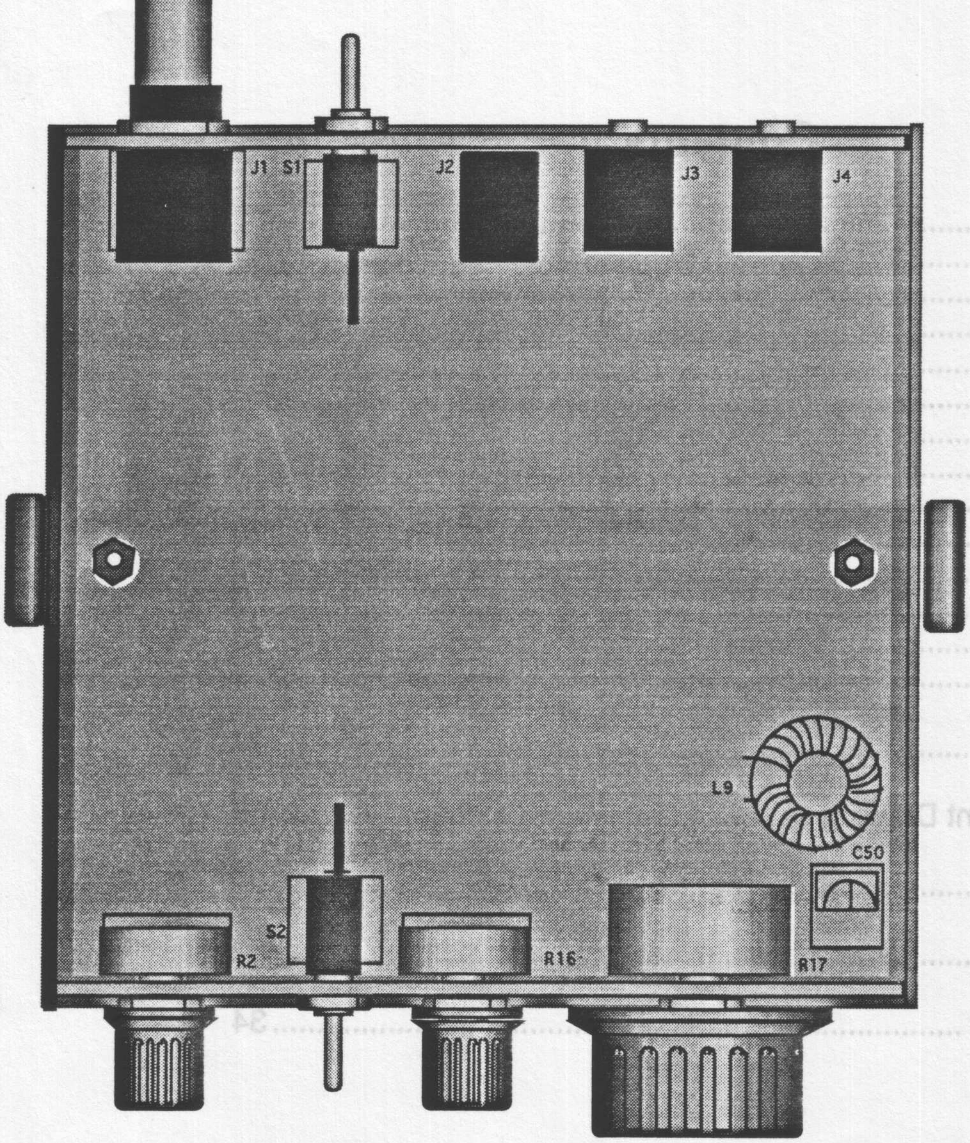
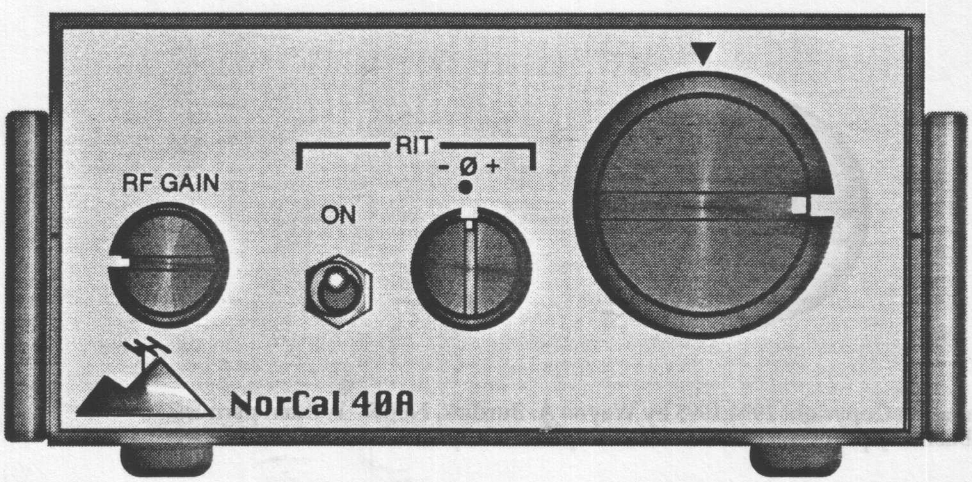


NorCal 40A

QRP CW Transceiver



Assembly and Operating Manual

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NorCal QRP Club

Rev. A, January 22, 1995

Contents

Introduction

The NorCal 40A QRP Transceiver is a project of the Northern California QRP Club. The design of the rig has been completely updated, taking advantage of what we learned during field testing of our first two club projects, the NorCal 40 and the Sierra. We hope that you'll find this second-generation kit easy to build and enjoyable to operate.

Since we introduced the NorCal 40 in 1993, NorCal has grown to over 1000 members. Our kits have been built by hundreds of QRP enthusiasts in both the U.S. and abroad. The secret to this success is the high level of interaction between club members, whether in person, by phone, by mail, or via the Internet. Once again, we encourage you to experiment, share ideas, and help other club members you're in contact with. Let's continue the NorCal tradition and make the NorCal 40A one of the most modified rigs in history!

I'd like to thank a few people who worked hard to help get this updated rig into production. Eric Swartz, QRPp's technical editor, endured many circuit revisions, providing wisdom, moral support, and a willingness to trash his own NorCal 40 PC board. Dave Meacham checked the final artwork and manual. Jim Cates was well organized, as usual, taking orders and wielding the mighty checkbook. Doug Hendricks beat the jungle drums, keeping club members informed in print and by Email. And Bob Dyer put it all together, packing and mailing the kits.

Designing kits is the fun part; ordering parts and putting kits together is just plain hard work. To lighten the load on NorCal volunteers we have for the first time enlisted the help of an experienced third party: Oak Hills Research, owned and operated by Dick Witzky. As many of you know, OHR has its own line of QRP rigs, and thus maintains a large parts inventory. For a small per-kit fee, OHR purchases and kits all of the small parts for the NorCal 40A. This cost has *not* been passed on to the builders; NorCal has recovered its initial R&D expenses on the project, allowing us to keep the price the same.

If you have comments on the rig design or the manual, please send them to Wayne Burdick, N6KR, 1432 6th Ave., Belmont, CA 94002. (E-mail: wayne@interval.com.)

72, N6KR

NorCal Kit Policy

1. We will refund your money if you return the kit unbuilt.

2. If anything is missing or broken before you start, we'll replace it free.

3. If--after your best efforts--it still doesn't work, we'll try to identify a club member in your area who can help.

General Description

The NorCal 40A is a compact 40-meter CW transceiver optimized for portable, battery-powered operation. It has very low receive-mode current drain--only about 15mA. Operating features include RIT (receive incremental tuning), smooth T-R switching, transmit signal monitoring, and variable power output up to about 2 watts.

The receiver is a superhet, providing excellent sensitivity, selectivity, and freedom from 60-Hz hum pickup. There's enough AF output to drive a speaker, and a unique differential AGC (automatic gain-control) circuit is used to keep strong signals relatively constant. An RF gain control is provided to attenuate extremely loud signals. The conversion scheme used results in a stable, low-frequency VFO (variable-frequency oscillator), operating at about 2MHz. See **Circuit Details** for more information.

To make assembly as easy as possible, all components, including the controls, connectors, and even the case parts are mounted on a single printed circuit board. There is virtually no chassis wiring. Alignment is reasonably simple, and can in some cases be done with no test equipment, or with only a separate transceiver that covers the 40-meter CW band.

There is plenty of room inside the case and on both the front and rear panels for additional controls and built-ins, such as a keyer. Long-life plastic latches on either side of the case allow easy access to the interior .

NorCal 40A vs. the NorCal 40

Physical: The '40A is the same size as the '40, but the circuit board sits lower to provide more panel and interior space. The PC board layout is completely redone; the board is now double-sided and plated through, with much more ground plane and *no* jumpers. Instead of long standoffs to hold the cover on, the '40A uses the same latches used on the Sierra, freeing up additional interior space. The VFO pot is larger and more mechanically stable, and both S1 and S2 now have threaded bushings, making the panels much more rigid.

Receiver: Overall receiver gain is improved by about 8dB, enough so that a speaker can be driven to moderate volume. At the same time, AF hiss has been greatly reduced. AGC range is a bit larger (by around 10 to 15dB), and the tone is cleaner now as the AGC approaches saturation. The BFO frequency can now be varied, which allows you to set the pitch heard at the center of the crystal filter's passband. Last but not least: tentative results indicate that the new PC board layout has eliminated the 7.023MHz "birdie" that could be heard on most of the original NC40s. (Some will mourn its loss as a band-edge marker; others will gather their wits and build a 25kHz crystal calibrator.)

Transmitter: The transmit waveform's falling edge is shaped, with a not-too-soft fall time of about 2 milliseconds. You can adjust the transmit monitor pitch.

Specifications

Numeric values given are typical; your results will be slightly different. All measurements were made with a 13.0V supply and 50Ω load at the antenna.

General

Size:	2.2" (H) x 4.6" (W) x 4.5" (D)
Power Requirements:	10 to 15VDC; reverse-polarity protection
Receive:	15mA
Transmit:	200mA at 1.8 watts output
VFO operating frequency:	2.085MHz nominal[1]
Tuning Range:	Any 40kHz portion of 40 meters
Drift:	100Hz total from cold start at 65°F
Calibration:	Supplied by builder

Transmitter

Output:	0 to 2.0W, adjustable
Final Amp efficiency:	70 - 80%
Load Tolerance:	brief operation into high SWR
Transmit offset:	400-800 Hz, adjustable
T-R (transmit-receive) delay:	200 milliseconds

Receiver

Sensitivity:	Better than 0.5uV for 10dB S+N/N
Selectivity:	400Hz @ -6dB, 1.5kHz @ -30dB
I.F.:	4.915MHz, 4-pole Cohn crystal filter
R.I.T. Range:	+/-2kHz at center of VFO tuning range
Audio output impedance:	8Ω or higher (headphones or speaker)

[1] At an operating frequency of 7.0MHz. (VFO frequency is related to operating frequency using the formula: RF = VFO + 4.915 MHz.)

Unpacking the Kit

Before proceeding, verify that you've received all of the components. The box should contain:

- one large bag of components
- printed circuit board
- metal enclosure (front, back, top, and bottom)

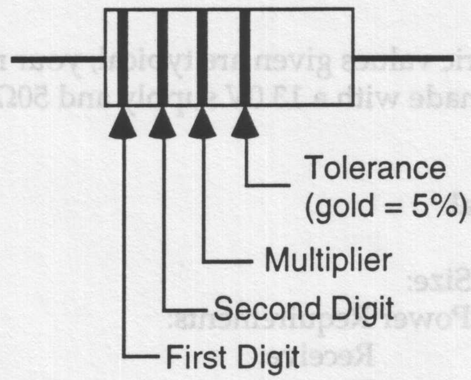
Here, you encounter the first of many instructions with check-off boxes ([ ]). These should be checked-off (√), in order, to help you stay on course.

