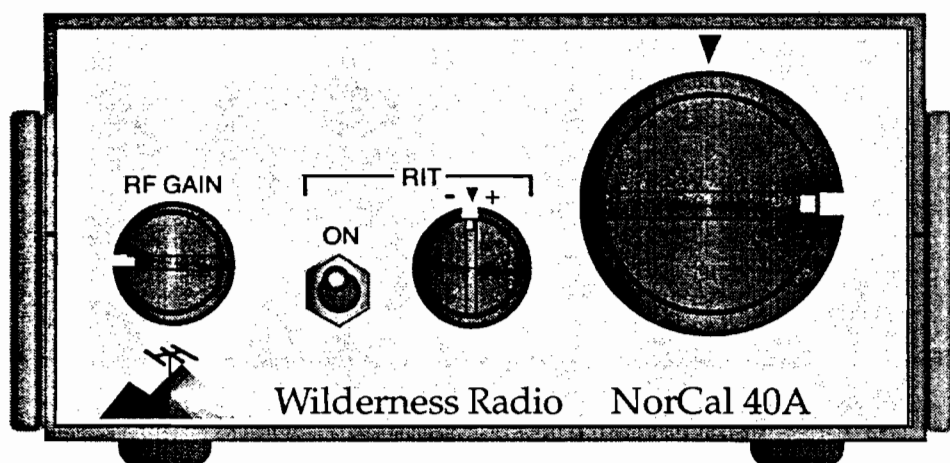


# NorCal 40A 40-Meter CW Transceiver

## Assembly and Operating Manual



## Wilderness Radio





# Contents

Introduction .....	3
General Description .....	4
Specifications .....	5
Preparation for Assembly .....	6
Assembly Tips .....	7
PCB Assembly .....	7
Controls, Connectors, and Panels .....	12
Final Assembly .....	13
Alignment and Test .....	14
Operation .....	17
Troubleshooting .....	19
Theory of Operation .....	21
Modifications .....	23
Appendix A, Parts List .....	26
Appendix B, Component Placement Drawing .....	29
Appendix C, Block Diagram .....	30
Appendix D, Schematic .....	31
Appendix E, Toroid Winding Chart .....	33

Wilderness Radio  
P.O. Box 734, Los Altos, CA 94023-0734  
(415) 494-3806

NorCal 40A design and documentation Copyright 1994,1995 by Wayne A. Burdick, N6KR. Written permission from Wayne Burdick and Wilderness Radio is required to republish any portion of this manual . Manual revision date: February 27, 1996.

Printed on recycled paper

# Introduction

Wilderness Radio's NorCal 40A is a compact and efficient 40-meter CW transceiver. No other QRP kit offers its combination of extremely low current drain, high performance, reliability, and ease of assembly. These and other features have made the NorCal 40A the transceiver of choice for many operators, both for home station and lightweight field use.

Originally a project of the Northern California QRP Club,<sup>1</sup> the NorCal 40A and its predecessor, the NorCal 40 have been field-tested by hundreds of QRP enthusiasts worldwide. Wilderness Radio has further revised the design, making it easier than ever to build and operate. We've also added a painted and silk-screened enclosure.

We've retained one essential ingredient that has made this rig so successful: the flexibility to adapt the '40A to your own needs. There's plenty of extra front- and rear-panel and interior space, and we encourage you to add your own accessories.

We hope you enjoy building and operating the NorCal 40A, and that the rig will facilitate your exploration of both electronics and low-power communications.

73,

Bob Dyer, KD6VIO  
Wayne Burdick, N6KR

## *Wilderness Radio's Kit Policy*

1. Unbuilt kits may be returned within 30 days for a full refund, less a 15% restocking fee. Customer must pay cost of shipping the kit to Wilderness Radio.
2. Missing or defective parts will be replaced free of charge within 30 days.
3. If--after your best efforts--the kit still does not work properly, we will repair it for a fixed fee of \$50 plus \$5 for return shipping. The kit must be in good condition; damaged kits may not be repairable. Customer must pay cost of shipping the kit to Wilderness Radio.
4. Technical support is available by phone Monday through Friday, 10 a.m. to 5 p.m. Pacific time at 415-494-3806. Send all other inquiries to:

Wilderness Radio, P.O. Box 734, Los Altos, CA 94023-0734

---

<sup>1</sup>For more information on the NorCal QRP Club, write to Jim Cates, 3241 Eastwood Road, Sacramento, CA 95821.

## 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—typically 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 AGC (automatic gain-control) 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 **Theory of Operation** for circuit details).

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 usually 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 Wilderness Radio's model KC1 keyer and frequency counter. Long-life plastic latches on either side of the case allow easy access to the interior.

### NorCal 40A Revisions

This information is provided for comparison with previous revisions of the NorCal 40A and NorCal 40. The Wilderness Radio NorCal 40A is currently at revision B. A number of changes were made to the revision A circuitry, including:

- All JFETs (junction FET transistors) are now J309s, improving AGC performance, transmit power output, and alignment repeatability.
- A low-pass filter was added following the VFO to improve receiver image rejection by about 10 dB.
- AGC and QSK components values were changed to improve attack/decay times and reduce audio thumps.
- L-C circuit values were changed slightly to make alignment easier.

In addition, the chassis and PC board have been modified to improve placement of controls and connectors, and the chassis is now supplied silk-screened and painted.

# Specifications

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

## General

Size:	2.2" (H) x 4.6" (W) x 4.5" (D)
Power Requirements:	10 to 16VDC; reverse-polarity protection
Receive:	15 to 20 mA
Transmit:	225mA at 2.0 watts output
VFO operating frequency:	2.085MHz nominal <sup>2</sup>
Tuning Range:	Any 40 to 45 kHz segment of the 40m CW band (7.0-7.15MHz)
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 0.2uV 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:	8 $\Omega$ or higher (headphones or speaker) (Stereo headphone plug required—see Operation)

---

<sup>2</sup>At an operating frequency of 7.0MHz. (VFO frequency is related to operating frequency using the formula:  
RF = VFO + 4.915 MHz.)

## Preparation for Assembly



**Note:** This symbol is used to alert you to important information about assembly, alignment, or operation of the NorCal 40A.

☒ As you complete each step, put a mark in the check-off box as shown here.

☐ Take a moment to familiarize yourself with the parts list (Appendix A). Components are listed alphabetically by the letters in their *reference designators* (e.g., "R" for resistor). Within a category, parts are listed in order by value (e.g., resistors start with 20 $\Omega$ , then 100 $\Omega$ , etc.).

To help identify parts, the parts list includes drawings of most components, capacitor markings (in quotes), and color code bands (see color code chart below).

**Note:** There are six translucent plastic crystal spacers in the bag which may be hard to see. These spacers are oval in shape, about 1/2" long, and very thin. If you lose any of them, you can make your own spacers from plastic or heavy paper.

### Capacitor Markings

All of the capacitors in the kit can easily be identified by their drawings and descriptions in the parts list. However, you may find it helpful to understand the markings of small capacitors.

