



**Hendricks QRP Kits  
BITX17A  
Assembly Manual**

*22 March 2009*

The BITX20 idea originated with a transceiver designed by Ashar Farhan, VU2ESE that was intended to be easy to build from surplus and salvage components. That transceiver has been built and used with great success by many hams worldwide. [WWW.QRPKITS.COM](http://WWW.QRPKITS.COM) has made a PCB based kit of the original BITX20. This is the BITX20A Kit. Recently Nigel, G0EBQ modified assembly of the BITX20A PCB for operation on 17 Meters. The BITX17A by Hendricks QRP Kits is a 17 meter band PCB realization of the original BITX20 design which includes a parts kit so you don't have to locate all the necessary components. In addition, several upgrades have been added to make the transceiver output cleaner and to raise power output to the full QRP limit of 10 watts.

There is a BITX discussion group available at: <http://groups.yahoo.com/group/BITX20/>  
Doug Hendricks KI6DS web site for kit sales is at: <http://www.qrpkits.com>  
Farhan's original BITX20 design web site is at: <http://www.phonestack.com/farhan/bitx.html>

This is how your new BITX17A kit will look as delivered.



Photo by KC0WOX

No, you don't get the pen or the wire stripper, just the box of parts.



Illustration 1: PCB in Optional Chassis Kit

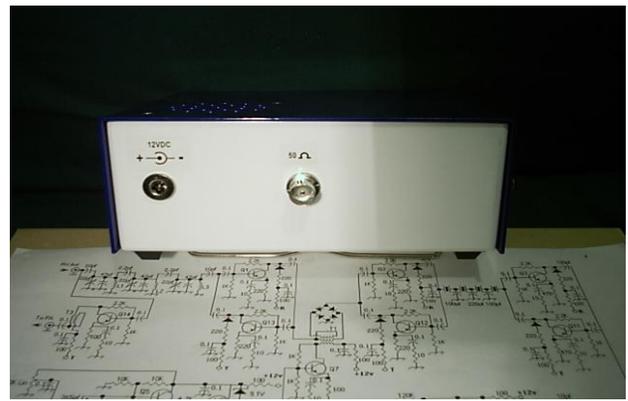


Illustration 2: Rear-View of the Chassis Kit

Opening the box you will see bags of parts and a PC Board.



Photo by KC0WOX



Photo by KC0WOX

Parts Inventory:

<b>Quantity</b>	<b>Value</b>	<b>Device</b>	<b>Quantity</b>	<b>Value</b>	<b>Device</b>
1	160 pf	External tuning cap	1	2.2 ohm	Resistor
5	10 mfd	POLARIZED CAP	1	4.7 ohm	Resistor
7	100 mfd	POLARIZED CAP	9	10 ohm	Resistor
1	130 pf	POLYSTYRENE	2	22 ohm	Resistor
2	390 pf	POLYSTYRENE	13	100 ohm	Resistor
4	30 pf	Trim capacitor	16	220 ohm	Resistor
			2	470 ohm	Resistor
1	0.01 mfd		3	10K ohm	Resistor
41	0.1 mfd		2	150 K ohm	Resistor
3	8.2 pf		17	1K ohm	Resistor
6	100 pf		11	2.2K ohm	Resistor
1	15 pf		1	2.7K ohm	Resistor
2	180 pf		1	22K ohm	Resistor
1	120 pf		1	3.3K ohm	Resistor
2	220 pf		11	4.7K ohm	Resistor
3	33 pf		5	12.96 MHz	XTAL/S
1	0.022 mfd				
			<b>Quantity</b>	<b>Value</b>	<b>Device</b>
1	56 pf		1	33v	ZENER 33V **
1	6.8 pf		1	5.6v	ZENER 5.6V **
3	82 pf		1	9.1v	ZENER 9.1V **
5	68 pf		1	1N4004	Diode
1	47 pf		12	1N4148	Diode **

<b>Quantity</b>	<b>Value</b>	<b>Device</b>	<b>Quantity</b>	<b>Value</b>	<b>Device</b>
16	2N3904	Transistor	1	SB320	Diode
1	2N5486	Transistor	2		HEATSINK
4	2N7000	Transistor	1		RELAY
2	BS170	MOSFET			
1	FQN1N50C	MOSFET			
1	LM386N-4	AF PA			
2	IRF510	MOSFET	<b>Quantity</b>	<b>Value</b>	<b>Device</b>
2	200 ohm	3318_TRIMMER*	1	1.0 uH	molded choke
3	10K ohm	3318_TRIMMER	1	6.8 uH	molded choke
1	10k ohm	Fine tune external pot	8	FT37-43	Toroid Core (Black)
1	10K ohm	Volume control external	5	T37-6	Toroids Core (Yellow)

\* If you read the 200 ohm trimmer designation upside down it looks like "102". Make sure you read the label correctly.

\*\* Small glass encased diodes are labeled on the body. You may need a magnifying glass to see the writing. Using a bright light and holding the diode in front of a white surface also helps.

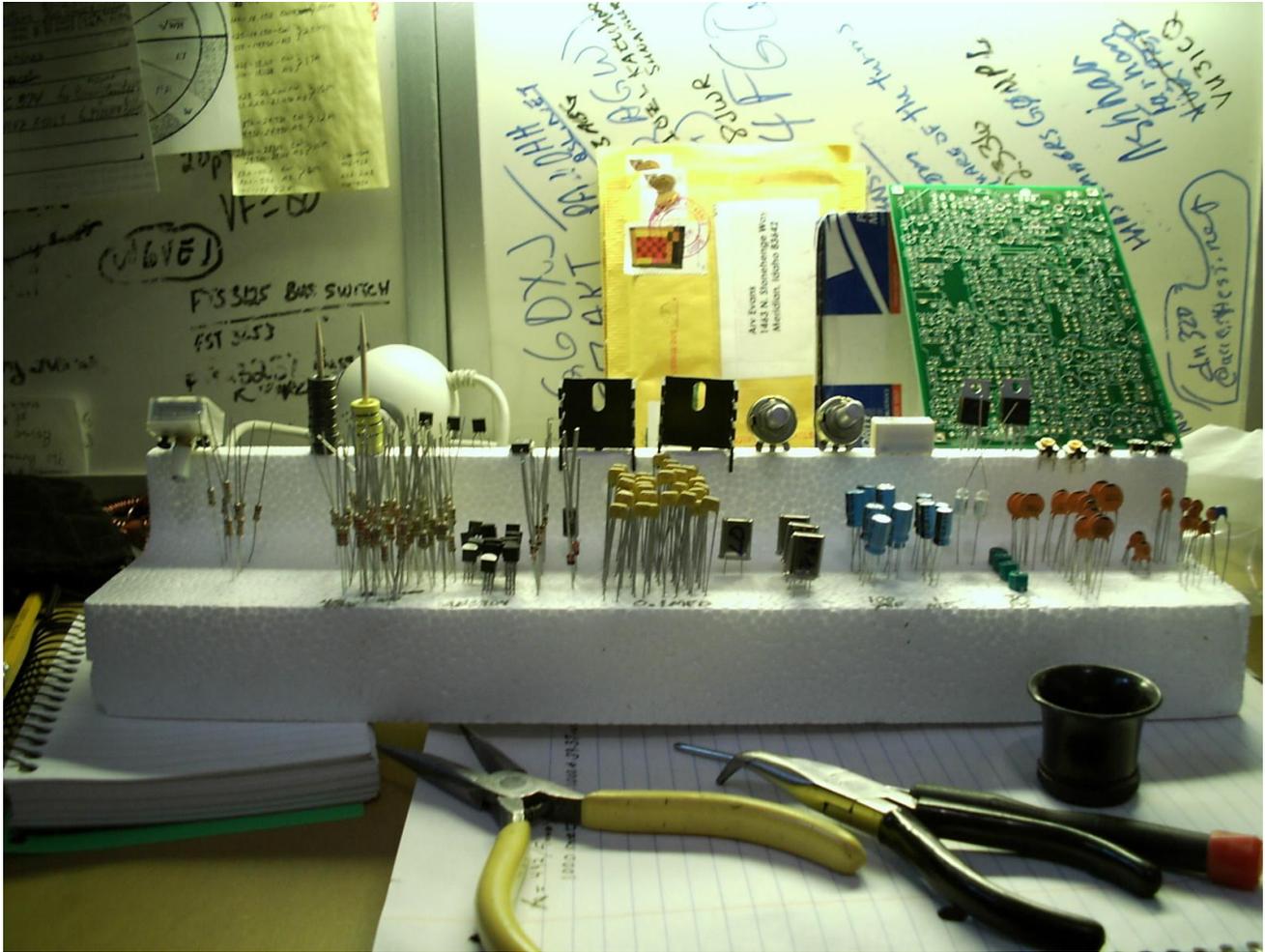


Photo by K7HKL

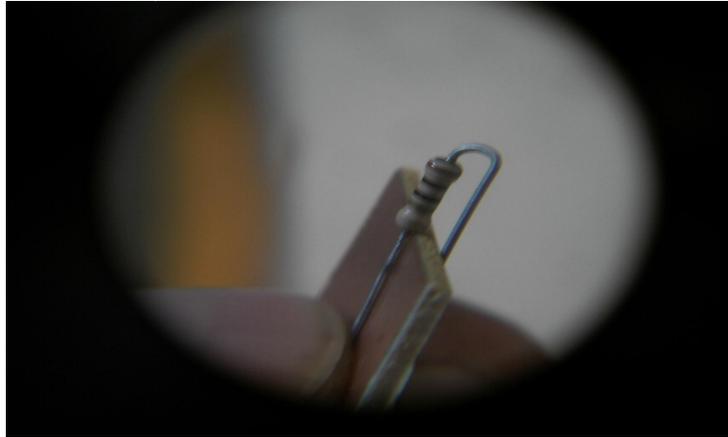
It is advisable that you inventory your parts to make sure everything is available and ready for assembly. Each builder may have his/her own way of organizing parts, but if you do not, you might try using a block of Styrofoam packing material as shown in the above picture (cover the Styrofoam with aluminium foil if you worry about static charge damaging components). Parts are sorted by type and size (ohms, micro-farads, etc). Toroid cores in this picture are stacked on wooden toothpicks which were inserted into the Styrofoam. Screws, bolts, and other hardware can be kept in a small plastic food container until you are ready to use them.

A few wooden toothpicks, the round kind, can be a great help if you have to open up a solder filled thru-hole in your PCB, or clear solder from the opening in a potentiometer terminal. Look for the kind that are made from hardwood instead of the very inexpensive softwood kind.

### Some Assembly Recommendations:

Before you start assembling your new BITX17A, there are a few things you might want to review.

1. Most of the resistors, diodes, and some axial leaded capacitors in this kit are installed on end. To make your kit look more professional, it is advisable to bend the longer lead of these components over a scrap of PCB material so that all your exposed lead bends look approximately the same.