[ ] Take a moment to familiarize yourself with the parts list (Appendix A). Drawings are provided for many of the hard-to-identify components. Parts are listed alphabetically by reference designator, except for miscellaneous mechanical components which appear at the end.

[ ] Using the parts list and the resistor/inductor color code chart below, identify all of the components in the bag. If anything is missing or damaged, call or write Jim Cates, 3241 Eastwood Road, Sacramento, CA 95821; 916-487-3580.

[ ] Separate the components into piles, i.e. one pile for resistors, one for disc capacitors, etc.

Color Code



Color	Digit	Multiplier
Black	0	x 1
Brown	1	x 10
Red	2	x 100
Orange	3	x 1K
Yellow	4	x 10K
Green	5	x 100K
Blue	6	x 1M
Violet	7	
Gray	8	
White	9	

Capacitor Markings

While some capacitors have obvious markings (e.g., "3.3µF"), others may simply use one, two or three digits. If there are two digits or less, this is the value in pF (picofarads). If there are three digits, the first two are significant and the third is *usually* a multiplier (power of 10). Examples: 271 is 270pF, 103 is 10000pF (or .01µF), and 225 is 2,200,000pF (2.2µF).

When you find a capacitor with a 0 as the third digit, start by assuming that the 0 is a significant digit--*not* a multiplier. In that case a capacitor marked "150" would be 150pF. However, some capacitors may actually use the 0 as a multiplier of 10^0 (i.e., 1), so a cap marked "150" could actually be 15pF. You can resolve which it really is by looking for both values on the parts list; hopefully, only one of the values is used. As a last resort, compare the size of the capacitor to others of the same type and voltage rating that have unambiguous markings.

Assembly Tips

Throughout the manual you'll find interesting technical details wherever you see this symbol:

Also pay close attention to instructions in **boldface**.

Installation and Soldering

1. Install all of the components in each group as described below before soldering them. If you have missing or incorrectly-installed parts, it will then become apparent before you commit them to solder.

2. As you install each component with long leads, seat it flush against the PC board, then bend the leads at about a 45° angle. After installing each component with long leads, cut the leads off to a length of about 1/16". This is easier than trimming a cactus farm of tangled component leads. The short leads on components such as ICs and connectors need not be trimmed.

3. Use a pencil-type soldering iron of 15 to 25 watts with a fine tip, not a hefty, two-handed relic from a 1947 flea market. As for solder, Radio Shack cat. #64-009 (.032" dia., 60:40 tin:lead) works, but look around for better quality solder containing silver if possible.

4. **Warning**: these boards have **plated-through holes**, making component removal a more difficult than it is from single-sided boards. Save yourself some rework and double-check part values before soldering.

5. Please resist the temptation to use sockets for the ICs or transistors; they are often unreliable and add lead length that can cause instability.

6 If you must remove a component, 3/32" or 1/8" wide desoldering braid (also called solder-wick) is a good bet, as is a solder-sucker if you know how to use it. **Do Not** use Archer or other cheap brands of desoldering braid, however: it may be of poor quality. Try to find Ungar-Wick or another professional brand. If all else fails, put the board in a Panavise (gently!) and remove parts using the wiggle-and-pry method--long-nose pliers on one side and soldering iron on the other. Then clean the hole with solder wick.

Toroids

Toroids will be covered in detail later, but a few things are worth repeating:

1. Completely remove insulation from toroid leads before soldering. Making a shiny pool of solder around an improperly prepared toroid lead isn't going to improve its chances of making contact. **You MUST use a match or cigarette lighter--or solder-strip the leads-- to get a clean connection.** I personally fixed several NorCal 40s and Sierras which all had the same problem: the toroid leads were not stripped completely! If you suspect, remove it and redo it.

2. Don't bunch the turns on one side of the toroid--spread them evenly around 80 to 90% of the core. This keeps the toroid self-shielding.

3. When winding cores with many turns--especially L9--keep the turns close-spaced, but try not to let any of them overlap.

PCB Assembly

Install and solder each group of components as indicated. Part locations can be identified from the outlines and reference designators on the PC board.

There are a few places on the board where it may be hard to read the component designators. In such cases you can refer to the Component Placement Drawing (Appendix B).

Low-Profile Things First: Resistors, Diodes, and Chokes

[ ] Install and solder resistor network R5, the skinny, 8-pin SIP (single-inline package). One end of R5 has a black dot that indicates pin 1; this pin goes into the square pad, the pad nearest the R5 reference designator. (Actually, R5 is symmetrical and it will work just as well if you put it in backwards.) Bend the two pins at either end slightly--in opposite directions--to hold R5 in place, then solder.

[ ] Install the remaining fixed resistors, double-checking the color code to make sure you're installing the proper value. The resistors should all be oriented in one direction for ease of reading the color codes later--e.g., first band to the left or top, last band to the right or bottom.

[ ] Install the trimmer potentiometers, R8, R13, and R6. Be sure to place them all in the direction indicated on the PC layout.

[ ] Solder all of the fixed resistors and trim pots.

[ ] Diodes must be installed with the cathode end--the end with the widest band--oriented in the same direction as the banded end on the PC board outlines. The exception is D8, which has a flat-sided package like a transistor. Install this part as shown on its PC board outline, and about 1/16" inch above the board. Double-check the orientation of D8 by looking at Appendix B.

[ ] Install all of the chokes (L1, L4, L5, and RFC1 and 2). The color code on the choke represents the value in µH; e.g., brown-green-black is 15µH.

The NorCal 40A uses two kinds of inductors: solenoidal (the miniature RF chokes) and toroidal. You might expect all of the miniature RF chokes to have "RFC" (radio-frequency choke) as reference designators, and all of the toroids to have "L" (inductor) or "T" (transformer) designators. However, in keeping with current design practice, the designators reflect the *purpose* of the component--not the physical form. Either kind of inductor can act as an RF choke or filter element.

[ ] Solder the diodes and chokes.

Capacitors

[ ] Install all of the fixed capacitors, starting with the disc, mylar, and polystyrene types. These capacitors are easily damaged, so don't pull on or stress the leads. Double-check the values.

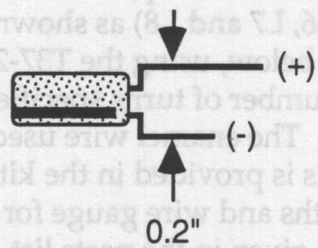
[ ] Solder all of these capacitors.

[ ] Next, install the electrolytic capacitors. There are two things to keep in mind:

> **(1)** All of the electrolytics are polarized; be sure that the (+) lead is installed in the (+) hole in the board--the one with the **square** pad. The (+) lead is usually longer than the (-) lead.

The (-) lead is usually marked on the body of the capacitor with a black band. (If you install one of these caps backwards, you may be rewarded with smoke and pyrotechnics later on!)

(2) The capacitors can be mounted flush against the board if you bend the leads out so that they're spaced about 0.2" apart, as shown below:



[ ] Solder all of the electrolytic capacitors.

[ ] Install the air variable capacitor, C50. The silkscreen for this cap shows it how it appears when the plates are fully *meshed*; set the plates this way before installing it to avoid confusion. The reason we're concerned about the orientation is that we want the rotor--the part that moves--to be grounded. This makes alignment with a metal screwdriver possible.

[ ] Next, install the miniature trimmer capacitors. Align the trimmers as they appear on their PC board outlines. Refer to Appendix B if part of the silkscreen is obscured.

[ ] Solder all of the trim caps.

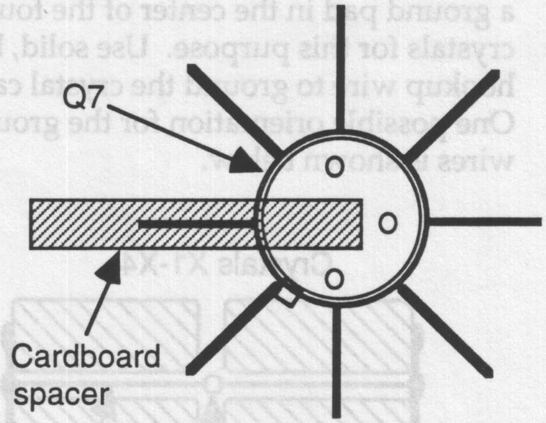
ICs , Transistors, and Crystals

[ ] Install all of the transistors *except* Q7, the final amplifier transistor. Align the flat side of each transistor with its PC board outline. These transistors can sit about 1/8" to 1/4" above the board; don't force them all the way down.

[ ] Solder all of the transistors installed so far.

[ ] Q7 uses a heat sink, which should be pressed carefully onto Q7 *before* installing it on the board. If you've never used a press-on heat sink before, be forewarned that it's tricky. Don't bend the leads as you're doing it--they may break. You may need to spread the heatsink slightly by pulling on the fins, but don't stretch it too far. It should fit tightly onto Q7.

[ ] Install Q7--with the heatsink already pressed on--with its body roughly 1/32" to 1/16" above the PC board. This small space is required to keep the transistor case from shorting to its pads on the top of the board. Set the spacing by temporarily inserting a small strip of thin cardboard or plastic between the transistor and the PC board as shown below. Solder the transistor, then remove the cardboard. (You'll use this tool again later when installing the crystals.)



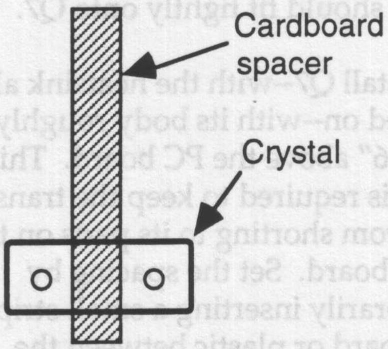
[ ] Make sure that the heatsink on Q7 isn't touching any of the surrounding components.

[ ] Install all of the ICs. All ICs except U5 are 8-pin DIPs (dual-inline packages) and are oriented in the same direction. The notched or dimpled end of each IC must be aligned with the notched end of its PC board outline. **(Since there are no sockets**

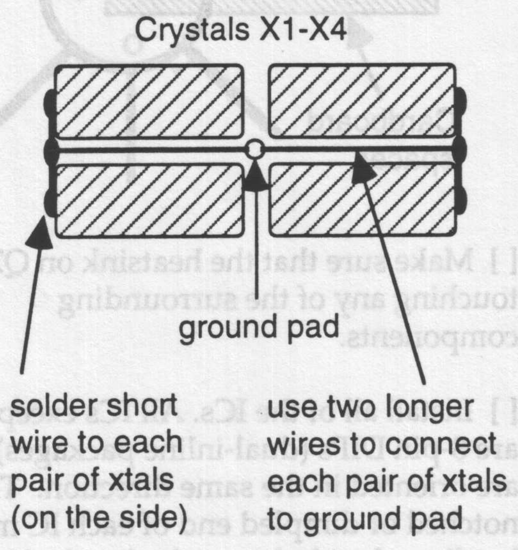
used, please be careful to install the ICs correctly!) U5 is a flat-sided unit like a plastic transistor; install it as indicated on its PC board outline.

[ ] Solder all of the ICs.

[ ] Install all six crystals. Use the cardboard spacer you used for Q7 to space the crystals 1/32" to 1/16" above the PC board while soldering.



[ ] The cases of crystal X1 through X4 can optionally be grounded to eliminate "blow-by" from very loud signals, i.e., leakage around the crystal filter. There is a ground pad in the center of the four crystals for this purpose. Use solid, bare hookup wire to ground the crystal cases. One possible orientation for the ground wires is shown below.