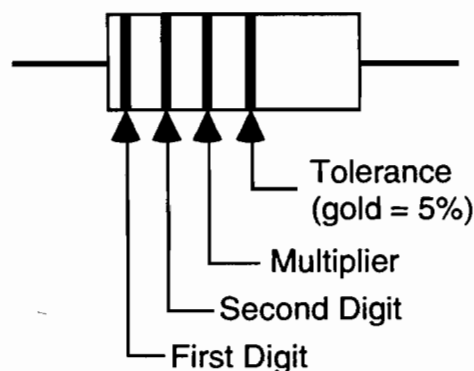
Small (< 1000 pF) disc ceramic capacitors are usually marked with 1, 2, or 3 digits and no decimal point. If 1 or 2 digits are used, that is the value in pF (picofarads). If there are 3 digits, the third digit is *usually* a multiplier. For example, a capacitor marked "151" would be 150pF (15 with a multiplier of 10 to the first

power). Similarly, "330" would be 33 pF, and "102" would be 1000 pF.

Occasionally, disc capacitors use "0" as a place holder rather than a multiplier, so that "330" might actually mean 330 pF, not 33 pF. However, the NorCal 40A kit does not contain any ambiguous capacitor values (e.g., there isn't both a 33 and a 330 pF disc capacitor in the kit).

Disc or film capacitors with values over 1000pF may use a decimal point in the value, such as .001 or .02. This is the value in microfarads ( $\mu$ F).

### Resistor 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	

☐ Using the parts list, identify all components in the kit. If anything is missing or damaged, call or write to Wilderness Radio immediately.

# Assembly Tips

## Tools

- Use a pencil-type soldering iron of 15 to 25 watts with a fine tip. Do not use a soldering gun, or an iron with a large, flat tip. These are not intended for PC board work, where excess heat can damage pads and traces.
- Solder containing 2% silver is preferred. Otherwise, use 60:40 (tin:lead) solder such as Radio Shack cat. #64-009.

## Component Installation and Soldering

1. Install all of the components in each group as described, then check your work before soldering them. This may save you the trouble of removing a part that was soldered in the wrong place.
2. Use good lighting to avoid confusing color bands on resistors. If you're unsure of a resistor's color bands, check the value with an ohmmeter.
3. 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 (integrated circuits) and connectors need not be trimmed.
4. Sockets are not necessary for the ICs or transistors.

## Component Removal

The NorCal 40A PC board is double-sided with **plated-through holes**. This results in a very clean layout, but also makes

component removal more difficult than it is from single-sided boards. If you need to remove a component, 3/32" or 1/8" wide desoldering braid (also called *solder-wick*) works well. Do Not use Archer or other cheap brands of desoldering braid; it may wick solder very poorly. Use a professional brand such as Ungar-Wick.

If a component can't be removed with wick or a solder sucker, try using long-nose pliers on one side and soldering iron on the other. Use only the amount of heat necessary. Then remove any remaining solder from the hole with solder wick.

## PCB Assembly

PC board assembly begins with low-profile components—e.g., resistors and diodes—and works up to the higher-profile parts. This keeps the board stable as you turn it over each time to solder.

Install and solder each component (or group of components) in the order shown. Part locations can be identified from the outlines and reference designators on the PC board. There is also a component location drawing (Appendix B).

### Resistors, Diodes, and RF Chokes

☐ Using the parts list, locate the first fixed resistor listed (R12), which is 20Ω (red-black-black). To find where it goes, look for a rectangular outline on the PC board with the label "R12." Some areas of the board are densely populated with components, so be careful to locate the resistor outline closest to the "R12" label.

☐ Install R12 so that it is seated flush with the top of the board, then bend and clip the leads on the bottom of the board as described previously. Do not solder this resistor until the remaining fixed resistors have been installed.



☐ Install the remaining fixed resistors, double-checking the color code to make sure you're installing the proper value. (If you have trouble seeing the color bands, ask someone to identify the resistors for you.) The resistors should all be oriented in one direction for ease of reading the color codes later: the first significant-digit band should be towards the left or top.

☐ Install and solder resistor network R5, an 8-pin SIP (single-inline package). One end of R5 has a black dot indicating pin 1; this pin goes into the square pad. Bend the two pins at either end slightly—in opposite directions—to hold R5 in place, then solder.

☐ You should have one 15 M $\Omega$  resistor left over. This can be used for R4 in place of the 8.2M resistor to reduce the monitor tone volume if desired (see **Alignment**).

☐ Install trimmer potentiometers R8, R13, and R6. These are NOT all the same value; check the parts list. Be sure to place them all in the direction indicated by their PC board outlines.

☐ Solder all of the fixed resistors and trimmer potentiometers.

☐ 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.

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



The NorCal 40A uses two kinds of inductors: solenoidal (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, the designators reflect the *purpose* of the component—not the physical form. Either kind of inductor can act as an RF choke or as a filter element.

☐ Solder the diodes and chokes.

### Capacitors

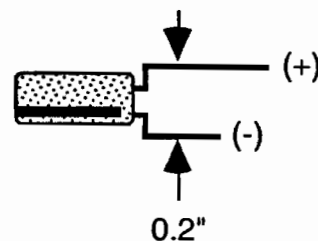
☐ Install all of the fixed capacitors (except the electrolytics). These capacitors are easily damaged, so don't pull on or stress the leads. Double-check the values.

☐ 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.

☐ Next, install the miniature trimmer capacitors. Orient the trimmers as they

appear on their PC board outlines. (The air variable capacitor, C50, will be installed later.)

- ☐ 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.

☐ Carefully remove the existing heat sink from Q7, if any. Be careful not to damage the leads.

☐ Slide the TO-5 transistor spacer onto the leads of Q7. The spacer has four holes, but you can use any three for the transistor's leads.

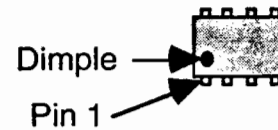
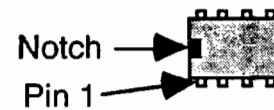
☐ Install Q7, pressing it down onto the board so that it is flush against the plastic spacer. The spacer should also be flush against the PC board, and there should be no excess lead length visible.

☐ Solder Q7.

☐ Carefully press the heat sink onto Q7. You may need to pull the heatsink from either side slightly as you work it on. **Don't force it--you could damage the transistor.** Once installed, make sure that the heatsink isn't touching any of the surrounding components.

☐ Install all of the ICs (except U5). These ICs are 8-pin DIPs (dual-inline packages). Since there are no sockets used, be careful to install the ICs correctly. **The notched and/or dimpled end of each IC must be aligned with the notched end**

of its PC board outline as shown in the following drawing.



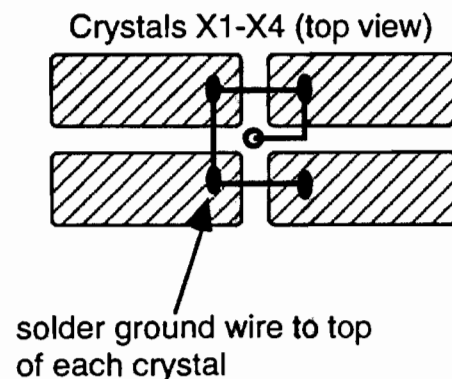
☐ Install U5. This is a flat-sided unit like a plastic transistor; install it as indicated on its PC board outline.

☐ Solder all of the ICs.

☐ Slide a crystal spacer onto the leads of each crystal. The spacers should be pressed all the way onto the leads until they are flush with the crystal body.

☐ Install all six crystals. Make sure that the crystals are flush with the PC board, then solder.