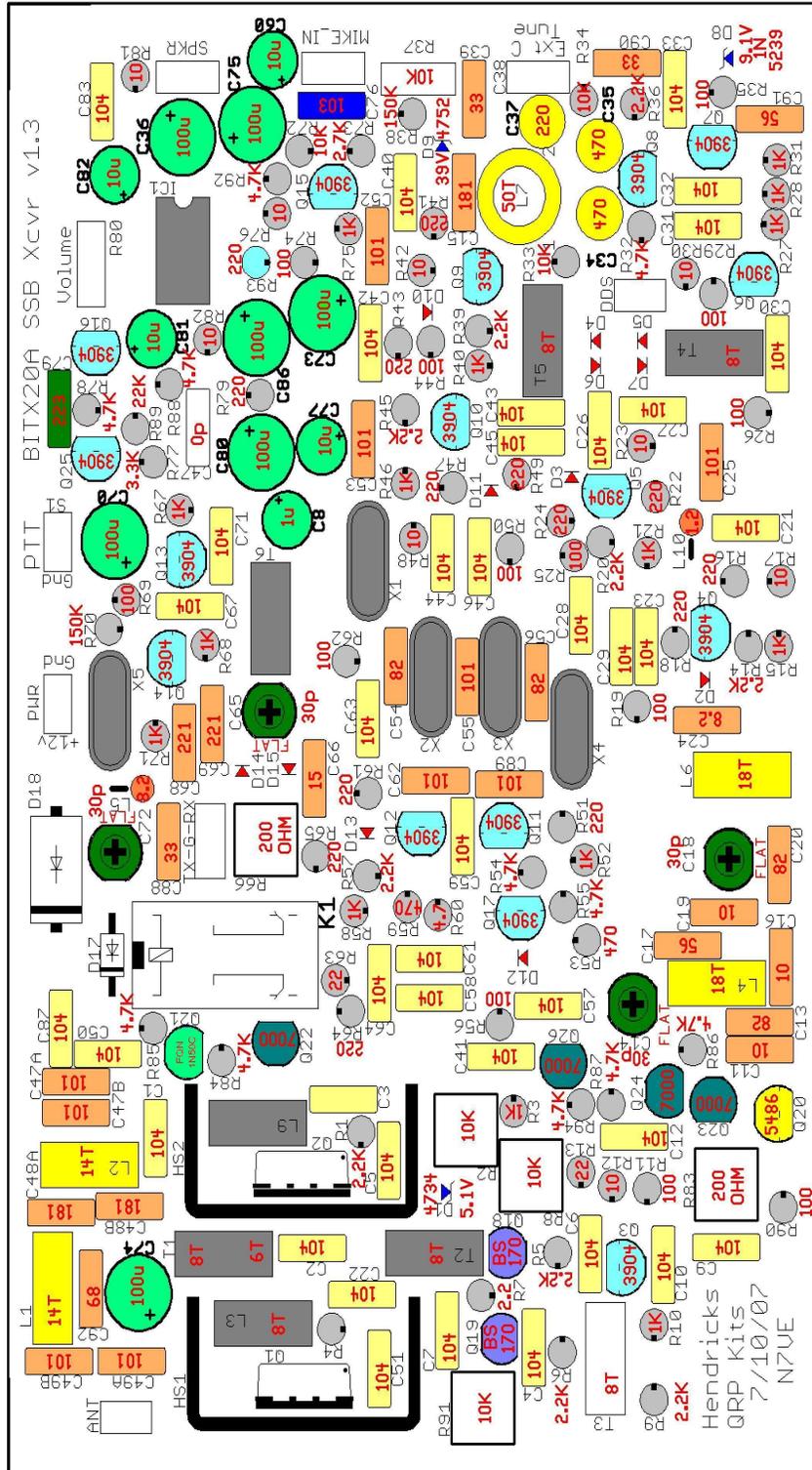
2. You will be twisting enamel coated wires together to make windings for toroid transformers. To do this you can use the drill and bent nail method or fabricate a manual twisting device from stiff wire and a tubular insulator.



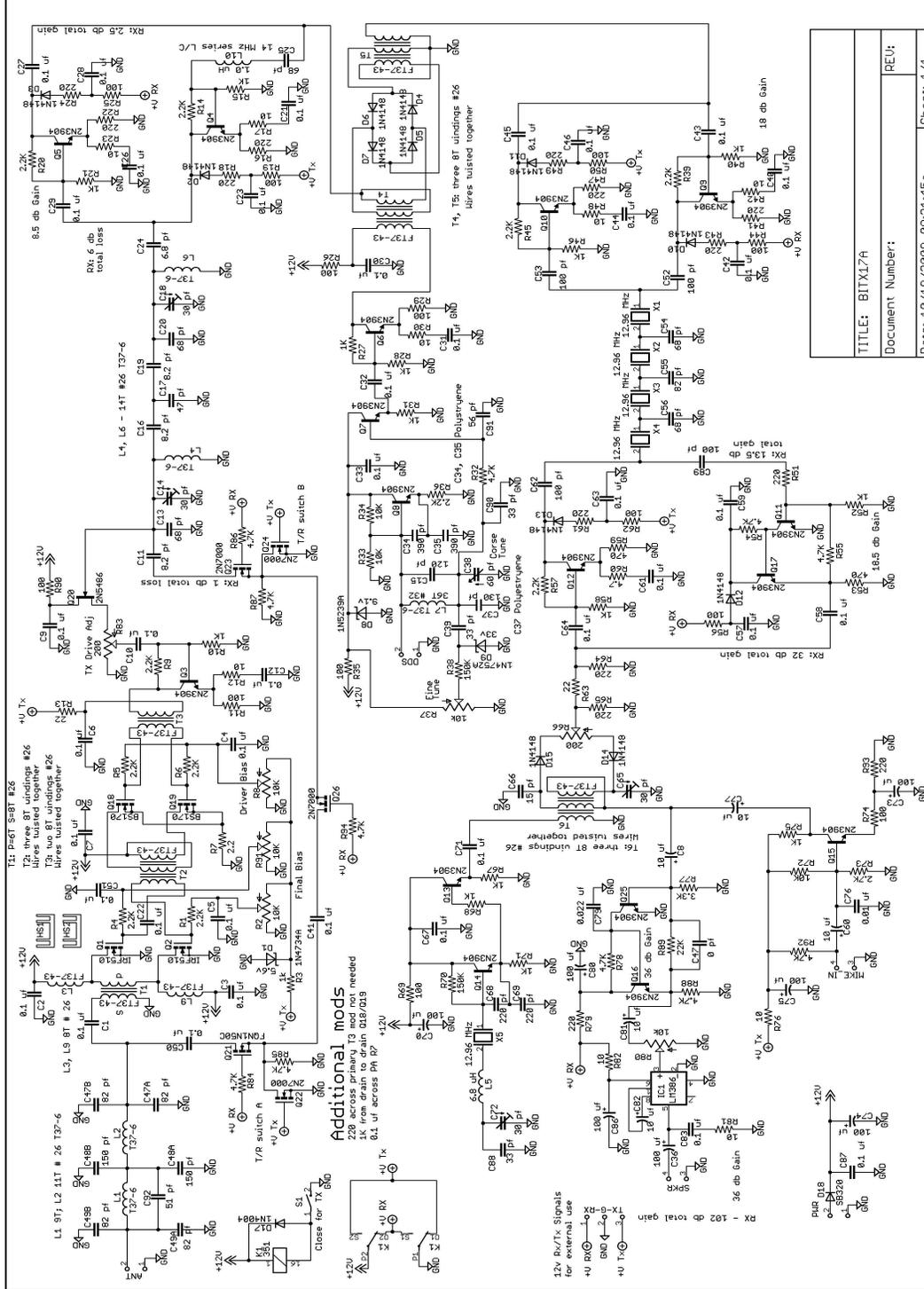
3. Be especially observant of component orientation stenciled on the PCB. Polarized components must be installed correctly. In some cases the exposed lead on a resistor or capacitor is specifically selected to provide test equipment access for tune up and troubleshooting.

# Parts Placement Diagram:

( Drawing by KD1JV )



# Schematic Diagram:



TITLE: BITXL7H
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Date: 10/18/2008 09:31:45a
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(Drawing by N7VE)

## Kit Assembly:

### Receive-Transmit Power Changeover Relay and Power Input Components



*Illustration 3: D-17 and D-18 Installation (N7VE Photo)*

- [ ] D-17, 1N4004      Observe Polarity
- [ ] K1, 351 Relay      Hold the relay body flat to the PCB while soldering.
- [ ] Connect push-to-talk part of microphone connector, or a temporary momentary switch as PTT.

Note: Pads for the push to talk connection are provided along one edge of the board and are marked as “PTT” with the ground pad also marked with “Gnd”. Or if you do not want to connect your microphone jack yet, you can just solder a small momentary switch across these pads for testing purposes during alignment.

Caution: The changeover relay applies ground to the receive section power feeds during transmit mode and ground to transmit power feeds during receive mode. This means that you cannot jumper +12 volts to the transmit sections while in receive mode, and cannot jumper +12 volts to the receive sections when in transmit mode without shorting something and possibly damaging your PCB or components.

- [ ] D-18, SB320 Observe Polarity
- [ ] C-87, 0.1 mfd (marked 104)
- [ ] C-74, 100 mfd Observe Polarity

- Solder
- Clip Excess Lead Length
- Inspect Solder Connections

**TEST:** At this time you can apply +12 volts and test the relay by shorting the PTT pads. Measure Receive and Transmit voltages to see that power is being transferred properly.

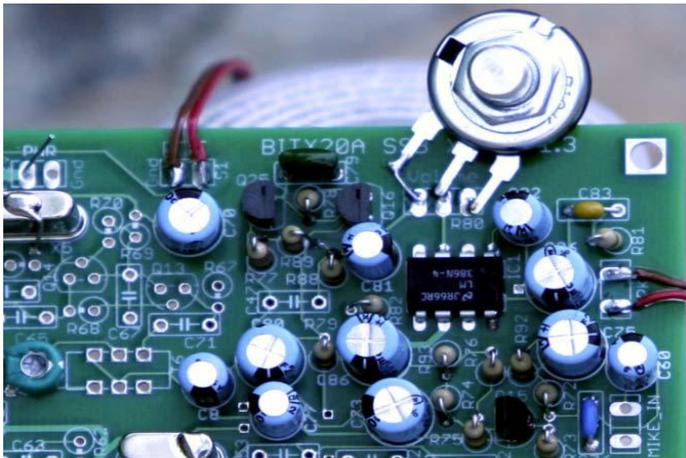


Illustration 4: Receive Audio Pre-Amplifier (N7VE Photo)

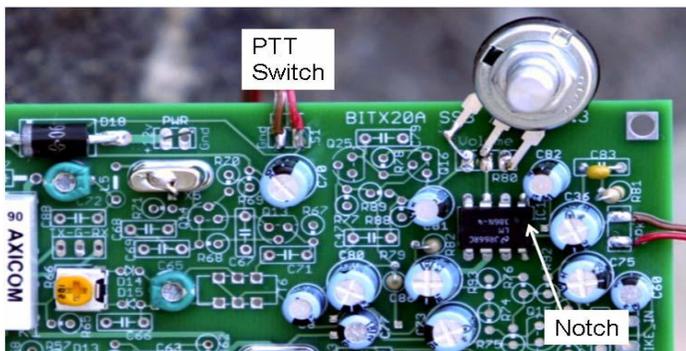


Illustration 5: Receive Audio LM-386 Power Amplifier (N7VE Photo)

