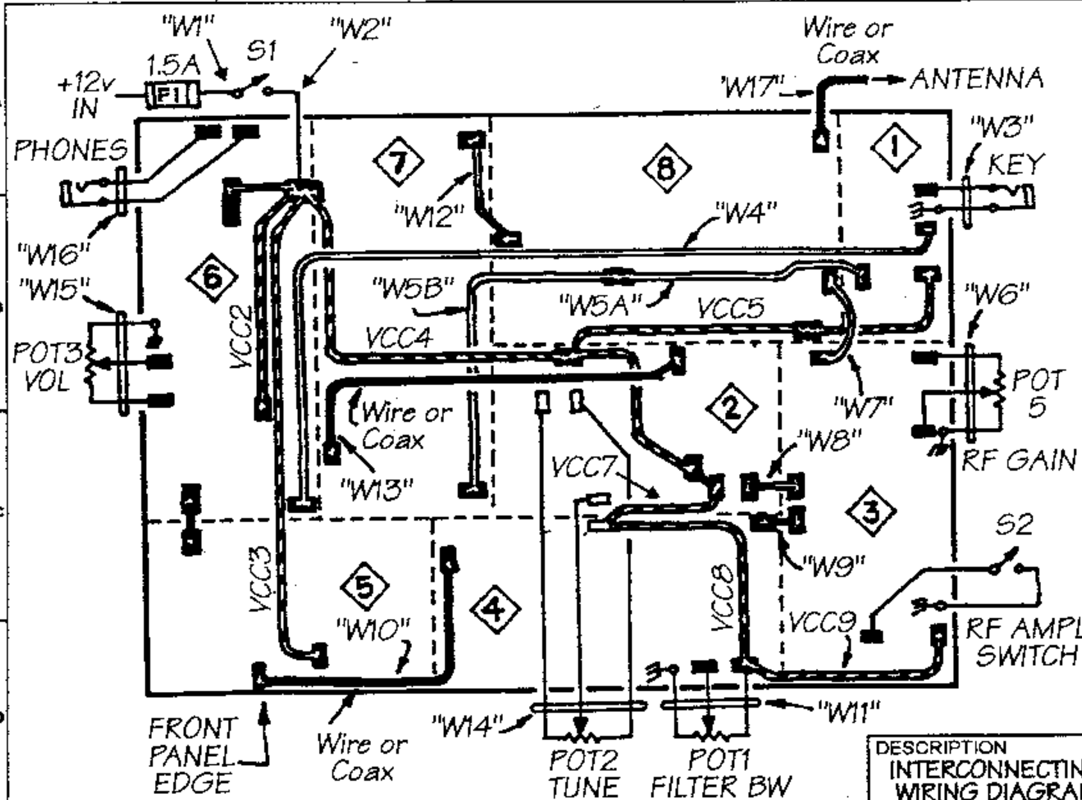


2N2 Board Layout and Pad Locations

Each assembly drawing illustrates in detail the location of every pad and every component in the 2N2/40 rig. However, the assembly drawings are *not drawn to exact scale* due to the "artistic latitude" required to clearly show every component. This drawing shows the EXACT location of the "pads." This is what should be used to layout the position of the pads ... always striving to keep within the footprint size for each section.

Major components only are shown for reference.

DESCRIPTION	**2N2/40 QRP RIG**
2N2 Board Layout & Location of "Pads"	Designed by Jim Kortge, K8IQY Drawn by Paul Harden, NA5N



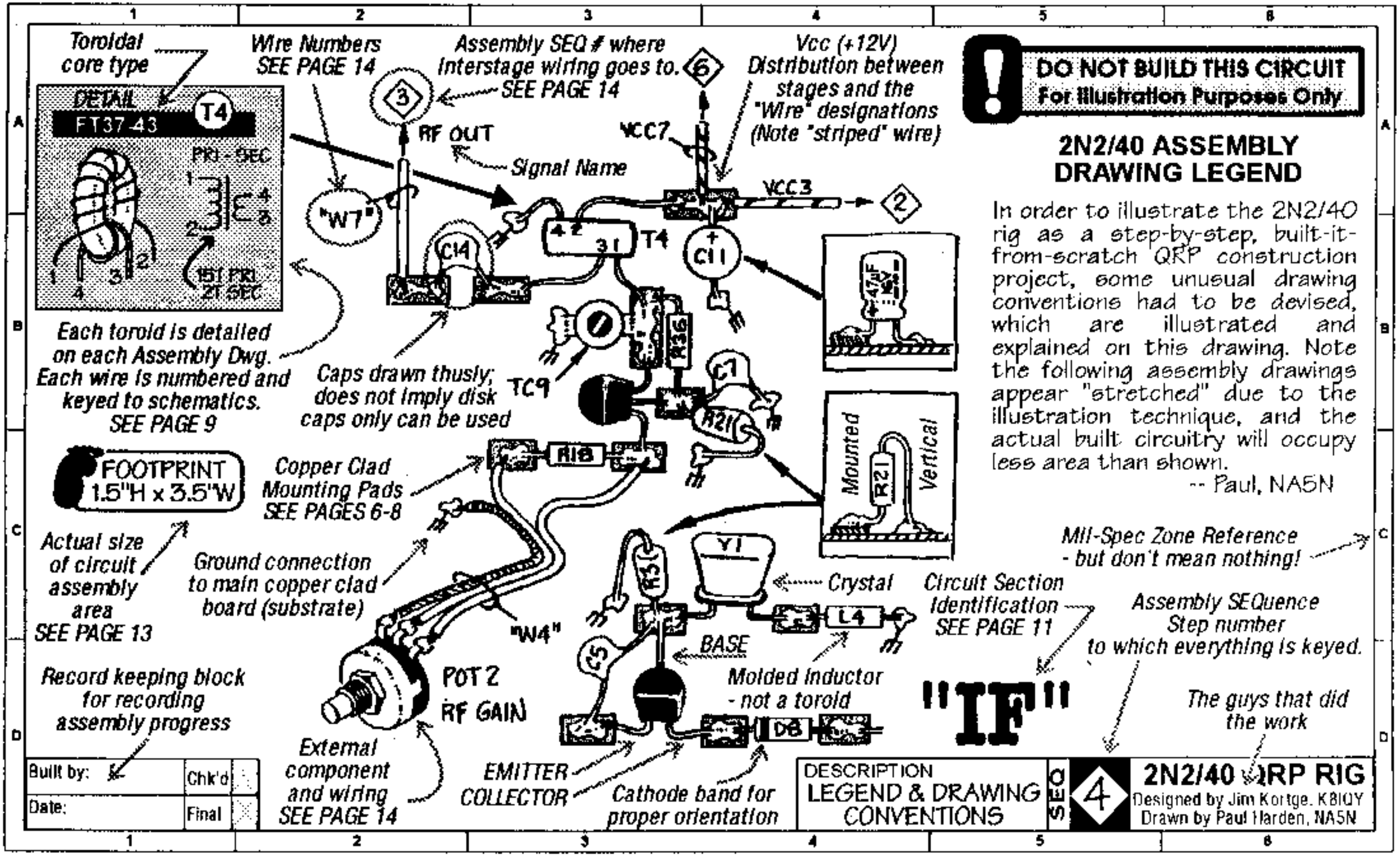
2N2/40 Interconnecting Wiring

One of the advantages of Jim's design is very little wiring to perform except for the external components and the internal wiring for:

- +12v Vcc distribution
- RX and TX terms
- The VFO L.O. signals
- Connections between the sections.

Each wire is given a name (i.e. "W5," "VCC2), which is also shown on each assembly drawing. Use this drawing to check & verify that all section-to-section and external wiring is in place.

DESCRIPTION	2N2/40 QRP RIG
INTERCONNECTING WIRING DIAGRAM	Designed by Jim Kortge, K8IQY Drawn by Paul Harden, NA5N



Toroidal core type
DETAIL
T4
FT37-43
PRI - SEC
1
2
4
3
15T PRI
2T SEC
Wire Numbers SEE PAGE 14
"W7"
3
RF OUT
Signal Name
Assembly SEQ # where Interstage wiring goes to.
SEE PAGE 14
6
VCC7
VCC3
2
Vcc (+12V) Distribution between stages and the "Wire" designations (Note "striped" wire)
DO NOT BUILD THIS CIRCUIT
For Illustration Purposes Only
2N2/40 ASSEMBLY DRAWING LEGEND
In order to illustrate the 2N2/40 rig as a step-by-step, built-it-from-scratch QRP construction project, some unusual drawing conventions had to be devised, which are illustrated and explained on this drawing. Note the following assembly drawings appear "stretched" due to the illustration technique, and the actual built circuitry will occupy less area than shown.
-- Paul, NA5N
C14
T4
C11
TC9
R36
C7
R21
Mounted
Vertical
Each toroid is detailed on each Assembly Dwg. Each wire is numbered and keyed to schematics. SEE PAGE 9
Caps drawn thusly; does not imply disk caps only can be used
FOOTPRINT 1.5"H x 3.5"W
Copper Clad Mounting Pads SEE PAGES 6-8
R18
Actual size of circuit assembly area SEE PAGE 13
Ground connection to main copper clad board (substrate)
"W4"
POT 2
RF GAIN
Y1
R5
C5
Crystal
L4
BASE
Molded Inductor - not a toroid
D8
Circuit Section Identification SEE PAGE 11
Mil-Spec Zone Reference - but don't mean nothing!
Assembly SEQuence Step number to which everything is keyed.
"IF"
The guys that did the work
Record keeping block for recording assembly progress
Built by:
Date:
Chk'd
Final
External component and wiring SEE PAGE 14
EMITTER
COLLECTOR
Cathode band for proper orientation
DESCRIPTION
LEGEND & DRAWING CONVENTIONS
SEQ
4
2N2/40 QRP RIG
Designed by Jim Kortge, K8IQY
Drawn by Paul Harden, NA5N

CONSTRUCTION SECTION

Let's build a rig!

5. Circuit and Construction Details - Receiver

❶ RX/TX Driver

Schematic	Assembly Dwg.
Sht. 4	SEQ. #1

Circuit Description.
The Rx/Tx driver switching circuit provides receiver and transmitter control. Transistor Q21 is normally "on" due to base drive from bias resistor R59 and R60. The port labeled "Rx" supplies current to audio muting transistor, Q9, via resistor R59 also. Since the collector of Q21 is near ground potential, (0.2 volts actually) transistor Q22 is turned "off", and no current is flowing out of its emitter.

When the "key line" is brought to ground via a straight key or keyer, the two transistors revert to their opposite states. Transistor Q21 is turned "off", and the current that was flowing through its collector-emitter junction is now flowing into the base of Q22, turning it "on". The emitter of Q22 now provides current to all of the transmitter sections that require current from the port labeled "Tx". These include the Tx LO, Tx Cascode Amplifier, and the Tx RF Driver stages.

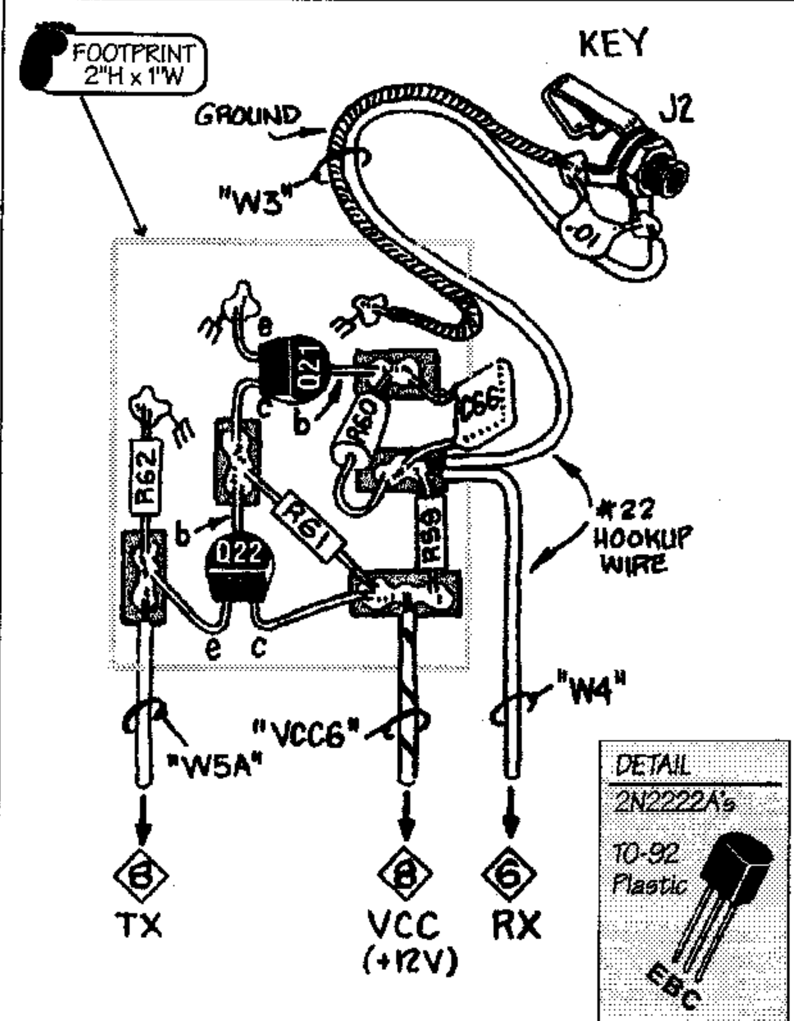
The voltage available at the Q22 emitter is the supply voltage, Vcc, minus its base-emitter forward drop, a value of approximately 0.7 volts, minus its collector-emitter saturation voltage, another 0.2 volts, or Vcc minus 0.9 volts. Had we been able to use a PNP transistor for Q22, the base-emitter drop would be eliminated, but then we wouldn't be using all 2N2222 transistors, as the contest rules required. Not having full supply voltage available to the transmit stages reduces their gain and output power by perhaps 10 percent, not enough to keep the design from working.

Assembly.
The RX/TX Driver is by far the easiest section in the whole rig to build. For that reason, it is the first to build, just to gain some experience mounting the pads and using the "Manhattan" technique to build the rig on this simple circuit block.

As you can see, this section is really simple - nothing critical in terms of layout, and lots of space to build it. Once completed, its port pads for terms RX and TX will be wired to the corresponding port pads in the receiver and transmitter. These switching terms will be wired to the other sections, as you build them, using hookup wire. Refer to the Interconnecting Wiring Diagram on page 14.

- Term RX is wire run "W4"
- Term TX is wire run "W5"

Testing.
For testing, you can add the external components with leads long enough that they will be appropriate when the rig is assembled in a case. With power applied, it should be in the receive mode, that is, RX=+11v, TX=0V. In the transmit "key-down" mode, RX=0v and TX=+11v. The real testing of this circuit, however, need not be performed until the 2N2/40 construction is completed.



NOTES:

1. Assembly drawings are not drawn to exact scale. Illustration technique makes layout appear larger than actually required.
2. Actual size of layout is shown by the "Footprint" dimensions.
3. Wiring for terms TX and VCC will be installed when SEQ8 is built; term RX will be installed when SEQ6 section is built.

"T-R"

Built by:	Chk'd	SECTION RX-TX DRIVERS (T-R Switching)	SEQ 1 — 2N2/40 QRP RIG Designed by Jim Kortge, K8IQY Drawn by Paul Harden, NA5N
Date:	Final		

❷ Varicap Tuned VFO

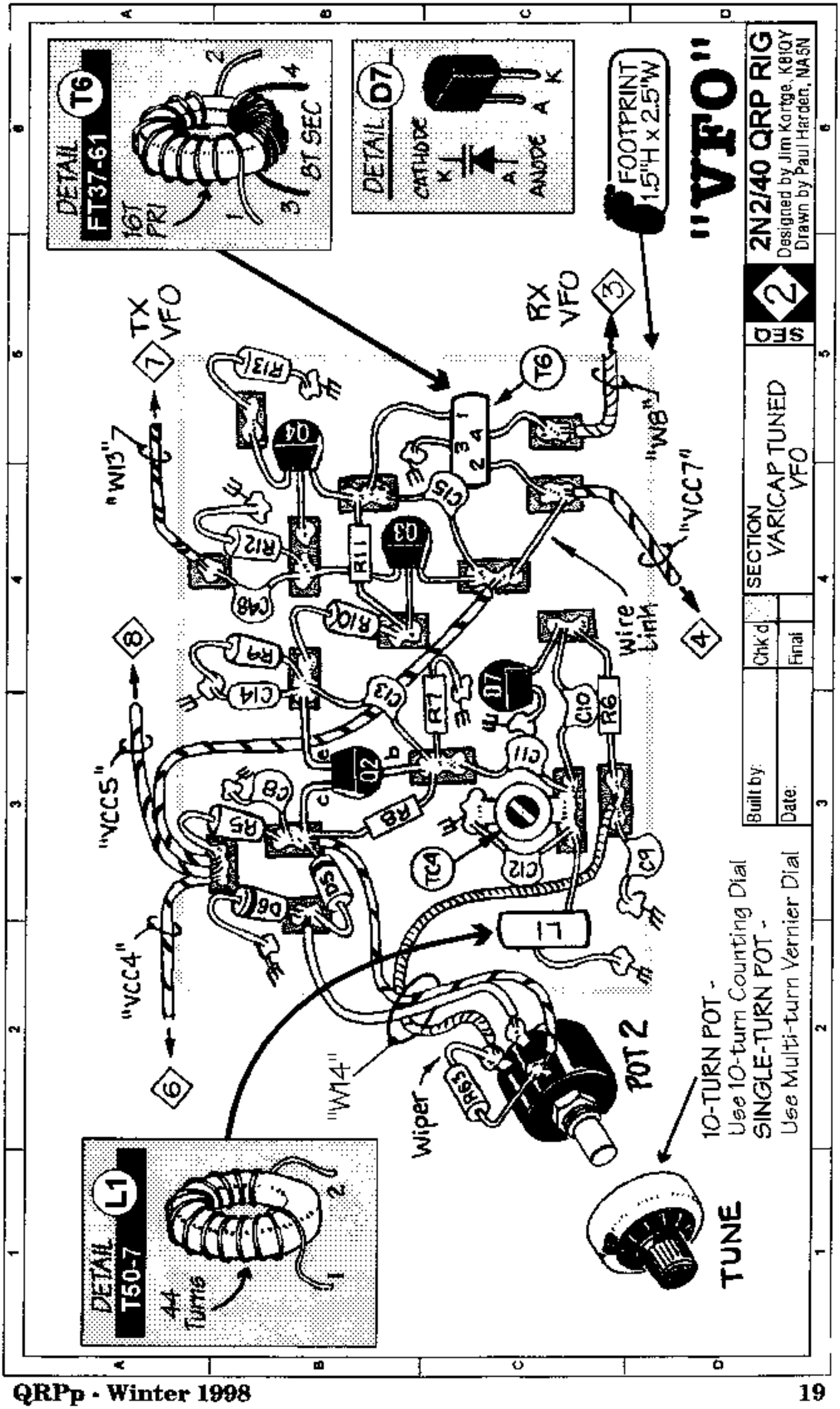
Schematic	Assembly Dwg.
Sht. 1	SEQ. #2

Circuit Description.
The VFO (variable frequency oscillator) is a classic Colpitts design, using a MVAM109 voltage variable capacitance diode for the tuning. It tunes from nominally 2.085 to 2.185 MHz, 100 KHz of band coverage. Trimmer TC4 is used to set the lower frequency limit, and TC3, if included, sets the upper frequency. Some adjustment of the turns on inductor L1 may be required to get the correct frequency range, with the values shown.

Important features include the main inductor, L1, which is wound on a T50-7 powered iron core. With the 44 turns required on this core, the inductance should come in around 8.5uH. Type 7 cores have the best temperature characteristics of any of the commonly available cores. What frequency drift occurs is downward in frequency as the temperature increases. To compensate for this drift, a negative temperature coefficient capacitor is employed, C12a, which moves the frequency upward with increasing temperature. Polystyrene capacitor C12a, in conjunction with C12b (NPO type) provides the correct amount of compensation to keep the frequency stable with changing temperatures. The combination of Zener diode D5 and power diode D6 provide a total of 6.9 volts from the 13.8 volt supply. Keeping the collector voltage low (~7 volts) on transistor Q2 and its components reduces heat dissipation, also helping VFO stability. All of the capacitors in the VFO are NPO types except for C12a and C13 and C14. C13 and C14 are 5% tolerance polyester capacitors, which are quite stable with temperature. VFO drift from a cold start is under 200 Hz. The VFO tuning linearity is improved by swinging the varicap diode, D7, between 6.9 and 0.7 volts, avoiding the most non-linear portion of the capacitance curve, which occurs near 0 volts. Resistor R63, also helps linearize the VFO tuning by effectively changing the linear potentiometer, POT2, into a non-linear unit which approximately matches the tuning diode capacitance versus voltage curve.

Transistor Q3 serves as a buffer, keeping load changes from affecting Q2, the oscillator. Output from the emitter of Q3 is used to drive the transmitter single balanced mixer. The VFO signal is further amplified by transistor Q4, to provide the +10 dBm drive level (0.7 volts rms) required by the receiver double balanced mixer. Signal output is transformer--coupled to the receiver mixer from the secondary winding of T6. The primary winding is 16 turns on a FT37-61 core for 14 to 15 uH of inductance, depending how it is wound. It is tuned by capacitor C15 to provide the required driving power, and to reduce harmonic content output. The VFO also has low phase noise, as shown in the spectral display measured by NA5N on page 20.