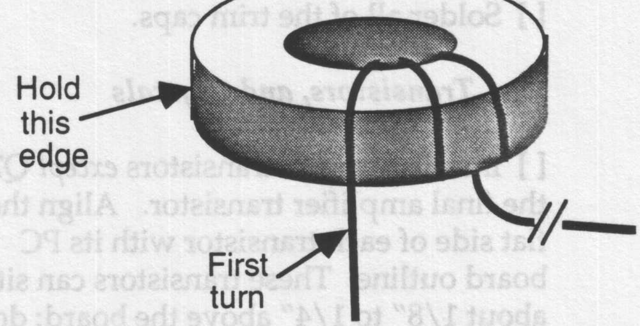
Toroids

This isn't rocket science, and you don't have to be a licensed jeweler, but if you've never wound a toroid before you should take your time and read this entire section to familiarize yourself with the finer points.

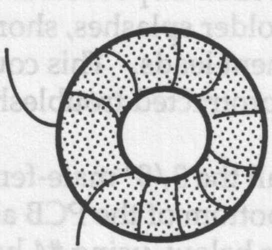
[ ] First, as a warm-up, wind the simplest toroids (L6, L7 and L8) as shown in the drawings below, using the T37-2 cores and the number of turns specified in the parts list. The enamel wire used to wind the toroids is provided in the kit, and the wire lengths and wire gauge for each toroid are given in the parts list. (There's also a toroid wire length chart, Appendix E.) #26 wire is just slightly thicker than #28, and if you're lucky will be a different color, too.

Always begin winding toroids as shown: grip the core on its left side, pass the first turn over the top, then pull all the wire through, winding from left to right. Be very careful not to kink the wire.

Since each pass through the core (i.e., through the hole) counts as one turn, the toroid shown has 3 turns on it so far. The remaining wire to be wound on the core continues off to the right.



After winding, the turns should be spaced evenly around most of the core, leaving a small gap between the first and last turns as shown below. (Note that the number of turns shown in the drawing is different from the actual number of turns used.)



[ ] Cut the toroid leads to about 1/2 inch long. **Use a wooden match or cigarette lighter for about 8 seconds on each lead to burn off the insulation.** Follow up with medium-grit sandpaper to remove the charred insulation to within about 1/8" of the toroid body. Don't nick the wire or sand it down too thin.

The enamel wire supplied with the kit may be of the solder-strippable type. If so, you can optionally remove the insulation by holding a well-tinned soldering iron tip up to the wire. Follow the lead up to about 1/8" from the toroid body, then clean off any excess insulation.

[ ] Tin the stripped portions of the leads with solder.

[ ] Install these toroids (L6, L7, and L8) vertically, as indicated by the PC board outlines. Keep the toroids firmly pressed up against the board and pull the leads taut on the other side.

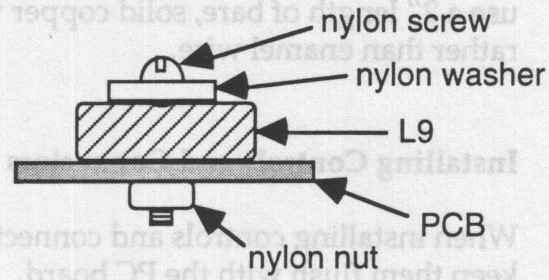
[ ] After pulling them through, make sure you can see *tinned wire* where the lead intersects the pad. A common mistake is to pull the lead through so far that the *insulated* part of the lead is intersecting the pad.

[ ] Trim the leads and bend them down onto the pads, then solder. If you burned off, sanded and tinned the leads properly, the solder will cleanly stick to the leads. If not, remove the toroid from the board and re-prepare the leads. This will save you (and maybe others) headaches later!

[ ] Next, wind L9, the VFO toroid. This toroid has a lot of turns, so be sure to wind the turns as close together as possible without overlapping. Prepare the leads as described previously.

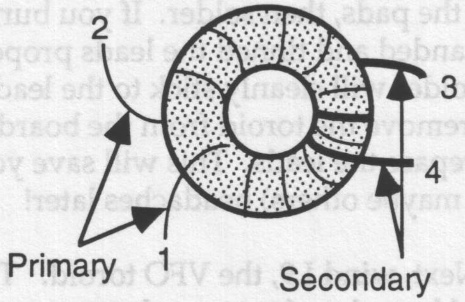
<u>**Important**</u>**: If you're planning to use the NorCal 40A in the Novice band, use 59 turns on L9 rather than 62.**

[ ] Insert L9's leads into their correct locations on the board, and secure the toroid to the PC board as shown below using nylon hardware. Do not over tighten--the stress can cause VFO instability. Solder L9.



Note: The FT-37-43 cores and FT-37-61 cores are both <u>black</u>, but the -43 cores have an <u>orange dot</u> (added by NorCal). These cores have very different characteristics and cannot be interchanged.

[ ] Next, wind toroidal transformer T1. **Use the black core with the orange dot as described above.** The secondary winding (the one with fewer turns) should be wound on top of the primary winding, resulting in something like the drawing below.



[ ] Remove the insulation from T1's leads as described above and install it on the circuit board. Make sure that the primary and secondary leads line up with the numbers on the PCB outline. Solder T1.

[ ] Finally, wind and install T2 and T3 in the same manner as T1. In all cases, wind the *smaller* winding on *top* of the larger winding, regardless of which is called the primary or secondary. **Note that T2 has only one turn on its primary; this means that this "winding" actually passes through the core only once.** For this winding only, you may find it easier to use a 2" length of bare, solid copper wire rather than enamel wire.

Installing Controls and Connectors

When installing controls and connectors, keep them flush with the PC board. This will insure good alignment with the front and rear panels.

[ ] Install J3 and J4. Bend the leads slightly to hold the jacks in place, and solder.

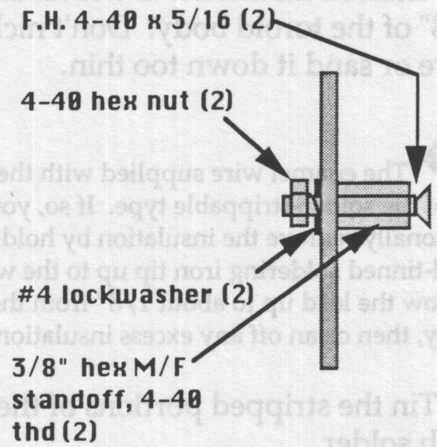
[ ] Install J1, J2, S1, and S2, and solder.

[ ] Remove the small metal tabs (near the shafts) of potentiometers R2, R16, and R17. Install the pots on the PC board. When seated correctly, each pot will sit a bit above the PC board. Double-check the values of R2 and R16 before soldering--the value is stamped onto the body of the pot near the shaft.

Final Assembly

[ ] Do a final inspection for cold solder joints, solder splashes, shorts, and broken component leads. This could save you from a protracted troubleshooting session!

[ ] Install the 3/8" male-female standoffs on the bottom of the PCB as shown in the drawing below, using #4 hardware. The standoffs are placed at the center-left and center-right edges of the PC board, near C1 and C30. (The 4-40 x 5/16 flathead screw is shown for reference; it will be installed later to hold the bottom cover to the PC board.)



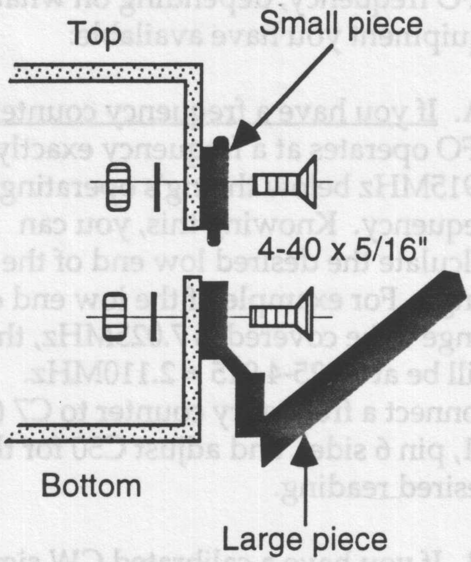
[ ] **Due to a layout error, the pad for the center pin of VFO pot R17 hits the front edge of the PCB. To prevent a short, you must put a small piece of electrical tape on the inside of the front panel where this pin might make contact.**

[ ] Install the front and rear panels onto the control and connector shafts. Use the washers and control nuts provided.

[ ] Attach the large knob to the VFO pot and the two smaller knobs to the RF gain and RIT pots.

[ ] Separate the two plastic latches into four pieces: two small pieces that go on the sides of the top cover, and two larger pieces that go on the sides of the bottom cover. Have ready four 4-40 x 5/16" flat-head screws, along with #4 lock washers and nuts.

[ ] Install the latches as shown below using #4 hardware. Keep both parts of each latch squared with the edges of the covers.



[ ] Install the bottom cover, securing it to the PC board with two 4-40 x 5/16" flat-head screws.

[ ] Stick on the four rubber feet, approximately 1/4" from each corner of the bottom cover.

[ ] Temporarily install the top cover and lock the two latches. The fit should be snug, with a hearty **"snap!"** as you lock the latches down. (You may be skeptical about these latches, but they are rated at millions of cycles. That's a lot of times showing off your NC40A before replacing them.)

[ ] **You should have one thing left: P1, the mating connector for J2.** If there's anything else left over, make sure you didn't miss any assembly steps.

Alignment and Test

Refer to the panel labeling drawings in the **Finish and Labeling** section for control and connector locations. If you have any difficulty with the procedure below, refer to the **Troubleshooting** section.

Initial Test

Before beginning alignment, follow these steps:

1. Make sure S1 (power) is in the down (off) position.

2. Connect a 50Ω, 2-watt (minimum) dummy load to the antenna jack. You can make a dummy load from parallel combination of larger resistors, if necessary; for example, eight 390Ω, 1/4-watt resistors will be close. Keep the leads short.

3. Using a small (1/8") flat-blade screwdriver, turn R13 (drive) and R8 (AF output) both fully counter-clockwise.

4. Connect a well-regulated and filtered 11 to 15V DC power supply (or battery) capable of supplying 300mA to J2; the preferred voltage is 13V. Then turn on the power supply and S1. If any component is warm to the touch or you see or smell smoke, turn S1 OFF immediately, disconnect the power supply, and turn to the **Troubleshooting** section.

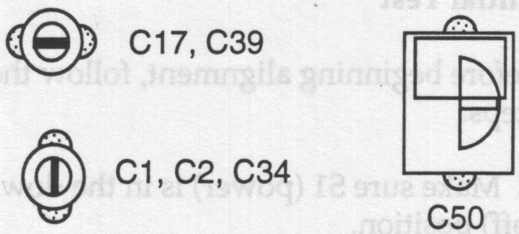
5. If you have a milliameter, connect it in series with the supply and note the current reading, which should be approximately 15mA. If the reading differs by more than a few mA from this

value, chances are you have a short or open or a bad component.

Receiver Pre-test

1. Temporarily disable the AGC by turning R6 (AGC threshold) fully clockwise.

2. Set all of the trimmer capacitors at mid-range, as shown below. The capacitors are shown as they appear from the front of the PC board, with the pads on the top of the board shown for reference.



3. Set VFO tuning pot R17 to its midpoint. Make sure the RIT switch (S2) is off (down). Set the RF gain control (R2) fully clockwise.

4. Connect a pair of headphones or a speaker to J4.

5. Connect an antenna--at minimum a quarter-wave (33') piece of wire--to J1. The larger and higher the antenna, the easier receiver alignment will be.

6. Turn on power, and adjust R8 (AF level) until you can hear some noise (hiss).

7. Using a small (preferably non-metallic) tuning tool, alternately adjust C1 and C2 for maximum atmospheric noise. The peaks will be fairly sharp. If the band is quiet and you don't get any increase in noise, try loosely coupling a 7-MHz signal generator to the antenna wire (in other words, put the generator next to the wire). Tune the signal generator between 6.9 and 7.2MHz until you hear a signal, then peak C1 and C2 a couple of times.

After the VFO is aligned in the following steps, C1, C2, C17, R6 and R8 will be re-adjusted for best performance.