### **Receiver AF Amplifier**

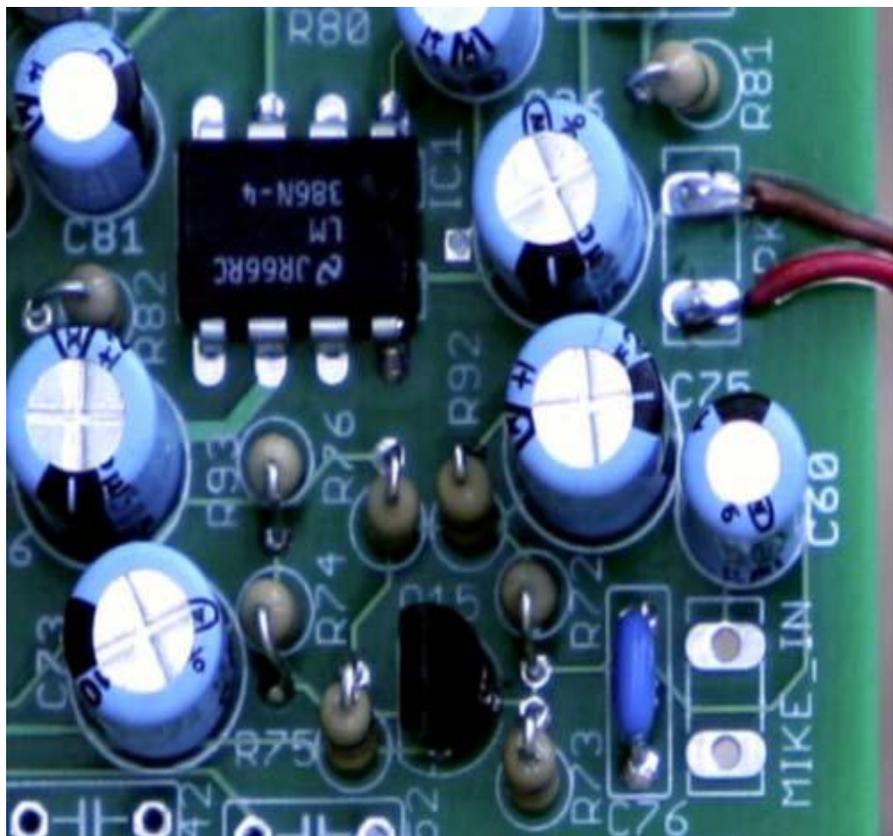
- C-36, 100 mfd Observe Polarity
- C-83, 0.1 mfd (marked "104")
- R-81, 10 ohms (brown-black-black)
- C-82, 10 mfd, Observe Polarity

- IC-1, LM386, Make sure you get this positioned properly when you insert it.
  
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
  
- C86, 100 mfd, Observe Polarity
  
- R-82, 10 ohms (brown-black-black)
  
- R-79, 220 ohms (red-red-brown)
  
- R-80, 10K ohm potentiometer NOTE: Off-board component. Use 6 inch leads.  
Ground lead near C-82, Hot lead near Q-16.
  
- C-81, 10 mfd Observe Polarity
  
- C-80, 100 mfd Observe Polarity
  
- R-78, 4.7K ohms (yellow-violet-red)
  
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
  
- Q-16, 2N3904 (Position as stenciled on the PCB)
  
- Q-25, 2N3904 (Position as stenciled on the PCB)
  
- R-88, 4.7K ohms, (yellow-violet-red)
  
- R-89, 22K ohms (red-red-orange)
  
- C-47, 0 pf (This is an artifact from an older PCB design. Do not install any capacitor here.)
  
- C-79, 0.022 mfd (marked 22K)
  
- R-77, 3.3K ohms (orange-orange-red)
  
- C-8, 10 mfd Observe Polarity
  
- Speaker or Headphone Jack Connection. Use 6 inch leads.

Ground is the pad near C-75.

- [ ] Solder
- [ ] Clip Excess Lead Length
- [ ] Inspect Solder Connections

**TEST:** At this point you can test your receiver audio amplifier by connecting a speaker, and applying +12 volts to the power input pads. Insert a tone at the negative side of C8, and adjust the volume control for a comfortable listening level.



*Illustration 6: Transmitter AF Amplifier (N7VE Photo)*

### Transmitter AF Amplifier (Microphone Amplifier)

R-76, 10 ohms (brown-black-black)

R-92, 4.7K ohms (yellow-violet-red)

NOTE: This is power for FET mike. Omit for dynamic or crystal mike.

C-60, 10 mfd Observe Polarity

C-76, 0.01 mfd (marked 103)

R-73, 2.7K ohms (red-violet-red)

R-72, 10K ohms (brown-black-orange)

R-75, 1K ohms (brown-black-red)

Solder

Clip Excess Lead Length

Inspect Solder Connections

Q-15, 2N3904 (position matching that stenciled on PCB)

R-74, 100 ohms (brown-black-brown)

C-73, 100 mfd Observe Polarity

R-93, 220 ohms (red-red-brown)

C-77, 10 mfd Observe Polarity

C-75, 100 mfd Observe Polarity

Solder

Clip Excess Lead Length

Inspect Solder Connections

**TEST:** You can test the microphone audio stage by using an audio amplifier to monitor the negative side of C-77 while you key your microphone and talk into it. The exposed top of C-77 is its negative side and is a good place to touch a probe for monitoring microphone amplifier output, and also a place for inserting AF signal to test the receive audio amplifier section. If you touch your finger to this point

in receive mode you should hear some noise in the receive amplifier.

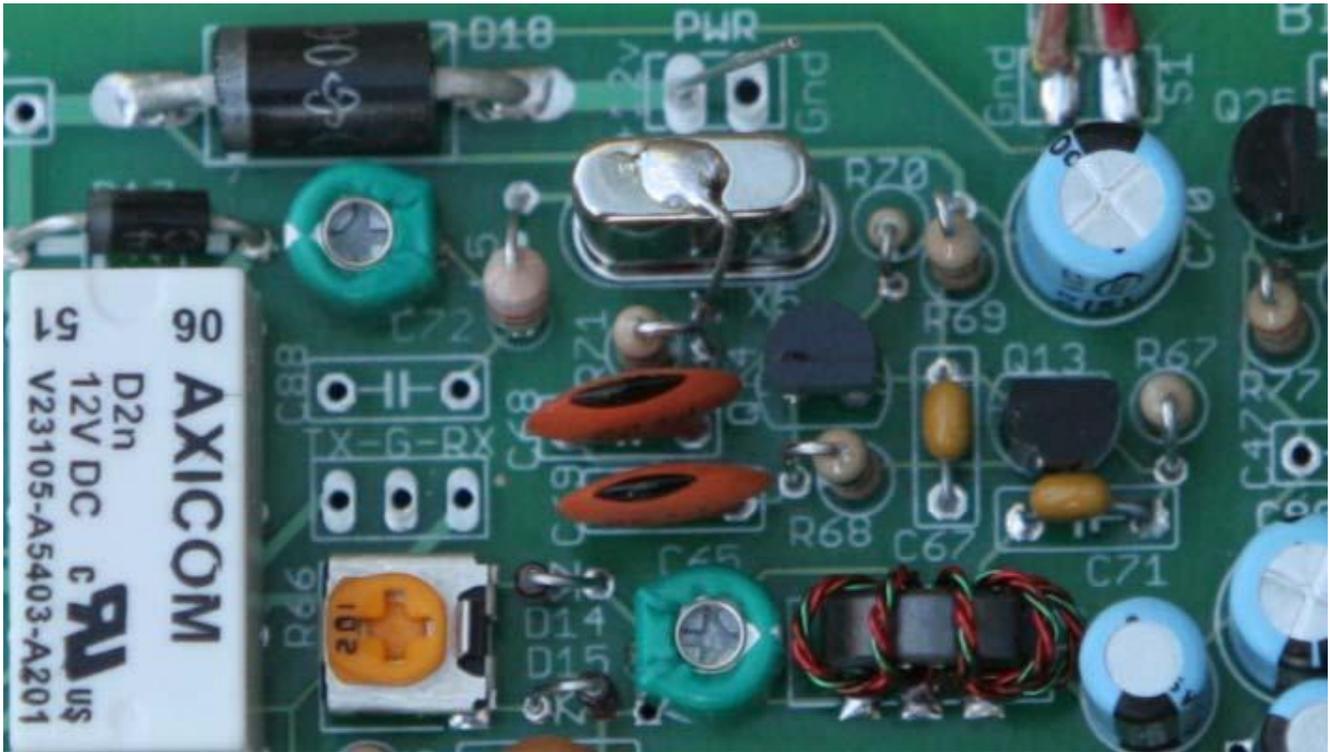
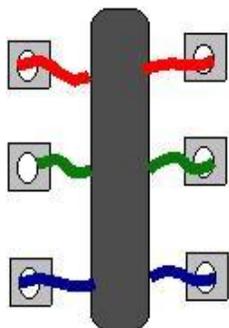


Illustration 7: BFO Mixer Section (N7VE Photo)

### **BFO Mixer Assembly**

[ ] T-6, 8:8:8 turns #28 trifilar on FT37-43 (black) core. This is three wires, each 6 inches long. Twist them together for 8 twists per inch and wind this on the core.

Note: Other kits might have you solder a pair of winding ends together to make up a center-tapped winding. In this kit you do not have to do that. The center-tap connections are made via PCB traces between transformer connection pads.



**Trifilar Transformer  
Winding Connections**

Match up the winding ends on each side of the transformer by wire color, or by using an ohmmeter to identify individual windings if you made all the windings with a single color of wire.

Illustration 8: Toroid Detail, K7HKL Drawing

C-66, 15 pf (marked 15)

C-65, 30 pf variable capacitor. Note: Flat side is RF side, round side is ground.  
If you get this installed backwards, it will detune the circuit when you put a metallic screwdriver in it to make adjustments.

R-66, 200 ohm PCB type potentiometer. Marked "201". Looks like "102" if read upside down!

R-65, 220 ohms (red-red-brown)

R-63, 22 ohms (red-red-black)

R-64, 220 ohms (red-red-brown)

**NOTE:** Pay particular attention to the location and values of R-63, R-64, and R-65.  
If you get these in the wrong places your receiver sensitivity and transmitter power output may be degraded. Swapping the 22 ohm resistor with one of the 220 ohm resistors is a common mistake in early BITX units and possibly in BITX17A kits.