Assembly.
The VFO layout is shown in Assembly Drawing **SEQ#2**. As you can see, the construction starts on the left at L1, and flows to the right, where the main output, the secondary of T6, is positioned to be close to the receiver DBM in section SEQ#3. The output going to the transmitter single balanced mixer, Tx VFO on SEQ#7, will be routed through shielded cable (RG-174, etc.) to reduce radiation into surrounding circuitry. There is some latitude for constructing the VFO in terms of alternate part locations. It doesn't have to be built as shown. Just try to keep the overall size within the footprint, so that you have enough room for the other sections.

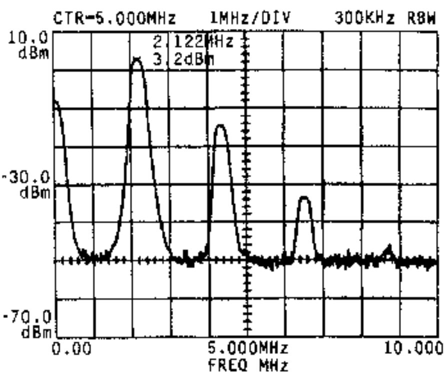

"VFO"
2N2/40 QRP RIG
Designed by Jim Kortge, K8IQY
Drawn by Paul Harden, NA5N
SECTION
VARICAP TUNED VFO
SEC 2
Built by:
Date:
Chk'd
Final
DETAIL T6
FT37-61
16T PRI
8T SEC
DETAIL D7
CATHODE
ANODE
FOOTPRINT 1.5"H x 2.5"W
DETAIL L1
T50-7
44 Turns
TUNE
10-TURN POT -
Use 10-turn Counting Dial
SINGLE-TURN POT -
Use Multi-turn Vernier Dial
POT 2
Wiper
"W14"
"VCC4"
"VCC5"
"W13"
"W8"
"VCC7"
TX VFO
RX VFO
Wire Link

SEQ#2: VFO con't.
Varicap diode D7 looks like a TO-92 transistor, but with only 2 leads. Ensure it is installed properly. See the detail for identifying the anode and cathode on the SEQ#2 drawing.

Testing.
Once built, this section can be tested quite easily if you have a general coverage receiver. The VFO needs to tune nominally from **2.085 MHz to 2.185 MHz**. Attach a short length of wire to the pad marked "Rx VFO". Power it up by applying 12 to 13.8 vdc (use a fused supply) to all of the pads marked Vcc, and tune your receiver until you hear the VFO. It should be quite strong. If you have a counter or oscilloscope, they can also be connected to the same output pad for measurement and signal observation. The unloaded output from the secondary of T6 should be around 3 volts peak to peak.

2N2/40 on the Test Bench

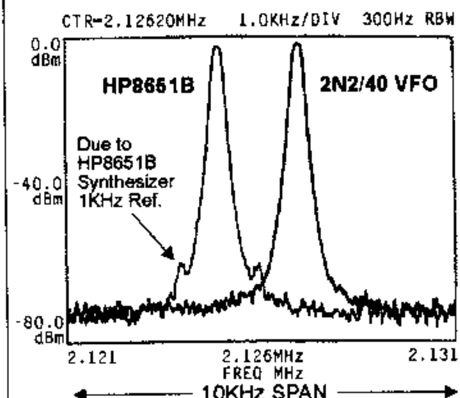
VFO Power & Spectral Output



As Jim discussed in his article, harmonic power from the VFO is reduced by the inductance of T6-primary and C15. Without C15, the 2nd harmonic (4.2MHz) is only down about 6dB. With C15, as shown here, the 2nd harmonic is down 18dB (-18dBc) and the 6.3MHz 3rd Harmonic is -37dBc. The lower the harmonic content of the VFO (LO), the less image power out of the mixer. The spectrum here was measured at the center-tap of T5 (RX LO power).

VFO close-in Purity (Phase Noise)

Oscillator Close-in Sideband Power
2N2/40 VFO vs. HP8651B Sig. Gen.



Oscillator phase noise is the very small "wiggling" of the oscillator that causes power to appear in the very close-in (<20KHz) sidebands. Of interest to QRP rigs is <2KHz, as this will cause noise power in the detected CW audio and other problems. It is also a measure of oscillator quality and stability. The VFO in the 2N2/40 has very low noise power, being -65dBc at 750Hz and -68dBc at 2KHz for a phase noise of slightly less than 2°. The 2N2/40 VFO close-in spectrum is shown here compared to an HP 8651B signal generator.

❸ Receiver "Front End"

Schematic	Assembly Dwg.
Sht. 1	SEQ. #3

- RX T/R Switch
- Input Filter
- Switchable RF Amplifier
- Diode Double Balanced Mixer

Circuit Description.
The RX T/R switch configuration used in the 2N2/40 is not the first design that I actually built. My first design was more robust, but required too many transistors to generate the drive signals, and in the end, had to be scrapped. This design, I believe, comes from Roy Lewellan, W7EL and has been used by many others. While it works very well for such a simple design, it does have some limitations. Its main fault is that it doesn't handle strong signals well, which could lead to third order intercept problems. However, if your 2N2/40 isn't used at field day or in similar situations, where really strong signals are present, it does just fine.

As originally implemented, the circuit used a trimmer at TC9, a 12uH inductor at L8, and the series resonance of this pair could be tuned. However, the loaded Q of the circuit is quite low, about 4, which makes the tuning so broad that this capability is wasted. I'd recommend building this circuit with TC9 being a fixed 47pF capacitor, and L8 being a 10uH molded inductor. That saves a trimmer, and the performance is virtually unchanged.

The input filter receives the signal from the T/R switch. This filter is a classic double tuned band pass filter, using light coupling between the two resonators. Its half power bandwidth is about 150 KHz with the component values used. The secondary of input transformer T1 has an inductance of 3.6uH, and is resonated at 7.05 MHz with capacitor C1 and trimmer TC1. The three-turn primary provides a 50 ohm match to the antenna.

Output transformer T2 uses a 7-turn link, to match the 350 ohm input impedance of the r.f. amplifier. T2 is tuned to resonance with capacitor C3 and trimmer TC2. The coupling between the two resonators is 3pF. In the prototype rig, this capacitor is 3.9pF, but additional circuit tests suggests a 3pF value provides flatter frequency response over the desired 7.0 to 7.1 MHz region, without appreciable change in overall 3dB bandwidth. It should also make input tuning a bit less critical.

The r.f. amplifier is based on a common emitter design. With the component values used, it has 10 dB of power gain. Computer modeling shows that it can handle an input signal in excess of +13 dBm without distortion or going into gain compression. Another 10 dB of gain can be accomplished by paralleling emitter resistor R4 (82 ohms) with a 12 ohm resistor (R65). My 2N2/40 has a front panel switch for doing this, although I don't use the 20 dB gain position very often. Running the higher gain also reduces the input impedance to about 100 ohms, causing a mismatch with the input filter. However, it does let you to hear really weak signals, under the right conditions. A 4:1 impedance ratio bifilar transformer, T3, is used to couple the output to the receiver's diode DBM.

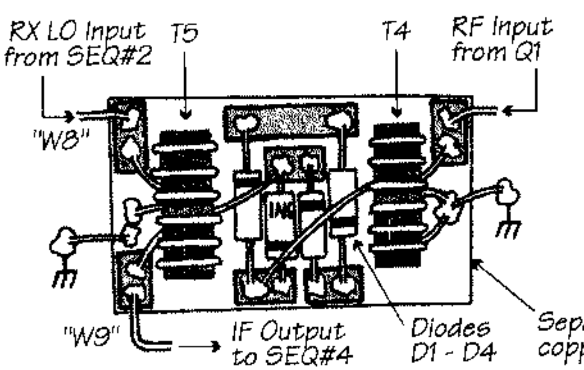
The receiver diode double balanced mixer (DBM) in the prototype rig was constructed on a very small (1/2 inch X 3/4 inch) piece of single sided PC board material, instead of on the main substrate. The reason for doing this was so that it could be easily replaced (after Dayton, of course) with a commercial DBM if my home-brew unit didn't work well. That DBM implementation was detailed in Paul Harden, NA5N's "QRP Hints and Kinks" section of the Summer 1998 issue of QRPp. (see below). I'm not sure that I would recommend building yours quite that small, unless you have lots of patience! The provided layout essentially uses the same geometry, but with more room between the various components. However, keeping the all the leads as short as possible helps maintain the balance necessary for the DBM to work well. Also, the 1N4148 diodes should be matched for forward resistance. Just measure a bunch, and pick 4 that are within a 1 ohm of each other. Since the diode leads are cut short, don't keep the soldering iron on these connections very long, or you will overheat the diode and change it's forward resistance characteristics.

Assembly.
This section should be built from the (rear panel end) to the bottom (towards front panel edge), and from right to left. Start with the input pad for the T/R switch (Port A on the schematic, or wire "W7" on the assembly drawing) and end with the DBM on the bottom left. Once this portion is built, it too can be tested, using a general coverage receiver. I'm assuming that you have the VFO built and working correctly and its output is routed to the pad labeled VFO (Term RX VFO, wire "W8" from dwg. SEQ#2). Solder a temporary jumper across the two pads labeled Pot 5 Wiper and Pot 5 High (RF Gain control).

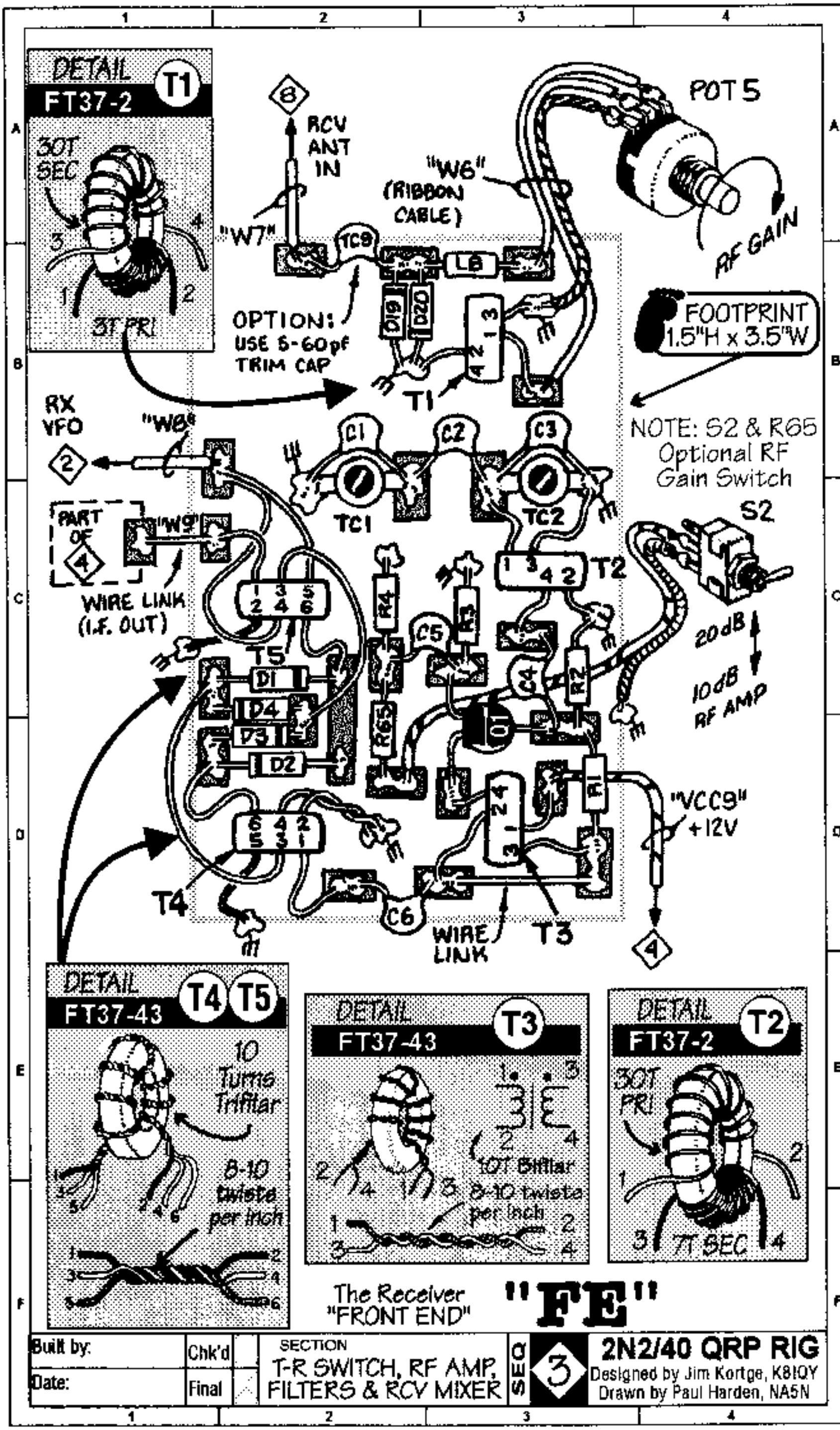
Testing.
Set the VFO to its mid-frequency, 2.135 MHz. Attach an antenna or 4-5 foot piece of wire to the pad labeled A. (Wire "W7"input). Connect the output pad labeled "C" (Wire link "W9") to the antenna input on your receiver with a piece of coax cable. Tune the receiver to 4.915 MHz. Using a signal generator, or a QRP rig fed into a dummy load, generate a signal on 7.050 MHz. You should find a signal very near 4.915 MHz, the 2N2/40 i.f. frequency.

Once you find the signal, peak the input trimmers TC1 and TC3. Go back and forth between these two a couple of times until it is as strong as you can get it. If you built this section using a trimmer for TC9, peak that trimmer also. At this point, you should be able to leave the receiver tuned to 4.915 MHz, and tune the 40 meter CW band using the VFO. The general coverage receiver is acting as our crystal filter, i.f. amplifier, and detector. We'll build those next.

Double Balanced Mixer (DBM) -- Alternative Layout



This alternative approach builds the DBM on a separate piece of copper clad. It would be useful for builders wanting to experiment with different diodes for the mixer, or to remove later to install an SBL-1, etc.



DETAIL T1
FT37-2
30T SEC
3T PRI
RCV ANT IN
"W7"
"W6" (RIBBON CABLE)
POT 5
RF GAIN
OPTION: USE 5-60pF TRIM CAP
FOOTPRINT 1.5"H x 3.5"W
RX VFO
"W8"
NOTE: S2 & R65 Optional RF Gain Switch
PART OF
"W9"
WIRE LINK (I.F. OUT)
20dB
10dB RF AMP
"VCC9" +12V
WIRE LINK
DETAIL T4 T5
FT37-43
10 Turns Trifilar
8-10 twists per inch
DETAIL T3
FT37-43
10T Bifilar
8-10 twists per inch
DETAIL T2
FT37-2
30T PRI
7T SEC
The Receiver "FRONT END"
"FE"
Built by:
Date:
Chk'd
Final
SECTION
T-R SWITCH, RF AMP, FILTERS & RCV MIXER
SEQ 3
2N2/40 QRP RIG
Designed by Jim Kortge, K8IQY
Drawn by Paul Harden, NA5N

4 Crystal Filter/IF Amp

Schematic	Assembly Dwg.
Sht. 2	SEQ. #4

- Mixer Amplifier
- Variable Crystal Filter
- I.F. Amplifier

Circuit Description.
These elements make up the next major section of the receiver. With the addition of the Local Oscillator (RX LO) and the Product Detector in the section SEQ#5, we have essentially a complete receiver, down to detected audio. We'll get to that point shortly.

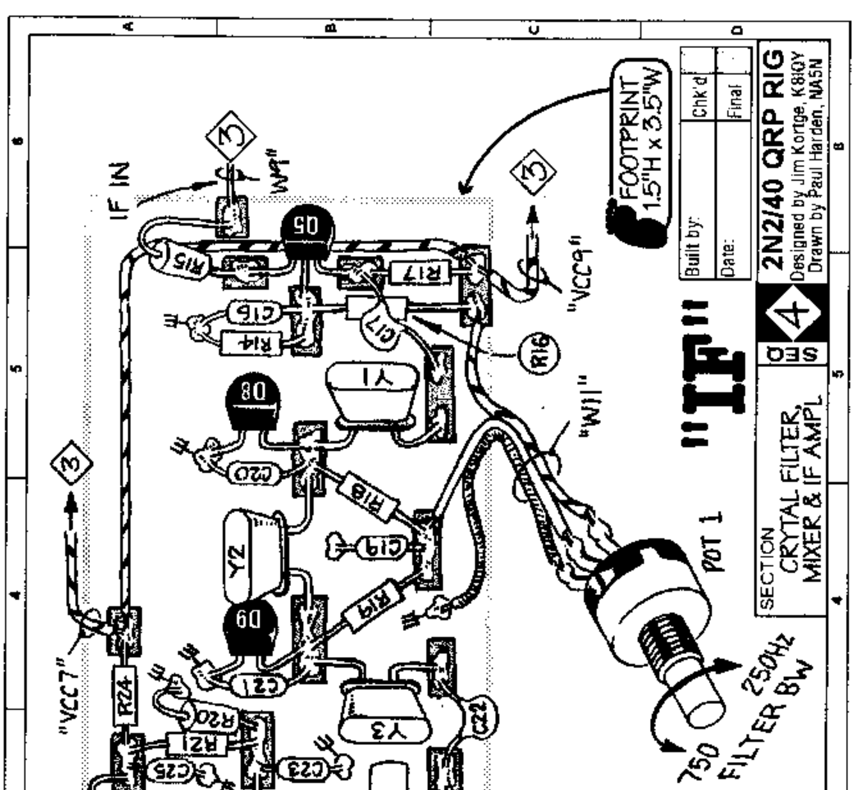
Mixer Amplifier. The diode DBM IF output signal (from SEQ#3) is fed to common base amplifier Q5. I've not seen this done before, and am not sure why. Since one of the goals in terminating a DBM is to have it working into a constant impedance load, this amplifier fits the bill nicely.

As configured, the input impedance is constant at 50 ohms resistive, from DC to beyond 30 MHz. Using this circuit, we don't need a diplexer, nor do we need an attenuator, to keep the load on the mixer i.f. port constant. In addition, with the 270 ohm collector resistor, this amplifier produces about 6 dB of power gain. It also has reasonable output to input isolation, so that impedance changes from the downstream crystal filter don't reflect back to the mixer.

Variable IF Crystal Filter. Following the mixer amplifier is a 3 pole, variable bandwidth (VBW), Cohn style crystal filter, consisting of Y1 to Y3. It uses matched 4.915 MHz series mode crystals. The bandwidth can be changed from about 700 Hz, down to 300 Hz. (See the NA5N measurements on page 26). Bandwidth control is accomplished using a pair of MV2115, voltage variable capacitance diodes. These diodes provide a capacitance change of about 100pF, as the voltage on them is varied from 0 to 13.8 vdc. Bandwidth control voltage is provided by a variable potentiometer, POT1. The 270 ohm source and terminating impedances for the filter are provided by collector resistor R17, on the input side, and the transformed input impedance of Q6, the first i.f. amplifier transistor, on the output side. The output impedance transformation is done with transformer T7, which has a 15-turn to 2-turn turns ratio, and approximately 56 to 1 impedance ratio. The 2-turn secondary should be wound on the "cold" (grounded) end of the primary.

The IF Amplifier. Following the VBW crystal filter is the intermediate frequency amplifier, Q6 and Q7, using another somewhat unconventional design. My first thought for the i.f. amplifier was to use a common cascode arrangement, i.e. a common emitter amplifier driving a common base amplifier. That configuration was modeled, and although it provided plenty of gain, it showed a wide variance in the input impedance with frequency. I felt the crystal filter ought to be working also into a constant load, just like the receiver DBM, for optimum performance. This led to building a new computer model which had the common base amplifier first (Q6), driving a common emitter amplifier (Q7).

As with the common cascode configuration, the two transistors, Q6 and Q7, are direct coupled. Modeling once again showed this configuration could supply more than enough gain, but more importantly to me, the input impedance was constant over a very wide frequency range. However, the input impedance is only a few ohms, which resulted in the wide turns ratio transformer, T7, being required to couple the


2N2/40 QRP RIG
Designed by Jim Kortge, K8IQY
Drawn by Paul Harden, NA5N
SECTION
CRYTAL FILTER,
MIXER & IF AMPL
"IF"
FOOTPRINT
1.5"H x 3.5"W
Built by:
Date:
Chk'd
Final
POT 1
250Hz
750
FILTER BW
IF IN
IF OUT
"VCC7"
"VCC9"
"W10"
"W11"
DETAIL
FT37-43
DETAIL
D8 D9
CATHODE
ANODE
Ensure proper orientation of D8-D9

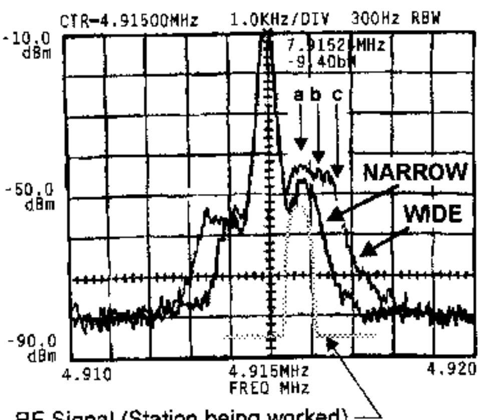
crystal filter into the amplifier. With the component values shown, the power gain of this stage is nearly 50dB, with a response peak at 4.9 MHz. Output is taken from a bifilar wound, 4:1 impedance ratio transformer, T8. The output impedance from this stage is 50 ohms, suitable for driving the product detector. This amplifier also shows no stability problems when properly terminated.