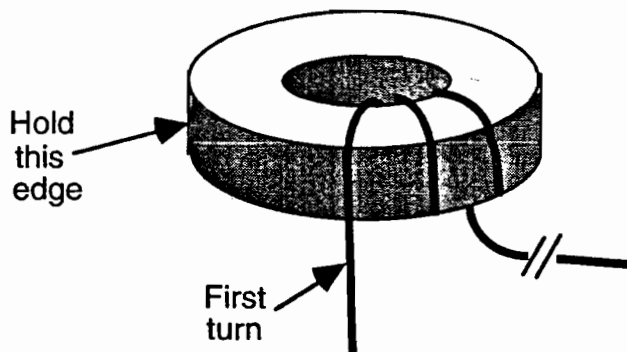
☐ The cases of crystal X1 through X4 should be grounded to eliminate "blow-by" from very loud signals, i.e., signal leakage around the crystal filter. There is a ground pad in the center of the four crystals for this purpose. Use #26 or larger solid, bare hookup wire to ground the crystal cases as shown below.



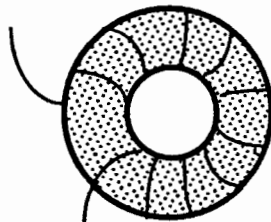
## Toroid Tutorial

If you've never wound a toroidal inductor before, here are some things to keep in mind. Read through this section once before trying your hand at one of the easiest to wind, L6.

- 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 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 roughly even around most of the core, leaving a small gap between the first and last turns as shown below. (The number of turns shown in the drawing is different from the actual number of turns used.)



## Toroid Winding and Installation

☐ Locate toroid L6 on the parts list. The **Part Number** column specifies the toroid core type, in this case a red T37-2 core. The "37" in the part number means 0.37 inches in diameter, and the "-2" is a specific type of iron-powder core material which is color-coded red.

☐ Wind L6 as described in the *Toroid Tutorial*, above. The parts list specifies the number of turns ("28T" means 28 turns), wire gauge (#28 enamel), and the length of wire required (16 inches). The enamel wire used to wind the toroids is provided in the kit. Note that #26 wire is just slightly thicker than #28.

☐ After winding L6, cut its leads to about 1/2 inch long, then use a match or cigarette lighter to remove the insulation from the ends of the leads (to within about 1/8" of the toroid body). About 5 to 10 seconds on each lead should do it, or you can place the leads close together and burn the insulation off of both at once.

☐ Remove any remaining enamel coating from the wire using medium-grit sandpaper. Don't sand it down too thin, since this will weaken the wire.

☐ Install L6 vertically, as indicated by the PC board outline. Keep the toroid pressed up against the board and gently pull the leads taut on the other side.

☐ After pulling the leads through, make sure you can see *bare wire* where the lead intersects the pad on the bottom of the board. Don't pull the lead through so far that the *insulated* part of the lead is seen protruding from 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. As a check, use an ohmmeter to measure

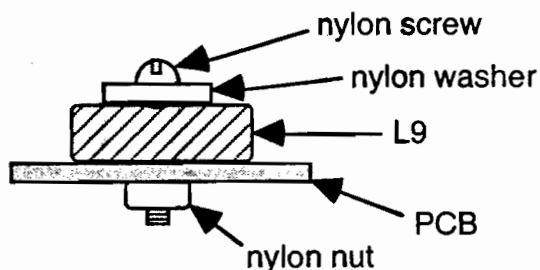
from one pad to the other. There should be continuity through the toroid (nearly zero ohms) if you have two good solder joints.

□ Wind L7 and L8 in the same manner as L6, using the number of turns and wire type specified in the parts list. These toroids also use red cores.

□ Next, wind L9, the VFO toroid, on the large white core. 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.

**⚠ Important:** If you're planning to use the NorCal 40A in the Novice band, use 58 turns on L9 rather than 60.

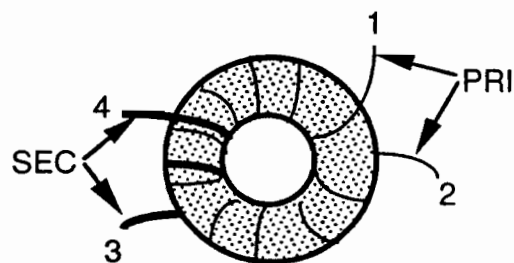
□ Insert L9's leads into their correct locations on the board, and secure the toroid to the PC board as shown below using nylon hardware. Do not over tighten—such stress can cause VFO instability. Solder L9.



### *Toroidal Transformers*

**⚠** In the following steps you'll be using two different kinds of black toroid cores. The FT-37-43 and FT-37-61 cores are both black, but the -43 cores have an orange marking added by Wilderness Radio. These two core types have completely different characteristics and must not be interchanged.

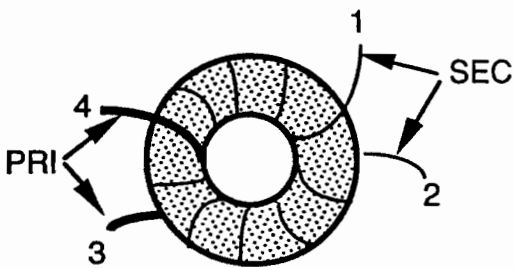
□ Toroidal transformer T1 uses an FT37-43 core, a black core with an orange dot. This is a very simple transformer: it is just two windings wound one on top of the other. The drawing below shows how this works. (Note that this and other toroid drawings do not necessarily show the actual number of turns required.) Start with the primary or "PRI" winding, identified by the digits 1 and 2, using 14 turns of #26 enamel wire. The secondary or "SEC" winding can then be wound on top of the primary winding, using 4 turns #26.



**⚠** Electrically speaking, the primary of a transformer is the input winding, and the secondary is the output winding. However, for physical identification of the leads we use arbitrary numbers (1 through 4), which also appear on the PC board. There is no standard numbering system for primary and secondary leads.

□ Remove the insulation from all four of T1's leads using heat and sandpaper as described previously. Install it flat on the circuit board. Make sure that the primary (1, 2) and secondary (3, 4) leads are inserted into the corresponding numbered pads on the PCB outline for T1. Pull the four wires taut on the bottom of the board. Trim the leads and solder.

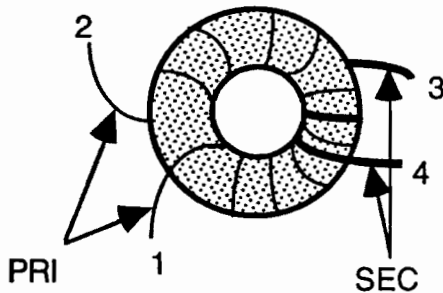
□ Toroidal transformer T2 uses a black core without an orange dot. The windings of T2 are identified in the drawing below. Start by winding the secondary (20 turns #26).



☐ As shown in the drawing above, T2 has only one turn on its primary winding. This means that the wire 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.

☐ Remove the insulation from T2, then install and solder it in the same fashion as T1. Be sure to line up the primary and secondary windings with the numbered pads on the PC board. Also make sure that the 1-turn primary leads aren't touching each other.

☐ T3 uses another black core without an orange dot. (This should be the only toroid core remaining.) First wind the primary (23 turns #28), then the secondary (6 turns #26), as shown in the drawing below.



☐ Wind and install T3 in the same manner as T1 and T2.

### *Air-Variable Capacitor*

☐ Install the air-variable capacitor, C50. The silk-screen for this capacitor shows it how it appears when the plates are fully *meshed*; set the plates this way before installing it.



This orientation keeps the rotor—the part that moves—grounded, allowing alignment to be performed with a metal screwdriver.

## Controls, Connectors, and Panels

Follow the procedure below carefully to insure proper panel alignment. Be sure to hold each control or connector flush against the PC board while soldering.