Solder

Clip Excess Lead Length

Inspect Solder Connections

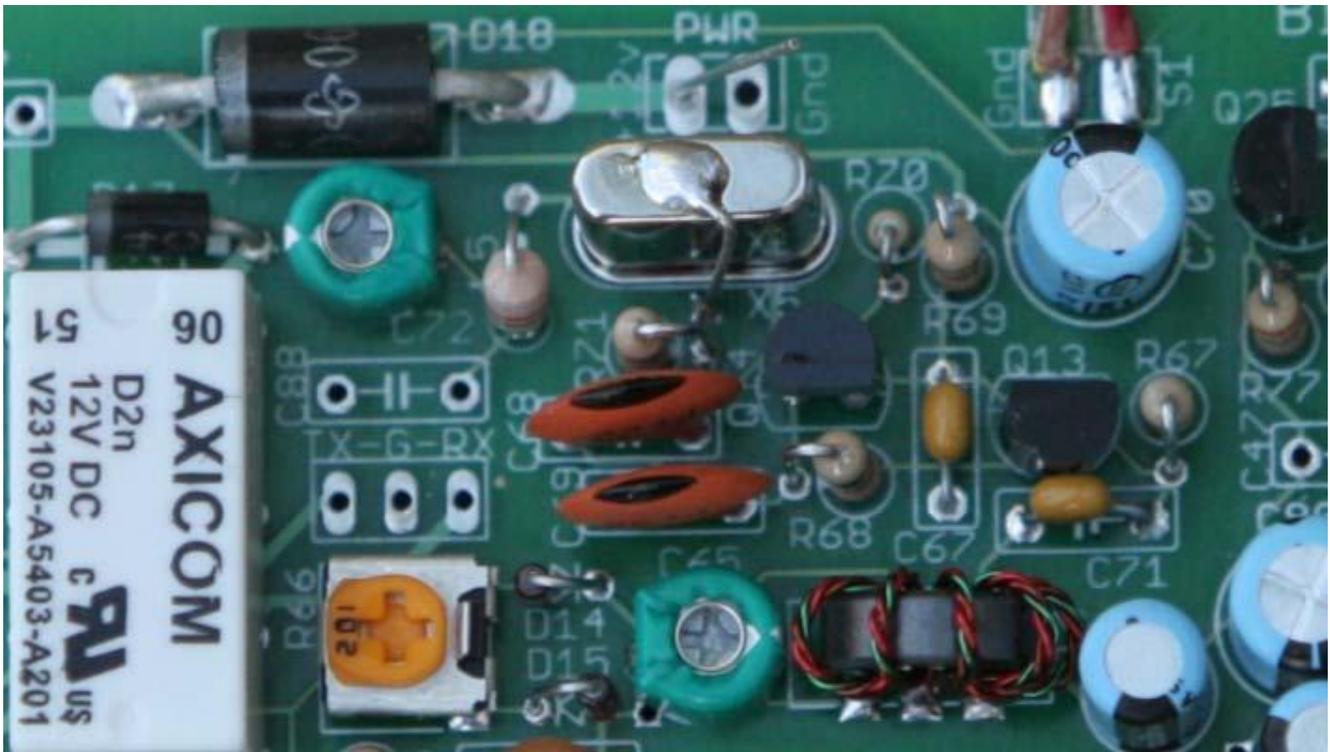


Illustration 9: BFO/Carrier Oscillator Section (N7VE Photo)

### **BFO & Carrier Oscillator**

- C-88, 33 pf                    NOTE: May not be needed, but provided to insure adequate tuning range.
- C-72, 30 pf variable capacitor,    Note: flat side is RF side, round side is ground.
- L-5, 6.8 uh molded inductor (looks like a fat resistor with blue-gray-gold-gold bands)
- X-5, 12.96 MHz Crystal.     Add ground wire soldered to crystal case
- C-68, 220 pf (marked 221)
- C-69, 220 pf (marked 221)
- R-70, 150K ohms (marked brown-green-yellow)
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
- Q-14, 2N3904 (Position according to layout stenciled on PCB)

- R-71, 1K ohms (brown-black-red)
- C-70, 100 mfd Observe Polarity
- R-69, 100 ohms (brown-black-brown)
- R-68, 1K ohms (brown-black-red)
- Q-13, 2N3904 (Position according to layout stenciled on PCB)
  
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
  
- C-67, 0.1 mfd (marked 104)
- C-71, 0.1 mfd (marked 104)
- R-67, 1K ohms (brown-black-red)
- D-14, 1N4148 Observe Polarity
- D-15, 1N4148 Observe Polarity
  
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections

**TEST:**

Insert a 12.960 MHz signal across R-64 (at the junction of R-64, C-64, and C-58) and listen for a beat-note from the receive audio amplifier. You may have to tune up or down a couple of Khz to find the signal.

If you temporarily connect a few feet of wire or an antenna through a 100 pf capacitor to the junction of R-64, C-64, and C-58 you should hear noise and probably some AM broadcast signals.

You may hear strong hum or oscillation sounding signal at this time. This is usually because the balanced modulator is not balanced. If you are monitoring the junction of R64, C-64, and C-58, with an oscilloscope or diode probe on a volt meter you should be able to “null” the carrier level at that point by adjusting C-65 and R-66. There is some interaction, so go over the adjustment several times to get the deepest null. If you do not have a scope or diode probe, then just adjust for minimum noise (this adjustment will be addressed again during final adjust procedures).

Once the modulator is properly balanced you should not hear any audio oscillation that may have been present earlier.

Connect a frequency counter to the exposed wire side of R-67. You should see a signal that is close to 12.96 MHz. Try adjusting C-72 while observing the frequency. You should be able to change the frequency by approximately 1 KHz (maybe a bit more if you did not install C-88).

#### OPTIONAL STEP:

The crystals supplied for the crystal filter should provide an acceptable bandpass if they are randomly selected, but you now have the option of further categorizing them by finding their relative frequency. If you decide to do this step, you can use the BFO oscillator to perform the test. This involves connecting each of your crystals individually into the BFO oscillator and measuring the frequency output. *Do not solder each crystal, just bend the leads so there is some contact pressure when you insert them into the PCB holes.* Each crystal should then be marked with it's default frequency, and the 4 crystals which are closest in frequency selected for the crystal filter. The remaining crystal should then be soldered into the BFO circuit to become the BFO oscillator crystal of choice. It does not really matter how much capacitance you have in C-72 for this test. What is important is that you don't change it while making frequency comparison measurements.

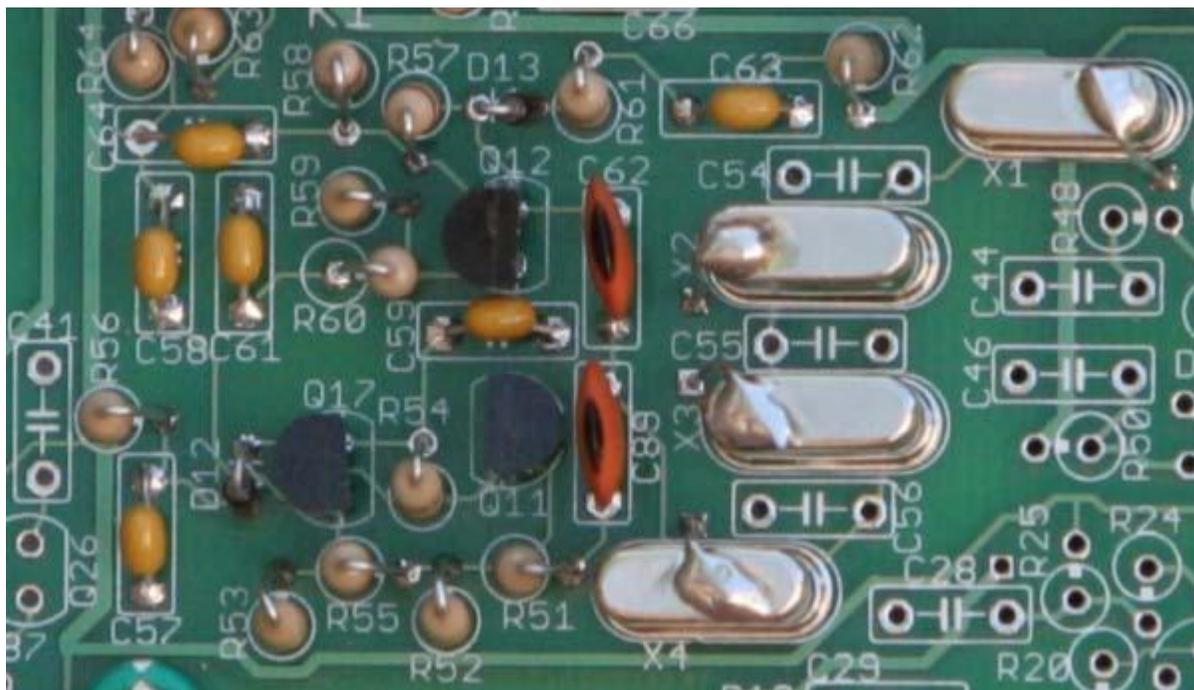


Illustration 10: Second IF Amp Section (N7VE Photo)

### **Receive 2nd IF Amp and Transmit 1st IF Amp**

- C-64, 0.1 mfd (marked 104)
- R-58, 1K ohms (brown-black-red)
- R-57, 2.2K ohms (red-red-red)
- Q-12, 2N3904 (Position according to marking stenciled on PCB)
- R-60, 4.7 ohms (yellow-violet-gold)
- C-61, 0.1 mfd (marked 104)
- R-59, 470 ohms (yellow-violet-brown)
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
- D-13, 1N4148 Observe Polarity
- R-61, 220 ohms (red-red-brown)
- C-63, 0.1 mfd (marked 104)
- R-62, 100 ohms (brown-black-brown)
- R-56, 100 ohms (brown-black-brown)
- C-57, 0.1 mfd (marked 104)
- D-12, 1N4148 Observe Polarity
- Q-17, 2N3904 (Position according to layout stenciled on PCB)
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
- C-58, 0.1 mfd (marked 104)

- R-53, 470 ohms (yellow-violet-brown)
- R-55, 4.7K ohms (yellow-violet-red)
- R-52, 1K ohms (brown-black-red)
- Q-11, 2N3904 (Position according to markings stenciled on PCB)
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
- R-54, 4.7K ohms (yellow-violet-red)
- C-59, 0.1 mfd (marked 104)
- R-51, 220 ohms (red-red-brown)
- C-89, 100 pf (marked 101)
- C-62, 100 pf (marked 101)
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections

**TEST:** Insert a 12.96 MHz signal at the junction of C-62 and C-89, and listen for a beat-note from the receive audio amplifier. You have quite a bit of gain now, so it may not be necessary to actually connect your signal generator to the C-62 and C-89 junction. Just bringing a lead from the signal generator close to the PCB may be enough for a strong zero-beat.

If you have an oscilloscope or diode probe and voltmeter you can connect these to the junction of C-62 and C-89. When you key the transmitter you should see the infamous “10 millisecond burst-of-carrier” that is present in almost all BITX series transceivers when the mike is keyed. If you temporarily unbalance the modulator (connect an ungrounded clip lead to either D-14 or D-15) you should be able to measure some RF on your scope or voltmeter.

Now might be a good time to fine-tune the carrier balance. Remove any test equipment except for the scope or voltmeter probe attached to the junction of C-62 and C-89. Add a short across the microphone connection so there will be no audio input. Key your transceiver and adjust C-65 and R-66 for minimum voltage indication. These adjustments are interactive so you need to repeat this several times until no more improvement is possible. Carrier balance to less than 10 millivolts is normal, but this is somewhat dependent on how quiet your power supply might be.