Assembly.
I'd recommend building this portion of the rig by starting at the right, near the DBM output in SEQ#3, and building toward the left until you're done with the i.f. amplifier. Probably the only critical thing here is keeping as much room between the i.f. input and output transformers, T7 and T8, as you can. This will help to insure stability. Placing the transformers at right angles to each other also minimizes coupling, but is not required.

Testing.
If you would like to test the rig at this point, connect the output of the i.f. (port pad marked "IF Out," or wire "W10") to the antenna input of your general coverage receiver, again using coax or a shielded scope probe. Tune the general coverage receiver to 4.915 MHz and power up the 2N2. This time, signals should be very strong, since we now have another 50 dB of gain from the i.f. amplifier. In fact, on very strong signals, you may have to reduce the r.f. gain of the communications receiver to keep from overloading it. You can also play around with the VBW crystal filter by grounding the pad marked "Pot 1 Wiper" or by taking this point to the Vcc supply. When this pad is grounded, the filter will be in its most "narrow" position, and when at Vcc, the filter will be running in its "wide" position. Of course, if you hook up POT1, you can set the filter to any passband width within its capability.

2N2/40 on the Test Bench

The Variable Bandwidth IF Crystal Filter



This spectrum analyzer display was made by injecting a -70dBm wideband noise source into the antenna (an S3-S4 signal) to "paint" the overall shape of the IF response.

This spectrum analyzer display shows the IF bandwidth at the crystal filter output for both the ***wide*** and ***narrow*** settings on the VBW control (POT1). Point "a" is the IF peak. The -3dB points are shown at "b" (narrow) and "c" (wide). This shows a bandwidth of 800Hz in the wide setting, and 300Hz at narrow, for a very nice variable IF filter for CW reception. If there was a signal 1KHz higher, note it would be attenuated by 6dB in *wide*, and in *narrow* by 28db! This gives the 2N2/40 good selectivity and rejection of nearby interfering signals.

--NA5N

5 RX LO Oscillator and Product Detector

Schematic	Assembly Dwg.
Sht. 2	SEQ. #5

Circuit Description.
The receiver local oscillator is a Colpitts configuration, just like the VFO. Perhaps the only unique feature of the circuit is tapping the output off the split emitter resistor pair, R29 and R28 and using a parallel tuned circuit to shape the waveform and reduce harmonics. I'm not sure going these extra steps has any payoff, but the output waveform is a clean sinewave. Something that may not be obvious about this oscillator setup is that its frequency is below the i.f. passband because this rig uses the Cohn filter as an upper sideband filter, instead of the more traditional, lower sideband arrangement. Lowering the crystal frequency is accomplished by adding inductive reactance from L2, in series with the crystal. Trimmer TC5 lets us adjust the amount of inductive reactance. For proper receiving, the frequency of this local oscillator is adjusted to be 750 Hz *below* the 4.915 MHz passband. When this signal is mixed with the i.f. signal in the product detector, our desired 750 Hz CW note is recovered.

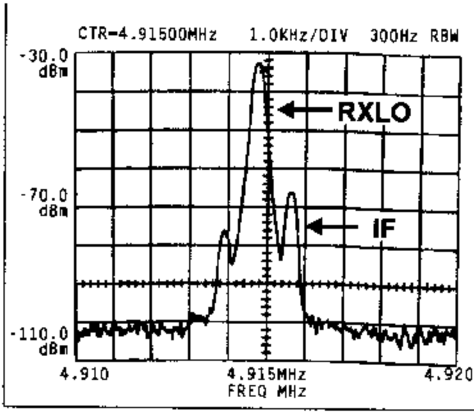
The product detector is simply a two-diode, single balanced mixer. The i.f. signal is mixed with the receiver local oscillator producing principally two frequencies. The sum frequency is at 9.83 MHz and is shunted to ground by the reactances of C27 and C28. The difference frequency is 750 Hz, and adjustable by changing the frequency of the receiver local oscillator (also called the BFO -- the Beat Frequency Oscillator) via trimmer TC5. This is the recovered audio that will drive the speaker after it is amplified.

Assembly.
The RX LO oscillator and the Product detector are built to the left of the IF/crystal filter section to the left edge of the board. Layout is not tight, but plan things out to ensure you're not running out of "board" space.

Note T8, the trifilar wound transformer. Details for winding T8 are on the assembly drawing.

Testing.
There's not much to test at this point. Let's build the next section, the audio amplifier, and then we'll have a complete receiver to test and align.

2N2/40 on the Test Bench

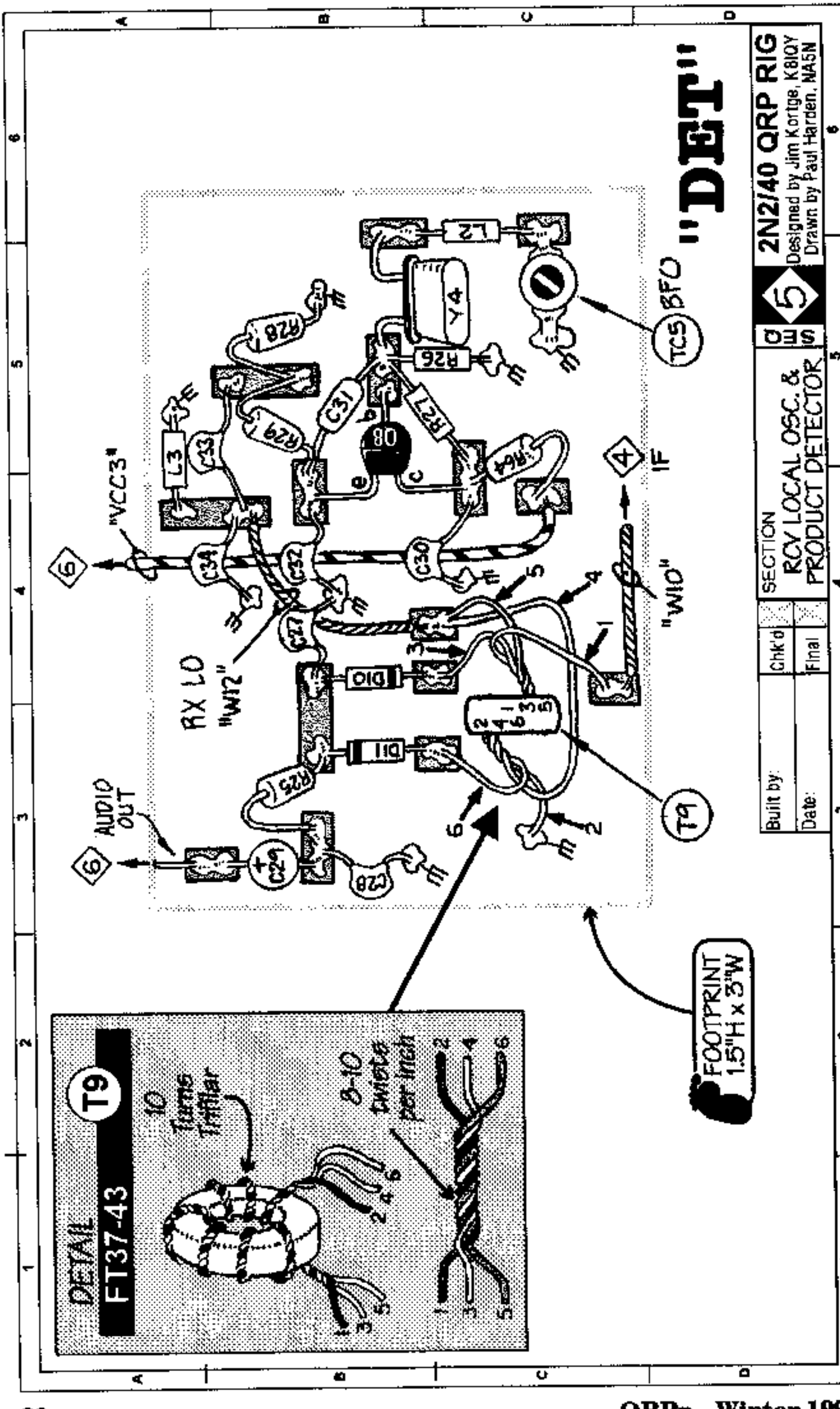


Input spectrum of the Product Detector

This shows how the product detector works to generate the desired "CW tone." The two input signals are:
4.915600 MHz - IF
4.914800 MHz - RXLO

The difference frequency is 800Hz ... the CW ***audio*** tone that will be present at the Product Detector output. The actual tone is set by TC5 - the BFO, which varies the RXLO frequency.

-NA5N



"DET"
2N2/40 QRP RIG
Designed by Jim Kortge, K8IQY
Drawn by Paul Harden, NA5N
SECTION
RCV LOCAL OSC. &
PRODUCT DETECTOR
Built by:
Date:
Chk'd
Final
DETAIL
FT37-43
T9
10 Turns Trifilar
8-10 twists per inch
FOOTPRINT
1.5"H x 3"W
AUDIO OUT
RX LO
"W12"
"VCC3"
"W10"
IF
BFO
TC5

❻ Receiver Mute and Audio Amplifier

Schematic	Assembly Dwg.
Sht. 2	SEQ. #6

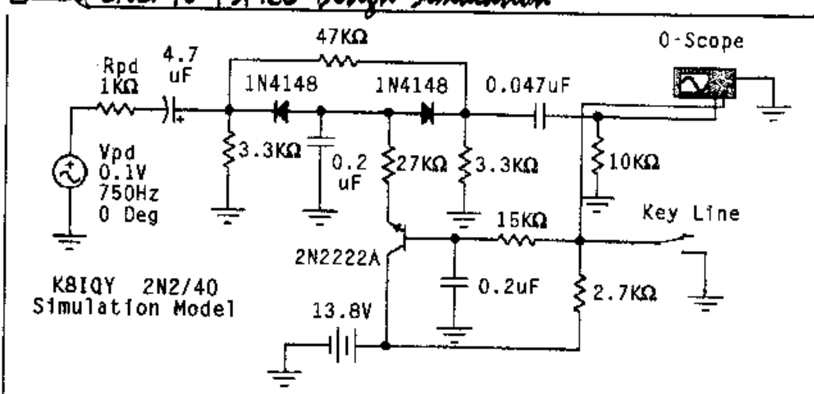
Circuit Description.
The receiver mute circuit passes recovered audio to the audio amplifier when the rig is in receive mode. In this condition, diodes D12 and D14 are forward biased, and have very low forward resistance. The bias is provided by transistor Q9, which is turned "on" by the "Rx" signal applied to the base. When the rig transmits, drive is removed from Q9, causing the bias on D12 and D13 to be removed. These diodes now appear as open circuits, and audio is blocked. A small amount of side-tone audio is passed on to the audio amplifier during transmit by resistor R31. Sidetone audio is provided by having the receiver listen to the transmitter. Caps C35 and C36 provide delays to keep audio "thump" to a minimum during receive-to- transmit and transmit-to-receive transitions.

PSPICE Analysis.
Before leaving this section, it seems appropriate to show an example of the analysis that can be done with today's computer modeling tools. In this case, the software product is the Personal Edition of Electronic Workbench. The company that produces this system offered it at reduced pricing this summer, so EWB was purchased. It works much like the MicroSim DesignLab (PSPICE) demo that I had been using, but is even more full-featured. When the educational Manhattan/Elmer 300 Project is done this winter over the internet, many more of these analyses will be discussed and shown. This one is just to whet your appetite!

The computer model of the receiver mute circuit is shown below.

As you can see, this simulation circuit is a duplicate of the real thing shown in the 2N2/40 schematic. Product detector output, which is the signal source for this simulation, is the ac source labelled Vpd, set for 100 millivolts rms at 750 Hz. The product detector source impedance is the 1K resistor labelled Rpd. The small oscilloscope in the upper right hand of the model is a simulated scope within EWB, and can be expanded to show waveforms while the simulation is running. That will be shown next.

2N2/40 PSPICE Design Simulation

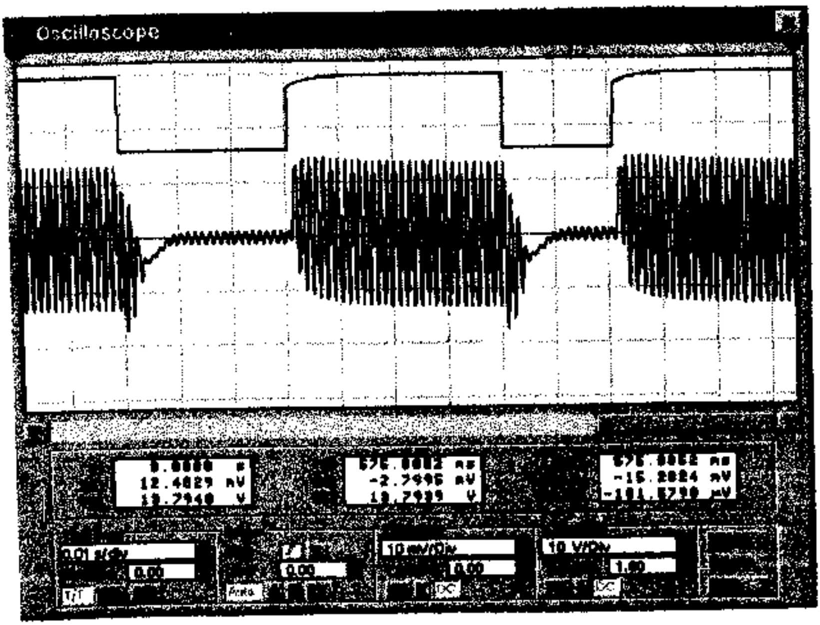


RX MUTE SIMULATION MODEL

The "key line" can be toggled while the simulation is running by tapping the space bar on the computer keyboard, so that the transitions from "receive mode" to "transmit mode" and back again can be studied. Actual CW could be simulated by hooking up the EWB digital word generator in place of the key line switch, but that's overkill for this simple circuit.

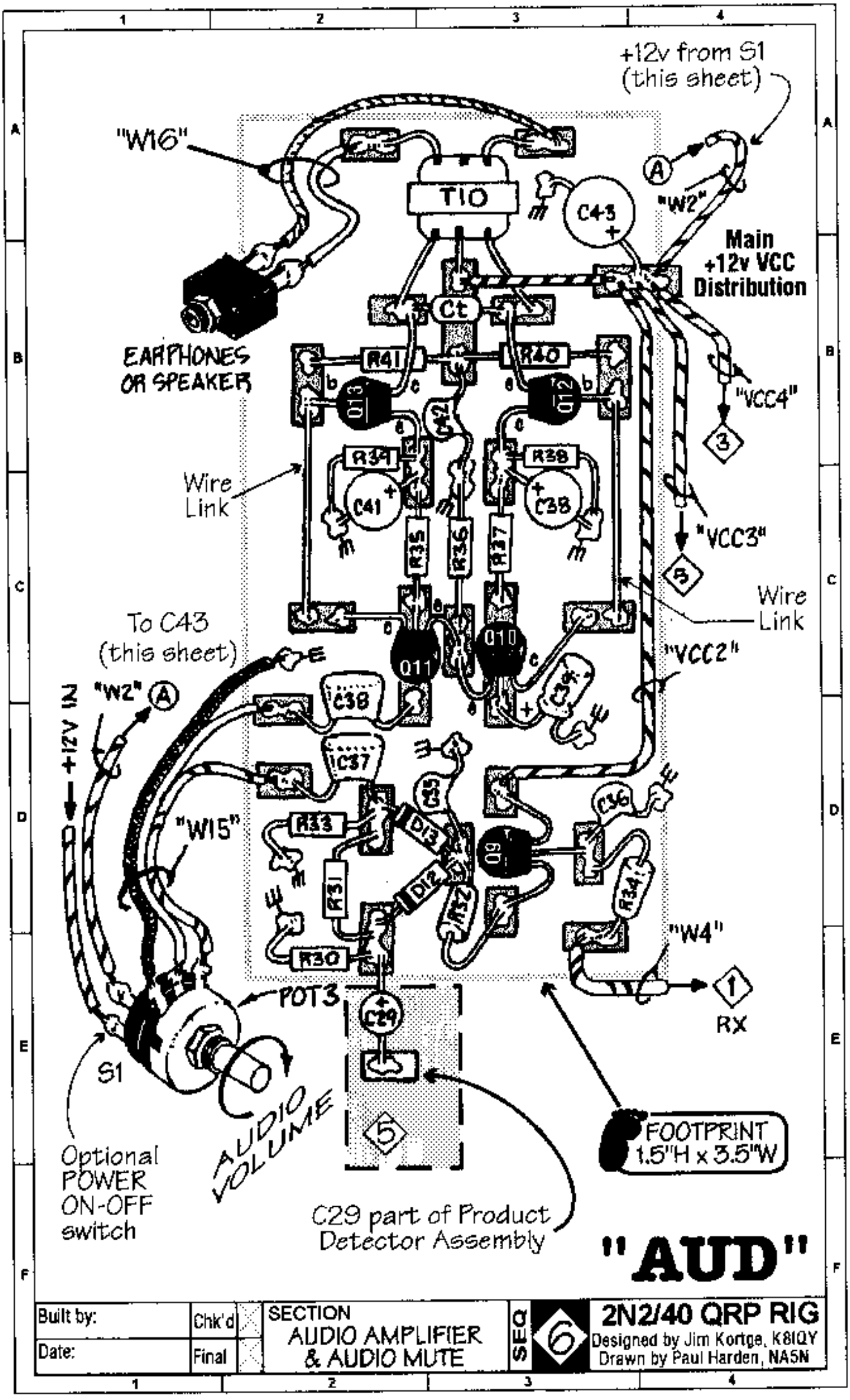
The resulting waveforms as the circuit is keyed is shown below.

The upper trace is the "key line" signal shown at 10 volts/division. The bottom trace is the output that is present on the wiper of the volume control potentiometer, POT3, at the full volume setting, shown at 10 millivolts/division. You can clearly see the effects of R31, the 47K resistor which "leaks" a bit of audio through during transmit so that we have keying sidetone. It should be apparent from this example what a marvelous tool modeling is, and the help it can be for checking out ideas, studying circuits, etc. without having to build anything physical.



Finally, getting back to the actual 2N2/40 ... the audio amplifier rounds out the receive chain.

The Push-Pull Audio Amplifier is another circuit of my design. Incoming audio is applied to the base of transistor Q11. As can be seen, Q11 shares a common emitter resistor, R36, with Q10. Q10's base is grounded for audio purposes, so it becomes yet another common base amplifier, being driven in its emitter from the signal provided by Q11. The collector signals on Q11 and Q10 are of equal amplitude and 180 degrees out of phase with each other. These signals are then directly coupled to the bases of Q13 and Q12, where they are further amplified. Transformer T10 couples the push-pull signals from the collectors to the speaker. Note that the biasing of the input pair of transistors is derived from the emitters of the output pair. The large capacitors on the output


+12v from S1 (this sheet)
"W16"
T10
C43
"W2"
Main +12v VCC Distribution
EARPHONES OR SPEAKER
Ct
R41
R40
Q13
Q12
C42
R34
R38
C41
C38
Wire Link
"VCC4"
3
"VCC3"
R35
R36
R37
To C43 (this sheet)
Q11
Q10
C39
"VCC2"
+12V IN
"W2"
A
C38
C37
C35
C36
"W15"
R33
D13
Q9
D12
R31
R32
R34
R30
"W4"
1
RX
POT3
C29
S1
AUDIO VOLUME
5
FOOTPRINT 1.5"H x 3.5"W
Optional POWER ON-OFF switch
C29 part of Product Detector Assembly
"AUD"
Built by:
Chk'd
Date:
Final
SECTION
AUDIO AMPLIFIER & AUDIO MUTE
SEQ 6
2N2/40 QRP RIG
Designed by Jim Kortge, K8IQY
Drawn by Paul Harden, NA5N

The large capacitors on the output pair emitters bypass all audio. Capacitor Ct is chosen to resonate the primary inductance of T10 at 750 Hz, thereby providing additional CW signal selectivity. In the prototype rig, this capacitor is 0.082uF. While I haven't measured the power output of this amplifier, it is more than enough to drive a speaker to uncomfortable levels at full volume. It also has very low internal noise.

Assembly.
This layout is a bit more open than the others, since the size of T10 could vary depending on the part source. Circuitry should be built from T10 down. Nothing is very critical here, since we're now dealing with audio, and it's a bit easier to control. When you get to the audio amplifier, note that the leads of base bias resistors R35 and R37 need to pass under their respective transistor bodies, Q10 and Q11 (that is, Q10-Q11 sit on top of R35 and R37, or closer together than they appear on the SEQ#6 assembly dwg.) This is also true for resistors R40 and R41. I'd recommend that all of these resistors be soldered in first, before adding the other components. Before testing. you should wire in POT3, so you have a volume control. **At this point, you now have a complete receiver.**

Testing.
The only test to perform at this juncture is to see if it works in its entirety. Connect an antenna to the Port A pad, and a speaker on the T10 secondary pads, and apply fused power. If you've done the building correctly, and have passed the previous tests, you should have a 2N2/40 receiver that is working, maybe even hearing signals, but as yet, not aligned. Here is how to do the alignment.