VFO Alignment

1. Rotate the VFO knob fully counter-clockwise. Also make sure the RIT on/off switch, S2, is in the off (down) position.

2. There are three possible ways to set the VFO frequency, depending on what equipment you have available:

2A. <u>If you have a frequency counter:</u> The VFO operates at a frequency exactly 4.915MHz below the rig's operating frequency. Knowing this, you can calculate the desired low end of the VFO's range. For example, if the low end of the range to be covered is 7.025MHz, the VFO will be at 7.025-4.915 = 2.110MHz. Connect a frequency counter to C7 (on the U1, pin 6 side), and adjust C50 for the desired reading.

2B. <u>If you have a calibrated CW signal generator or 40-meter transmitter:</u> Set up the signal source for the low end of the desired RF range (e.g., 7.025MHz). Loosely couple the output of the signal source to the antenna input of the rig. Adjust C50 until the signal is heard at a pleasant, intermediate pitch (about 700 Hz).

2C. <u>If you have no equipment at all:</u> If you're an extra class you can define the band edge as "the place beyond which you don't hear any hams." Otherwise, borrow a transceiver or signal generator!

3. If you can't get the VFO set to the proper frequency, you may need to squeeze or spread the turns of L9,

depending on whether you can't go low enough or high enough, respectively. If this doesn't do it, you may need to add or remove turns from L9. Be sure you've wound L9 tightly and evenly spaced the turns. After adjusting the turns, re-do steps 1 and 2.

Each turn on L9 changes the VFO center frequency by about 35kHz. C50 varies this center frequency over a range of 75kHz.

4. Once the low end of the VFO has been set, you'll want to check the high end of the range. Rotate R17 fully clockwise and confirm--using the counter or signal generator--that the VFO is now 35 to 45kHz higher. Also check the RIT range by turning S2 on and adjusting R16.

Final Receiver Alignment

1. Turn the RF gain control all the way up (clockwise).

2. Locate a weak signal near the middle of the VFO tuning range, and re-peak C1 and C2 for maximum signal.

3. Find a clear frequency and adjust the AF level (R8) so that background (atmospheric) noise can be heard. If you now disconnect the antenna, the AF output should drop to almost nothing, indicating good receiver noise figure. If this is not the case, the receiver may not be aligned properly or you may have an assembly error. See **Operation** for more information about the setting of R8.

4. The BFO setting capacitor, C17, can now be adjusted. This determines the pitch heard at the center of the receiver crystal filter's passband. Adjust C17 while listening to the receiver noise or the output of a signal generator to determine your preferred setting. You can optionally leave C17 set at mid-point for now, which corresponds to a receiver center pitch of around 700Hz.

5. Finally, you'll need to set the AGC threshold. (This is optional: some operators prefer not to use AGC at all.) To set the AGC level, rotate R6 slowly counter-clockwise until you find a point at which the receiver audio output just starts to get reduced. This will occur somewhere between mid-way and fully counter-clockwise. Next, tune around and listen to strong stations; the AGC action should keep them at a fairly constant level. You may wish to experiment with the AGC setting. See **Operation** and **Modifications** for more details.

Transmitter Alignment

1. Set R13 to about 90% of maximum (clockwise). Rotate the VFO knob fully counterclockwise, then turn it clockwise about 1/3 of its total rotation. Turn the RIT off.

2. Connect a 50Ω dummy load to J1. If an inline watt meter or SWR bridge is available, connect it in series with the dummy load. If not, you'll need an RF voltmeter or oscilloscope to check the output at J1 (don't disconnect the load during the measurements!). If you don't have any way at all of measuring the output, you can peak the transmitted signal fairly well just by listening to the volume level of the monitor tone during key-down periods.

3. Connect a key or keyer to J3.

4. Key the transmitter for brief periods (maximum of 3 seconds) and adjust C39 for maximum signal strength on the meter or scope (or by ear).

5. Adjust R13 for the desired output level. The maximum output should be between 1.5 and 2.5 watts; the best setting of R13 is at about 90%, which keeps the driver stages operating efficiently. The output can be reduced all the way to zero.

If you'd like to calculate the final amplifier efficiency, you'll need an accurate watt meter (or oscilloscope, or an RF probe), a 50Ω dummy load, and milliameter in series with the power supply. Example: Suppose you measure 1.5 watts output, and a key-down current drain of 200mA at a supply voltage of 12V. Not all of this current is going into the final amplifier; about 40 mA is used by other receiver and transmitter circuits. This leaves 160mA of final amp current. Efficiency = power out/power in = 1.5 / (12 * .16) = 0.78, or 78%.

6. The transmit monitor tone should be plainly audible in the headphones. Adjust C34 for the desired pitch. Most operators will probably opt to set C34 so that the transmit monitor pitch falls near the center of the receiver's audio passband. (Recall that C17 can be adjusted to change the receive audio pitch; this will also affect the pitch of the transmit monitor tone, possibly requiring readjustment of C34.)

7. The received background noise should return shortly after keyup--around 200 milliseconds or so (1/5 of a second). See **Modifications** if you want to increase the T-R (transmit-receive) delay.

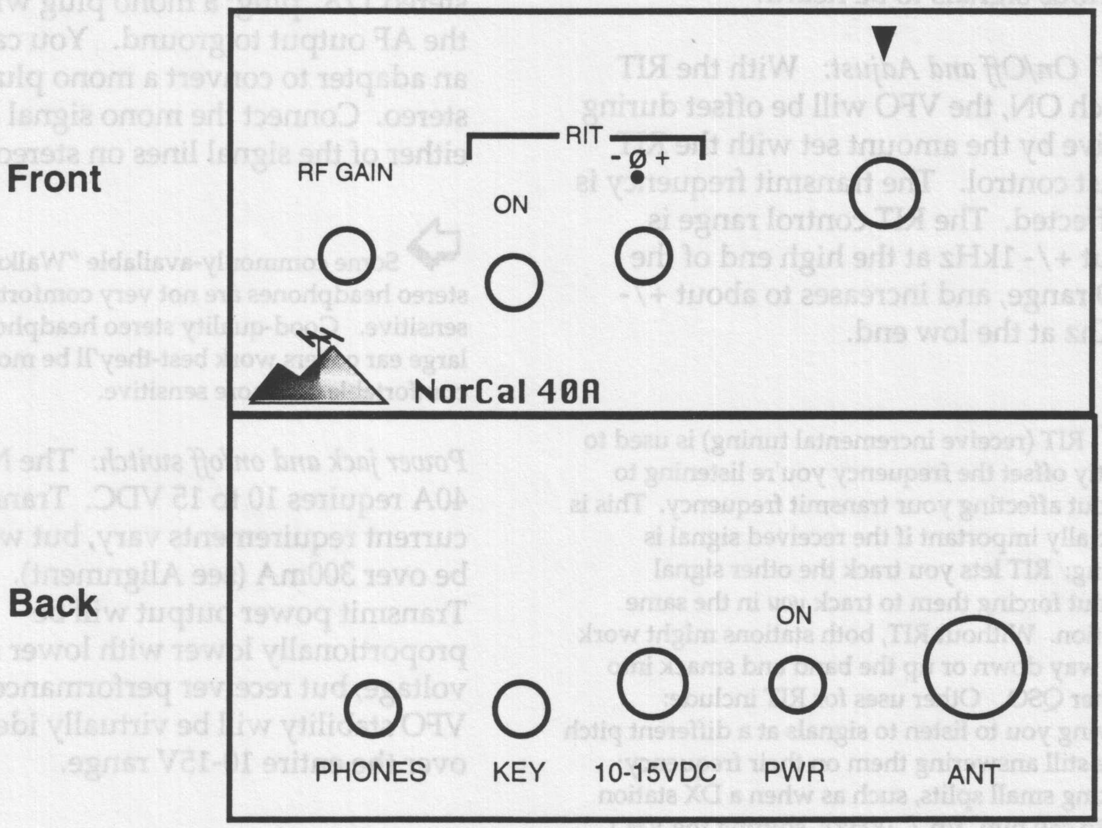
Finish and Labeling

You can finish the NorCal 40A however you see fit--from clear coat to zebra stripes. Or you can leave it as is, with the sanded aluminum finish.

One possible panel labeling scheme for the front and back panels is shown below, with panel and hole outlines shown for reference. This is what you'll get if you send your panels to Stan Cooper, K4DRD, 3214 Countryside Dr., San Mateo, CA 94403. Stan will be silkscreening in either **black** or **white** ink--please specify. **This service is free (thanks, Stan!) but you must include a self-addressed padded envelope with adequate return postage.**

VFO Labeling

There are at least two ways to calibrate the VFO knob: (1) Use a pointer on the panel, as shown here, then glue a white cardboard dial to the inside surface of the knob and add tic marks. (2) Use the pointer on the knob, combined with tic marks on the panel. Either way, your labeling will depend on what your VFO tuning range is. Make one tic mark every 5kHz or so using a calibrated signal source, and be sure to err on the conservative side when labeling band edges. Of course, you can always add a frequency counter--see back issues of QRPp for ideas from Jim Pepper and others.



Operation

Refer to the front- and rear-panel labeling drawings from the previous section to identify the controls and connectors.

Front Panel Controls

RF gain: Most of the time, the RF gain control will be set to maximum (fully clockwise), and the NorCal 40A's AGC circuit will maintain a consistent AF output level. However, you will need to turn the RF gain down if signal levels are extremely high, such as when listening to the DX hunter who lives two doors down. You may also have to turn down the RF gain if you're using a large antenna array, or if you're in an area known for AM short-wave broadcast interference, notably Europe. This will help prevent the receive mixer from getting overloaded, which can cause unwanted spurious signals to be heard.

R.I.T. On/Off and Adjust: With the RIT switch ON, the VFO will be offset during receive by the amount set with the RIT adjust control. The transmit frequency is unaffected. The RIT control range is about +/- 1kHz at the high end of the VFO range, and increases to about +/- 2.5Khz at the low end.

⇨ RIT (receive incremental tuning) is used to slightly offset the frequency you're listening to without affecting your transmit frequency. This is especially important if the received signal is drifting: RIT lets you track the other signal without forcing them to track *you* in the same direction. Without RIT, both stations might work their way down or up the band and smack into another QSO. Other uses for RIT include: allowing you to listen to signals at a different pitch while still answering them on their frequency; working small splits, such as when a DX station says to call him "up 2" (kHz); shifting the VFO position slightly to move an interfering signal out of the pass band or into zero beat.

VFO: The VFO (variable-frequency oscillator) control covers about 35 to 45kHz of the 40-meter band. The coverage is slightly non-linear due to the varactor tuning (see Circuit Details).

Rear-Panel Controls and Connectors

Key jack: You can use a hand key or any type of "key-to-ground" keyer here. If you're not sure what kind of keying your keyer produces, look at its output circuit: if the keyed output is connected to an NPN transistor's collector, chances are your keyer will work. Most keyers have an output of this kind.

Headphone/speaker jack: You can use either headphones (preferably stereo) or a speaker with the NorCal 40A. Regardless of which you use, you'll have to use a stereo 1/8" plug; a mono plug will short the AF output to ground. You can make an adapter to convert a mono plug to stereo. Connect the mono signal line to either of the signal lines on stereo plug.

⇨ Some commonly-available "Walkman"-style stereo headphones are not very comfortable or sensitive. Good-quality stereo headphones with large ear covers work best-they'll be more comfortable *and* more sensitive.

Power jack and on/off switch: The NorCal 40A requires 10 to 15 VDC. Transmit current requirements vary, but will rarely be over 300mA (see Alignment). Transmit power output will be proportionally lower with lower supply voltage, but receiver performance and VFO stability will be virtually identical over the entire 10-15V range.