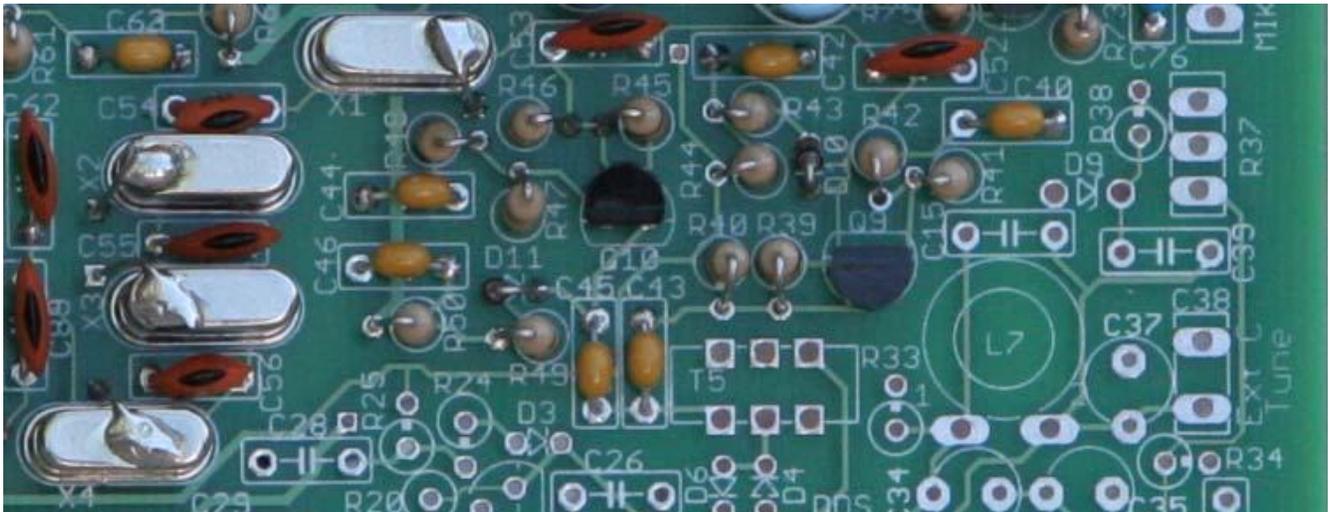


Illustration 11: Crystal Filter Section (N7VE Photo)

### **Crystal Filter**

C-56, 68 pf (marked 68)

C-55, 82 pf (marked 82)

C-54, 68 pf (marked 68)

X-1, 12.96 MHz  Add ground wire soldered to crystal case

X-2, 12.96 MHz  Add ground wire soldered to crystal case

X-3, 12.96 MHz  Add ground wire soldered to crystal case

X-4, 12.96 MHz  Add ground wire soldered to crystal case

Solder

Clip Excess Lead Length

Inspect Solder Connections

**TEST:** Insert a 12.96 MHz signal at pin-1 of X-1 and listen for a beat-note from the receive audio amplifier. You may have to tune around a bit to get the signal within the filter passband. It is not possible do meaningful testing of the filter bandwidth just yet because the input impedance is not properly matched. This is just a continuity test to insure that the filter components are properly

installed. You will evaluate the crystal filter bandwidth after building the next amplifier stage.

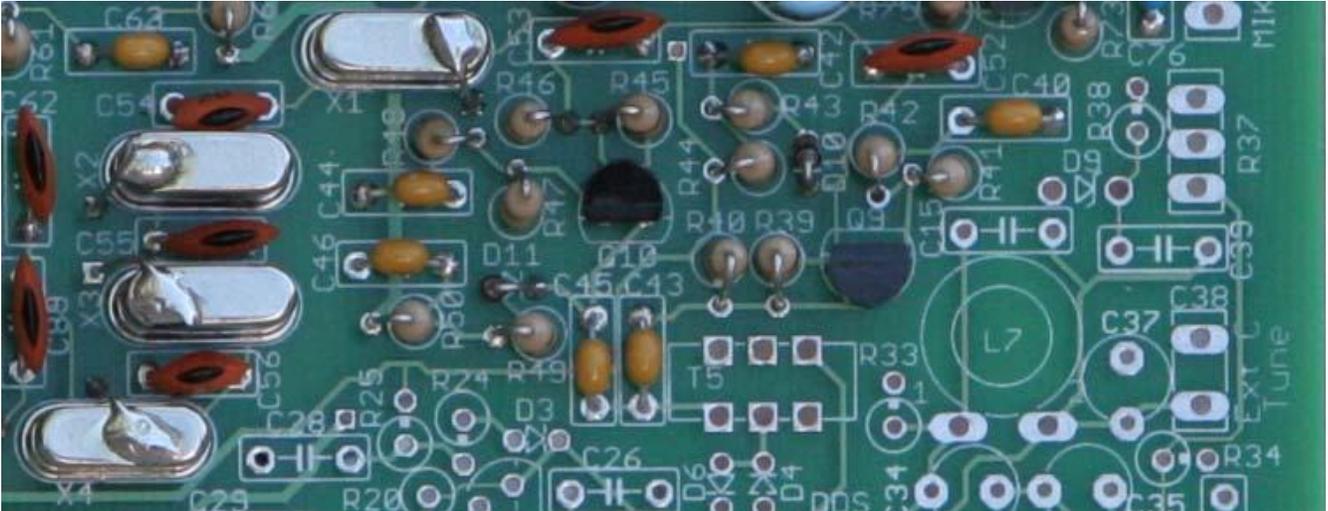


Illustration 12: Receiver First IF and Transmitter Second IF (N7VE Photo)

### **Receiver 1st IF and Transmitter 2nd IF**

- C-53, 100 pf (marked 101)
- R-46, 1K ohms (brown-black-red)
- R-45, 2.2K ohms (red-red-red)
- Q-10, 2N3904 (Position according to layout marked on PCB)
- R-48, 10 ohms (brown-black-black)
- C-44, 0.1 mfd (marked 104)
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
- R-47, 220 ohms (red-red-brown)
- D-11, 1N4148 Observe Polarity
- R-49, 220 ohms (red-red-brown)
- C-45, 0.1 mfd (marked 104)
- C-46, 0.1 mfd (marked 104)

- R-50, 100 ohms (brown-black-brown)
  
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
  
- C-52, 100 pf (marked 101)
  
- D-10, 1N4148 Observe Polarity
  
- R-43, 220 ohms (red-red-brown)
  
- C-42, 0.1 mfd (marked 104)
  
- R-44, 100 ohms (brown-black-brown)
  
- Q-9, 2N3904 (Position according to layout marked on PCB)
  
- R-39, 2.2K ohms (red-red-red)
  
- C-43, 0.1 mfd (marked 104)
  
- R-40, 1K ohms (brown-black-red)
  
- R-41, 220 ohms (red-red-brown)
  
- R-42, 10 ohms (brown-black-black)
  
- C-40, 0.1 mfd (marked 104)
  
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections

**TEST:** Insert a 12.96 MHz signal at the junction of C-43 and C-45, and listen for a beat-note from the receive audio amplifier.

At this point you have the first opportunity to see the IF Filter passband. If you slowly tune the 12.96 MHz signal across the IF frequency range while monitoring RF voltage at the un-grounded end of R-65 with an oscilloscope or an RF detection probe and voltmeter you can see the relative response at various frequencies. By recording the signal level at 200 Hz intervals

and plotting this on graph paper you can generate a picture of the IF filter response curve. Unless you convert your voltage readings to log scale though they will look a bit rough. For a truly representative graph you need to convert your voltage readings to db.

It is possible to set the BFO frequency now. Once you know where the lower edge of the IF filter passband is located, you can calculate the -20 db point on that slope and set your BFO for that frequency. Alternatively, you can adjust the BFO so you can hear the zero-beat as you tune across the upper sideband but not hear it on the lower sideband. That will get you in the right area for later fine tuning on a signal being received from the antenna.

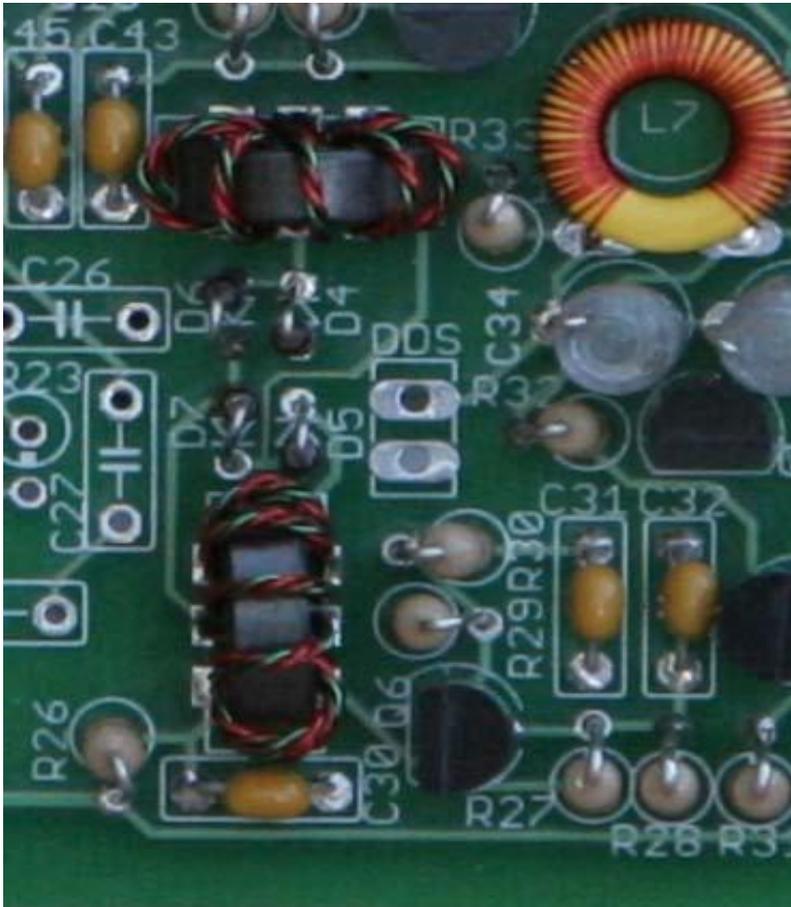


Illustration 13: First Mixer (VFO Mixer), (N7VE Photo)

### **1st Mixer (VFO Mixer)**

[ ] T-4, 8:8:8 turns trifilar, 6 inches per #26 on FT37-43 (black) core. Twist to 8 twists per inch

[ ] T-5, 8:8:8 turns trifilar, 6 inches per #26 of FT37-43 (black) core. Twist to 8 twists per inch

[ ] Solder **NOTE:** Make sure that there is a good solder bond to each wire on T4 and T5.