☐ Install J3 and J4. Bend the leads slightly to hold the jacks in place. Solder, holding the connectors flush with the PC board.

☐ Install J1, S1, and S2. These three components are responsible for correct front and rear panel alignment. Make sure they're flush with the PC board while soldering.

☐ Install one nut each onto the shafts of S1 and S2, removing all other hardware. Screw these nuts on finger-tight as far as they'll go.

☐ Install the rear panel onto the shafts of the connectors. Verify that the rear panel is flush with the back edge of the PC board and perpendicular to it. Secure the connectors to the panel using the provided control nuts.

☐ Remove the small metal tabs (near the shafts) of potentiometers R2, R16, and R17. Install these pots on the PC board, but do not solder them yet. When seated

correctly, each pot will sit slightly above the PC board.

☐ Install the front panel onto the shafts of the front panel controls, loosely securing the controls to the panel using the provided control nuts and washers.

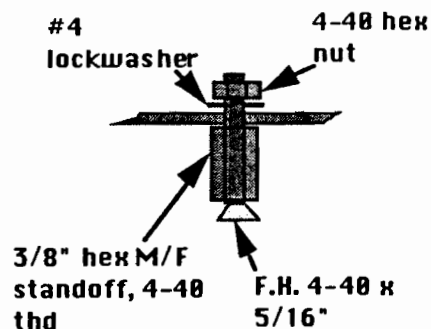
☐ Adjust the positions of R2, R16, and R17 as needed to keep the front panel flush with the front edge of the PCB and perpendicular to it. When the proper alignment is obtained, solder R2, R16, and R17. Tighten the control nuts.

☐ Install J2 on the PC board. Put a dab of solder on one pin of J2 to hold it to the PC board temporarily. Look at J2 through the rear-panel hole to see if the connector hole is concentric with the panel hole. If not, re-heat the solder joint and push the connector into position. Finally, solder the other two pins of J2.

## 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.

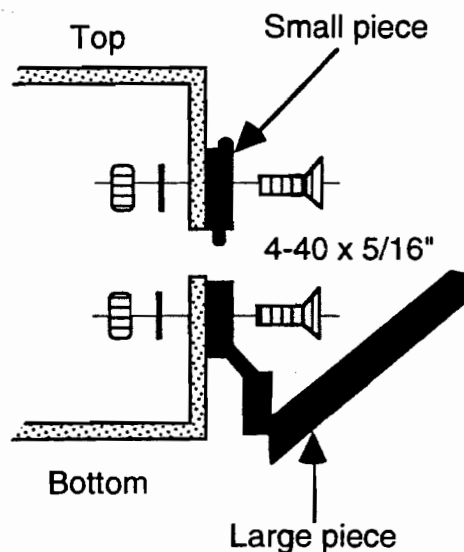
☐ Install the 3/8" male-female standoffs on the bottom of the PCB as shown in the drawing below, using #4 hardware. The standoffs are placed at the center-left and center-right edges of the PC board, near C1 and C30. (The 4-40 x 5/16 flathead screw is shown for reference; it will be installed later to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



☐ Attach the large knob to the VFO pot (R17) and the two smaller knobs to the RF gain and RIT pots (R2 and R16).

☐ 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 latches should snap into place as you lock them down.



Despite the thin-looking plastic hinges, these latches are rated at millions of cycles.

☐ You should have one connector left over: 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

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 10 to 16V DC power supply (or battery) capable of supplying 300mA to J2; the preferred voltage is 13.8V. 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 milliammeter, connect it in series with the supply and note the current reading, which should be approximately 15-18mA. 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

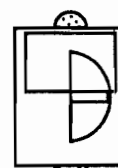
1. Temporarily disable the AGC by turning R6 (AGC threshold) fully clockwise.
2. Set all of the trimmer capacitors at mid-range, as shown below. The capacitors are shown as they appear from the front of the PC board, with the pads on the top of the board shown for reference.



C17, C39



C1, C2, C34



C50

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. **You must use stereo headphones**, or make an adapter to convert from mono to stereo (see **Operation**).
5. Connect an antenna--at minimum a long (at least 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 tuning tool or jeweler's screwdriver (preferably with an insulated handle), 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. If you have a frequency counter: 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  $7.025 - 4.915 = 2.110\text{MHz}$ . Connect a frequency counter to C7 (on the U1, pin 6 side), and adjust C50 for the desired reading.

2B. If you have a calibrated signal generator or 40-meter transmitter: 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. If you have no equipment at all: 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. If you need to add turns, it's OK to splice a piece of wire onto one lead of L9.

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. The RIT range is about +/- 2kHz.

5. Now that the VFO covers the desired range, you can optionally add calibration markings. At the very least you'll want to mark any important band edges, and perhaps the QRP calling frequency, 7040kHz. Small marks can be made directly on the panel using dry transfers. Or you can place a thin white plastic or cardboard band around the VFO knob



skirt, mark points on this band, and use the pointer silk-screened on the panel.

### 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. The audio amplifier circuit is optimized for a fairly low pitch of 600-650Hz.
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 1.8 and 3.0 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 milliammeter 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 =  $1.5 / (12 \times .16) = 0.78$ , or 78%.

6. The transmit monitor tone should be plainly audible in the headphones. Adjust C34 for the desired pitch, near the center of the receiver's audio passband. (Recall that C17 can be adjusted to change the receive audio pitch.) If the monitor tone volume is too loud, you can replace R4 with the 15M $\Omega$  resistor provided.

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

## Operation

### 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. 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. Turning down the RF gain will help prevent the receive mixer from getting overloaded, which can cause unwanted spurious signals to be heard.

**Note:** When you set the AF gain level (internal control R8), be sure that you have the RF gain control set fully clockwise (maximum gain).

**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 a bit non-linear due to the varactor tuning (see Theory of Operation).

### Rear-Panel Controls and Connectors

**Key jack:** You can use a hand key or any type of "key-to-ground" keyer here. Most keyers have an output of this kind (including the Wilderness Radio KC1 keyer/frequency counter module). If your keyer has a resistor of 10 ohms or greater in series with its keyed output, it may reduce the power output from the NorCal 40A. You may need to bypass this resistor to use the keyer with the '40A.



Some hand keys may cause an audible leading-edge "click." You can eliminate the click by inserting a 10 to 22 $\Omega$  resistor in series with D2. Cut the trace between D1 and D2, then solder the resistor to the anode of D2 and the cathode of D1. The resistor may be installed on the bottom of the PC board.

**Headphone/speaker jack:** You can use either headphones (preferably stereo) or a speaker with the NorCal 40A. Regardless

of which you use, you must 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. If you switch from headphones to speaker often, you may want to relocate the internal AF level control (see **Modifications**).



Good-quality stereo headphones with large ear covers work best—they'll usually be the most comfortable. You may also use good-quality Walkman-style stereo headphones or ear buds.

*Power jack and on/off switch:* The NorCal 40A requires 10 to 16 VDC. Transmit current requirements vary, but will rarely be over 350mA (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 10-16V 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 typical silicon power diode like a 1N4001, so it will not significantly affect your transmit power output.

*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

Most QRP operation on 40 meters occurs near 7.040MHz in the United States, and around 7.030MHz in Europe. The most common Novice band QRP frequency is 7.110MHz. If you listen around these frequencies, especially in the evening, you'll eventually hear some QRP stations. Working QRP stations is more challenging than working high-power stations, and it will give you an idea of what others hear when they listen to your QRP signal!