There is a low-voltage-drop diode in series with the supply to protect the rig should you accidentally reverse the DC polarity. This shottky diode only "drops" 0.2 volts or so, compared to 0.7V for a 1N4001, so it will not significantly affect your transmit power output. The on/off switch completely disconnects the transceiver from the power supply.

Antenna jack: Always use a well-matched, 50Ω antenna. If you have any doubts, use an SWR bridge and, if necessary, an antenna tuner. It is possible to damage the output transistor of the NorCal 40A if you operate it into a poorly matched load for an extended period. Some protection is provided in the form of a zener diode, but this will not handle all mismatches, especially if you keep the transmitter keyed down for a long time.

The preferred type of SWR bridge to use with antenna tuners is the "absorptive" kind (see W1FB's QRP Notebook or the ARRL Handbook for example circuits). This type of bridge works well with simple QRP rigs because a relatively good load is provided to the final amplifier during tune-up.

Operating Tips

In general, your QRP signal will be harder to hear than higher-power signals. For this reason, experienced QRPers usually spend much more time listening than transmitting. If you've never operated QRP, there are many good books on the subject to help you get started, including The Joy of QRP by Adrian Weiss.

The NorCal 40A doesn't have a side tone oscillator. Instead, the signal you hear when you key the transmitter is the output signal itself, being picked up by the receiver and limited to a very low volume. Because of this, you can tell what pitch to listen to as you tune in other

stations: just occasionally check the pitch of your own transmitted signal. On the other hand, if a station calls *you* off frequency, turn on the RIT and tune it in. This is preferable to changing the frequency of your VFO, which could result in you chasing *each other* around the band.

When listening to your transmitted signal, note that a sudden change in its volume can indicate a problem with the transmitter. If the volume goes way down, chances are the final is blown or R13 isn't set properly.

If the band is very noisy or you hear very loud stations, turn the RF gain control down. The NorCal 40A uses NE602 ICs in the receiver, which provide excellent sensitivity at low cost and with little current drain, but they can't handle huge signals.

If you switch from headphones to speaker, you may need to readjust R8. This trimmer sets the volume level, and the AGC circuit keeps signals in the proper range. Also see **Modifications**.

Troubleshooting

Preliminary Steps

1. If you have a problem that you can *see* or *smell*, turn off power immediately.

2. Inspect the PC board for solder bridges, cold or non-existent solder joints, incorrectly-installed parts (backwards or wrong part), broken parts, and open circuit traces. **Absolutely the most likely problem by far is a poorly-stripped lead on a toroid.**

3. Double-check your setup. Often you can trace a problem to a bad scope probe, intermittent clip lead, incorrect power supply voltage, idle chit-chat from passers-by, weak coffee, etc. Try the alignment procedure again if it seems safe to do so.

4. Try signal tracing (below) and measure all DC voltages in suspect areas (see Table 1).

5. If you still have difficulties, seek help from another NorCal member nearby. Jim Cates, Doug Hendricks, or Wayne Burdick may be able to point you in the right direction.

Signal Tracing

Try signal tracing to locate where the signal is getting lost. A general signal tracing procedure is given below. Unless otherwise noted, measurements were taken with a high-impedance DMM set to DC Volts and an RF probe. (See any edition of the ARRL Handbook for RF probe circuits and construction details.)

Receiver:

a. VFO output at the junction of RFC2 and C31 should be roughly 650mV rms.

b. BFO at U2, pin 6: about 230mV rms.

c. Use a fine-point metallic tool (awl or screwdriver) to do "qualitative signal tracing"--this is often more effective than an RF probe when signal levels are small. *With your hand contacting the blade*, touch the tool to pins 2 and 3 of U3--you should hear the same amount of hum (a lot!) on each pin. Now work backwards to see where you're losing it: touch the tool to Q2 and Q3 source and drain, then to pins 4 and 5 of U2, then pin 1 of U2, and finally the left side of L4. If you can still hear loud noises when you touch L4, the only possibilities left are the crystal filter and first mixer.

Transmitter (drive set to 90% of maximum):

a. If you don't hear any transmit monitor tone when you key the rig, look for a problem in the transmit mixer or driver stage. Try the voltage checks in Table 1.

b. Power amp input, Q7 base/R14, should be about 0.7Vrms.

c. Power Amp output at Q7 collector: 13Vrms.

d. Output at antenna jack: 10V rms.

e. If power amp collector efficiency seems low (less than 60%), double-check the components in the low-pass filter. As a last resort, try reversing T2's secondary leads.

f. If there seems to be instability as power is increased, make sure you used the orange-dot core at T1.

DC Voltage Chart

These readings were taken with a DMM (30V scale) with the (-) probe at ground, under the following conditions: power supply = 13V (receive), 12.83 (transmit); dummy load at J4; transmit output 2 watts; RIT OFF.

In general, you should expect your readings to be within about 5 to 10% of these. Voltages marked with an asterisk (*) can't be measured easily without an oscilloscope.

Table 1. NorCal 40A DC Voltages, All Active Devices.

Device/Pin#	Rcv	Xmit	Device/Pin#	Rcv	Xmit	Device/Pin#	Rcv	Xmit
U1, pin 1	1.42	1.42	U3, pin 5	3.92	3.92	Q2, drain	6.75	7.93
U1, pin 2	1.42	1.42	U3, pin 6	7.94	7.93	Q3, gate	4.23	0.03
U1, pin 3	0.00	0.00	U3, pin 7	3.96	3.96	Q3, source	6.68	0.03
U1, pin 4	6.72	6.72	U3, pin 8	1.31	1.30	Q3, drain	6.68	7.93
U1, pin 5	6.73	6.73	U4, pin 1	0.00	1.42	Q4, emitter	0.00	7.93
U1, pin 6	7.86	7.86	U4, pin 2	0.00	1.42	Q4, base	7.41	7.19
U1, pin 7	7.14	7.14	U4, pin 3	0.00	0.00	Q4, coll.	7.94	7.93
U1, pin 8	7.94	7.93	U4, pin 4	0.00	6.72	Q5, gate	0.00	*0.0
U2, pin 1	1.44	1.44	U4, pin 5	0.00	6.73	Q5, source	0.00	1.60
U2, pin 2	1.44	1.44	U4, pin 6	0.00	7.86	Q5, drain	0.00	7.74
U2, pin 3	0.00	0.00	U4, pin 7	0.00	7.14	Q6, emitter	*7.0	0.90
U2, pin 4	6.68	6.59	U4, pin 8	0.00	7.93	Q6, base	0.05	1.60
U2, pin 5	6.75	6.63	U5, IN	12.68	12.49	Q6, coll.	12.68	12.50
U2, pin 6	7.88	7.88	U5, OUT	7.94	7.93	Q7 emitter	0.00	0.00
U2, pin 7	7.41	7.41	U5, GND	0.00	0.00	Q7, base	0.00	*0.0
U2, pin 8	7.94	7.93	Q1, emitter	0.00	0.00	Q7 coll.	12.68	*12.7
U3, pin 1	1.30	1.30	Q1, base	0.00	0.71	Q8, gate	*0.0	*0.0
U3, pin 2	0.01	0.01	Q1, coll.	0.00	0.00	Q8, source	0.03	0.03
U3, pin 3	0.01	0.01	Q2, gate	4.25	0.03	Q8, drain	7.94	7.93
U3, pin 4	0.00	0.00	Q2, source	6.75	0.03			

Theory of Operation

Take a look at the block diagram (Appendix C). This block diagram is a little more informative than some because it shows not only the desired signals at each point in the circuit, but also the unwanted signals that must be rejected. The frequencies shown assume that the NorCal 40A is set to cover 7.000 to 7.040MHz. Transmit, receive, and common functional blocks are represented by three different shapes.

Receiving

To trace the receive signal path, start at the antenna. Notice that the block diagram says "IN: Everything." This is a shorthand reminder that the RF input to the rig may contain everything from VLF through VHF, and the receiver has to deal with it. The first line of defense is the low-pass filter (LPF), which attenuates signals above about 8MHz. The amount of attenuation increases with frequency, improving to about 40dB at 14MHz. The receive band-pass filter (RX BPF) is much sharper, leaving us with just what we want--the low end of the 40 meter band.

The receive mixer (RX MIX) produces the sum and difference of its inputs, in this case the VFO at 2.085-2.125 and the RF input at around 7MHz. As shown in the block diagram, this yields two mixer outputs: one centered around 4.9MHz, the other around 9.1MHz.

The 4.9MHz signal--the I.F., or intermediate frequency--is the one we want, and this is what's selected by the 4.915MHz crystal filter, which is very sharp (only about 400Hz wide at the -6dB points). The 9.1MHz range of signals is virtually eliminated.

An important concept here is that by following the mixer with a sharp filter, and by having a tunable VFO, we now can choose exactly the frequency we want to listen to. For example: When the VFO is at 2.085MHz, only an RF input signal at exactly 7.000MHz will produce a signal at 4.915MHz that can make it through the crystal filter.

By the way, you ask, why 4.915MHz? This happens to be a good compromise frequency at which we can easily make a sharp filter. Why not 5.000MHz? The problem with this and other even multiples of 1MHz is that you can easily end up with a loud "birdie" at the low end of the band, so loud that it is too annoying to be useful as a band-edge marker.

We can't hear 4.915MHz, so we add the next stage: the product detector. This is really just another mixer which gets its two inputs from the crystal filter and from the BFO (beat-frequency oscillator). The BFO has to be adjusted so that it is either above or below the crystal filter's center frequency. In this case, our BFO is above it by 700Hz. Thus the difference frequency output from the product detector is around 700Hz. The sum component at around 9.8MHz is completely eliminated by simply putting an RF bypass cap across the output.

The 700Hz signal passes through the AGC circuit, described later, on its way to the AF amp.

Transmitting

On transmit everything happens in reverse, starting with the VFO. Let's follow the transmit signal that we get when the VFO is set for 2.085MHz.

The first thing that happens when you key the rig is that the transmit mixer (TX MIX) is turned on, along with its on-board oscillator at 4.9150MHz. This oscillator happens to be at exactly the center frequency of the receiver's crystal filter, which accomplishes two goals: you will be transmitting at exactly the same frequency as stations you're listening to, *and* you can hear your own signal when you transmit. No sidetone is needed.

The outputs from the TX MIX are the sum and difference between the VFO and the transmit 4.9150MHz oscillator. The one we want is the sum, or 7.000MHz, and this is the one selected by the sharp transmit band-pass filter (TX BPF). The difference frequency at 2.830 is just about zero after this filter.

The buffer, driver and power amp (PA) stages bring this tiny 7.000MHz signal up to 2 watts. Finally, the low-pass filter removes most of the harmonic content generated by the PA, which is operating class C (that is, like a fast on-off switch).

Support Circuitry

Refer to the schematic, Appendix D, as we look at a few of the finer points.

The audio output at pin 5 of U3 (sheet 1) is kept relatively constant by Q2 and Q3, the AGC/mute transistors. Q2 and Q3 are JFETs, and their source-drain resistance increases as their gate voltages go more negative. D5 and D6 full-wave rectify the output of the audio amplifier, U3, to provide a voltage that is about 0.5 volts with no received signal, but goes as low as -3 volts when a loud signal is present. D1, 2 and3 allow Q2 and Q3 to also perform the muting function when the transmitter is keyed. Without these isolation diodes, the AGC and mute voltages would interact.

When the transmitter is keyed, Q4 conducts (see sheet 2 of the schematic), providing +8V from the voltage regulator, U5, to the transmit circuits. Transmit mixer U4 mixes the VFO signal with the signal from its on-chip crystal oscillator to provide an output at the operating frequency.

The receiver's RF input is obtained at the pickoff point between C44 and the lowpass filter. This signal is routed to U1 via C1 and L1 (sheet 1), which form a low-loss series-resonant circuit. When transmitting, Q1 is saturated, shunting most of the transmitted signal to ground before it gets to U1, and effectively making C1 a small part of the lowpass filter.