[ ] Clip Excess Lead Length

- Inspect Solder Connections
- D-4, 1N4148 Observe Polarity
- D-5, 1N4148 Observe Polarity
- D-6, 1N4148 Observe Polarity
- D-7, 1N4148 Observe Polarity
- R-26, 100 ohms (brown-black-brown)
- C-30, 0.1 mfd (marked 104)
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections

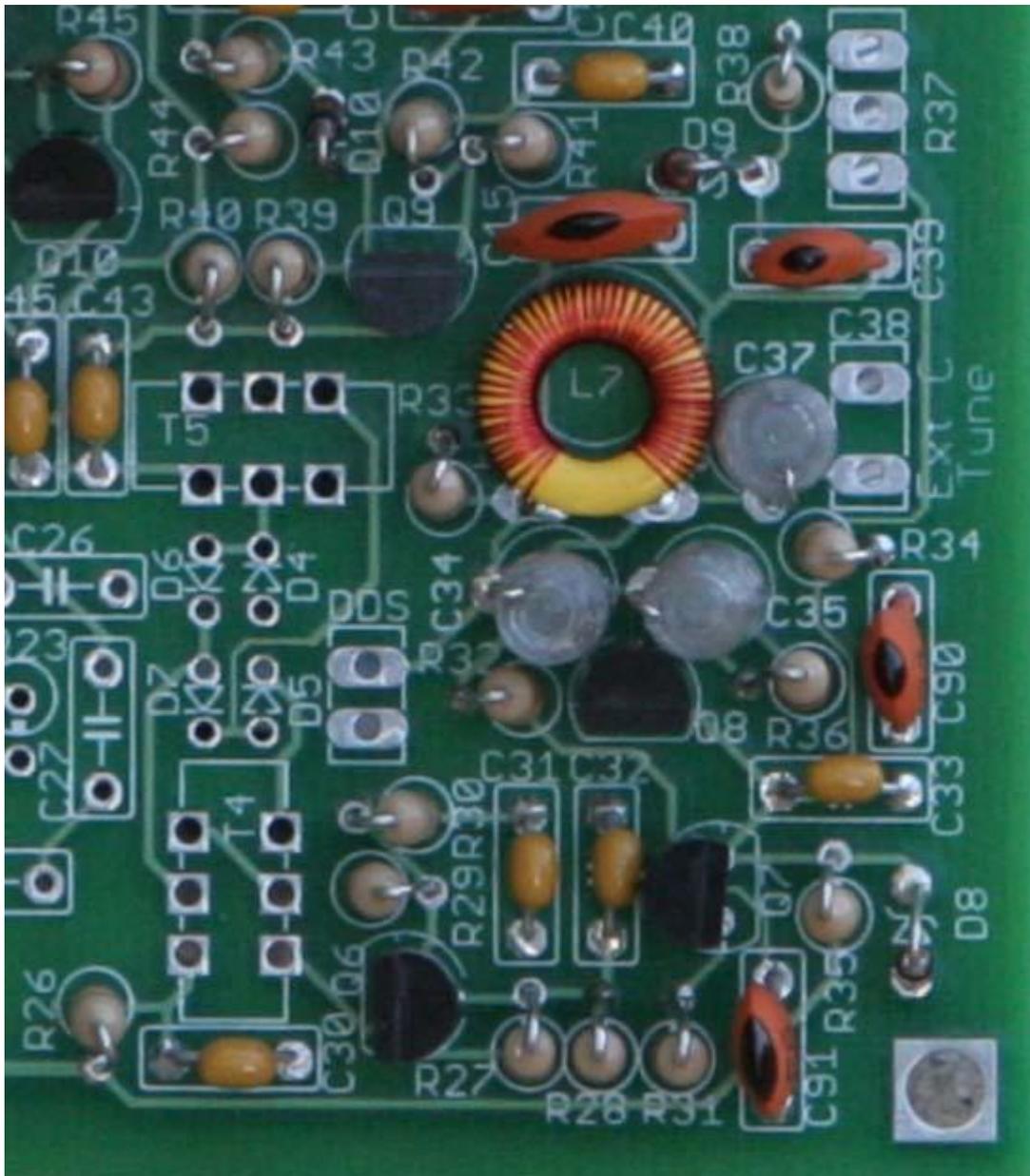


Illustration 14: VFO Section (N7VE Photo)

## VFO

- [ ] R-35, 100 ohms (brown-black-brown)
- [ ] D-8, 1N4739A, 9.1 Volt Zener      Observe Polarity
- [ ] R-33, 10K ohms (brown-black-orange)
- [ ] R-34, 10K ohms (brown-black-orange)

C-33, 0.1 mfd (marked 104)

Solder

Clip Excess Lead Length

Inspect Solder Connections

Q-8, 2N3904 (position according to layout marking on PCB)

Q-7, 2N3904 (position according to layout marking on PCB)

Q-6, 2N3904 (position according to layout marking on PCB)

Solder

Clip Excess Lead Length

Inspect Solder Connections

R-31, 1K ohms (brown-black-red)

C-32, 0.1 mfd (marked 104)

R-28, 1K ohms (brown-black-red)

R-27, 1K ohms (brown-black-red)

R-30, 10 ohms (brown-black-black)

R-29, 100 ohms (brown-black-brown)

C-31, 0.1 mfd (marked 104)

Solder

Clip Excess Lead Length

Inspect Solder Connections

R-36, 2.2K ohms (red-red-red)

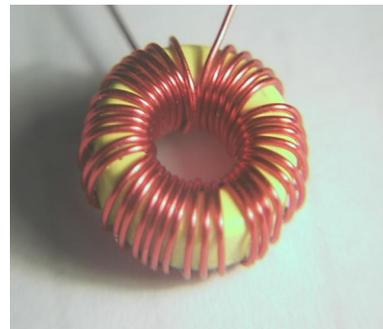
C-90, 33 pf (marked 33) Should be NPO type with a black band on it's top edge.

C-35, 390 pf Polystyrene (marked 390) NOTE: Polystyrene caps are encased in clear plastic.

C-34, 390 pf Polystyrene (marked 390) NOTE: Polystyrene caps are encased in clear plastic.

- [ ] C-15, 120 pf (marked 121) Should be NPO type with black band on the top edge.
- [ ] C-37, 130 pf Polystyrene (marked 130) NOTE: Polystyrene caps are encased in clear plastic.
- [ ] C-39, 33 pf (marked 33) Should be NPO type with a black band on the top edge.
- [ ] R-32, 4700 ohms (yellow-violet-red)
- [ ] C-91, 56 pf (marked 56) Should be NPO type with a black band on the top edge.
- [ ] D-9, 1N4752A, 33 Volt Zener (used as fine tuning varicap) Observe Polarity
- [ ] Solder
- [ ] Clip Excess Lead Length
- [ ] Inspect Solder Connections
- [ ] R-38, 150K ohms (brown-green-yellow)
- [ ] L-7, 36 turns #36 on T-37-6 (yellow) core. 20 inches (50 cm) of wire required.

Note: Do not secure L-7 to the PCB until you are sure that you have the desired tuning range. You may have to add or delete a turn to get it right on frequency. Once you are sure you have the proper tuning range you can secure the VFO inductor by cutting a small scrap of hot-melt glue, placing that inside the toroid and melting it with the tip of your soldering iron. Be sure to wipe the iron tip soon afterward or it will smell like baked hot-melt glue.



*Illustration 15: L-7, K7HKL Photo*

- [ ] C-38, 60 pf Variable Capacitor. Polyvaricon used as main tuning.

This is the front panel Main Tuning control and needs to be connected with fairly stiff leads to minimize any potential for vibration. The 60 pf section is the top connection if you hold the polyvaricon with it's shaft facing you and the leads to your right.

NOTE: You can control your tuning range by selection of which capacitor sections you use:

**POLYVARICON TUNING RANGE:**

<u>Polyvaricon</u>	<u>Pf</u>	<u>Trimmer Open</u>	<u>Trimmer Closed</u>
Section-A	60pf	185 kHz	180 kHz
Section-B	180pf	377 kHz	277 kHz
Sections A+B	240pf	448 kHz	416 kHz

R-37, 10K Potentiometer. This is the fine tuning adjustment.

Solder

Clip Excess Lead Length

Inspect Solder Connections

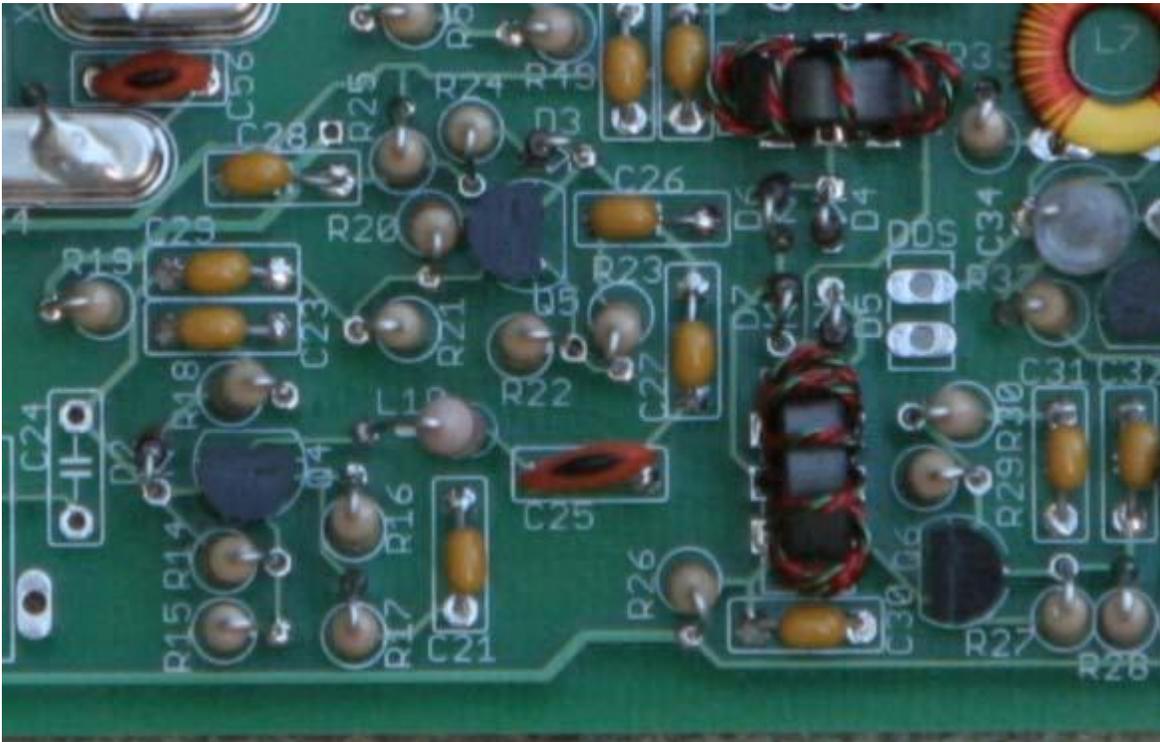
**TEST:** Monitor the VFO frequency using a frequency counter or with a receiver that is capable of tuning 5.108 to 5.208 MHz. A good place to connect for monitoring VFO output frequency is the exposed wire end of R-27.

The IF & BFO Frequency is 12.96 MHz. If you want to receive 18.068 MHz, the VFO needs to be at  $18.068 - 12.96 = 5.108$  MHz. For receiving 18.168 MHz the VFO needs to be at  $18.168 - 12.96 = 5.208$  MHz.

Trimmer capacitor adjustments on the back of the polyvaricon (C-38) allow some adjustment of VFO frequency. If this does not provide range enough to get the VFO on frequency, then you may need to change the value of C-90. Add more capacitance to lower frequency and decrease capacitance to raise frequency. You can also add or remove a turn from L-7 if you need to make a large change in VFO frequency.

If you hold a bright light against the side of the polyvaricon you can see inside and should be able to determine position of the internal trimmer capacitor.

At this point in assembly you can connect an antenna through a 100 pf capacitor to the pad for C-25 that is closest to R-26 and probably hear some shortwave stations. Try adjusting the frequency with both Fine and Coarse tuning adjustments to insure that both are working.



*Illustration 16: Receive and Transmit RF Amplifiers (N7VE Photo)*

### **Receive and Transmit RF Amplifiers**

- C-27, 0.1 mfd (marked 104)
- C-29, 0.1 mfd (marked 104)
- R-20, 2.2K ohms (red-red-red)
- R-21, 1K ohms (brown-black-red)
- R-23, 10 ohms (brown-black-black)
- R-22, 220 ohms (red-red-brown)
- C-26, 0.1 mfd (marked 104)
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
- Q-5, 2N3904 (position according to layout stenciled on PCB)

- D-3, 1N4148 Observe Polarity
- R-24, 220 ohms (red-red-brown)
- R-25, 100 ohms (brown-black-brown)
- C-28, 0.1 mfd (marked 104)
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
- D-2, 1N4148 Observe Polarity
- R-18, 220 ohms (red-red-brown)
- C-23, 0.1 mfd (marked 104)
- R-19, 100 ohms (brown-black-brown)
- R-16, 220 ohms (red-red-brown)
- R-17, 10 ohms (brown-black-black)
- C-21, 0.1 mfd (marked 104)
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
- R-14, 2.2K ohms (red-red-red)
- Q-4, 2N3904 (position according to layout marked on PCB)
- R-15, 1K ohms (brown-black-red)
- L-10, 1.0 uh molded inductor (brown-black-gold-silver) It looks like a fat resistor.
- C-25, 68 pf (marked 68)
- Solder
- Clip Excess Lead Length

Inspect Solder Connections

TEST: You can test the receive side of your work to this point by connecting an antenna through a 100 pf capacitor to the C-24 mounting pad that is closest to R-19.. You should hear noise and probably some short wave stations or carriers.