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.

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 reduced to a comfortable 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 an NE602 as the receive mixer—providing excellent sensitivity and low current drain—but it can get overloaded by very large 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

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. **The most likely problem, by far, is a poorly-stripped lead on a toroid. Also likely is an incorrect resistor or capacitor value.**

3. Double-check your setup. Often you can trace a problem to a bad scope probe, intermittent clip lead, incorrect power supply voltage, etc.

4. 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 R23 should be roughly 1V rms.
- b. BFO at U2, pin 6: about 240mV 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 0.7V rms.
- c. Power Amp output at Q7 collector: 13V rms.
- 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 T1's secondary leads.
- f. If there seems to be instability as power is increased, make sure you used the correct core at T1: a black core with an orange mark.

## DC Voltage Chart

These readings were taken with a DMM (30V DC scale) with the (-) probe at ground, under the following conditions: power supply = 13V (receive), 12.8 (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 (\*) may be difficult to measure or will vary with control settings.

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	U4, pin 1	0.00	1.42	Q1, emitter	0.00	0.00
U1, pin 2	1.42	1.42	U4, pin 2	0.00	1.42	Q1, base	0.00	0.71
U1, pin 3	0.00	0.00	U4, pin 3	0.00	0.00	Q1, coll.	0.00	0.00
U1, pin 4	6.72	6.72	U4, pin 4	0.00	6.72	Q2, gate	*4.25	*0.70
U1, pin 5	6.73	6.73	U4, pin 5	0.00	6.73	Q2, source	6.75	*
U1, pin 6	7.86	7.86	U4, pin 6	0.00	7.86	Q2, drain	6.75	*
U1, pin 7	7.14	7.14	U4, pin 7	0.00	7.14	Q3, gate	*4.23	*0.70
U1, pin 8	7.94	7.93	U4, pin 8	0.00	7.93	Q3, source	6.68	*
U2, pin 1	1.44	1.44	U5, IN	12.68	12.49	Q3, drain	6.68	*
U2, pin 2	1.44	1.44	U5, OUT	7.94	7.93	Q4, emitter	0.00	7.93
U2, pin 3	0.00	0.00	U5, GND	0.00	0.00	Q4, base	7.65	7.31
U2, pin 4	6.68	6.59	U6, pin 1	*	*	Q4, coll.	7.94	7.93
U2, pin 5	6.75	6.63	U6, pin 2	1.44	1.44	Q5, gate	0.00	*0.0
U2, pin 6	7.88	7.88	U6, pin 3	7.94	7.94	Q5, source	0.00	1.50
U2, pin 7	7.41	7.41	U6, pin 4	0.00	0.00	Q5, drain	0.00	7.74
U2, pin 8	7.94	7.93	U6, pin 5	1.44	1.44	Q6, emitter	*	0.90
U3, pin 1	1.30	1.30	U6, pin 6	7.94	7.94	Q6, base	0.05	1.60
U3, pin 2	0.01	0.01	U6, pin 7	0.02	0.02	Q6, coll.	12.68	12.50
U3, pin 3	0.01	0.01	U6, pin 8	7.94	7.94	Q7, emitter	0.00	0.00
U3, pin 4	0.00	0.00				Q7, base	0.00	*0.0
U3, pin 5	3.92	3.92				Q7, coll.	12.68	*12.7
U3, pin 6	7.94	7.93				Q8, gate	*0.0	*0.0
U3, pin 7	3.96	3.96				Q8, source	0.03	0.03
U3, pin 8	1.31	1.30				Q8, drain	7.94	7.93

## Theory of Operation

Refer to the block diagram (Appendix C) and schematic (Appendix D). The 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, J1. 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 (U1) produces the sum and difference of its inputs, in this case the VFO at 2.085-2.125 (Q8) 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 (X1-X4) 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.



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 a signal at 4.915MHz, so we add the next stage: the product detector (U2). This is really just another mixer which gets its two inputs from the crystal filter and from the BFO (beat-frequency oscillator, also part of U2). 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 (C19) across the output.

The 700Hz signal passes through the AGC circuit, described later, on its way to the AF amp, U3.

### Transmitting

On transmit everything happens in reverse, starting with the VFO (Q8). 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 (U4) is turned on, along with its on-board oscillator at 4.9150MHz. This oscillator happens to be set to 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 transmit mixer are the sum and difference of the VFO and the transmit 4.9150MHz oscillator (which is also part of U4). The one we want is the sum, or 7.000MHz, and this is the one selected by the sharp transmit band-pass filter (C38, C39 and L6). The difference frequency, 2.830, is attenuated to an insignificant level by this filter.

The buffer (Q5), driver (Q6) and power amp (PA, Q7) 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 (a power-efficient amplifier type that only draws current during the positive half of the driving signal).

### Support Circuitry

(Refer to the schematic, Appendix D.)

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 with a low pinch-off voltage of from 1 to 4 volts; their source-drain resistance increases as the gate voltages go more negative. The AGC bias circuitry (R6, R5, and D5-D6) provides a threshold voltage to the gates of Q2 and Q3. This voltage is adjusted so that the source-drain resistance is quite low with no signal.

D5 and D6 full-wave rectify the output of the audio amplifier, U3, to provide a voltage that goes as low as -3 volts when a loud signal is present. D1, 2 and 3 allow Q2 and Q3 to perform a muting function when the transmitter is keyed. Without these isolation diodes, the AGC and mute time constants would affect each other.

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.



## Modifications

This section describes some modifications to the design that some builders may want to include. There are a few unlabelled holes on the PC board that will facilitate access to certain signal lines (listed below). Also, the toroid winding chart (Appendix E) may come in handy for some modifications.

### *Signals available on the PCB*

The pads for these signals are not labeled on the PC board. The table below tells where to find them (looking at the PCB from the component side).

+8VDC	Near U1, pin 6
+12VDC	Between S1 and C43
VFO output	Near C32
VFO output GND	Near C32
Aux. A.F. input	Near U3, pin 8
Keyline	Near D11 cathode
8V TX	Near R15
Ground	Near J1 and R2 (2 holes each)

### KC1 Keyer/Frequency Counter

The KC1 keyer/frequency counter board is custom-tailored to the NorCal 40A. It is only 2.5" by 0.8" and will fit directly above the controls on the front panel. The KC1 provides an iambic keyer with nonvolatile message buffers, as well as a "displayless" frequency counter. Instead of a display, the KC1 uses Morse-code audio output to report your operating frequency as 3 digits. The KC1 is fully programmable and will even work with multiband rigs. Refer to the KC1 manual for installation instructions.

### Adjustable-Bandwidth Xtal Filter (ABX)

With the addition of a few components, you can vary the bandwidth of the receive crystal filter. The heart of the modification is three MVAM108 varactor diodes, which are used as variable capacitors across the crystals in the filter. Since a DC voltage is all that's required to vary the capacitance, you can control the bandwidth with a panel-mount potentiometer. Typically, the bandwidth can be varied from 150 to about 1500Hz. Contact Wilderness Radio for information on how to obtain these components.

### External AF gain control

If you plan to switch between speaker and headphones often, you may want to relocate R8, the AF gain control, to the rear panel. A 250 $\Omega$  to 1K $\Omega$  panel-mount pot of any kind will do. Keep the leads as short as possible. If you relocate the AF gain control to the front panel, you must twist the three wires together over their length to eliminate any A.F. instability.