The VFO is a fairly standard Colpitts type. D8 is a hyper-abrupt junction varactor diode--one with a very wide capacitance range. R17 controls the voltage applied to D8 and hence the VFO frequency. U6 switches in RIT control R16 during receive if the RIT switch is in the ON position.

More Circuit Details

In this section, we describe a few tricks and compromises that make the NorCal 40A different from other rigs. We'd like to hear your ideas for modifications. After all, this is a club project!

I.F..: The receiver doesn't use an I.F. amp. It really isn't needed since the '602 has plenty of gain at 7MHz, and because automatic gain control has been moved to the AF channel (see below). As anyone who has used an MC1350 I.F. amp with NE602s can attest, that's more gain than you really need for a 40-meter receiver, and it adds about 15mA of current drain.

AGC/Mute: Q2 and Q3 form a differential version of the usual JFET mute circuit, and double as AGC elements. The balanced configuration is used to take advantage of the balanced output from the product detector and balanced input to the LM386.

The gate bias network (R5/R6/D5/D6) sets the gate voltage such that, with no signal, the JFETs are at about their minimum drain-source resistance of around 150Ω. As the AF level increases, C29 acquires a negative DC voltage, pulling the gates lower and increasing R_{ds} up to 1MΩ or more.

Resistor network R5 is a new addition to the original NC40 AGC: it isolates the JFET gates from each other and linearizes the response of the JFETs to large signals, increasing "head room" by 10 to 15 dB. R3 and D4 are also new; they compensate for the effect of pulling the gates to ground to keep the voltage on the AGC detector at its nominal level.

D1, 2 and 3 keep the AGC time constant from affecting the mute time constant, and vice-versa. C29 has its (+) lead connected to 8V so that on power-up there is no delay in receiver output while C29 charges up (a problem with the old circuit).

Only a milliamp or so of current is required for this AGC circuit. On the negative side, you have the usual thumps associated with AF-derived AGC, and there is a limit to the size of signals that Q2 and Q3 can pass without distortion--hence the RF gain control.

AF Amp: This LM386 circuit is similar to others, except for the addition of C55 and R22. These components shape the '386 response so that nearly all hiss is removed. The audio response peaks at around 600 to 650 Hz, providing a bit of audio filtering.

Xmit Mixer: This is a conventional circuit, except for C32, which has the effect of reducing the harmonic content from U4 and reducing the VFO shift induced by U4 when it turns on.

Buffer/Driver: Q5's gate circuit saves one component by providing DC bias through L6 and R10 rather than using capacitive coupling and a separate gate bias resistor. The value of R10 is a compromise, chosen to look like a small coupling cap at the operating frequency, and yet still isolate the gate from L6 to improve DC bias stability. Q5 and Q6 form a minimum-component source-follower/driver, and the usual emitter-bypass cap isn't needed because Q6 has plenty of gain at 7MHz.

Key Shaping: The NorCal 40A uses the same key shaping circuit found on the Sierra (C56 and D10). On key-up, C56 discharges in about 2ms through the emitter of Q6, producing a clean exponentially-shaped falling edge.

RIT and VFO: D8 is a very high-capacitance device (50 to 150 pF). That, combined with the nonlinear resistance/rotation curve of R17/R20, and the relatively small value of C49, results in a fairly linear frequency tuning range. R16 is 10% of the size of R17, so if the VFO range is 40kHz, the RIT range is about 4.0kHz (+/- 2). Comparator U6 drops in a fixed resistor, R15, during transmit or when S2 is in the "OFF" position. The RIT range increases as you turn the VFO knob CCW with this arrangement. That has the beneficial effect of giving you over +/- 2.5kHz near the bottom end of the band, useful when you want to call DX stations up or down.

Modifications

This section describes some modifications to the design that individual builders may want to include. Please submit your own ideas for modifications to QRPp.

The toroid winding chart (Appendix E) may come in handy for some modifications.

External AF gain control

If you plan to switch between speaker and headphones frequently, you may want to relocate R8, the AF gain control, to the rear panel. A 500Ω to 1KΩ panel-mount pot of any kind will do. Keep the leads as short as possible.

TX monitor volume level

If the transmit monitor tone is too loud or too soft, try a different value of R4. A smaller value (e.g., 10MΩ) will make the monitor tone proportionally louder.

T-R delay

The T-R (transmit-receive) delay time can be lengthened by increasing the value of C28. A smaller value of C28 is not recommended because the current value is just large enough to mute the receiver during the key-up click. You may want to use a switch to select one of two different caps depending on operating conditions.

AGC time constant

The AGC cap, C29, was chosen to work well over a broad range of input signals and code speeds. Some operators may prefer a smaller value, which will provide both faster AGC attack and decay at the expense of some thumps when listening to slow, loud stations. One convenient value is 3.3μF. You can simply swap C15 and C29, since 10μF will work just as well at C15 as 3.3μF.

If you use the rig for a while you'll discover that hitting the key makes the AGC recover. This can be annoying if a loud signal is right on top of you, since the AGC will have to re-attack each time. Increasing the value of R3 will reduce this effect.

VFO tuning range

The NorCal 40A is intended to be a narrow-band rig--that accounts for some of the simplicity of the design. However, you can make C49 larger to cover a wider range. **Read this whole section before you try it.**

If you increase the range much above 60kHz you'll probably want to replace the VFO pot, R17, with a 3- or 10-turn unit. These are available from Mouser and other sources; a 3/4" or 1" diameter pot will fit, but you'll have to drill a larger hole (most likely 3/8"). You may also consider adding a frequency counter or mechanical shaft counter (like the time-delay counter on an oscilloscope) since you can't label the panel directly when using a multiturn pot.

If you increase the value of C49 you'll find that the transmitter power dips at the ends of the tuning range. This is due to the narrow-band filter formed by L6, C38, and C39. To increase the range of this filter, you have two choices:

(1) The preferred method is to expand the filter to two identical stages, isolated from each other by a 5pF cap. The extra parts will have to go on the bottom of the board. Alignment will be a bit harder, but the extra harmonic suppression is worth it.

(2) A simpler method is to increase the size of L6 and remove or reduce C38. The

reason this works is that, by increasing the inductive reactance of L6, you will slightly increase the RF output from the filter. This in turn will keep the buffer and driver stages saturated over a wider frequency range.

With method (2), depending on the size and type of inductor you choose, you may cause instability or reduce the harmonic suppression afforded by the original circuit, so proceed with caution. A possible starting point is to reduce C38 to 47pF and increase L6 to 36 turns of #28 on a T50-2 core (about 6.6µH).

80 meter conversion

I have tried this modification and it works well. There are eleven parts to change:

L1: 47µH (use the same type of miniature RF choke); **T2:** 30-turn secondary (#28) and 2-turn primary (#26) using original core; **L6:** 48 turns #28 on T50-2 or 14 turns #26 on FT37-61; **R11:** 1.8K; **L7/L8:** 23 turns #26 on original cores; **C45/C47:** 820pF; **C46:** 1800pF; **C49:** 82pF; **L9:** 92 turns #30 on original core.

That's not a misprint: 92 turns on L9. You'll want to make a small H-shaped piece of cardboard or plastic as a bobbin--small enough to pass through the core. Wind all of the wire onto the bobbin first. This will dramatically simplify winding the toroid, which I have to admit was the hardest one I've ever wound! If you get fewer than ten wire crossovers and kinks, pat yourself on the back (mine worked with seven).

On 80 meters the rig will tune backwards as compared to the 40-meter tuning unless you reverse the clockwise and counterclockwise leads on the pot. This will require 2 cuts and 2 jumpers on the PC board.

Other Bands

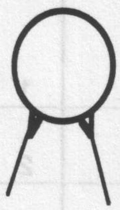
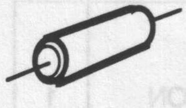
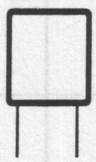
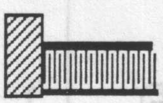
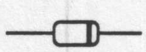
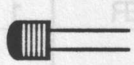
The NorCal 40A can be modified for use on other bands besides 80 meters, but--depending on how you alter the mixing scheme--you may find new birdies in the tuning range and unwanted spurious content in the transmitted output. Also, as you go up in frequency, the receiver sensitivity and transmit power output will probably both go down proportionally.

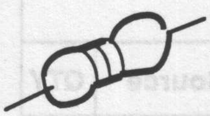
In all cases you'll have to choose new component values for the receiver input (L1 and T2), the TX bandpass filter (L6, C38), and the low-pass filter (L7/L8 and C45-C47). This is not an effort to be undertaken lightly: a good, high-frequency scope is recommended to make sure you're not outputting some kind of radical spurious energy due to your new mixing scheme. On the other hand, if it works, let us know! Here are some possibilities:

30 meters: Change all six crystals to 8.000MHz. Change the crystal filter input and output networks (C6, T3, L4 and C14) to provide the necessary impedance match to/from the NE602s. Adjust the VFO to cover about 2.100 to 2.140MHz using C50.

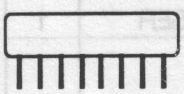
20 meters: Change the I.F. to 12MHz and retune the VFO to cover 2.0 to 2.1. You will probably have a birdie at 14.000 that acts as a band-edge marker. With an I.F. of 12MHz, the crystal filter bandpass will be much wider than 500 Hz. Another possibility is to use 8MHz as the I.F. and change the VFO range to 6.0 to 6.1, but the VFO will not be as stable under temperature extremes as it is at 2.0MHz.

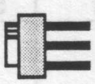
Appendix A: NorCal 40A parts List, Rev. A, 1-22-94

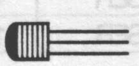
	Ref.	Description	P/N	Source	QTY
	C4,C7,C31,C37	CAP,DISC,5pF,10%	21CB005	MOUSER	4
	C6,C14,C32, C49	CAP,DISC,39pF,5%, NPO	P4451-ND	DIGIKEY	4
	C38	CAP,DISC,150pF,5%	P4026-ND	DIGIKEY	1
	C9-13,C18,C35	CAP,DISC,270pF,5%	P4029-ND	DIGIKEY	7
	C45,C47	CAP,DISC,330pF,5%	P4030-ND	DIGIKEY	2
	C46	CAP,DISC,820pF,5%	P4035-ND	DIGIKEY	1
	C19,C22,C48,C55	CAP,DISC,.01µF,20%,25V	P4424-ND	DIGIKEY	4
	C5,C8,C33,C36,C43, C54,C57	CAP,DISC,.047µF,20%,25V	P4428-ND	DIGIKEY	7
	C51	CAP,POLY,390pF,5%	23PS139	MOUSER	1
	C52,C53	CAP,POLY,1200pF,5%	23PS212	MOUSER	2
	C20,C21,C44	CAP,MYLAR,0.1µF,100V	140-PM2A104K	MOUSER	3
	C28,C30	CAP,ELEC,0.33µF,50V	P6641-ND	DIGIKEY	2
	C15,C23,C24	CAP,ELEC,3.3µF,25V	140-XRL25V3.3	MOUSER	3
	C25,C26,C29,C42,C56	CAP,ELEC,10µF, 25V	140-XRL25V10	MOUSER	5
	C27,C41	CAP,ELEC,100µF,25V	140-XRL25V100	MOUSER	2
	C50	CAP,VAR,2-24pF, AIR	530-189-0509-5	MOUSER	1
	C1,C2,C17,C34,C39	CAP,VAR,8-50pF,MICA	24AA024	MOUSER	5
	D1-6,D9,D11	DIODE,SWITCHING	1N4148	DIGIKEY	8
	D12	DIODE,ZENER,36V,1W	333-1N4753A	MOUSER	1
	D7,D10	DIODE,SHOTTKY	1N5817	DIGIKEY	2
	D8	DIODE,VARACTOR	MVAM108	HALLMARK	1
	J3,J4	JACK,3.5MM,STEREO,PC-MT,W/SPST SWITCH	161-3500	MOUSER	2
	J1	JACK,BNC,PC-MOUNT	177-3138	MOUSER	1
	J2	JACK, DC POWER, 2.1MM	16PJ031	MOUSER	1