2N2/40 on the Test Bench -- Receiver Alignment

Receiver Alignment -

✔ Set trimmer potentiometer TC5 to its maximum capacity position by either listening to the receiver local oscillator on another receiver tuned to approximately 4.914 MHz, or by measuring the output frequency of the local oscillator by attaching a probe to the ungrounded end of L3 and adjusting TC5 for the lowest frequency obtainable.

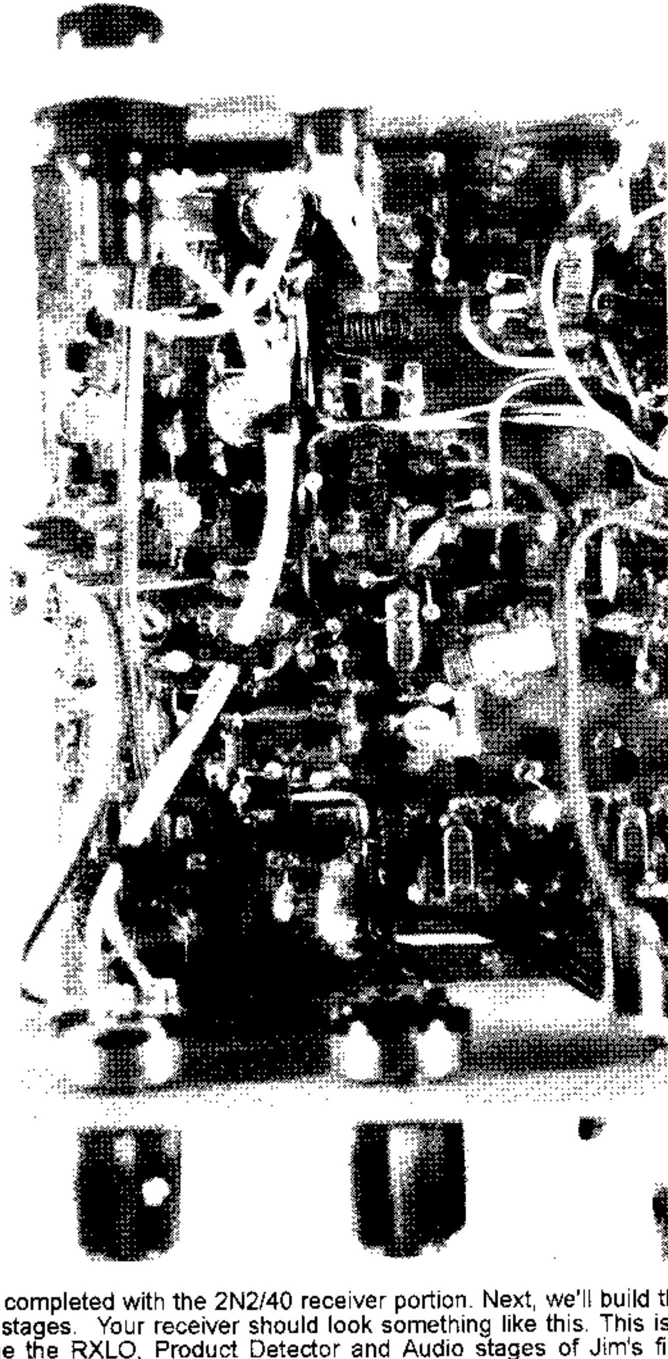
✔ Tune the receiver to a signal, or if possible, generate a signal about mid-band, around 7.050 MHz. Tune across this signal by rotating tuning potentiometer POT2. Notice that as the tuning potentiometer is rotated clockwise, the audio pitch of the signal goes lower.

✔ Listen for a peak in audio response as the signal is tuned. We want this peak to occur at about 750 Hz. With TC5 set for maximum capacity, the peak is probably upwards of 1500 Hz. Slowly rotate TC5 to a lower capacity setting. Go a little at a time, and retune the receiver, listening for the audio peak. You will hear it progressively moving to a lower pitch.

✔ Repeat the adjustment of TC5 and retuning the receiver until the pitch is where you like to listen to CW, and is the loudest you can make it. That's it.....the receiver is aligned.

What this does is place the receiver local oscillator frequency about 750 Hz below the center of the crystal filter passband. Remember, the crystal filter is being used as an upper sideband filter. To confirm that everything is working as it should, find a SSB station and see if you can tune in the audio so that it is intelligible. If you've done the alignment correctly, you should not be able to properly tune in the signal, since the station is operating on lower sideband, and the receiver is listening to the upper sideband.

– K8IQY



You're now completed with the 2N2/40 receiver portion. Next, we'll build the transmitter stages. Your receiver should look something like this. This is a photo of the the RXLO, Product Detector and Audio stages of Jim's first 2N2/40 rig, which differs only slightly from his 2nd version that this construction article is based.

7 TX Local Oscillator, Mixer & Amplifier

Schematic	Assembly Dwg.
Sht. 3	SEQ. #7

Circuit Description.
The Tx Local Oscillator, Single Balanced Mixer, and Cascode RF Amplifier - These elements make up the first section of the transmit strip.

TX Local Oscillator. The transmitter begins with another crystal oscillator, Q14 and associated circuitry, used to generate a CW signal at 4.915 MHz. This circuit is virtually a duplicate of the receiver local oscillator. Output signal is taken from the emitter through a 47pF capacitor, C46.

TX Mixer. The TX LO signal is fed to a diode, single balanced mixer (SBM) along with a signal from the VFO, which is applied to the SBM through capacitor C48. The SBM consists of a trifilar wound transformer T11, along with four 1N4148 diodes, D14 through D17. Details for winding the trifilar transformer, T11, is shown on the SEQ#7 assembly drawing. As with the receiver DBM, the diodes should be matched for forward resistance. The sum of the Tx LO signal and VFO signal produce an output at 7 MHz that is used in the transmit strip. The difference frequency, along with the original mixer signals and higher order mixer products, are filtered out by the tuned input and output circuits of the next stage, a cascode RF amplifier.

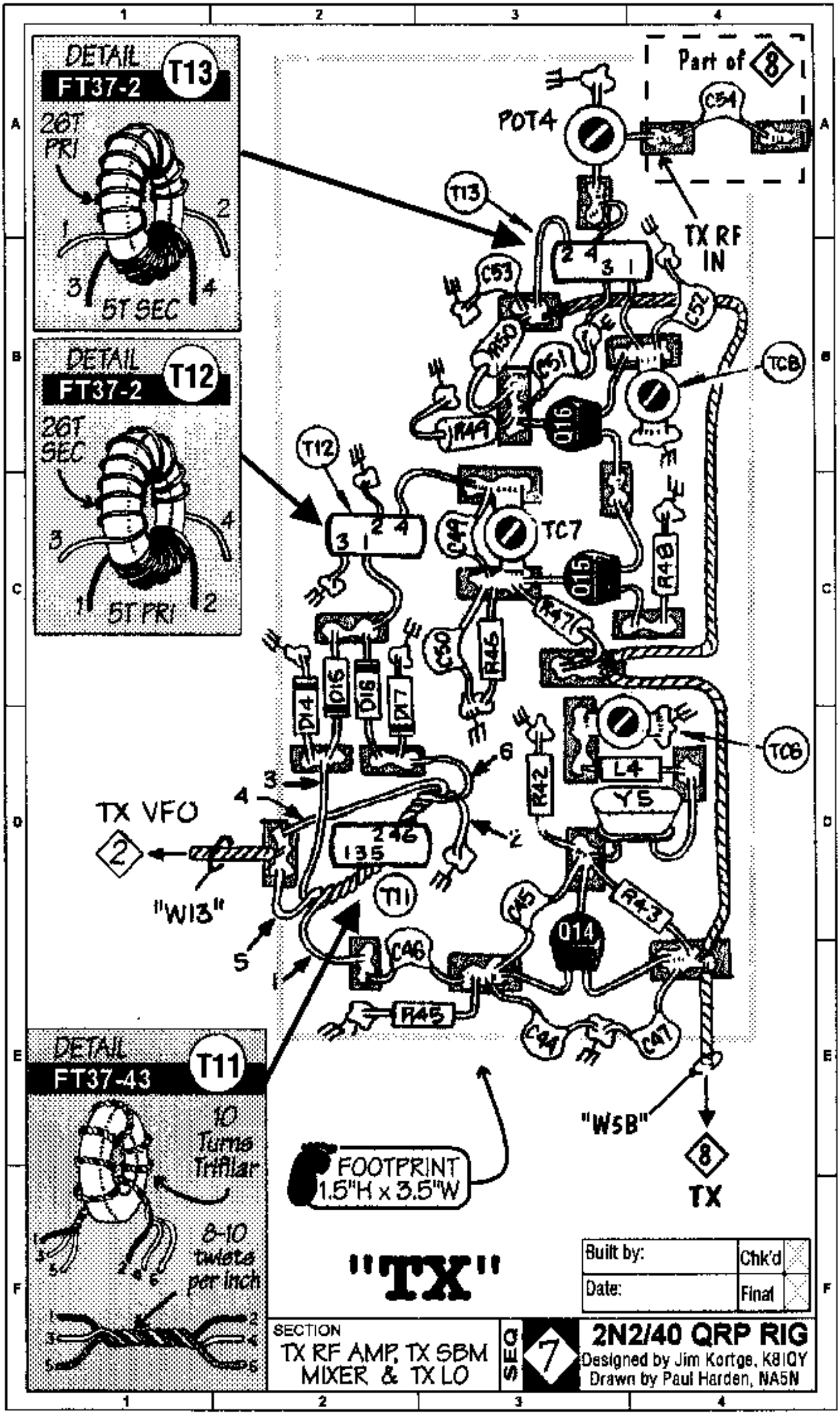
The TX Cascode RF Amplifier uses a conventional grounded emitter stage, Q15, direct coupled to a grounded base stage, Q16. Total power gain for this transistor pair is on the order of 40 dB. The input is a link-coupled, tuned circuit comprised of T12 and capacitors C49, C50, and trimmer TC7. A tuned output is employed using another link-coupled transformer, T13 and capacitor C52 and trimmer TC8. Output from this stage is taken from the 5-turn secondary link, and feeds the power control potentiometer, POT4. As a point of reference, the 26-turn windings on T12 and T13 should measure at 3.0uH. Maximum power output from this stage is about 10 milliwatts, or 0 dBm. However, with the 2N2/40 running at 1.5 watts output, this stage only needs to feed the driver with 0.2 milliwatts, or -6 dBm.

Assembly.
I'd recommend starting with the single balanced mixer and then follow that with the local oscillator. These two sections could almost be done together, since they are adjacent to each other, and tightly integrated.

When the local oscillator and single balanced mixer have been completed, build the cascode RF amplifier. Items that are critical here are the placement of the input and output transformers. They should be as far apart as you can get them, and ideally, at right angles to each other. They're not show in that orientation on the layout for clarity, and will also work fine as shown.

Testing.
Once all of the elements are completed, they can be tested following this procedure.

The Tx local oscillator can be tested by itself by applying power to the Tx lead, and listening for a signal at 4.915 MHz on a general coverage communications receiver. You can also attach a frequency counter probe to the mixer side of


DETAIL
FT37-2
T13
26T PRI
5T SEC
DETAIL
FT37-2
T12
26T SEC
5T PRI
DETAIL
FT37-43
T11
10 Turns Trifilar
8-10 twists per inch
POT4
Part of 8
C54
TX RF IN
C53
C52
R50
C51
TC8
R49
Q16
TC7
C49
Q15
R48
R47
C50
R45
D14
D16
D15
D17
TX VFO
2
"W13"
R42
TC6
L4
Y5
C45
Q14
R43
C46
R45
C44
C47
"W5B"
8
TX
FOOTPRINT
1.5"H x 3.5"W
"TX"
Built by:
Chk'd
Date:
Final
SECTION
TX RF AMP, TX SBM MIXER & TX LO
SEQ
7
2N2/40 QRP RIG
Designed by Jim Kortge, K8IQY
Drawn by Paul Harden, NA5N

capacitor C46 to verify that the circuit is oscillating at the correct frequency.

Once all of the elements are complete, they can be tested following this procedure. Connect a short test lead or your counter probe to the wiper pad of POT4 and adjust POT4 to maximum by turning the screwdriver adjustment to the full CW position. Apply power to the receiver in the normal manner. Apply power to the pads labeled Tx through a 1N4004 or equivalent diode, to simulate the approximate voltage level that will be present when the Rx/Tx switch is active. Listen for a signal at 7 MHz on a receiver. Verify that the signal changes frequency when the VFO is tuned. With the VFO set to a frequency of 2.135 MHz, its mid-frequency, adjust trimmers TC7 and TC8 for maximum signal. Go back and forth between these two a few times as there is some interaction. When you are done with this test, we are ready to build the other half of the transmit strip.

8 Transmit RF Driver, Power Amplifier & Output Filter

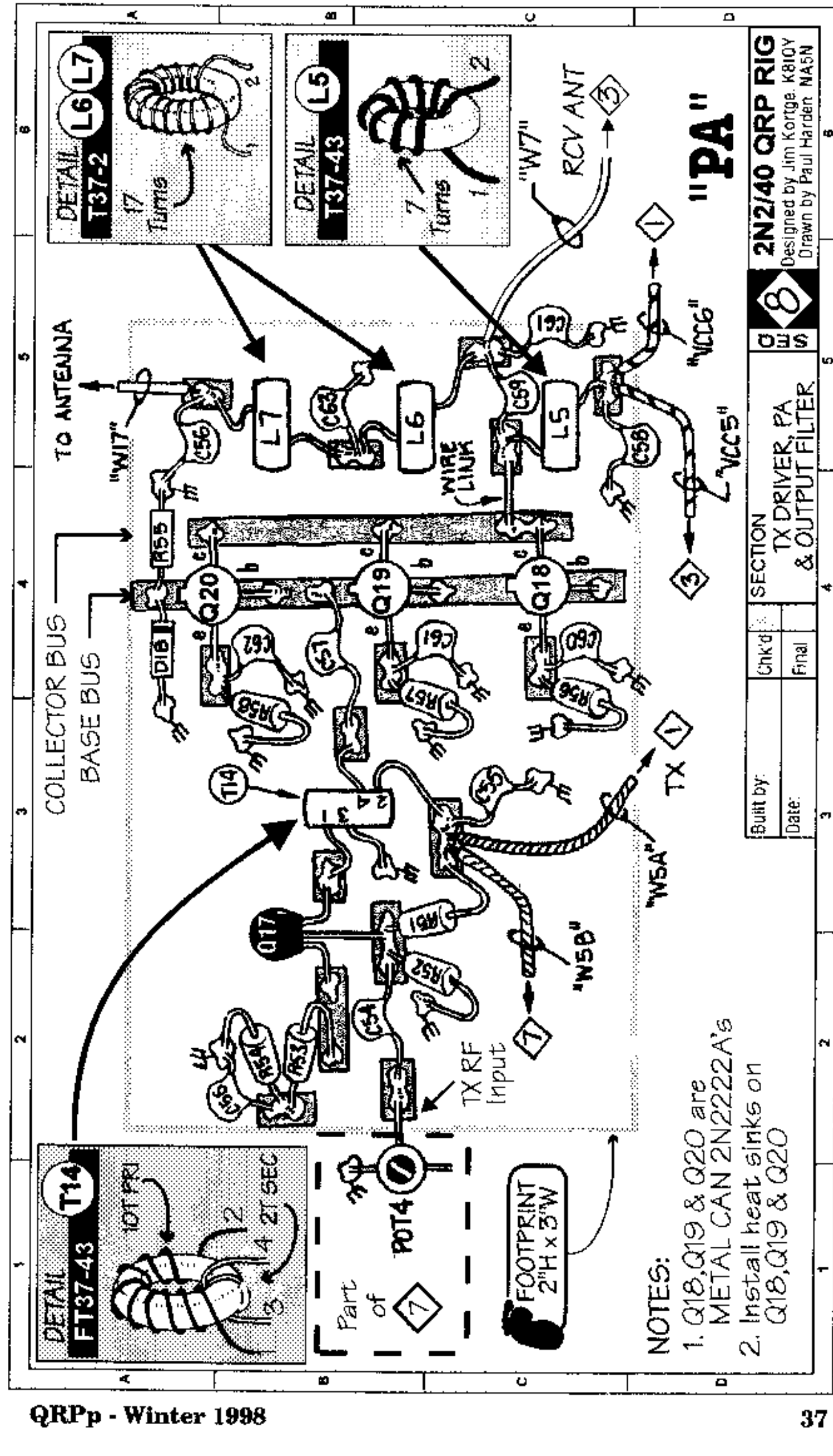
Schematic	Assembly Dwg.
Sht. 3	SEQ. #8

Circuit Description.
The Tx RF driver consists of Q17 and associated circuitry. Q17 is the first of the 2N2222A metal transistors used in the rig. A heat sink can be used on this transistor to manage the power being dissipated, but is not necessary. This stage is an untuned, class A amplifier, which produces the drive necessary for the final. Its output is via a 2-turn link on transformer T14. This transformer translates the higher collector load impedance down to the lower input impedance of the three parallel 2N2222A metal output transistors. Power output from this stage is about 10 milliwatts, or +10 dBm, with -6 dBm of drive from the previous stage.

The Power Amplifier (PA). The output from the TX driver is fed through capacitor C57 and on to the input circuitry of the final. This circuitry is a 1N4148 diode, D18, in parallel with R55, a 100 ohm resistor. Capacitor C57 charges minus to plus on the negative excursion of the drive signal. On positive going excursions, the voltage on C57 is added to the positive signal, thereby doubling the effective positive level, and providing more drive to the final transistors. This circuit is often referred to as a "dc restorer".

The final transistors, Q18, Q19, and Q20, are also **2N2222A metal case** types and *should be run with heat sinks*. This amplifier stage runs in class C, and measured efficiency is around 70 percent. Each transistor uses a bypassed 2.2 ohm resistor in its emitter to help keep the collector currents balanced, without having to gain match the 3 devices. Three transistors were used in the final because that's how many were left after building all of the rest of the rig (in keeping with the original rules of 22 maximum transistors).

I had expected to get about 1 watt output from the three 2N2222A's, and was pleasantly surprised to find that one can easily get 2 to 2.5 watts of output without excessive heating. I originally ran about 1.5 watts of output power without the heat sinks, but added them later, just to be on the safe side. The output impedance is about 50 ohms if the calculations are done with a Vcc of 12.5 volts and a power output of 1.5 watts, i.e. Vcc^2/2*Po.


DETAIL
T37-2
L6 L7
17 Turns
DETAIL
T37-43
L5
7 Turns
"W7"
RCV ANT
3
TO ANTENNA
"W17"
COLLECTOR BUS
BASE BUS
WIRE LINK
"VCC5"
"VCC6"
TX
"W5A"
"W5B"
TX RF Input
DETAIL
FT37-43
T14
10T PRI
4T SEC
POT4
Part of 7
FOOTPRINT 2"H x 3"W
"PA"
2N2/40 QRP RIG
Designed by Jim Kortge, K8IQY
Drawn by Paul Harden NA5N
SECTION
TX DRIVER, PA & OUTPUT FILTER
Built by:
Date:
Chk'd
Final
NOTES:
1. Q18, Q19 & Q20 are METAL CAN 2N2222A's
2. Install heat sinks on Q18, Q19 & Q20

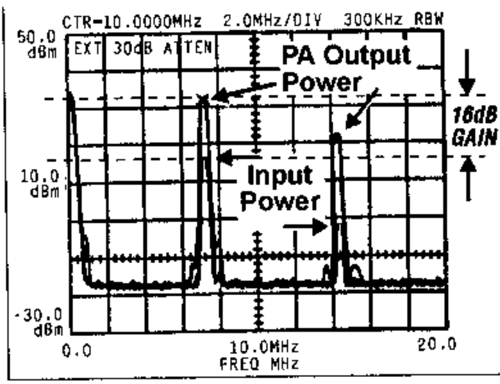
The Output Filter. The output power from the PA leads us to the output filter. This is a very standard, 5 pole, Chebyshev low pass filter taken out of table 11, page 2-44, of the 1988 ARRL handbook. It is filter number 86, using standard E24 capacitor values. The capacitors for this filter should be C61 and C65 at 430pF and C63 at 820pF. However, capacitor C61 is reduced to 360pF to compensate for the output capacitance of the 2N2222 finals, and the Rx T/R switch capacitance, that of TC9 (located on SEQ#1). These two sources add a total capacitance of 70pF in parallel with C61. All output capacitors should be silver mica units. Inductors, L6 and L7, should measure 1.6uH. Mine have fewer turns than the formula predicts, but measure at that value, using an AADE L/C Meter IIB. By the way, if you don't have one of these meters, get one! It is one of the best investments you will ever make in an inexpensive, very accurate, component test instrument.

Assembly.
The TX driver, PA and output filter is built on the last section remaining on the substrate board, as shown on assembly drawing SEQ#8. Note that the collectors and bases of PA transistors Q18, Q19 and Q20, are connected together in parallel by making two strips of copper clad to make two long pads. If you have difficulty making these long strips, an alternative would be to solder a buss wire (#20 solid or so) between two pads, ensuring they do not make contact with the ground board. Also ensure you allow sufficient clearance around the PA metal 2N2222A's for the heatsinks to be added.

Your 2N2/40 rig is now virtually complete. Ensure all wiring interconnecting the sections, such as the RX and TX terms, and all Vcc wiring is installed.