The transmit side can also be tested to keying the PTT and looking for RF voltage at the C-24 mounting pad closest to R-19.

**Receive and Transmit Front End Filter**

C-24, 6.8 pf (marked 6.8 )

L-6, 14 turns (9 inches) #26 on T-37-6 (yellow) core

C-18, 30 pf Observe Polarity

NOTE: The rounded side connects to ground and the flat side to RF

C-20, 68 pf (marked 68)

Solder

Clip Excess Lead Length

Inspect Solder Connections

C-19, 8.2 pf (marked 8.2)

C-17, 47 pf (marked 47)

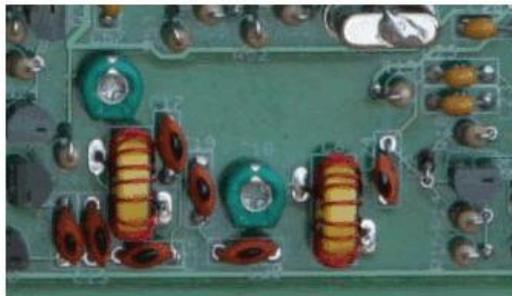
C-16, 8.2 pf (marked 8.2)

L-4, 14 turns (9 inches) #26 on T-37-6 (yellow) core

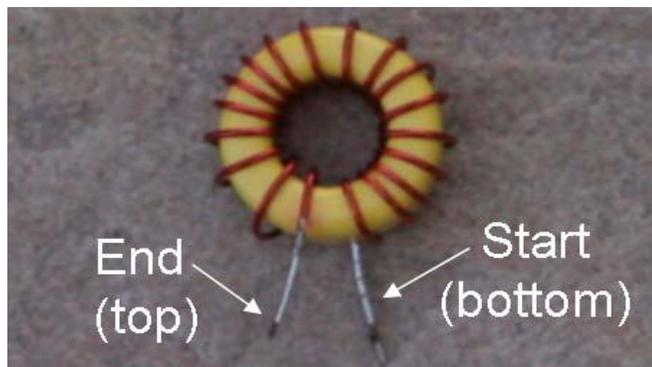
Solder

Clip Excess Lead Length

Inspect Solder Connections



*Illustration 17: Receive and Transmit Front-end Filter (N7VE Photo)*



*Illustration 18: L-4 Winding Detail (N7VE Photo)*

C-14, 30 pf      Install this capacitor according to outline stenciled on the PCB

**NOTE:** The rounded side connects to ground and the flat side to RF

C-13, 68 pf (marked 68)

C-11, 8.2 pf (marked 8.2)

Solder

Clip Excess Lead Length

Inspect Solder Connections

**TEST:** Connect an antenna to the Q-23 side of C-11 and tune the VFO for received signals. At this point you can peak the two RF front end tuning capacitors C-18 and C-14. This peaking adjustment can be done with off-the-air signals or with a signal generator (at this point you have the full gain of the receiver available, so the signal generator will need to be set at no more than a few mv of output).

While not necessary at this point, you can connect a dummy load or maybe even an antenna to the Q-23 side of C-11 at this time and test the transmit side. When keying the transmitter and inserting a tone in the microphone you should be able to get peak-to-peak readings of approximately 2 volts output across a 50 ohm non-inductive resistor or dummy load. The power level at this point will be less than 0.2 watts, but it may be possible to work nearby stations at this level.

**NOTE:** Testing of the TR Switches, Transmit Drivers, and Transmit PA will be done as part of the alignment process after wiring is completed.

### **T:R Switches**

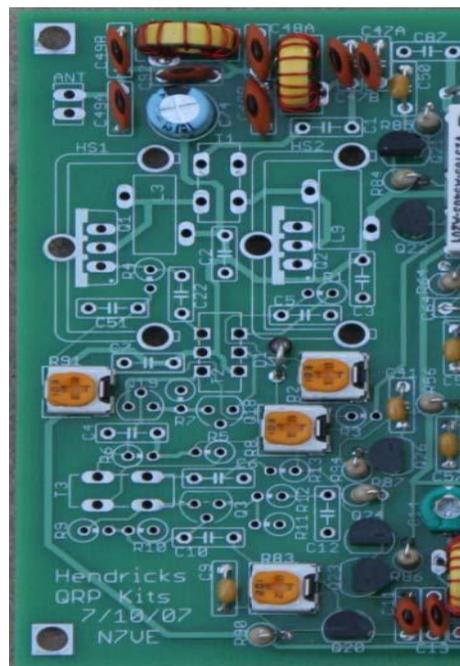
Q-23, 2N7000 (position according to layout marked on PCB)

R-86, 4.7K ohms (yellow-violet-red)

R-87, 4.7K ohms (yellow-violet-red)

Q-24, 2N7000 (position according to layout marked on PCB)

Q-26, 2N7000 (position according to layout marked on PCB)



R-94, 4.7K ohms (yellow-violet-red)

C-41, 0.1 mfd (marked 104)

Solder

Clip Excess Lead Length

Inspect Solder Connections

R-85, 4.7K ohms (yellow-violet-red)

Q-22, 2N7000 (position according to layout marked on PCB)

R-84, 4.7K ohms (yellow-violet-red)

Q-21, FQN1N50C (position according to layout marked on PCB)

C-50, 0.1 mfd (marked 104)

Solder

Clip Excess Lead Length

Inspect Solder Connections

### **Antenna Filter**

C-47A, 82 pf (marked 82)

C-47B, 82 pf (marked 82)

L-2, 11 turns #26 (8.5 inches) on T-37-6 (yellow) core

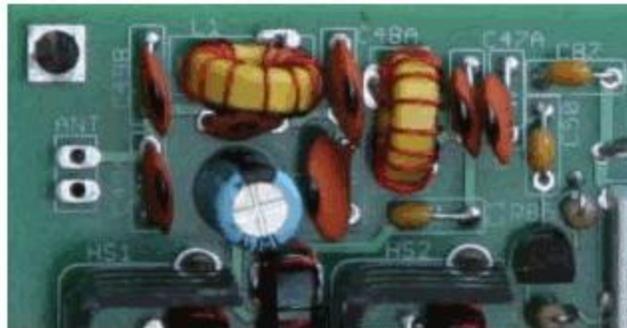
C-48A, 150 pf (marked 151)

C-48B, 150 pf (marked 151)

Solder

Clip Excess Lead Length

Inspect Solder Connections



*Illustration 20: Antenna Filter (N7VE Photo)*

L-1, 9 turns (7 inches) #26 on T37-6 (yellow) core



Illustration 21: L-1 Winding Detail (N7VE Photo)

C-92, 51 pf

C-49B, 82 pf (marked 82)

C-49A, 82 pf (marked 82)

Solder

Clip Excess Lead Length

Inspect Solder Connections

### **RF PA Drivers**

R-90, 100 ohms (brown-black-brown)

C-9, 0.1 mfd (marked 104)

Q-20, 2N5486 (position according to layout marked on PCB)

R-83, 200 ohm variable **NOTE:** Turn fully CCW (Counter Clock-Wise)

C-10, 0.1 mfd (marked 104)

Solder

Clip Excess Lead Length

Inspect Solder Connections

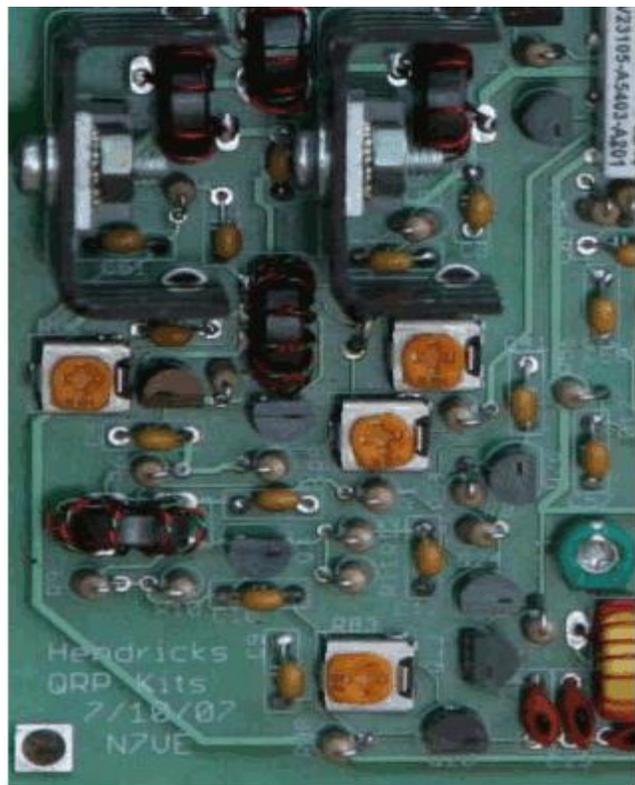


Illustration 22: RF PA Drivers (N7VE Photo)

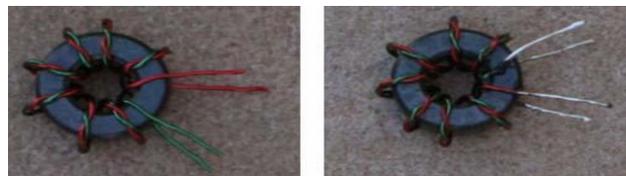
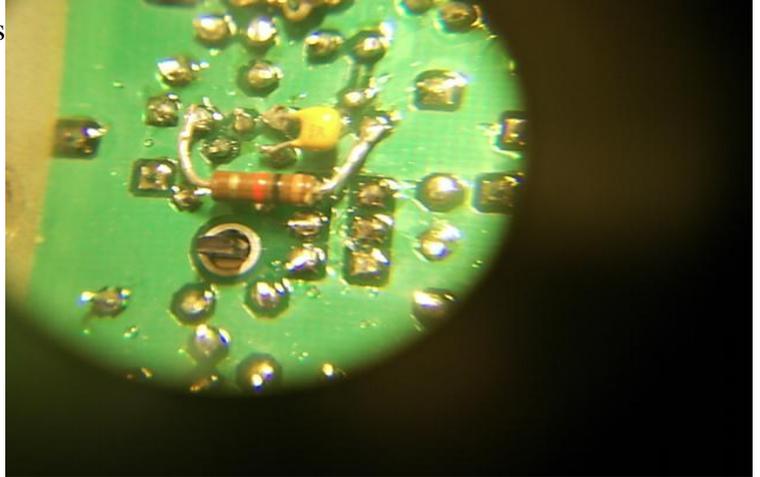


Illustration 23: T-3 Winding Detail (N7VE Photo)

- R-9, 2.2K ohms (red-red-red)
- R-10, 1K ohms (brown-black-red)
- Q-3, 2N3904 (position according to layout marked on PCB)
- R-12, 10 ohms (brown-black-black)
- C-12, 0.1 mfd (marked 104)
- R-11, 100 ohms (brown-black-brown)
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
- R-13, 22 ohms (red-red-black)
- C-6, 0.1 mfd (marked 104)
- T-3, 8:8 turns (6 inches each lead) bifilar on #26 on FT37-43, (black) core. Twist to 8 turns per inch
- R-5, 2.2K ohms (red-red-red)
- R-6, 2.2K ohms (red-red-red)
- C-4, 0.1 mfd (marked 104)
- R-8, 10K potentiometer      NOTE: Turn fully CCW
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
- Q-18, BS170 (position according to layout marked on PCB)
- Q-19, BS170 (position according to layout marked on PCB)
- R-7, 2.2 ohms (red-red-gold)

NOTE: For increased drive level on 17 meters it is necessary to add a 0.1 mfd capacitor across R-7. This is done on the bottom of the PCB, as shown in this picture. This capacitor increases stage gain to provide more drive and compensate for lower gain of the IRF-510 MOSFETS at 18 MHz.