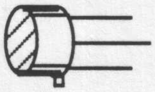


L1	IND,CHOKE,15UH	43LS155	MOUSER	1
L4,L5,RFC1	IND,CHOKE,18UH	43LS185	MOUSER	3
RFC2	IND,CHOKE,1MH	43LS103	MOUSER	1
L6	IND,TOROID,26 turns #28 (16"),T37-2 (2.5uH)	T37-2 (red, 0.37" O.D.)	AMIDON	1
L7,L8	IND,TOROID,18 turns #26 (12"),T37-2 (1.3uH)	T37-2 (red, 0.37" O.D.)	AMIDON	2
L9	IND,TOROID,62 turns #28 (56"),T68-7 (21uH)	T68-7 (white, 0.68" O.D.)	AMIDON	1
T1	XFMR,TOROID; PRI: 14 turns #26 (10"); SEC: 4 turns #26 (4"),FT37-43	FT37-43 (black w/orange dot, 0.37" O.D.)	AMIDON	1
T2	XFMR,TOROID; SEC: 21 turns #26 (14"); PRI: 1 turn #26 (2", see text), FT37-61	FT37-61 (black, 0.37" O.D.)	AMIDON	1
T3	XFMR,TOROID; PRI: 24 turns #28 (16"); SEC: 6 turns #26 (6"),FT37-61	FT37-61 (black, 0.37" O.D.)	AMIDON	1
R12	RES,20Ω,1/4W,5%	20Q	DIGIKEY	1
R14	RES,100Ω,1/4W,5%	100Q	DIGIKEY	1
R10,R11,R15	RES,510Ω,1/4W,5%	510Q	DIGIKEY	3
R22	RES,1.8K,1/4W,5%	1.8KQ	DIGIKEY	1
R1,R20	RES,4.7K,1/4W,5%	4.7KQ	DIGIKEY	2
R3,R9,R19,R21	RES,47K, 1/4W, 5%	47KQ	DIGIKEY	4
R4	RES,15M,1/4W,5%	15MQ	DIGIKEY	1
R5	RES. NETWORK, 8-PIN SIP,1M	770-83-R-1MEG-ND	DIGIKEY	1
R8,R13	RES,TRIMMER,500Ω	36C52-ND	DIGIKEY	2
R6	RES,TRIMMER,100K	36C15-ND	DIGIKEY	1
R2, R16	RES,POT,1K	31CW301	MOUSER	2
R17	RES,POT,10K	314-1410-10K	MOUSER	1
S1,S2	SWITCH, SPDT, PC-MT, RIGHT ANGLE, THD BUSHING	CK 7101SDAV2QE	CAL SWITCH	2
Q1	TRANS,2N4124,PLASTIC (TO-92)	592-2N4124	MOUSER	1
Q6	TRANS,2N2222A,TO-92	592-PN2222A	MOUSER	1



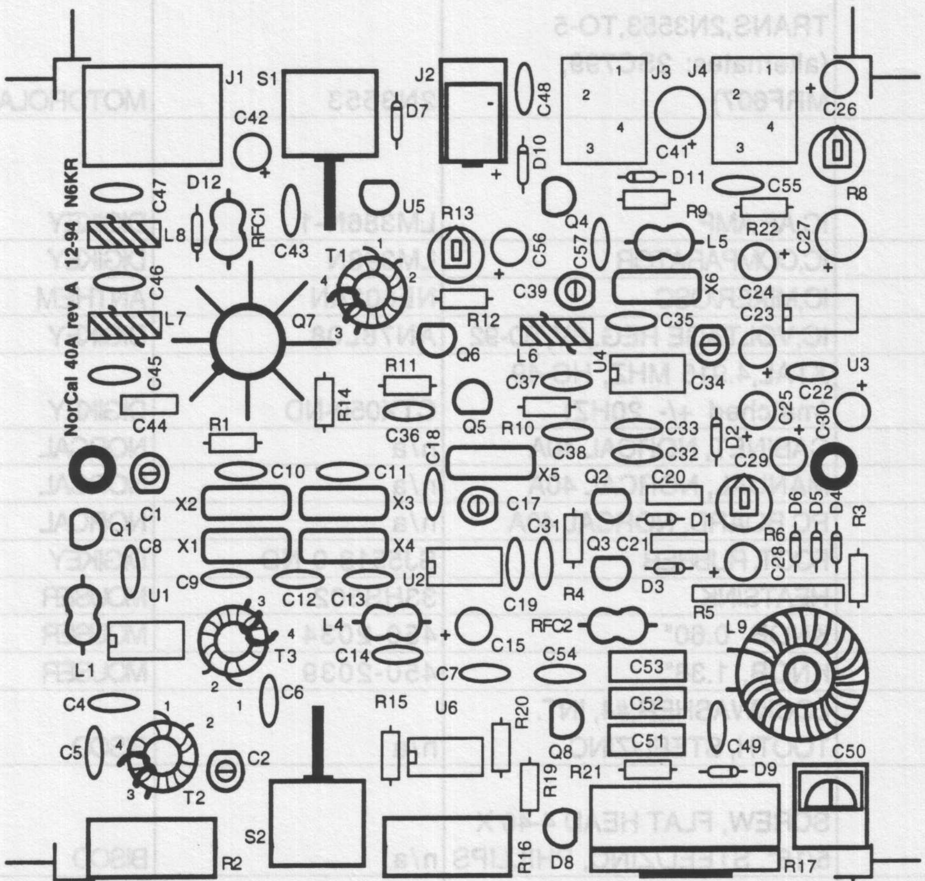






Q7	TRANS,2N3553,TO-5 (alternates: 2SC799, MRF607)	2N3553	MOTOROLA	1
U3	IC,AF AMP	LM386N-1	DIGIKEY	1
U6	IC,COMPARATOR	LM393N	DIGIKEY	1
U1,U2,U4	IC,MIXER/OSC	NE602AN	ANTHEM	3
U5	IC,VOLTAGE REG.,8V,TO-92	AN78L08	DIGIKEY	1
X1-6	XTAL,4.915 MHZ, HC-49 (matched +/- 20HZ)	CTX050-ND	DIGIKEY	6
MISC	CABINET, NORCAL 40A	n/a	NORCAL	1
MISC	MANUAL, NORCAL 40A	n/a	NORCAL	1
MISC	PC BOARD, NORCAL 40A	n/a	NORCAL	1
MISC	FOOT, RUBBER	SJ5518-0-ND	DIGIKEY	4
MISC	HEATSINK	33HS502	MOUSER	1
MISC	KNOB, 0.60"	450-2034	MOUSER	2
MISC	KNOB, 1.38"	450-2039	MOUSER	1
MISC	LOCKWASHER,#4, INT. TOOTH, STEEL/ZINC	n/a	BISCO	6
MISC	SCREW, FLAT HEAD 4-40 X 5/16", STEEL/ZINC, PHILLIPS	n/a	BISCO	6
MISC	#4 hex nut (small)	n/a	BISCO	6
MISC	SCREW,NYLON,0.5",6-32	561-J632.5	MOUSER	1
MISC	NUT,NYLON,6-32	561-G632	MOUSER	1
MISC	SHOULDER WASHER,NYLON,#6	7682K-ND	DIGIKEY	1
MISC	STANDOFF, HEX, MALE/FEM, 3/8" LONG,4-40 THD, 0.25" ACROSS FLATS	J211-ND	DIGIKEY	2
MISC	LATCH SET, PLASTIC (UPPER AND LOWER PARTS)	07-10-102-12 (SOUTHCO)	BISCO	2
MISC	WIRE,#26 ENAMEL, 8 FEET	n/a	OHR	1
MISC	WIRE,#28 ENAMEL, 8 FEET	n/a	OHR	1