Testing.
You should add all external components (if you haven't already) with leads long enough for mounting in an enclosure. You can run it on the bench "as is." I did this with mine and had a blast making contacts with it sitting "nude" on the benchtop. To me, there is a certain fascination and beauty with having an operating rig on the bench, uncased, so that you can see all of the components, while watching the output power meter swing up as you key it in QSO. One can almost imagine all of the electrons moving here and there, doing their part to allow reception, or generating RF to be radiated.

2N2/40 on the Test Bench



Power Amplifier (PA) Power Levels

The 7MHz fundamental and 2nd Harmonic powers are shown at the input and output of the PA amplifier, *before the output filters.*

Input power at Q18-base is +16dBm (40mW) and the output is +32dBm (1.6W), showing Q18-Q20 provides 16dB of power gain.

-NA5N

2N2/40 on the Test Bench -- Transmitter Alignment

Transmitter Alignment.
Before aligning the transmitter, be sure the rig is connected to a dummy load, since we will be keying it and generating r.f.

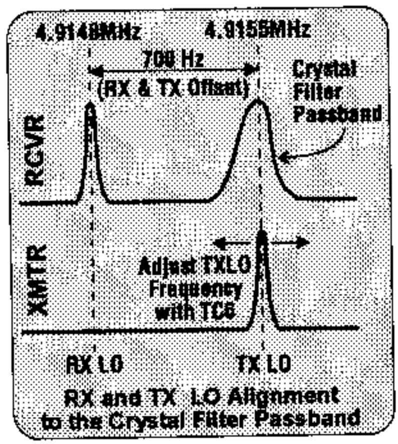
✔ Setting the transmitter local oscillator trimmer, TC6, to the minimum capacity position. Use the same method we used with the receiver to determine where this is. With TC6 at minimum capacity, the transmitted signal will be far above the center of the crystal filter. Our goal is to slowly move the transmit frequency down until it is in the center of the receive passband. When that happens, we will hear it at the same pitch as we hear a properly tuned CW station.

> **! *Do not keep the transmitter on the air continuously for longer than 20 seconds while making these adjustments. If you have a keyer, let it send a series of dits.***

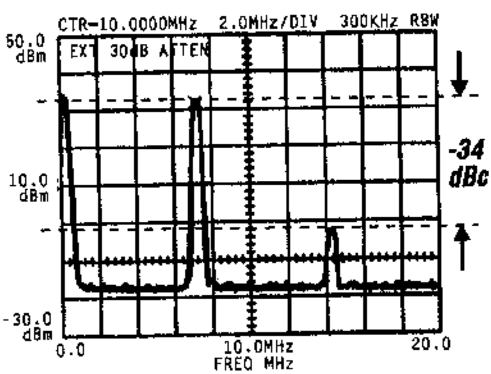
✔ With the transmitter keyed, slowly turn trimmer TC6. As you do, you will eventually hear the transmit signal at a very high pitch as it enters the crystal filter pass-band from the higher frequency end. Keep turning until the pitch of the note heard is the same as a properly tuned CW station. When they are nominally the same, stop adjusting TC6.

✔ Once you're on the air with the rig, you can trim up the setting of TC6 so that the receiver and transmitter are "dead on". The station you are listening to and your transmitted signal will be heard at the exact same pitch. Shown below is a diagram of a properly aligned rig, showing example Rx and Tx local oscillator frequencies and their relationship to each other and the crystal filter passband.

-- K8IQY



2N2/40 on the Test Bench



The 2N2/40 Output Spectrum

The 7MHz fundamental and 2nd Harmonic power *after the output filters* (at the antenna terminal) are shown here. Compare with the spectrum on page 38 and notice how the second harmonic (14MHz) has been attenuated to 34dBc (34dB below the carrier) for FCC compliance. This is due to low-pass filters L6-L7 and C61-C65.

-NA5N

7. Bill of Materials (BOM)

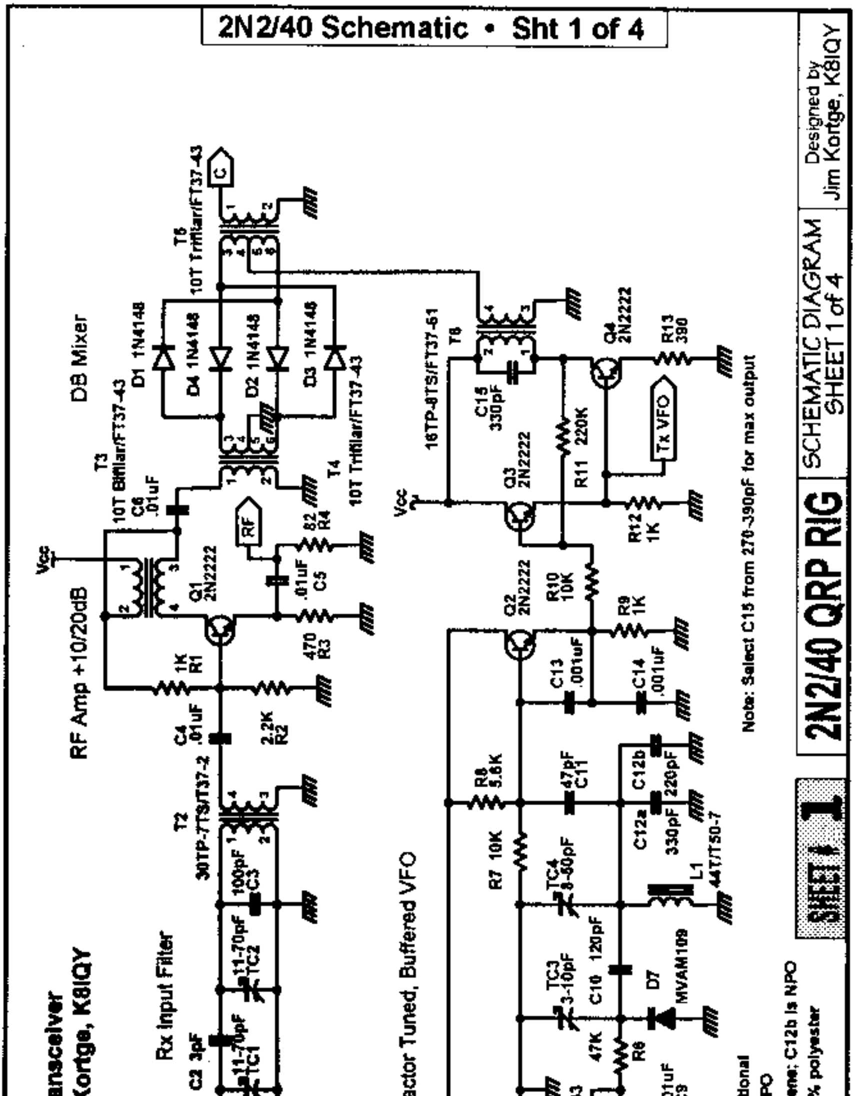
K8IQY 2N2/40 Parts List (Ver. 2.1) - Sheeet 1 of 2

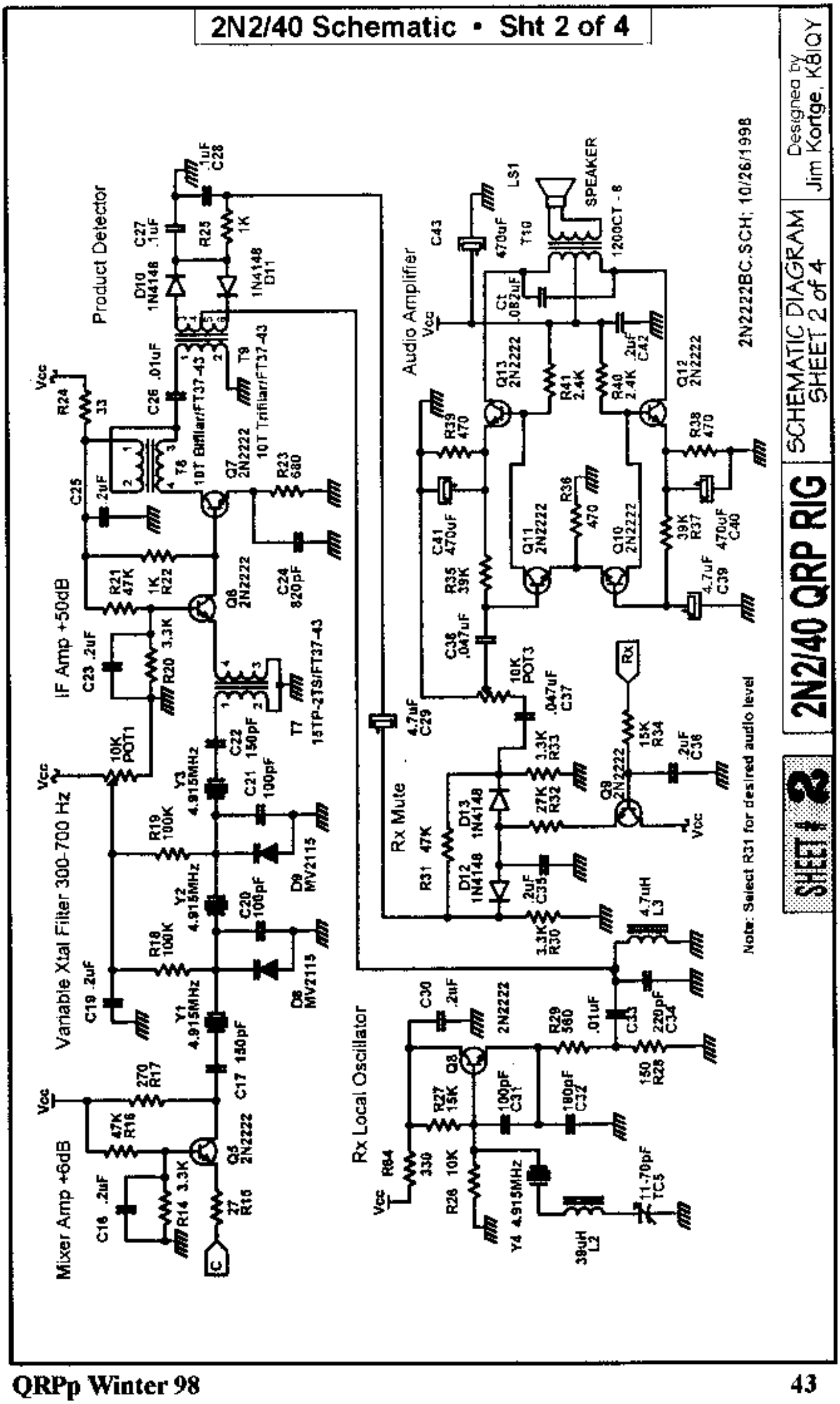
ITEM	QTY	REF. DESIG./DESCRPTION	VALUE	MFR/PART NO.	✔
1	3	R56,R57,R58	2.2Ω		
2	1	R53 All Resistors	10Ω		
3	1	R65 5% 1/8W	12Ω		
4	1	R15 Carbon Film	27Ω		
5	1	R24	33Ω		
6	1	R65	47Ω		
7	2	R4,R54	82Ω		
8	2	R48,R55	100Ω		
9	1	R28	150Ω		
10	1	R17	270Ω		
11	2	R44,R64	330Ω		
12	1	R13	390Ω		
13	4	R3,R36,R38,R39	470Ω		
14	2	R5,R29	560Ω		
15	1	R23	680Ω		
16	6	R1,R9,R12,R22,R25,R45	1.0K		
17	1	R52	1.5K		
18	2	R2,R46	2.2K		
19	2	R40,R41	2.4K		
20	2	R59,R61	2.7K		
21	4	R14,R20,R30,R33	3.3K		
22	1	R62	4.7K		
23	1	R8	5.6K		
24	1	R51	6.8K		
25	7	R7,R10,R26,R42,R47, R49,R50	10K		
26	4	R27,R34,R43,R6	15K		
27	1	R32	27K		
28	2	R35,R37	39K		
29	4	R6,R16,R21,R31	47K		
30	3	R18,R19,R60	100K		
31	1	R11	220K		
32	1	POT4 (Trim Pot)	100Ω		
33	1	POT5	1.0K		
34	1	POT1	10K		
35	1	POT3 (Includes switch SW1)	10K		
36	1	POT2 (10 Turn)	20K		
37	1	C2 NPO	3pF		
38	3	C11,C46, or TC9 Alternate NPO	47pF		
39	6	C1,C3,C20,C21,C31, C45 NPO	100pF		
40	2	C10,C52 NPO	120pF		
41	2	C17,C22 NPO	150pF		
42	2	C32,C44 NPO	180pF		
43	2	C12B,C34 NPO	220pF		
44	1	C50 NPO	270pF		
45	1	C12a Polystyrene	330pF		
46	1	C15 NPO	330pF		
47	1	C61 Silver Mica	360pF		
48	1	C49 NPO	390pF		

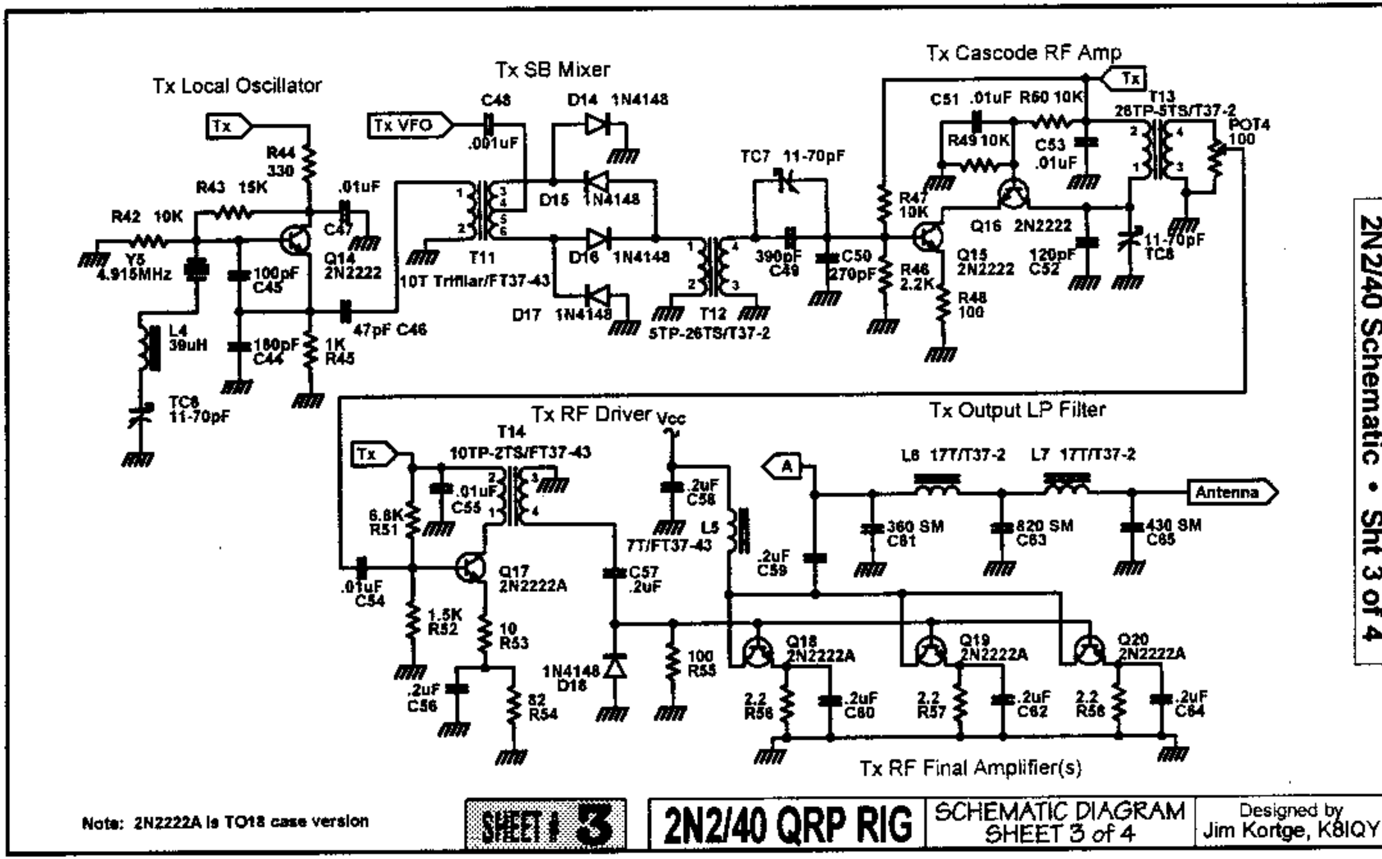
K8IQY 2N2/40 Parts List (Ver. 2.1) - Sheet 2 of 2

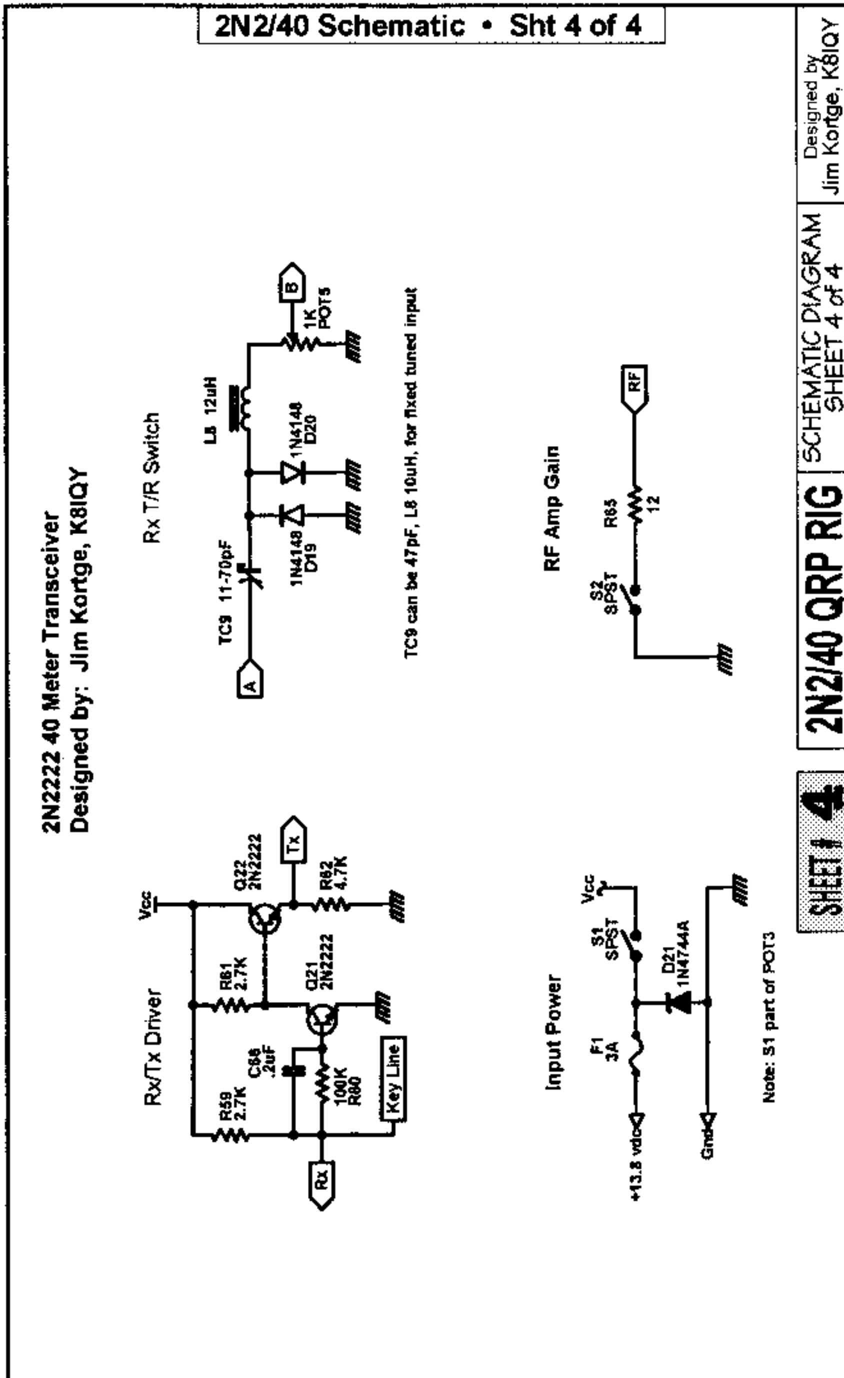
ITEM	QTY	REF. DESIG./DESCRPTION	VALUE	MFR/PART NO.	✔
49	1	C65 Silver Mica	430pF		
50	1	C24 NPO	820pF		
51	1	C63 Silver Mica	820pF		
52	2	C13,C14 5% Polyester			
53	1	C48	.001uF		
54	11	C4,C5,C6,C9,C26,C33, C47,C51,C53-C55,C68	.01uF		
55	2	C37,C38	.047uF		
56	1	Ct (Select to tune primary @ 750 Hz)	.082uF		
57	2	C27,C28	.1uF		
58	18	C7,C8,C16,C18,C19,C23 C25,C30,C35,C36,C42, C56-C60,C62,C64,C66	.2uF		
59	2	C29,C39,C67	4.7uF		
60	3	C40,C41,C43	470uF		
61	1	TC3 Trim Cap-optional	3-10pF		
62	1	TC4 Trim Cap	8-50pF		
63	6	TC1,TC2,TC5-TC8	11-70pF		
64	2	L2,L4 (Molded)	39uH		
65	1	L3 (Molded)	4.7uH		
66	1	L8 (Molded)	12uH		
67	6	L6,L7,T1,T2,T12,T13,	T37-2		
68	1	T6	FT37-61		
69	1	L1	T50-7		
70	9	L5,T3,T4,T5,T7,T8,T9 T11,T14	FT37-43		
71	1	T10 Audio Transformer 1200ΩCT:8ΩCT			
72	15	D1,D2,D3,D4,D10,D11, D12,D13,D14,D15,D16, D17,D18,D19,D20	1N914B or 1N4148B		
73	1	D5 6.2 volt Zener	1N4735A		
74	1	D6 Rectifier diode	1N4001		
75	1	D21 15 volt Zener	1N4744A		
76	1	D7 Varicap	MVAM109		
77	2	D8,D9 Varicap	MV2115		
78	5	Y1 thru Y5 (Match Y1-Y3 within 25 Hz)	4.915 MHz		
79	18	Q1-Q16,Q21,Q22 TO-39	2N2222A	Plastic	
80	4	Q17 thru Q20 TO-18	2N2222A	Metal	
81	1	LS1 8-ohm Speaker			
82	1	F1 Fuse	3AG 3A		
83	4	HS1 TO-18 Heatsink			
84	1	PC1 Power Connector			
85	1	J1 Stereo Jack	3.5mm		
86	1	J2 Mono Jack	3.5mm		
87	1	J3 Antenna Connector	BNC		
88	1	FH1 Fuse Holder			
89	1	SW2 Toggle Switch	SPST		

MFR/Part No. - Use to record exact manufacturer part number, or ordering part number/stock number from Mouser, DigiKey, Radio Shack, etc.
✔ - Use to indicate part on-hand, on-order, received, installed, etc.