### TX monitor volume level

If the transmit monitor tone is too loud or too soft, try a different value of R4. A 15M $\Omega$  resistor is included in the kit; this will reduce the monitor tone volume.

### 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 specified value is just large enough to keep the receiver muted during the key-up transition. 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 3.3 $\mu$ F. You can simply swap C15 and C29, since 10 $\mu$ F will work just as well at C15 as 3.3 $\mu$ F.

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 such as the Wilderness Radio model KC1, since you can't label the panel directly when using a multi-turn pot.

When the VFO range is increased, the RIT range will increase proportionally. If you want to cut the RIT range, you can add a resistor from the junction of R15/16/17 to ground. A 1K resistor here will cut the RIT range in half.

Another thing you'll find with an increase in tuning range is that the transmitter power may dip at the low and high ends. This is due to the narrow-band filter formed by L6, C38, and C39. To increase the range of this filter, you could 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.

## 80 meter conversion

This modification works well. There are eleven parts to change:

**L1:** 47 $\mu$ H (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; **L7/L8:** 23 turns #26 on original cores; **C45/C47:** 820pF; **C46:** 1800pF; **C49:** 82pF; **L9:** 92 turns #30 on original core.



To wind L9 more easily, 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.

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.



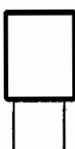
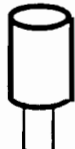




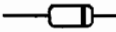
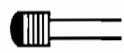
*30 meters:* One approach to this conversion can be found in the Dec. '95 issue of QRPp, page 63: "NC40 to NC30 conversion," by Ed Burke. Regardless of the details, you'll have to change all six crystals to 8.000MHz, and modify the crystal filter input and output networks

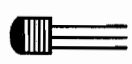
(C6, T3, L4 and C14) to provide the necessary impedance match to/from the NE602s at this new I.F. Adjust the VFO to cover about 2.100 to 2.140MHz using C50. As with any band change, you'll need to modify the other receive and transmit tuned circuits, including the low-pass filter.

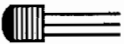


*20 meters:* One possibility is to change the I.F. to 12MHz and retune the VFO to cover 2.0 to 2.1. You will probably have a birdie at 14.000 that acts as a band-edge marker. With an I.F. of 12MHz, the crystal filter bandpass will be much wider than 500 Hz. Another possibility is to use 8MHz as the I.F. 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.

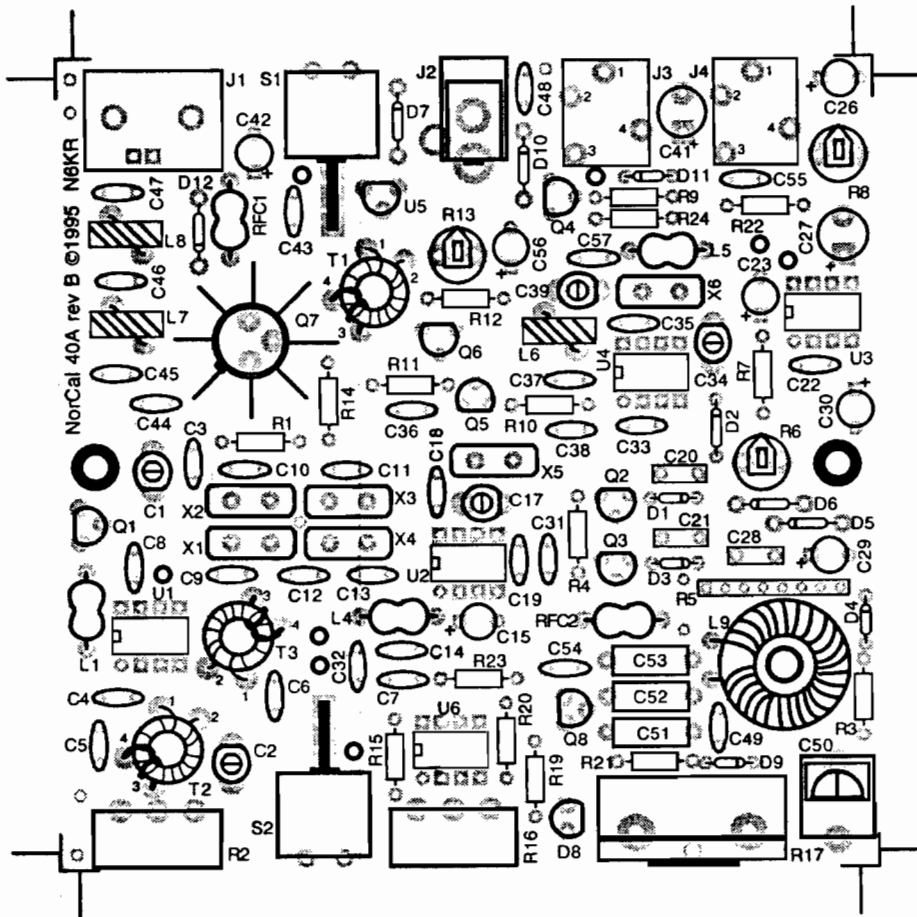
# Appendix A: NorCal 40A parts List

Rev. C, 2-20-96

Drawing	Ref.	Description, markings ("")	Part Number	Source	Qty
	C4,C31,C37	CAP,DISC,5pF,10% ("5")	140CD50S2-00-5J	MOUSER	3
	C6,C14,C49	CAP,DISC,47pF,5% ("47")	P4452-ND	DIGIKEY	3
	C38	CAP,DISC,100pF,5% ("101")	1313PH-I	DIGIKEY	1
	C32	CAP,DISC,150pF,5% ("151")	P4026-ND	DIGIKEY	1
	C9-13,C18,C35	CAP,DISC,270pF,5% ("271")	P4029-ND	DIGIKEY	7
	C45,C47	CAP,DISC,330pF,5% ("331")	P4030-ND	DIGIKEY	2
	C46	CAP,DISC,820pF,5% ("821")	P4035-ND	DIGIKEY	1
	C5,C7,C19,C22, C48,C55	CAP,DISC,.01μF,20%,25V ("103")	P4424-ND	DIGIKEY	6
	C3,C8,C33,C36, C43,C44,C54,C57	CAP,DISC or MONO,.047μF,20%,25V ("473")	P4428-ND	DIGIKEY	8
	C51	CAP,POLY,390pF,5% ("390")	23PS139	MOUSER	1
	C52,C53	CAP,POLY,1200pF,5% ("1200")	23PS212	MOUSER	2
	C20,C21,C28	CAP,MYLAR,0.1μF,100V ("104")	140-PM2A104K	MOUSER	3
	C15,C23,C30	CAP,ELEC,2.2μF,25V ("2.2μF")	140-XRL25V2.2	MOUSER	3
	C26,C29,C42,C56	CAP,ELEC,10μF, 25V ("10μF")	140-XRL25V10	MOUSER	4
	C27,C41	CAP,ELEC,100μF,25V ("100μF")	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
	D1-4,D9,D11	DIODE,SWITCHING	1N914 or 1N4148	DIGIKEY	6
	D12	DIODE,ZENER,36V,1W	333-1N4753A	MOUSER	1
	D5-7,D10	DIODE,SHOTTKY	1N5817 (alt: 1N5818)	DIGIKEY	4
	D8	DIODE,VARACTOR	MVAM108	Wilderness	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