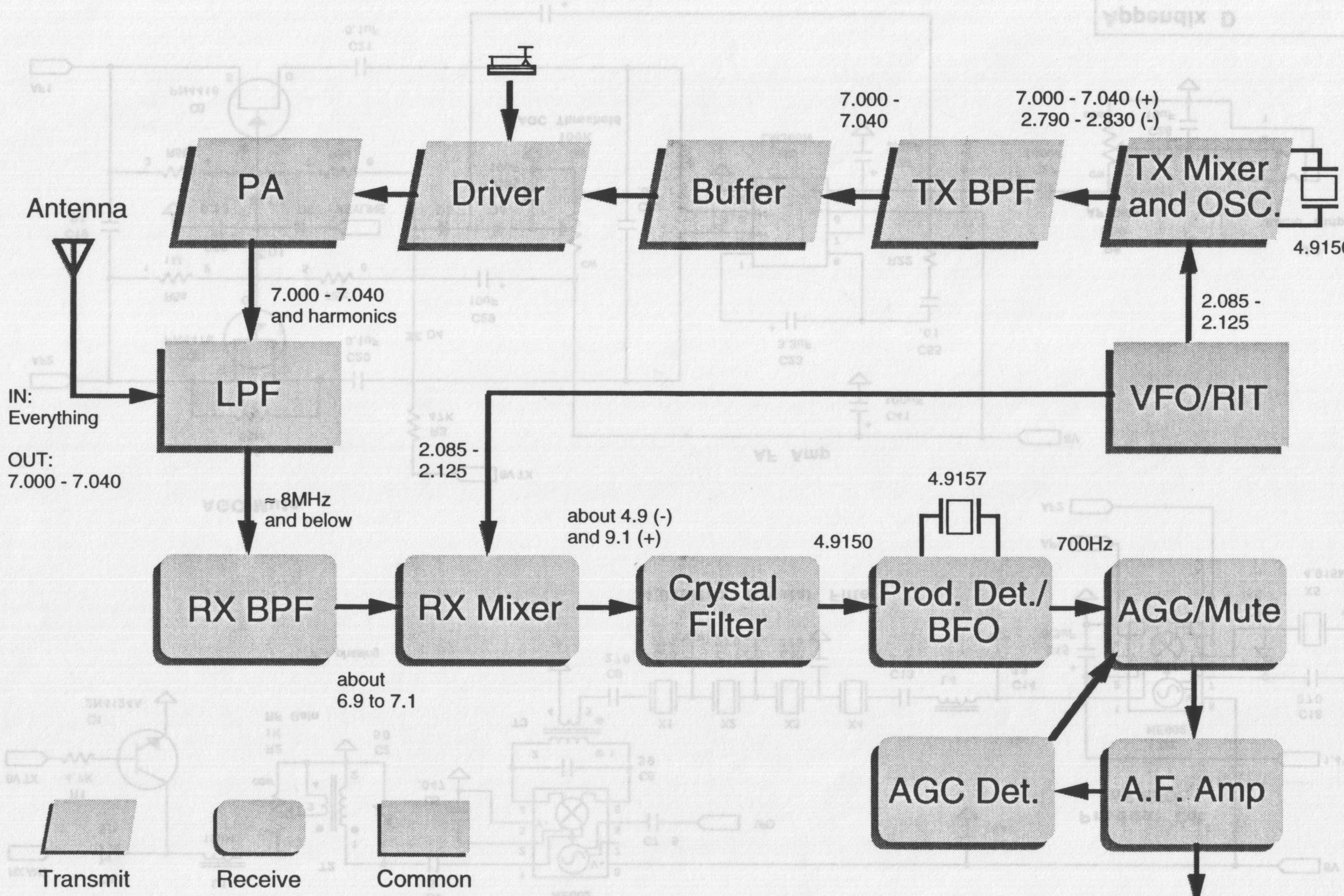
Rear



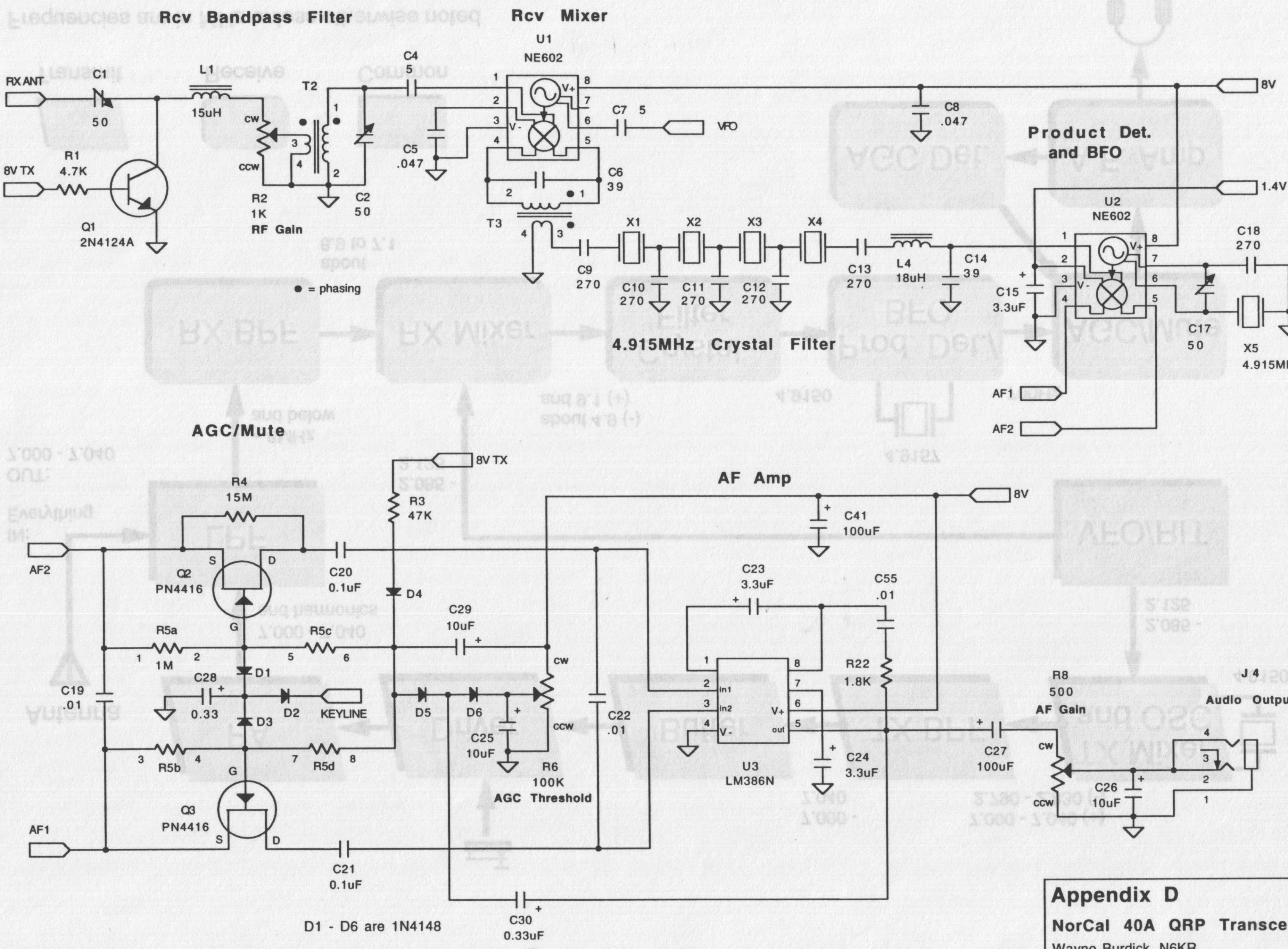
Front

Appendix B Component Placement Drawing

Appendix C - NorCal 40A Block Diagram



Frequencies are in MHz unless otherwise noted

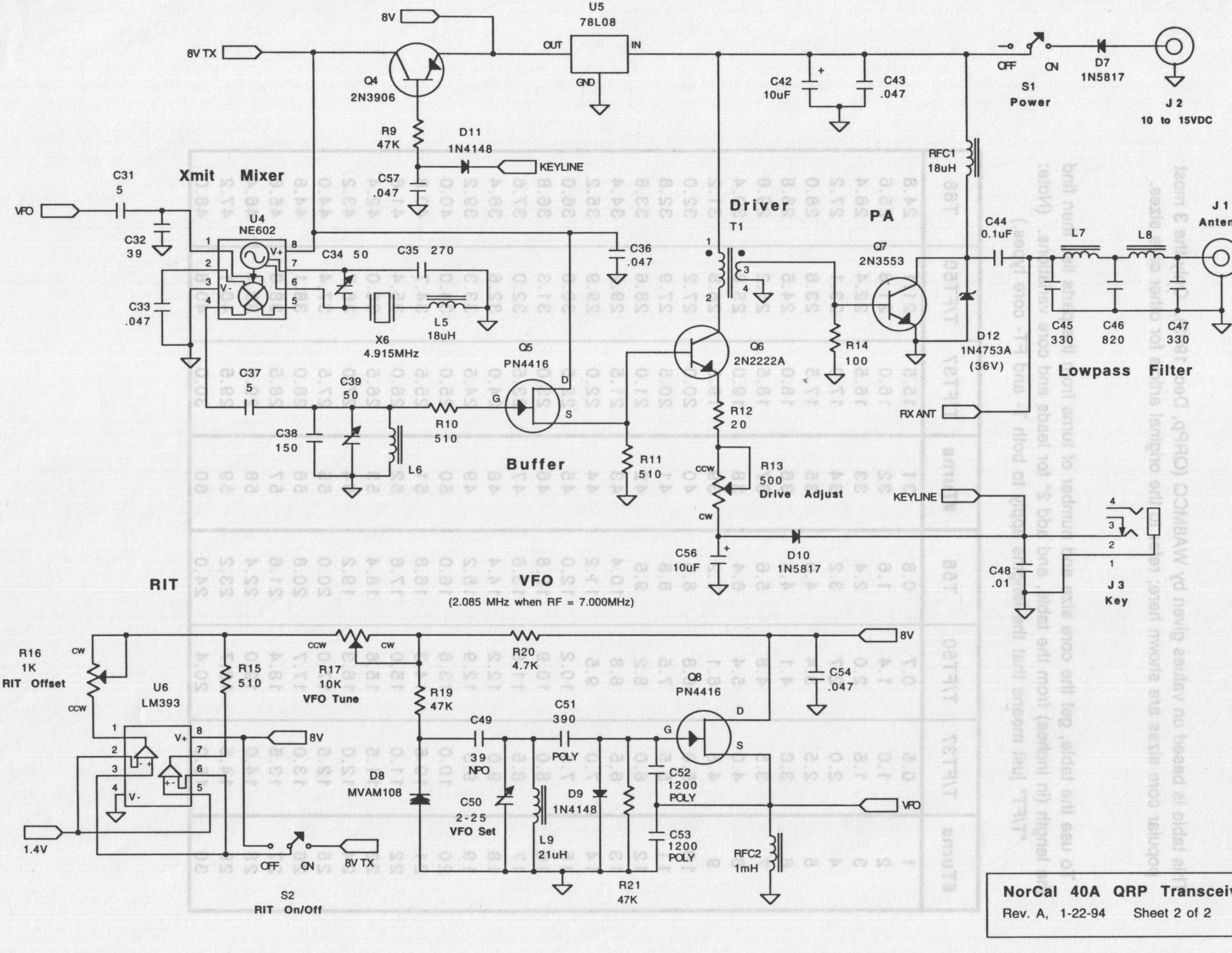


Appendix D

NorCal 40A QRP Transce

Wayne Burdick, N6KR

Rev. A, 1-22-94 Sheet 1 of 2


Xmit Mixer
Driver
PA
Lowpass Filter
Buffer
VFO
(2.085 MHz when RF = 7.000MHz)
RIT
U4 NE602
U5 78L08
Q4 2N3906
Q5 PN4416
Q6 2N2222A
Q7 2N3553
Q8 PN4416
U6 LM393
D7 1N5817
D8 MVAM108
D9 1N4148
D10 1N5817
D11 1N4148
D12 1N4753A (36V)
X6 4.915MHz
T1
L5 18uH
L6
L7
L8
L9 21uH
RFC1 18uH
RFC2 1mH
R9 47K
R10 510
R11 510
R12 20
R13 500 Drive Adjust
R14 100
R15 510
R16 1K RIT Offset
R17 10K VFO Tune
R19 47K
R20 4.7K
R21 47K
C31 5
C32 39
C33 .047
C34 50
C35 270
C36 .047
C37 5
C38 150
C39 50
C42 10uF
C43 .047
C44 0.1uF
C45 330
C46 820
C47 330
C48 .01
C49 39 NPO
C50 2-25 VFO Set
C51 390 POLY
C52 1200 POLY
C53 1200 POLY
C54 .047
C56 10uF
C57 .047
S1 Power
S2 RIT On/Off
J2 10 to 15VDC
J1 Antenna
J3 Key
8V TX
8V
VFO
KEYLINE
RX ANT
1.4V
NorCal 40A QRP Transceiver
Rev. A, 1-22-94 Sheet 2 of 2

This table is based on values given by WA8MCQ (QRPp, Dec. 1993). Only the 3 most popular core sizes are shown here; refer to the original article for other core sizes.

To use the table, get the core size and number of turns from the parts list, then find the length (in inches) from the table, and add 2" for leads and core variations. (Note: "T/FT" just means that the lengths apply to both T- and FT- core types.)

#Turns	T/FT37	T/FT50	T68	#Turns	T/FT37	T/FT50	T68
1	0.5	0.7	0.8	31	15.5	21.1	24.8
2	1.0	1.4	1.6	32	16.0	21.8	25.6
3	1.5	2.0	2.4	33	16.5	22.4	26.4
4	2.0	2.7	3.2	34	17.0	23.1	27.2
5	2.5	3.4	4.0	35	17.5	23.8	28.0
6	3.0	4.1	4.8	36	18.0	24.5	28.8
7	3.5	4.8	5.6	37	18.5	25.2	29.6
8	4.0	5.4	6.4	38	19.0	25.8	30.4
9	4.5	6.1	7.2	39	19.5	26.5	31.2
10	5.0	6.8	8.0	40	20.0	27.2	32.0
11	5.5	7.5	8.8	41	20.5	27.9	32.8
12	6.0	8.2	9.6	42	21.0	28.6	33.6
13	6.5	8.8	10.4	43	21.5	29.2	34.4
14	7.0	9.5	11.2	44	22.0	29.9	35.2
15	7.5	10.2	12.0	45	22.5	30.6	36.0
16	8.0	10.9	12.8	46	23.0	31.3	36.8
17	8.5	11.6	13.6	47	23.5	32.0	37.6
18	9.0	12.2	14.4	48	24.0	32.6	38.4
19	9.5	12.9	15.2	49	24.5	33.3	39.2
20	10.0	13.6	16.0	50	25.0	34.0	40.0
21	10.5	14.3	16.8	51	25.5	34.7	40.8
22	11.0	15.0	17.6	52	26.0	35.4	41.6
23	11.5	15.6	18.4	53	26.5	36.0	42.4
24	12.0	16.3	19.2	54	27.0	36.7	43.2
25	12.5	17.0	20.0	55	27.5	37.4	44.0
26	13.0	17.7	20.8	56	28.0	38.1	44.8
27	13.5	18.4	21.6	57	28.5	38.8	45.6
28	14.0	19.0	22.4	58	29.0	39.4	46.4
29	14.5	19.7	23.2	59	29.5	40.1	47.2
30	15.0	20.4	24.0	60	30.0	40.8	48.0