2N2/40 Schematic • Sht 1 of 4
2N2222 40 Meter Transceiver
Designed by: Jim Kortge, K8IQY
Rx Input Filter
RF Amp +10/20dB
DB Mixer
Varactor Tuned, Buffered VFO
T1 3TP-30TS/T37-2
C1 100pF
C2 3pF
TC1 11-70pF
TC2 11-70pF
C3 100pF
T2 30TP-7TS/T37-2
C4 .01uF
R1 1K
R2 2.2K
Q1 2N2222
R3 470
C5 .01uF
R4 82
RF
T3 10T Bifilar/FT37-43
C6 .01uF
T4 10T Trifilar/FT37-43
D1 1N4148
D2 1N4148
D3 1N4148
D4 1N4148
T5 10T Trifilar/FT37-43
C
Vcc
C7 .2uF
R5 560
D5 1N4735A
D6 1N4004
C8 .2uF
R63 15K
POT2 20K-10T
C9 .01uF
R6 47K
TC3 3-10pF
D7 MVAM109
C10 120pF
TC4 8-50pF
R7 10K
L1 44T/T50-7
R8 5.6K
C11 47pF
C12a 330pF
C12b 220pF
C13 .001uF
C14 .001uF
Q2 2N2222
R9 1K
R10 10K
Q3 2N2222
R11 220K
R12 1K
16TP-8TS/FT37-61
T6
C15 330pF
Tx VFO
Q4 2N2222
R13 390
Note: TC3 is optional
C10 & C11 are NPO
C12a is polystyrene; C12b is NPO
C13 & C14 are 5% polyester
Note: Select C15 from 270-390pF for max output
SHEET # 1
2N2/40 QRP RIG
SCHEMATIC DIAGRAM
SHEET 1 of 4
Designed by
Jim Kortge, K8IQY


2N2/40 Schematic • Sht 2 of 4
Mixer Amp +6dB
Variable Xtal Filter 300-700 Hz
IF Amp +50dB
Product Detector
Audio Amplifier
Rx Local Oscillator
Rx Mute
SPEAKER
Note: Select R31 for desired audio level
2N2222BC.SCH; 10/26/1998
SCHEMATIC DIAGRAM
SHEET 2 of 4
Designed by
Jim Kortge, K8IQY
2N2/40 QRP RIG
SHEET # 2


2N2/40 Schematic • Sht 3 of 4
Tx Local Oscillator
Tx
R44 330
R43 15K
R42 10K
.01uF
C47
Q14 2N2222
Y5 4.915MHz
100pF C45
180pF C44
1K R45
47pF C46
L4 39uH
TC6 11-70pF
Tx SB Mixer
Tx VFO
C48 .001uF
D14 1N4148
D15 1N4148
D16 1N4148
D17 1N4148
T11 10T Trifilar/FT37-43
T12 5TP-26TS/T37-2
TC7 11-70pF
390pF C49
C50 270pF
Tx Cascode RF Amp
Tx
C51 .01uF R60 10K
R49 10K
C53 .01uF
T13 26TP-5TS/T37-2
POT4 100
R47 10K
Q16 2N2222
Q15 2N2222
120pF C52
11-70pF TC8
R46 2.2K
R48 100
Tx RF Driver
Vcc
T14 10TP-2TS/FT37-43
Tx
.01uF C55
6.8K R51
.01uF C54
Q17 2N2222A
1.5K R52
10 R53
.2uF C56
82 R54
.2uF C58
L5 7T/FT37-43
C57 .2uF
1N4148 D18
100 R55
Tx Output LP Filter
A
L6 17T/T37-2
L7 17T/T37-2
Antenna
.2uF C59
360 SM C61
820 SM C63
430 SM C65
Q18 2N2222A
Q19 2N2222A
Q20 2N2222A
2.2 R56
.2uF C60
2.2 R57
.2uF C62
2.2 R58
.2uF C64
Tx RF Final Amplifier(s)
Note: 2N2222A is TO18 case version
SHEET # 3
2N2/40 QRP RIG
SCHEMATIC DIAGRAM SHEET 3 of 4
Designed by Jim Kortge, K8IQY


2N2/40 Schematic • Sht 4 of 4
2N2222 40 Meter Transceiver
Designed by: Jim Kortge, K8IQY
Rx/Tx Driver
Vcc
R61 2.7K
Q22 2N2222
Tx
R62 4.7K
Q21 2N2222
R59 2.7K
C88 .2uF
100K R80
Key Line
Rx
Rx T/R Switch
A
TC9 11-70pF
1N4148 D19
1N4148 D20
L8 12uH
1K POT5
B
TC9 can be 47pF, L8 10uH, for fixed tuned input
Input Power
+13.8 vdc
F1 3A
S1 SPST
Vcc
D21 1N4744A
Gnd
Note: S1 part of POT3
RF Amp Gain
S2 SPST
R65 12
RF
SHEET # 4
2N2/40 QRP RIG
SCHEMATIC DIAGRAM SHEET 4 of 4
Designed by Jim Kortge, K8IQY

9. Miscellaneous Assembly Notes

This section will cover everything else that didn't fit under one of the previous categories. There are some general information items that are worth mentioning, which might make building a 2N2/40 a bit more successful.

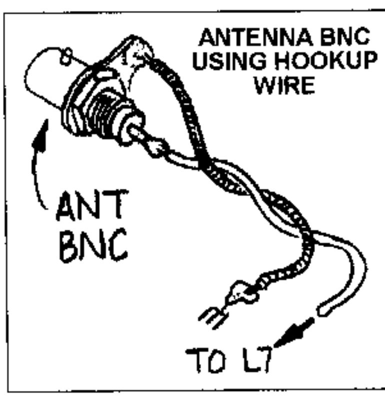
Interconnecting Wiring. If you look at the overall layout of the sections (see Interconnecting Wiring Diagram on page 14), it is apparent that there really are not very many wiring runs required. Standard hookup wire (and two short coax runs) are used throughout the 2N2/40.

Wiring. I used 22 gauge (AWG 22) stranded, Teflon coated hookup wire for this task. The Teflon wire is really nice because you can't melt the coating with normal soldering iron temperatures. This makes for better looking wiring, I think. Routing the wires between pads is more of following logic than anything else. I tried to add the "Vcc" wiring as the sections were built, so that it could be routed against the surface of the substrate. In some cases, it passes underneath the leg of a resistor or capacitor as an aid in keeping it tight to the surface (for example, see SEQ#5). The "Tx" and "signal" wiring was done in a similar manner. All external wiring to controls and connectors also use the AWG 22 hookup wire for the flexibity. Solid wire is not recommended for external wiring.

Coaxial Cable. The only two places that shielded signal wire was used were from the VFO to the Tx SBM ("W13" between SEQ#2 and #7) and from the i.f. amplifier to product detector transformer T9 ("W10" between SEQ#3 and #4). In these cases, a short length of RG-174 was prepared, with the shield grounded only at the VFO or i.f. amplifier end. The shield at the mixer and product detector ends were cut off, and the outside jacket pulled over the shield so that it could not make contact with the substrate surface. Doing the installation this way prevents having the shield grounded in two locations, which could cause a ground loop to exist.

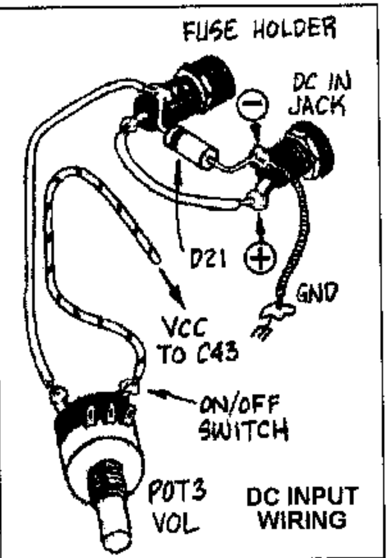
External Wiring. External wiring should also use *stranded* hookup wire for flexibility. Wiring to the potentiometers was done with flat, multiconductor cable, my favorite way to connect controls. If you haven't used this method, I encourage you to try it. You'll never go back to your old ways. You can buy 2 feet of 64 conductor, multicolored cable from many of the electronics suppliers for a couple of bucks, and that's enough wire for many, many rigs.

Antenna Jack. The lead from the "Antenna" pad to the coaxial connector (See SEQ#8) was so short in the prototype rig that I didn't bother with coax. A pair of 22 gauge wires was twisted together and used to make the connection.



However, the lead serving as the "shield" was terminated on the sub-board holding the PA transistors and output LP filter, and the BNC connector ground terminal. The total length of this run is about 1.5 inches.

DC (+12V Vcc) Wiring to the power connector was also done with leads twisted together. The Zener diode, D21, is just wired between the fuse holder "hot" lead and its ground terminal. Switch S1 is part of the audio control pot, POT3. By all means, make sure that you put in the fuse and the Zener diode. They will prevent smoking the rig if the power is hooked up backward, or if a power supply with an output higher than the Zener voltage (15 volts) is connected.



DC INPUT WIRING

Lacing. After all of the wiring was done, it was secured at a number of locations with old fashioned, waxed nylon lacing cord to keep the wires together. (HINT: use dental floss if you don't have lacing cord). Tie wraps canSo also be used. This is one of those cosmetic items, and has no effect at all on the performance of the rig.

Soldering. A good soldering iron is a must. Mine is a 25-watt, temperature controlled unit, with a 1/8 inch chisel point. For normal soldering, I keep the tip temperature at 320 degrees C. When I am soldering a lead to the substrate, I raise the temperature to 350 degrees C, which gives a bit more heat capacity to melt and flow the solder. Two of the musts in doing this type of construction are to have some desoldering braid on hand and some pure rosin liquid flux. The soldering braid is used to wick up extra solder on a connection, or remove all of it, if a component gets installed incorrectly.

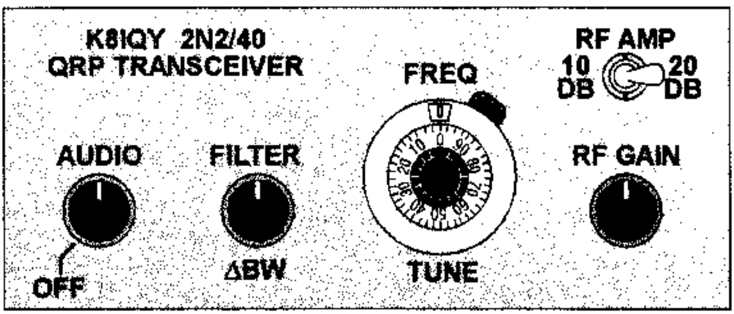
While all electronic grade solders contain flux, most have the minimum amount needed to properly "wet" a joint. A tiny amount of liquid flux can be brushed on a connection that appears to look overheated or "dry", and reheated to produce a superior solder joint.

Toroids. Winding toroidal inductors and transformers is explained on pages 8 and 9, and of course the details on the assembly drawings. Most people wind toroids without the use of any tools. The job is much easier if you use a small crochet hook. Each turn is wound by reaching through the center of the core with the crochet hook, and pulling the wire through the hole as the hook is retracted. Winding the core this way keeps the windings tight to the surface, and is much faster.

Use 26 or 28 gauge wire for all of the conventional transformers, but make sure there is a 20 to 30 degree gap remaining after all the windings are on a core. Transformer T14, and inductors L5 through L7 can be wound with a heavier gauge; number 24 is a good choice. All of the bifilar and trifilar transformers were wound using about 300 degrees of the core circumference. I use three strands of number 28 gauge, and twist them together at 6 to 8 turns per linear inch with an electric drill motor. Make a long piece (3 feet) of 3 strand, and another shorter piece (2 feet) of 2 strand, and then cut suitable lengths for winding each transformer.

The Enclosure. No rig is complete until it is installed in a case. For the 2N2/40 prototype, "home" became the inside of a TenTec TP-42 aluminum case. The case was painted flat black on all surfaces except the front and rear panels. These were painted light gray. A front panel overlay was drawn using COREL Draw. This overlay image was then reversed, and printed using a laser printer on a piece of transparency film. After trimming to size, the overlay was attached to the front panel with the printing on the inside, to keep it from being rubbed off. The control nuts from the various front panel controls hold it in place. If you build a 2N2/40 from this article, you will need to find a slightly larger case, as the TP-42 won't accommodate a 5X7 inch board. However, it appears a TenTec TP-46 or TP-47 case is the correct size case for the larger footprint. A custom case could also be built.

Front Panel. Here's what the front panel of the prototype rig looks like, which you can use for general control placement.



The 2N2/40 Front Panel Layout

10. ACKNOWLEDGEMENTS

Here is my chance to publicly thank all of the people that have helped along the way. There have been many, and they have helped immensely. First off is one of my heroes, Wayne Burdick, N6KR. It was Wayne who had the insight to propose the contest, and was the driving force behind keeping it pure. Many thanks to Bob Berlyn, N1PWU at HB Electronics, and their generosity in supplying ready-made 2N2222 semiconductor packages, at absolutely bargain basement prices. Their components are the heart of my original 2N2/40, and the second unit built for this article. Then comes Steve "Melt Solder" Weber, KD1JV. It was Steve who led the 2N2222 design charge, building the first working rig, and demonstrating to all of us that a viable design could be accomplished. Next comes Doug Hendricks, KI6DS, and his silent twin, Jim Cates, WA6GER. Without this "dynamic duo" there would be no NorCal, nor 2N2222 building contests, nor a long, admirable, legacy of great club kits. We are all indebted to these two fine gentlemen. Next on my heroes list is Paul Harden, NA5N. Paul was most helpful in putting the prototype through his "top 10 tests", to

verify that what I had observed qualitatively, was indeed based on quantitative performance measures. He alone is also responsible for all of the wonderful illustrations and pictures that are now a part of the 2N2/40 story. Without his help, this article would not have happened in the format you see it. And the last three that I'd like to thank are tall, skinny, Chuck Adams, K5FO, from big D, Preston Douglas, WJ2V, from the "big Apple", and another of my heroes, "Professor" Glen Leinweber, VE3DNL. It was Chuck (along with Doug H.) who provided much of the "push" to get the 2N2/40 project "out to the public", almost to the point of making me "go ballastic" with his timeline. He is a "let's do it" person. Preston Douglas' building a working 2N2/40 from an inaccurate set of schematics is almost an unbelievable feat. I had sent K5FO (and NA5N) an early set of schematics after Dayton, so he could see the general layout of the rig. While Preston was visiting Chuck, he also got a set. On his flight back to New York from Dallas, Preston decided that he was going to build the rig. To his credit, he did ask my permission and concurrence to proceed. Having him do that served two purposes: it gave me more confidence that the rig was reproducible, by hams who do not "bend wires or chase electrons" for a living; and we found one major and several minor, but none-the-less important, errors in the documentation. Kudos to Preston for his work. All but two of our communications took place via the internet, for those interested. And finally, Glen, VE3DNL for taking the time out of his busy fall schedule at the university to look over an early schematic and layout package. His observations always inspire me to "look out of the box" for unique solutions and better designs.

The very last person who needs to be thanked is here, all alone, because of her importance to me. That is my dear wife, soul mate, and lifelong friend, Kathy, KB8IMP. She has put up with untold hundreds of hours of my being squirreled away in the ham shack, working on the rig's design, building them, operating them, and putting the documentation together. Through it all she has been most patient, understanding, and supportive. Among her many areas of expertise is written English, and she contributed to this project by being my primary proof reader, and resident advocate for "getting the project done".

Summary - I indeed hope that this article has inspired you to get the parts and dive into scratch building a 2N2/40, or another design that you have fancied, but never built, using "Manhattan Style" construction methods. It is really a whole lot easier than it might appear at first blush. From personal experience, I can tell you that nothing you will ever build as a kit will compare to the satisfaction realized with doing a complete rig from scratch. If the dimensions of the layouts I provided look still look too small, build it on an even larger platform, maybe 6 X 8 inches, or even 7 X 9 inches. Or you could split it up into sections and build it that way, with the receiver on one board, the transmitter on another, and the VFO and Tx/Rx driver on a third, all appropriately wired together. I think the design is forgiving to the extent that it will work in almost any reasonable configuration. What I'm encouraging you to do is learn to build from scratch. It's fun, and a wonderful way to satisfy those creative desires. **Happy building!**

Building the Kortge 2N2/40 using "Paddyboard" or (Very) Ugly Construction Methods

By Preston Douglas WJ2V

This is a companion construction article to Jim Kortge's article and plans to build the 2N2/40 transceiver. A confession first. I came by these secret plans by illegitimate means. Last July I had to travel to Dallas for business, and spent some time with that gentleman QRPer, Chuck Adams, K5FO. He set aside almost a whole weekend of his valuable time for me, and we had a terrific time visiting the ham sites all over the metro Dallas region. Chuck had a preliminary set of drawings and schematics via Paul Harden for Jim Kortge's 2N2/40, and he kindly made me a set of copies. Chuck was enthusiastic about the design, but I didn't really have a chance to study the pages until I was on the plane headed home. Oh boy, this was some design. Despite the limitations of having only one kind of active device, this rig was very serious. It had a double balanced diode ring mixer, single balanced diode product detector, and smooth gain distribution. The filter was three 4.915 crystals; there were separate BFOs for the transmitter and receiver, so offset would be easy, and there was a serious effort at getting correct interstage impedances, accomplished mainly with lots of toroid transformers. It was designed for loudspeaker operation, with plenty of audio. The transmitter was also well thought out, with a neat, removable PA section so that at some future time the three 2N2222A parallel transistor array could be replaced by a "better" PA transistor. Plus, Paul Harden's drawings were brilliant. Unfortunately, only a few sections of the project were drawn up, so the thing couldn't be built until the rest was done and published.

Well, I couldn't wait. I had been reading Drew Diamond's book (sold by the G-QRP folks) about homemade projects using what he called "paddyboard" construction. Jim Kortge calls it "Manhattan" style; thus the original appellation of this project: The Manhattan Project. This is a system of "ugly" construction that uses little pads of PC board material, glued to a main "substrate" PC board. Each pad is an isolated island, making each one a soldering junction for several interconnected parts. Let me tell you, it works gangbusters. So, off I went with my unofficial copy of Jim's plans, to make a 2N2/40.

First, though, I did contact Jim, and Doug Hendricks, who was the inspiration and intended publisher of the 2N2/40 for their blessings. They thought it was a fine idea that I was going to try to build my own 2N2/40, and Doug even thought it would be great to publish a companion article to Jim's. This is it. Note, though, that my version of this system of building is just about as inelegant as Jim's design and construction patterns are elegant. If you build it my way, it will very likely work, but you certainly will want to build it into an opaque cabinet! Once it is surrounded by metal, no one will know you chose the ugliest method to build this terrific rig!

On homebrewing in general: I think you could probably build the 2N2/40 by just gluing the pads in accordance with Jim's or my patterns, solder on the parts, like laying carpet, and hope the rig works. But this is no kit, and you are going to be in for some hair pulling (assuming you have any left up there at your age) unless you have some test equipment. A scope is really helpful in some places to see where to set some of the trimmers, and you aren't going to know what went wrong without being able to follow signals through the stages, preferably as you build. That's just my opinion, and you may decide to build the rig "blind" and have your local Elmer get it to work! I have photographed the building process and included some pictures here to illustrate. Notice that the receiver was built around the edges of the main PC board, from the rear left around to the front left.

I thought I would start with the VFO first. That is, after all, the heart of any rig, and I figured if that wouldn't work, then I ought to quit while I was ahead. The plan for the VFO is Fig 1. Notice the linear layout, which is the way I hoped to build the whole rig. Indeed, the pundits all say to try to build in line to reduce interstage coupling. Plus, you will have a much easier time keeping track of where you are, with less chance of "wiring" errors. And, the bonus is that you can keep track of progress by the length of the construction line!