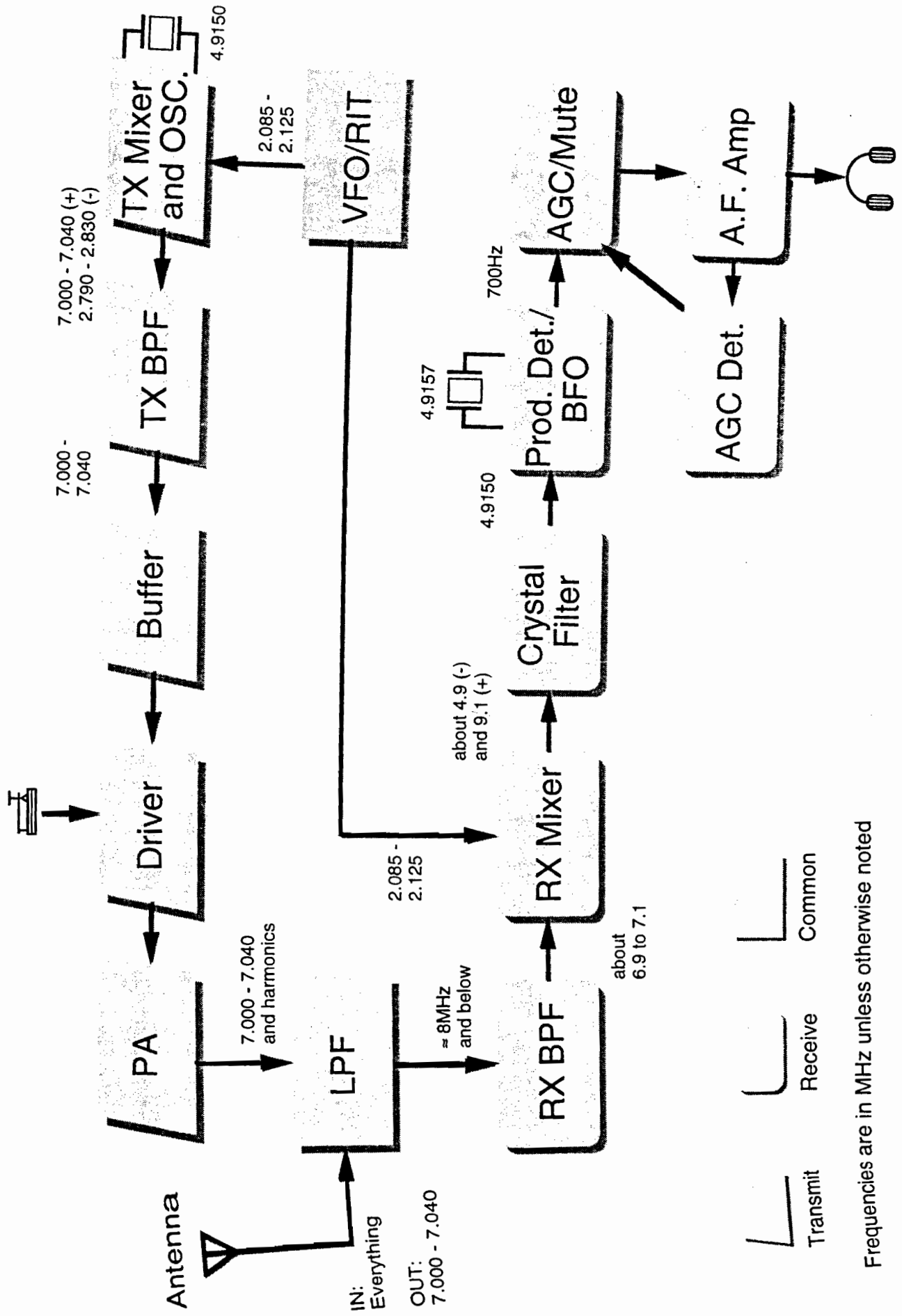
	P1 (MATING PLUG FOR J2)	PLUG,DC POWER,2.1MM	1710-2131	MOUSER	1
	L1	IND,CHOKE,15UH (brn-grn-blk)	43LS155	MOUSER	1
	L4,L5,RFC1	IND,CHOKE,18UH (brn-gray-blk)	43LS185	MOUSER	3
	RFC2	IND,CHOKE,1MH (brn-blk-red)	43LS103	MOUSER	1
	L6	IND,2.5μH,28T #28 (16")	T37-2 (red, 0.37")	AMIDON	1
	L7,L8	IND,1.3μH,18T #26 (12")	T37-2 (red, 0.37")	AMIDON	2
	L9	IND,21μH,60T #28 (56")	T68-7 (white, 0.68")	AMIDON	1
	T1	XFMR, PRI: 14T #26 (10"); SEC: 4T #26 (4")	FT37-43 (black w/ orange mark, 0.37")	AMIDON	1
	T2	XFMR, SEC: 20T #26 (14"); PRI: 1T #26 (2", see text)	FT37-61 (black, 0.37")	AMIDON	1
	T3	XFMR, PRI: 23T #28 (16"); SEC: 6T #26 (6")	FT37-61 (black, 0.37")	Wilderness	1
	R12	RES,20Ω,1/4W,5% (red-blk-blk)	20Q	DIGIKEY	1
	R14	RES,100Ω,1/4W,5% (brn-blk-brn)	100Q	DIGIKEY	1
	R10,R11,R15	RES,510Ω,1/4W,5% (grn-brn-brn)	510Q	DIGIKEY	3
	R1,R22,R23	RES,1.8K,1/4W,5% (brn-gray-red)	1.8KQ	DIGIKEY	3
	R20	RES,4.7K,1/4W,5% (yel-violet-red)	4.7KQ	DIGIKEY	1
	R7,R9,R19,R21	RES,47K, 1/4W, 5% (yel-violet-org)	47KQ	DIGIKEY	4
	R3, R24	RES,150K,1/4W,5% (brn-grn-yel)	150KQ	DIGIKEY	2
	R4	RES,8.2M,1/4W,5% (gray-red-grm)	8.2MQ	DIGIKEY	1
	R4 alternate	RES,15M,1/4W,5% (brn-grn-blue)	15MQ	DIGIKEY	1
	R5	RES. NETWORK, 8-PIN SIP,2.2M	BOURNS 4608X-102-225	Wilderness	1
	R8,R13	RES,TRIMMER,500Ω	36C52-ND	DIGIKEY	2
	R6	RES,TRIMMER,10K	36C14-ND	DIGIKEY	1
	R2, R16	RES,PANEL MOUNT POT,1K	31CW301	MOUSER	2
	R17	RES,PANEL MOUNT POT,10K	314-1410-10K	MOUSER	1
	S1,S2	SWITCH, SPDT, PC-MT, RIGHT ANGLE, THD BUSHING	CK 7101SDAV2QE	Wilderness	2
	Q1	TRANS,NPN,2N4124,TO-92	592-2N4124	MOUSER	1
	Q6	TRANS,NPN,2N2222A,TO-92	592-PN2222A	MOUSER	1
	Q2,Q3,Q5,Q8	TRANS,JFET,J309,TO-92	J309	Wilderness	4
	Q4	TRANS,PNP,2N3906,TO-92	592-2N3906	MOUSER	1
	Q7	TRANS,NPN,2SC799,TO-5 (alt: 2N3553)	2SC799 or Equiv.	Wilderness	1
	U3	IC,AF AMP	LM386N-1	DIGIKEY	1
	U6	IC,COMPARATOR	LM393N	DIGIKEY	1
	U1,U2,U4	IC,MIXER/OSC	NE602AN	Wilderness	3