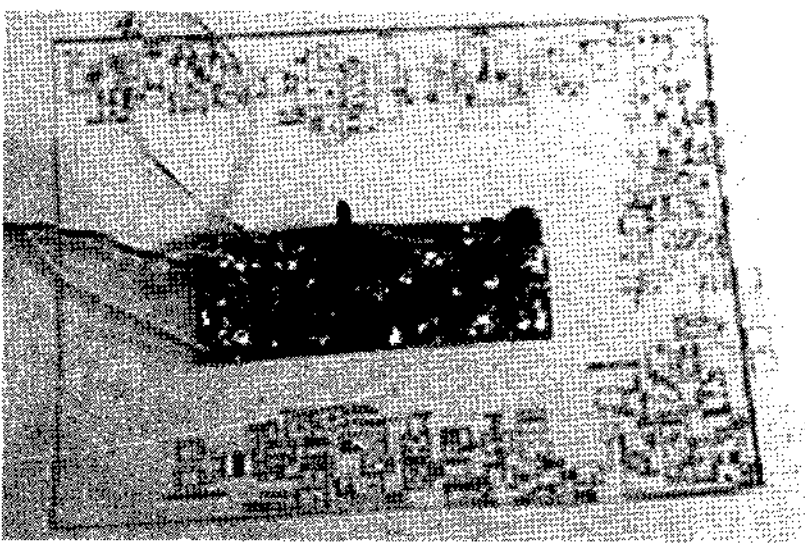
Since I really didn't trust myself to build a working rig this way, I decided early on in the planning stages that the pads would be big, ugly, and use plenty of room. I ordered a PC board that was 6 x 7 for this project, and though it still wasn't roomy, it gave me some space to work in. The pads were almost all squares or rectangles cut from scraps of PC material with a pair of tin snips. While others have suggested nibbling tools for making pads, my nibbler makes nibbles that are too small to be practical, and I wanted big pads anyway. Incidentally, the tin snips will occasionally bend up a piece, and these misshapen pads should be discarded if you are going to use super glue.

Crazy Glue brand super glue is terrific for attaching these pads to the substrate, but be careful. The glue is dangerous, poisonous, and hazardous to your eyes. Wear glasses, at least, and watch where you put your bare skinned hands with this stuff. You don't want to rub your eyes with super glue on your hands unless you like spending time in the ER. You can also glue your fingers together well enough to need to have them cut apart by a surgeon. No fooling. Keep the little ones (grandchildren etc.) well clear. Super glue will not fill gaps. It sticks well only when there are smooth, clean, fully contacted surfaces. Thus, the above-mentioned bent, twisted pads won't stick with super glue. Make sure to scrub the copper substrate with some Brillo and maybe alcohol too for gluing and electrical purposes. Of course, if you have unlimited time because you are already doing five to ten in Leavenworth (or was that Woolworth's?), then you can use epoxy and wait for it to harden with each pad.

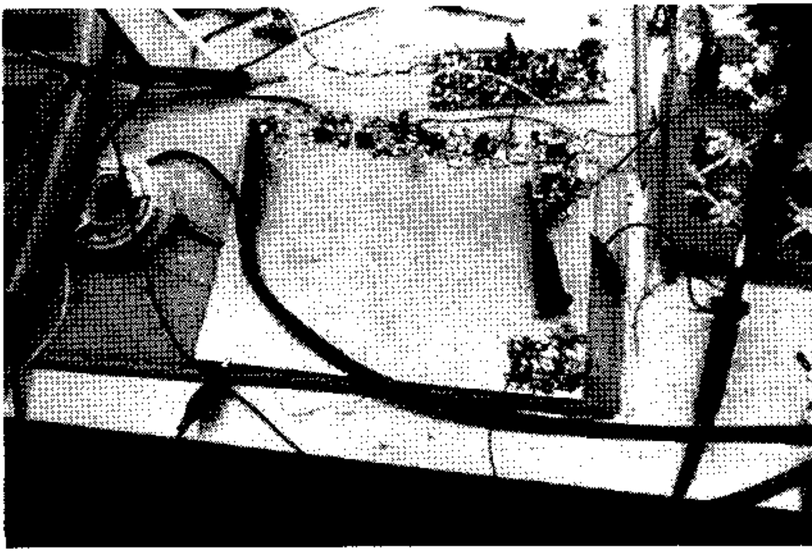
I started by sketching pad configurations for some of the stages. I drew the plans in modules, by hand, with a pencil; I could have built the rig from those hand drawings, but I couldn't get a handle on how big it would be, and whether the sections would fit on my PC board. So, I transferred all the drawings onto the computer. I don't have CAD; I find the Windows Paint program that comes with all versions of Windows is adequate for most drawing tasks. Thus, Fig. 1 and Fig. 2 were created. Actually, though, the building began even before the drawing was half finished. Incidentally, Fig. 3 is the PA and filter section; there are only three figures. You can make the whole rig from those three figures.

I suggest that if you are going to follow my drawings, you should start by building the VFO on a small rectangle of PC material, about 1" by 3-4". There are 15 pads and one little toroidal transformer to fit on this substrate board. You will want it to fit about where it is shown on Fig 1, so size your VFO strip accordingly. Note, that while there is some room to play with on a 6 x 7 board, you will want to leave yourself plenty of space by building the VFO reasonably small. Anyway, if you get

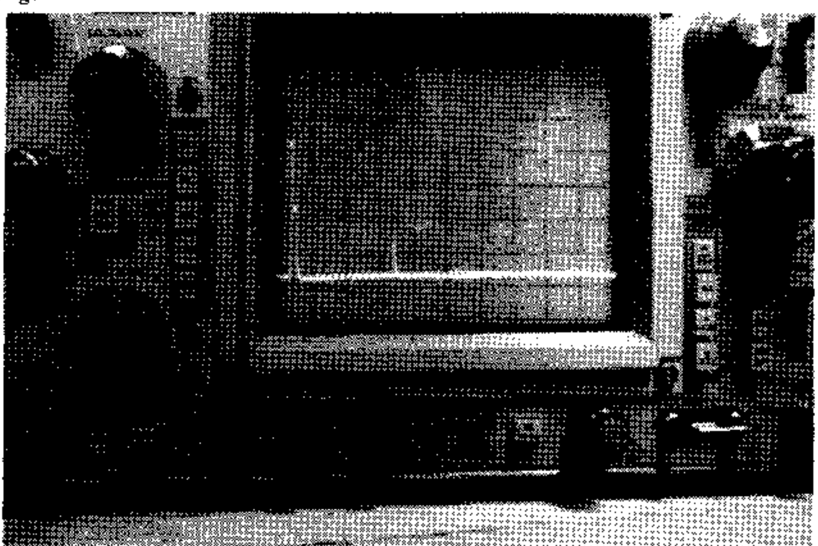
In background VFO board; in foreground is mainboard with front end at rear and RX LO near corner. Look at all that room to build!



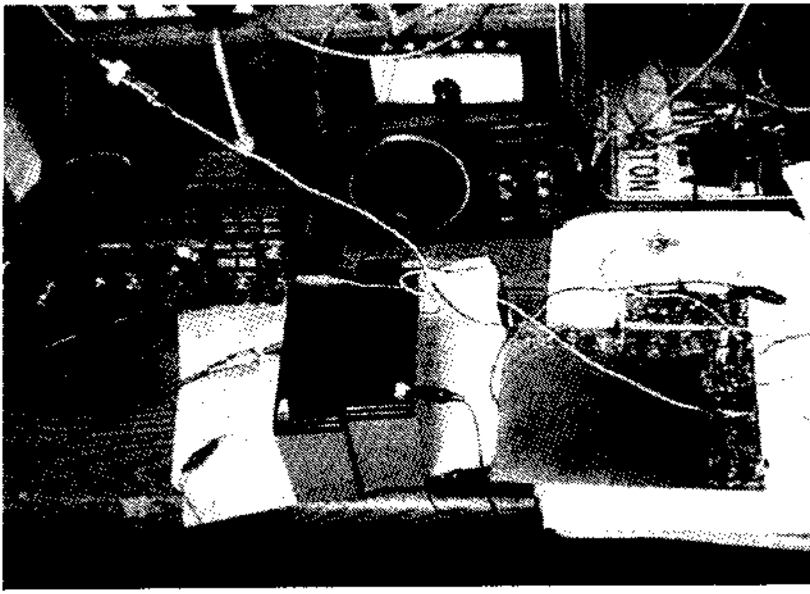
A look at the completed VFO board, sitting on a set of WJ2V plans showing the receiver layout for the mainboard.



Here you see the front end, RF amp, mixer and post-mixer amp, built along the rear edge; turning the corner, the three xtal filter is built along the right edge.

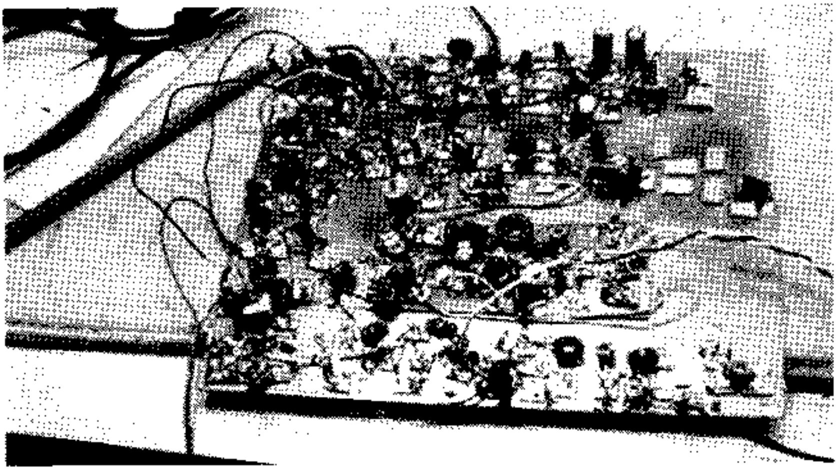


With the VFO powered up and connected to the mainboard double balanced mixer, and a 7 MHz signal injected at the front end...careful tuning of the VFO pot puts a 4.915 signal into the filter, and it appears at the output end of Y3 like magic on the Weber SA/SA MKII Spectrum Analyzer as a single clean signal. Wow, it works!

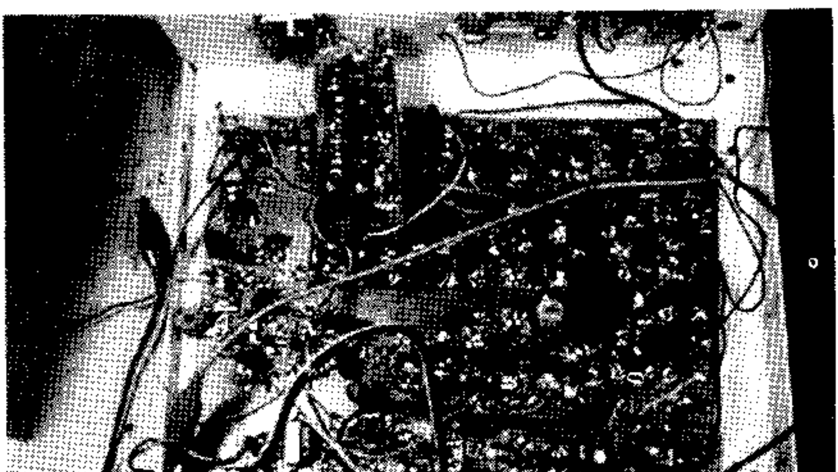


Here, a dipole was connected to the front end of the 2N2/40; taking the 4.915 amplified signal from the 2N2's IF amp stage (now built along the right edge-more progress), and using the Yaesu 757, tuned to 4.915 as a downconverter/product detector, I am hearing 40m signals through the RF and IF stages, as I tune the VFO. So far, so good!

The completed receiver. This shot shows the receiver actually receiving 40m signals on its own. The audio chain has been build along the front edge (foreground.)



Rx front end is in foreground now. VFO has been mounted to the mainboard with two bare, soldered wires at each end of the little VFO board. Next back towards the background is the incomplete transmitter chain. The T/R circuitry, TX LO, TX mixer are built. The pads for the cascode amp are in place, but not populated.



Rig is now completed. The AF circuitry is in front, the TX chain next behind. The TX is built in an "L" shape, the long end lying on its back, with the short end along the left edge. The "front end" of the receiver is along the rear edge. The VFO is seen under the PA board, which is hanging from a single solder lug attached to one of the antenna connector screws. Two contacts were made with the rig in this semifinished form in the QRP ARCI fall contest. The only alligator jumpers still in use here are to connect the keyer.

the VFO to work, you will know you have a fighting chance of making the whole rig work. If the VFO doesn't get off the ground, then perhaps the project should be re-evaluated.

Listen for the VFO on your station receiver and note that L1 may need a turn or two removed to get the oscillator into range. To tune 7000 to 7100, for instance, you would need the VFO to cover 2085 to 2185 kHz. You can increase the range of the VFO by increasing C10, but you may wish to consider that a limited VFO range (small C10) will allow adequate bandspread to eliminate the need for a ten turn pot which Jim specified in the design. By selecting a small C10, you can use a simple 20k pot and tune from say 7025-7055 easily. I found the C10 specified was somewhat small anyway.

You should have no trouble hearing this VFO on a general coverage receiver, as it is designed to drive a diode ring mixer, and these mixers require a healthy signal to drive them. Incidentally, for the double balanced mixer in the receiver, I was confused by the trifilar windings and Jim's compact layout. I redid the mixer layout to look like the textbooks, and changed to hot carrier diodes that are supplied by Dan's with his mixer kits. Three colored wires helped too. Together, these measures cured my unsatisfactory mixer results, but since I changed more than one factor at a time, I lost the chance to discover if 1N914 diodes would have done as well as the hot carriers, once correctly connected. So much for science. Trifilars are actually easy to wind. Take about 10" of three different colored wires, fix one end, and braid them like you would a kid's hair. I had no trouble fitting 10 turns of # 26 wire (less likely to break than # 28) on the 37 size cores.

Build, starting from the rear left corner, identified by the notation "to A". That first section is the protective front of the front end, and the RF input. Following that section, continue on into the double tuned front end. As you build each section, first you lay the pads in the pattern, then solder on the parts. It's just that easy. After you have built the first section, you can inject a 7 MHz signal and tune for max on you scope at C4 to see that the tuning works. Install the RF amp section and retune, if you have the equipment, for max signal at C6. Then build the mixer, the post-mixer amp and the filter, around the corner. Now, you should be able to tell if you are going to have a working rig. Connect up your VFO, inject a 7 MHz signal at point A, and look for it to squeak through the mixer at outer end of Y3. If you get this far, congratulations, it looks like you are going to make it all work.

Continue laying pads and filling them with parts for the IF amp. You can connect the IF amp at C26 to your general coverage receiver tuned to 4.915 MHz, to see if, by using your station receiver as a second IF and product detector you have most of the receiver running. You should be able to hear on the air signals this way. The product detector follows along the right side, and note that the corner area circled denotes the RX local oscillator. You might consider building that RX LO earlier (out of sequence), in case you need to test the IF filter-it makes a perfect test oscillator, and you can see it sweep through the filter with a scope or spectrum analyzer, if you need to.

Now, for the home stretch, turn the PC board around 180 degrees and build the AF section across the front as shown. You may just be astounded when you connect a speaker to the pads at the end of the chain, when the radio plays. An antenna at "A" ,VCC all around, and a little tuning should result in 40m CW playing its music. Note, too, that you will need to temporarily tack a 2.7 meg resistor from the point labeled "RX" to VCC to bring the AF section to life. This is replaced by the T/R circuitry in the other bordered area when the transmitter is built.

On to the transmitter. Note that the backbone of the transmitter is constructed inside and parallel to the AF section of the receiver, turning the corner and ending on the left edge of the board at the words, "To PA". First, the little T/R system is built, and you can test it for switching function. To do that, just try grounding the RX pad, and see that the TX pad goes to about 11 volts. Then the TX LO, the mixer, and the amps. At the end of the chain, you have a transceiver. Of course, without the PA, it isn't going to get you very far yet. Still, you should be able to hear sigs, see that the T/R works, and hear the transmitter! At the point you have the mixer done, connect the VFO into its insertion point and see that you are able to send a signal to your main station receiver by keying the RX line to ground. Keep going with the transmitter, until you reach the PA.

I had a bit of trouble with the Cascode amplifier. The transmitter chain depends on tuned circuits that must be resonant, else the signal getting through will be too feeble to drive the finals. I don't know if my primary of T13 had too few turns or not, but I had to add an additional cap across TC8 to get it to percolate at 7 MHz. Of course, the scope helped immensely here, and the spectrum analyzer gave me some hints too. I even tried dipping T13 in situ with my grid dip oscillator, and indeed it seemed to dip way up in the 8 MHz range until I added that extra cap in. This is the kind of problem that a homebrewer may face, and have to solve to get the rig to fly. Once you can see about 3 v p-p at the output side of C57, you know you have succeeded. You can then go on and build the PA and output filter circuitry on it own little board, and you are nearly done.

The PA and output filter are constructed on a separate strip of (double sided) PC board material, like the VFO, per Fig. 3. This module is mounted on a standoff, above the main PC. I stole an idea from one of Paul's illustrations and hung the whole PA board from a solder lug with one of the screws that holds the UHF antenna connector on the back panel.

I assume Jim will detail tune up of the receiver and netting of the transmitter. Here's a simple version. First, adjust TC5 in the RX LO until you hear the "rushing sound" that the late Roy Gregson described in his tune up instructions for his kits. This is the "live" sound you hear when the LO is mixing with the IF to allow you to hear backwards into the filter, kind of like getting the pipe lined up so you can hear the far end. Then, using an on air signal or injected one, peak TC1 and TC2 and TC9 for maximum volume. Now, get the signal centered by adjusting your VFO for loudness in the speaker (or, better still, tune for max with the scope on the output side of the filter at Y3-this is better because the human ear isn't sensitive enough and can be fooled into "hearing" changes in volume when it hears a change in pitch.) Now, adjust the RX LO trimmer, TC5 for a 700 Hz tone. That's it, the receiver is tuned.

Now, use a local signal in the shack and tune it in with your main receiver and the 2N2/40. Get the pitch of this local signal the same in both receivers. Now shut off the local signal, key the 2N2/40, and tune TC6 to get the same pitch on the station receiver. Your offset is now right. Key the transmitter and adjust Pot 4 for less than 1 watt-into a 50 ohm dummy load, please! Adjust TC 7 and TC 8 for max. and if you have a scope, adjust for cleanest signal. Keep an eye out for overheating of the PA transistors, and limit key down time. Once TC7 and TC8 are maxed, reset Pot 4 for about 1.5 watts out. I set my output for 1.25 watts, just to be on the safe side and assure longevity of the PA transistors.