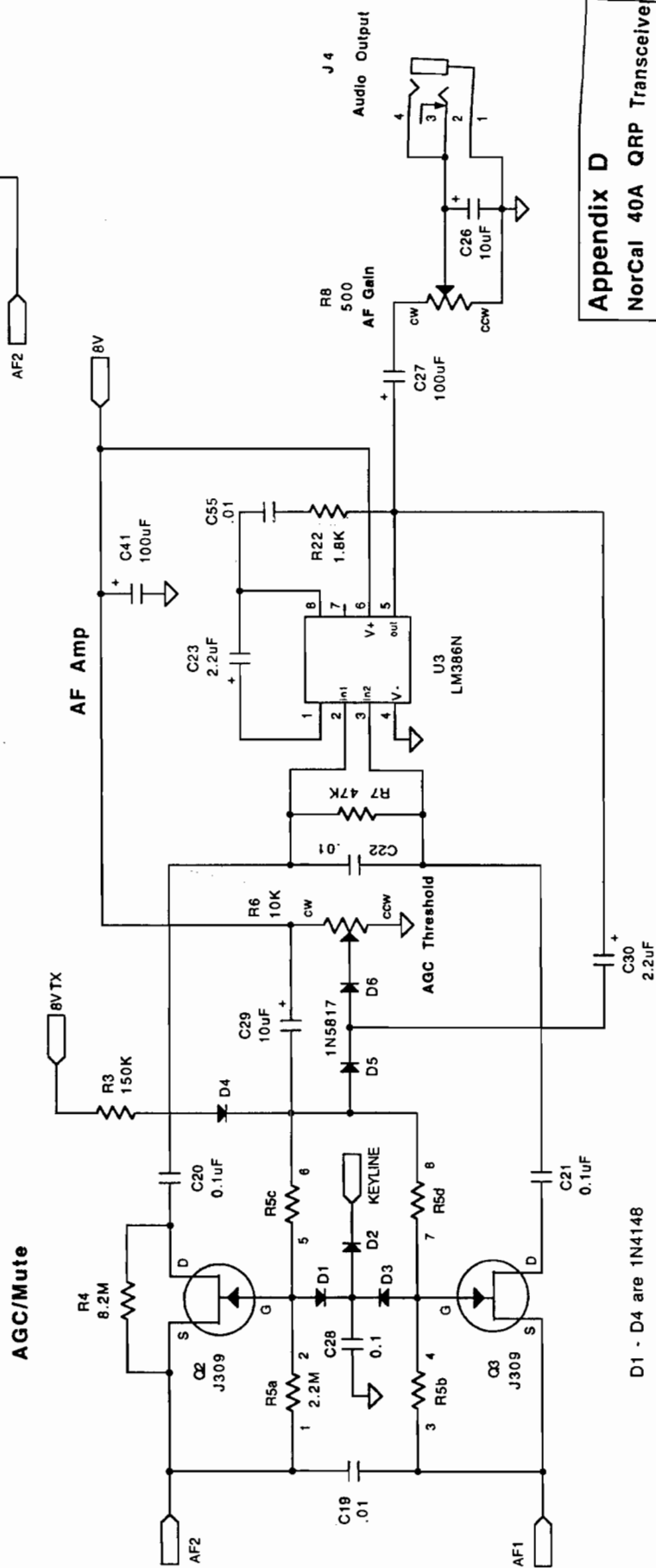
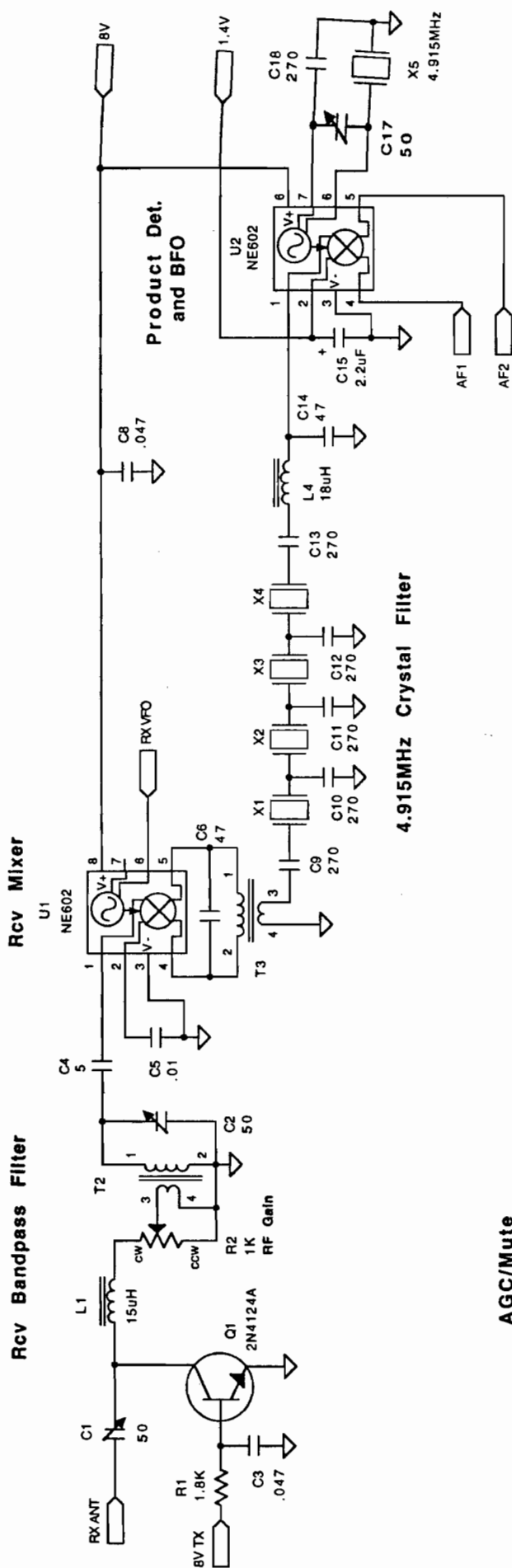
	U5	IC,VOLTAGE REG.,8V,TO-92	AN78L08	DIGIKEY	1
	X1-6	CRYSTAL, 4.915 MHZ, HC-49 (matched +/- 20HZ)	CTX050-ND	DIGIKEY	6
	MISC	CABINET, NORCAL 40A, SILKSCREEND AND PAINTED	n/a	Wilderness	1
	MISC	MANUAL, NORCAL 40A	n/a	Wilderness	1
	MISC	PC BOARD, NORCAL 40A	n/a	Wilderness	1
	MISC	FOOT, RUBBER	SJ5518-0-ND	DIGIKEY	4
	MISC	CRYSTAL SPACER	BIVAR CI-192- 028SR	Wilderness	6
	MISC	TO-5 TRANSISTOR SPACER	BIVAR 515-020	Wilderness	1
	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	Wilderness	6
	MISC	SCREW, FLAT HEAD 4-40 X 5/16", STEEL/ZINC, PHILLIPS	n/a	Wilderness	6
	MISC	#4 hex nut (small)	n/a	Wilderness	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)	Wilderness	2
	MISC	WIRE,#26 ENAMEL, 8 FEET	n/a	Wilderness	1
	MISC	WIRE,#28 ENAMEL, 8 FEET	n/a	Wilderness	1



Appendix B Component Placement Drawing

# Appendix C - NorCal 40A Block Diagram





## Appendix D

**NorCal 40A QRP Transceiver**

Wayne Burdick, N6KR

Rev. B, 7-10-95 Sheet 1 of 2