I leave the cabinetry details, the fuse circuitry (a slow-blow fuse is recommended), and switch wiring to you. If you can build the rig to this point, these tasks should be trivial to you. Enjoy this great rig. 72, Preston **Note: The layout files in color are on the NorCal Webpage: http://www.fix.net/norcal.html**

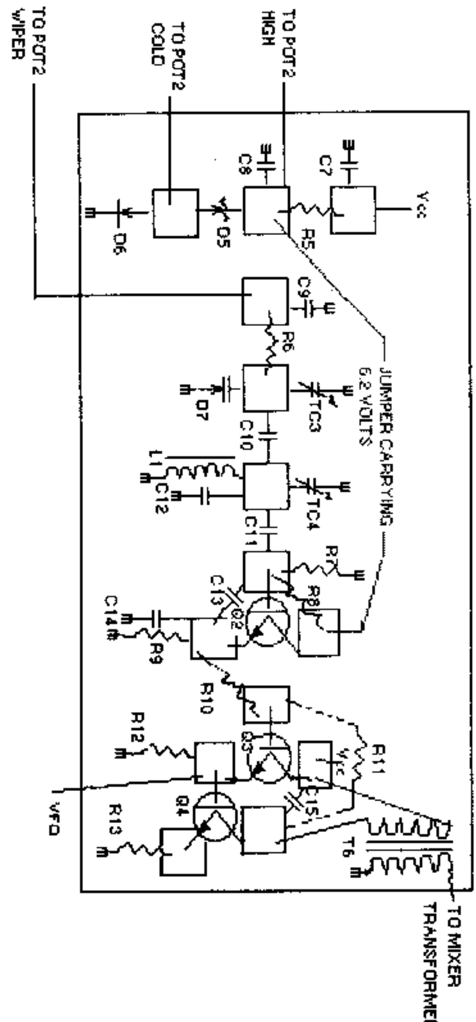


Fig. 1

FIG 3A

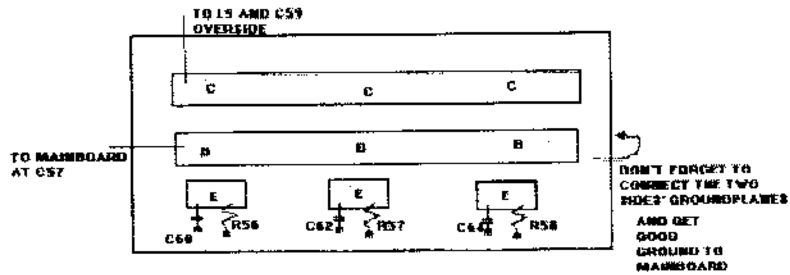
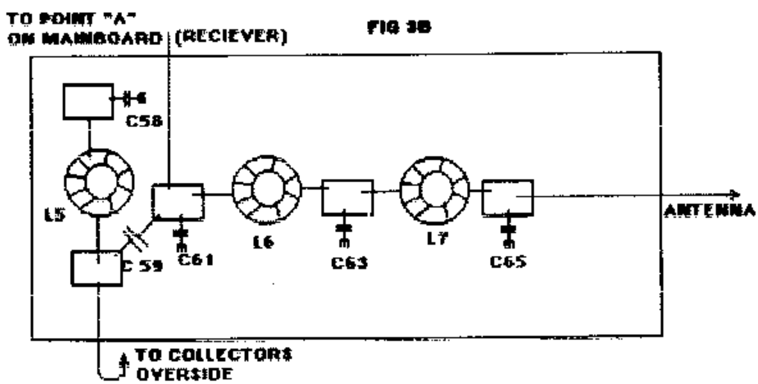
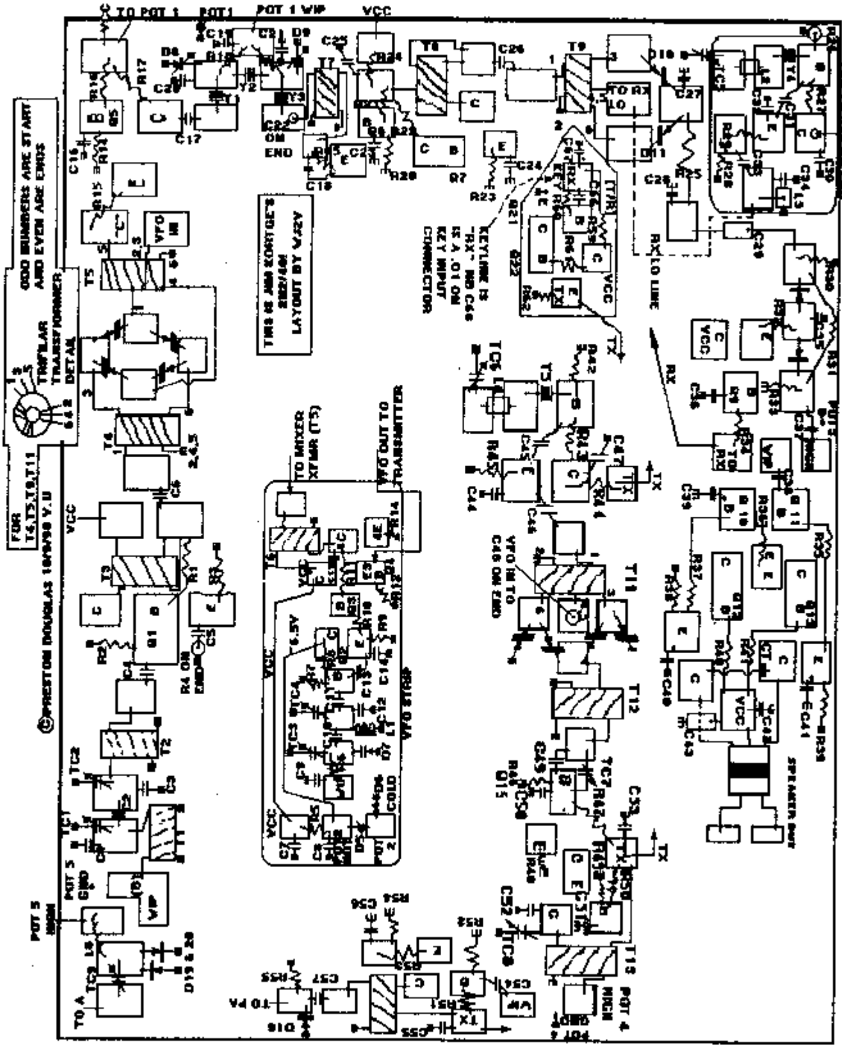

TO L5 AND C59
OVERSIDE
C
C
C
TO MAINBOARD
AT C57
B
B
B
E
E
E
C60
R56
C62
R57
C64
R58
DON'T FORGET TO
CONNECT THE TWO
SIDES' GROUNDPLANES
AND GET
GOOD
GROUND TO
MAINBOARD

FIG 3B


TO POINT "A"
ON MAINBOARD (RECIEVER)
C58
L5
C 59
C61
L6
C63
L7
C65
ANTENNA
TO COLLECTORS
OVERSIDE



Preston Douglas WJ2V's Layout of the 2N2/40

1998 QRP "Run to the Borders" to the Field Contest Results

by Joe Gervais, AB7TT
volc@primenet.com

Here are the results of the 1998 QRP To The Field "Run To The Borders" Field Day. You folks were GREAT! Couldn't believe how many triple-border points there were! Had to double-check the atlas a few times to make sure you weren't pulling my leg.

We were absolutely amazed at the great lengths many of you went to in order to get to your border sites. Hats off to you! And to those who got on the air from the homestead for a brief hour or so to give the Field Ops some QSOs, every Field Op owes you a beer. Or in my case, Barq's rootbeer or JoltCola....

95 logs were sent in - YOWZA! It's always great to read the comments you guys write. Helps make the long nights at the keyboard go faster. Thanks!

Some awesome scores, some VERY close calls, and a whole lot of fun. For a few folks this was their first contest ever, always nice to see you joining in the party! And whether you bagged 200+ QSOs or 2, you got on the air and proved that QRP not only works, it's also the best game in town.

Three Muli-Op stations (N0UR, N4ROA, W5ON) were neck-and-neck for 1st Place in their category. Team N0UR just BARELY beat out Team N4ROA by a mere 5,000+ points out of nearly 600,000 - less than 1%.

Roger (N7KT) took a solid 1st Place in the Single Op category, with his Four Corners x4 multi proving to be the clinching factor. Well done!

A total of 33 Field Ops ran for the borders.

Well over 95 QRPers had a great time! Thanks again to all for your support. Cheers de AB7TT, Joe, NorCal Contest Manager

———— QRPTTF '98 RESULTS ————

NOTES: A (*) by the callsign means multi-op. For location, H=home, F= field, FB = Field (Border), and M = mobile.

Callsign	Loc	Borders	Q's	SPC	Power	Score
N0UR(*)	FB	ND/SD/MN	146	67	5W	586,920
N4ROA(*)	FB	VA/TN/NC	167	58	4W	581,160
W5ON (*)	FB	AR/MO	173	76	5W	525,920
N7KT	FB	AZ/NM/UT/CO	81	47	4W	304,560
W5NC(*)	F	-	204	57	5W	232,560
WA7LNW	FB	UT/AZ	123	43	5W	211,560
KI0II	FB	WY/NE/CO	84	40	5W	201,600
N7CEE (*)	FB	AZ/NV/UT	88	38	5W	200,640
WU0L	F	-	163	61	5W	198,860
KW5OK	FB	MO/OK/KS	66	41	5W	162,360

W4ED	FB	GA/TN/NC	67	38	5W	152,760
W0CQC (*)	F	-	143	51	5W	145,860
AA7QU	F	-	140	49	5W	137,200
W0CH	FB	MO/KS/OK	55	39	5W	128,700
N4EO	F	-	109	45	5W	98,100
KD7S	F	-	119	39	5W	92,820
K9TSM(*)	FB	IN/MI/OH	45	34	3W	91,800
NQ2RP	F	-	91	50	5W	91,000
K0BC (*)	FB	AR/MO/OK	56	27	5W	90,720
KD7AEE	H	-	145	61	5W	88,450
K4JSI	FB	DE/MD/PA	45	31	5W	83,700
N6WG (*)	F	-	116	36	1W	83,520
K7NX (*)	FB	AZ/NM/Mex	46	30	5W	82,800
W4DEC	H	-	142	58	5W	82,360
WQ3RP (*)	FB	MD/VA/WV	34	26	5W	78,000
KG5N	F	-	94	39	3W	73,320
W5VBO	H	-	125	56	5W	70,000
WA1QVM	FB	MA/RI	54	32	4W	69,120
K5OI	FB	NM/TX/Mex	47	24	5W	67,680
AC6NT	FB	NV/CA/AZ	103	32	5W	65,920
AC6KW	F	-	88	37	5W	
65,120						
W5GIX (*)	FB	LA/MS	49	31	5W	60,760
W6RA	FB	CA/OR	63	23	3W	57,960
KG0MZ (*)	FB	KS/MO	44	31	5W	54,560
VE6DN (*)	F	-	85	31	5W	52,700
W3BTN (*)	F	-	77	33	5W	50,820
K8CV	H	-	103	46	5W	48,410
N9ZXL	FB	IL/WI	38	22	5W	48,400
WQ2RP (*)	F	-	79	29	5W	45,820
N7KE (*)	F	-	74	30	5W	44,400
W0YSE	FB	UT/WY	44	25	4W	44,000
W0QF	FB	SD/ND/MN	38	17	1W	38,760
K6ZNI	F	-	56	32	5W	35,840
WA2IPZ	FB	ID/UT/NV	32	18	4W	34,560
AA7MU	FB	UT/WY	52	31	4W	32,240
AE4GX (*)	FB	GA/SC/NC	21	24	5W	30,240
WE6W H	-		91	33	5W	30,030
KN1H	FB	NH/VT	32	23	900mW	29,440

N2TO	F	-	38	28	5W	28,112
N4KN	F	-	48	29	4W	27,840
AB5UA	F	-	43	23	5W	24,840
VE3ELA	F	-	41	29	3W	23,780
NQ7X	H	-	66	32	5W	21,120
KI6DS	FB	NM/TX/XE	29	12	5W	20,880
WA6FUH	F	-	30	23	5W	20,240
N0IBT	F	-	32	29	4W	18,560
CO4BM	H	-	68	27	5W	18,360
W0RSP	H	-	33	26	950mW	17,160
N7GS	FB	MT/WY	28	15	1.5W	16,800
AB7TT/flu	H	-	56	27	5W	15,120
WA8RXI	H	-	78	36	4W	14,040
AE6TT (*)	F	-	50	14	5W	14,000
WD7Y	H	-	72	19	5W	13,680
KS4V	F	-	40	16	2W	12,800
K4KJP	H	-	44	28	2W	12,320
NR3E	H	-	36	25	5W	9,000
K5RAC (*)	F	-	36	27	5W	8,640
N9UKX	H	-	37	23	5W	8,510
K0SU	F	-	22	20	5W	8,400
W8TM	H	-	39	21	4W	8,190
WA9WAC (*)	F	-	40	9	1W	7,200
W8TIM	H	-	34	16	2.5W	5,440
WA9PWP	M/H	-	32	17	5W	5,440
K2HPV	F	-	18	13	2W	4,680
W6ZH	H	-	23	20	5W	4,600
KD6JUI	F	-	18	12	5W	4,320
VE5RC	H	-	23	18	5W	4,140
KA1AXY	FB	MA/CT/RI	10	6	2W	3,600
N0QT	F	-	20	9	5W	3,600
AH7R	F	-	16	11	5W	3,520
KE6QMX	F	-	22	8	5W	3,520
WA8GHZ/5	M/H	-	18	12	5W	2,880
KC8JIE	H	-	18	14	5W	2,570
KB2VTN	FB	NY/NJ	14	11	5W	2,340
KU7Y	H	-	20	10	200mW	2,000
AB0AE	H	-	16	12	5W	1,920

KQ0I	H	-	14	13	5W	1,820
KK7HV	F	-	11	6	5W	1,320
N4UY	F	-	7	8	2W	1,120
W8LN	FB	AL/TN	5	5	5W	1,000
WA1OFT	H	-	13	12	5W	780
KB0VCC	F	-	6	5	5W	600
K2UD	H	-	6	5	2W	300
N7DW	F	-	3	3	5W	180
WD8MNV/6	H	-	3	2	5W	60
K8NI/flu	H	-	3	3	4W	45
K3TKS	H	-	2	2	5W	40
AF9J	H	-	3	2	4W	30

QRPTTF '98 Soapbox

(AB7TT Note: Thanks to all for the kind comments and encouragement! Makes the log processing much nicer!)

"This was my first contest ever on CW. It was a thriller. ... I was blocked by snowdrifts from reaching the CO/UT/WY state corners, so had to settle for UT/WY. I set up in semi-blizzard squall condx Friday night ... Had lots of fun and no company other than my dog, herds of elk and antelope, and a few yacking coyotes." - Lowell, AA7MU (AB7TT Note: Wow!)

"Everyone one of our group ... had a turn at operating, and afterward a tube steak and barby hamburger turned out by the XYL for lunch plus a dessert of donuts and cookies, followed by more coffee! ... Regardless of how we make out in the scoring, we all agreed that it was a great get-together and the day will be remembered for a long time." - John, VE6ZAA and the rest of the Calgary QRP Group.

"In spite of poor band condx, it was a lot of fun and I hope the format will be repeated next year!" - Mal, N7GS

"Had a great time handing out border QSO's - can't wait 'til next year's QRPTTF." - Joel, WA1QVM

"I had a fine time. I never heard any CW above 25 wpm. A nice friendly contest. ... If I'd known my XYL was going to be at a convention that day, I would've been in the field. Thanks for the event and I hope to work it next year." - Ed. WD7Y

"Called CQ on 10m. but no response. Didn't even bother with 80m. ... 15m was a surprise - along with KI0II for a triple. worked AH7R off the back of the beam! Good fun - hope that I can spend more time with this next QRPTTF." - Pete, W6ZH

"QRPTTF was scheduled for the opening day of trout season. ... I set up my little backpacker inverted-V on a ridge overlooking the river. 2,000 ft. below, drift boats were sliding by, each with 2 or 3 happy fisherman. Rats! But as the day unfolded ... calling CQ that morning began to feel like dropping a nice cast, right over by that promising riffle. Searching and pouncing was, I realized, the human analog of what trout do." - Russ, AA7QU (AB7TT. Note: Wow! Zen and the art of QRP fishing!

"I was running 2W from my unmodified HW-7. ... The guys I worked were real heroes for sending repeats my way ... It was completely deaf, having blown a front-end dual-gate MOSFET ... Oh well, I enjoy the minimalist approach (I also enjoy visits to the dentist)."- Howard, K2UD (AB7TT Note: There's a bit of masochism in all

QRPers!)

"Had mucho fun despite lousy condx ... Tnx for the contest!"- Dave, NR3E

"Had a great time, what a fun theme for a QTTF! Can't wait to find out what you'll come up with for next year." - John, KN1H (AB7TT Note: Surprise! If it's still fun, don't fix it! :-))

"First contact was Russ AA7QU (unlike his backpack camping I had hot and cold running water, propane stove and heat, and was out of the wind inside the camper). Things I learned ... Don't eat a big lunch during contest as no QSOs were logged during nap." - Charlie, WA2IPZ

"What a great contest! Here are my claimed scores ... Just think what this would have been if I'd just headed for the border (not Taco Bell)!" - Nick, KG5N

"Had to travel out of town for a club meeting, but still tried to get on for last half hour of the 'test to give out some QSOs." - Eric, AF9J

"I had KK5XO as a guest, was his first contest. Fun to watch him! The temp hit 90F and 40mph winds. Took lots of breaks. Did I mention the wind? " - Clif, AB5UA

"I did not even plan on entering, but since I was driving around and heard some QRP stations, well, I couldn't resist!" - Paul, WA9PWP/M

"Just 20 miles south of my very own front door is the BLM fence line that separates UT and AZ ... beautiful day and location for operating ... connected the ground radial system to the UT/AZ border fence, which I believe is a rather unique competitive advantage!" - Jack, WA7LNW

"We operated on an undeveloped park on the border between crazy and stupid. Had a lot of fun doing it and introduced a few people to QRP." - W5NC, Multi-Op (lots of ops).

"Our station was set up near ... where AR/MO/OK meet. This was the first QRP event for some of us and we really enjoyed this very much!" - Gary, K0BC

"I was very ill April 25th, but wanted to see what QRP sigs looked like so I dragged myself out of bed for about 10 minutes. Sigs were very good and I quickly worked 3 QSOs."- Norm, K8NI (AB7TT Note: Seems we had the same flu that day!)

"We operated from just after 9:00am until the wind blew over out operating tent ... it was strong enough that I could no longer hear stations with the earphones. Bill's two boys flew kites, until those were also dashed to pieces." - Lloyd, K7NX (AB7TT Note: Wow! Sure you weren't set up at Riley, NM?!?)

"Great contest - lots of fun - on the border of insanity I am sure. Two years I have been in the mountains for this and got snowed on. One year I was snowed in at the house. We gotta make this "Spring" thing later!" - Rick, K0SU

"This was a great event, a lot of fun. The Baton Rouge ARC operated as a club event. It was the first time some of the guys had ever operated QRP. Looks like it may not be their last. They all said we should make the NorCal TTF an annual event for us." - Tom, AC5JH (EAB7TT Note: Great!)

"QRP interest must be growing in leaps and bounds, judging from the congestion around 7.040. 40m didn't seem too good, but enjoyed the contest anyway." - Doug, W8TIM

"Sure enjoyed the contest. Took the gear and sat up on the IL/WI state line north of Durand, IL. Watched the farmers plant corn while I played radio! It was fun and enjoyable for my first TTF contest." - Dave, N9ZXL

"I had a great time. 20m was fading throughout the contest, so we worked QRP to QRP on propagation peaks - a greak skills enhancement exercise!" - Terry, K4KJP

The 5th Annual ... QRP TO THE FIELD '99

Run to the BORDER Part II

Sponsored by NorCal

Saturday, April 24, 1999
1600-2400UTC

Categories: Field, Home, DX, Taco Bell (see below) and multi-op
Exchange: RST and SPC (**S**tate/**P**rovince/**C**ountry)
Border stations send SPC's their border location sits on.
Example: "599 AZ/CA/NV" for a border station

QSO Points:
†Each domestic U.S. QSO -- 5 points
†Each DX QSO (incl. VE, HI, AK) -- 10 points
†Border ops count as one QSO for each SPC they send.
Example: "599 AZ/CA/NV" is 3 QSO's for 15 QSO points.

Multipliers:
x4 **Field** Location (battery power, temporary antennas)
x2 **Home** location (commercial power, fixed antennas)
x2 **DX stations** outside the contiguous U.S., including VE,HI,AK
Border stations: xK, where K=number of SPC's in exchange
Example: "599 AZ/CA/NV" K=3 (and your x4 field location!)
x**SPCs** for each band. (10 SPC's on 20M + 8 on 40M = 18 SPCs)

FINAL SCORE: Add QSO points. Apply multipliers listed above.

† Same station may be worked on more than one band for QSO points and SPC credit for each band.

Special TACO BELL Border: You will be allowed a 2-state "border" if you operate from near a TACO BELL restaurant. To qualify for this x2 multiplier, you must submit a photo with your log that shows **both** your station and the Taco Bell. Thus, you need not operate from the parking lot, but close enough to be in the "field of view" of the photo. Each Taco Bell has a store number. You must record the store number on your entry/summary sheet.
Exchange: Your state/Taco Bell
Example: "NY/TACO BELL" or "NY/TACO" (not "TB")
If you work a Taco Bell station, it is worth 2 QSO's (10 points).

KI6DS being frisked at the Mexican border during the 1998 QRPTTF "flagship" station

The Fine Print ...

- Logs must include the station location and description (rig, antenna and power). Logs without this information will be considered check logs.
- **Deadline** is **June 1, 1999.**
- All contest decisions are final.
- Results will be published in QRPp, and posted to QRP-L
- For rule clarification contact NA5N at pharden@nrao.edu

Send logs to:
Joe Gervais, AB7TT
QRPTTF Contest Manager
P.O. Box 322
Peoria, AZ 83580-0322
email: vole@primenet.com

How close must I be to the border?
Use common sense - get as close as feasible to the border without risking your welfare or safety. For borders running through bodies of water, operate from either shore. QRPTTF, like all contests, is on the honor system. The object is to have fun, both on-the-air and off. So get some QRPers together and HAVE FUN!

NorCal's T-Shirts

NorCal offers two shirts: The NorCal T-Shirt and The NorCal Zombie T-Shirt (Limited Edition) The price is $15 each plus $3 shipping and handling in the US, $5 shipping for DX. The shirts are the recognizable NorCal "GOLD" and high quality and heavy duty. The NorCal shirt is imprinted with the NorCal logo and the NorCal Zombie shirt is imprinted with the NorCal Zombie 'Toon. The shirts are gold with the NorCal Logos in black and the Zombie 'Toon is multicolor. To order Send $15 + $3 postage ($5 DX) to: Jerry Parker.
426 Tanglewood Ct.
Paso Robles, CA 93446

Don't forget to specify your size: M, L, XL, XXL (Note XXL shirts are $3 additional) Please make check or money order out to Jerry Parker. NOT NORCAL. US Funds Only.

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Shipping: US

$4 for 1 - 3 issues, $5 for 4 - 6 issues.

Shipping: Canada

$4 for 1 issue. $5 for 2 - 3 issues. $7 for 4 -6 issues.

Shipping: DX Europe & South America

$5 for 1 issue, $7 for 2 - 3 issues, $10 for 4 - 6 issues

Shipping: DX Pacific Rim, Australia & New Zealand

$5 for per issue ordered.

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QRP Frequency Crystals

NorCal has available the following crystals in HC49U cases for $3 each postage paid in th e following frequencies: 7.040 MHz. 7.122 MHz., 10.116 MHz. Send your order and payment in US Funds only to: Doug Hendricks , 862 Frank Ave. , Dos Palos, CA 93620, USA. Make check or money order to Doug Hendricks, NOT NorCal.

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