C-x 0.1 mfd (marked 104) Solder this capacitor across R-7 on the bottom of the PCB.

*The 1K resistor shown next to the 0.1 mfd capacitor is to increase RF PA section stability and will be addressed later in the assembly manual.*

*Illustration 24: Drive Level Mod. (K7HKL Photo)*

C-7, 0.1 mfd (marked 104)

T-2, 8:8:8 turns (6 inches each lead) trifilar #26 on FT37-43 (black) core. Twist to 8 turns per inch

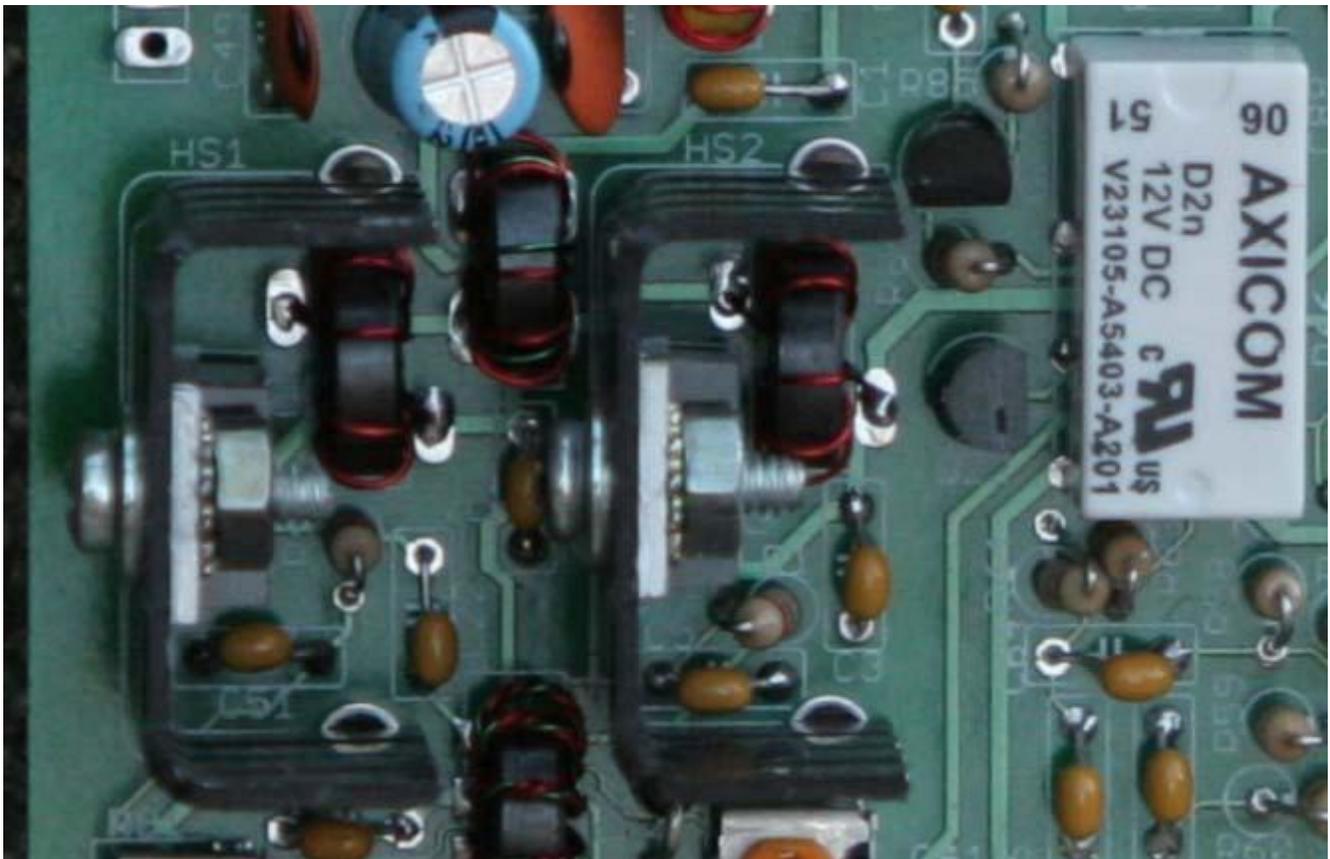
Solder

Clip Excess Lead Length

Inspect Solder Connections



*Illustration 25: T-2 Winding Detail (N7VE Photo)*



*Illustration: RF PA Stage*

### **RF PA Stage**

C-51, 0.1 mfd (marked 104)

R-91, 10K potentiometer      NOTE: Turn fully CCW

R-2, 10K potentiometer      NOTE: Turn fully CCW

C-5, 0.1 mfd (marked 104)

C-22, 0.1 mfd (marked 104)

R-4, 2.2K ohms (red-red-red)

R-1, 2.2K ohms (red-red-red)

Solder

Clip Excess Lead Length

Inspect Solder Connections

- C-1, 0.1 mfd (marked 104)
- C-2, 0.1 mfd (marked 104)
- C-3, 0.1 mfd (marked 104)
- D-1, 1N4734A 5.6 Volt Zener, Observe Polarity
- R-3, 1K ohms (brown-black-red)
- Solder
- Clip Excess Lead Length
- Inspect Solder Connections
- L-3, 8 turns (6 inches) #26 on FT37-43 (black) core
- L-9, 8 turns (6 inches) #26 on FT37-43 (black) core
- T-1, Primary = 6 turns, Secondary = 8 turns #26 on FT37-43 (black) core



*Illustration: T1 Winding Layout (N7VE Photo)*

Primary leads connect to pads closest to C-74.  
Secondary leads connect to pads closest to C-2.

Note that the windings are not twisted together, but are interleaved with each other.

- Q-1, IRF510 Bolt Q-1 to heat sink, then install MOSFET and heat sink as a unit  
The heat sink legs are inserted in PCB holes provided for them. There is no requirement to fasten them to the PCB. Soldering the attached MOSFETs to the PCB will be adequate for holding the heat sinks in place.
- Q-2, IRF510 Bolt Q-2 to heat sink, then install MOSFET and heat sink as a unit  
The heat sink legs are inserted in PCB holes provided for them. There is no requirement to fasten them to the PCB. Soldering the attached MOSFETs to the PCB will be adequate for holding the heat sinks in place.

- [ ] Solder
- [ ] Clip Excess Lead Length
- [ ] Inspect Solder Connections

**NOTE:** *Martien PA3BWI has suggested the following parts addition to further stabilize the RF PA section.*

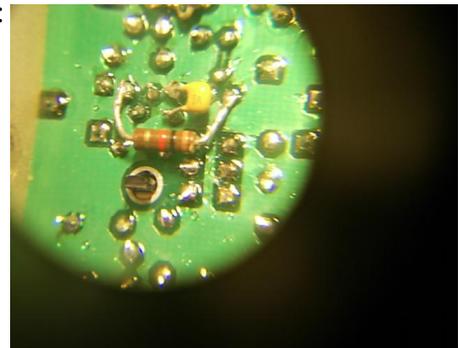
*[ ] R-x Add a 1K resistor (brown-black-red) between the drains of Q-18 and Q-19.*

*[ ] R-y Add a 220 ohm resistor (red-red-brown) across the primary of T-3.*

*These added components will need to be installed under the PCB. The original designer, recent builders, and the Hendricks kit developers all agree that this is a worthwhile modification.*

1K resistor between the drain leads of Q-18 and Q-19:

*The 0.1 mfd capacitor shown here was installed earlier in the assembly process and is across R-7 to increase drive level to the IRF510 MOSFETs at 18 MHz.*



*Illustration 26: 1!K Resistor Across Q-18 & Q-19 Drains (K7HKL Photo)*

220 ohm resistor across the primary of T-3:



*Illustration 27: 220 resistor across T-3 primary (K7HKL Photo)*

***Congratulations.*** You have completed wiring your BITX17A kit, and are ready to proceed with alignment of the transceiver, including transmitter driver stages and the MOSFET power amplifiers.

***Now might be a good time to check R-2, R-8, R-83, and R-91 to insure that they are turned totally counter-clockwise. This is to make sure that the transmitter RF drive level is at minimum, and that the MOSFET bias levels are also at minimum. During the alignment procedure you will set these potentiometers at their proper levels.***

At this point you should have a working receiver. Connect an antenna to the transceiver and verify that you can receive signals on the 17 meter band. This can be done using a signal generator or off-the-air signals. If you do not have a working receiver you may need to go to the troubleshooting section to find the problem.

To proceed with transmitter alignment you will need the following tools:

- 50 ohm Dummy load. This can be an actual dummy load, or a bank of non-inductive resistors which will withstand 12 watts or more for up to one minute.
- An oscilloscope, or diode voltage probe and voltmeter for measuring RF voltage levels at 18 MHz.
- A DC ampere meter capable of measuring 0 to 300 ma, and 0 to 2 amperes. There is an alternative way to measure the 0 to 300 ma levels using voltage across a resistor. This will be discussed in the alignment procedures.
- The microphone that you are going to use with this transceiver, or an audio signal generator and suitable attenuators to adjust it's output to normal microphone signal levels (nominally 10 to 50 millivolts).
- A frequency counter, or other means to determine VFO frequency and tuning range. A receiver with accurate frequency readout may be suitable.

### **Initial Alignment Procedure:**

1. Set the BFO and carrier oscillator frequency:

Adjust the BFO (C-72) so that when you tune across a steady carrier you can hear the zero-beat on each side of that carrier frequency. Then adjust C-72 to a slightly lower frequency where you can hear the upper-sideband zero-beat tone but the lower-sideband one is either gone or very much attenuated. Now tune in an on-air SSB signal and adjust C-72 very slightly for best audio quality.

2. Determine and adjust the VFO frequency and tuning range:

Set your Fine Tuning potentiometer to mid-range. Leave it there for the following procedure. Since the BFO and IF sections operate on 12.96 MHz, your BITX17A VFO must tune between  $18.068 - 12.960 = 5.108 \text{ MHz}$  and  $18.168 - 12.960 = 5.208 \text{ MHz}$ . Turn your Course Tuning adjustment (the polyvaricon capacitor) fully to the left. Adjust the trimmer on the back of your polyvaricon variable capacitor so that with the knob turned fully left (minimum capacitance) your VFO is at or slightly above 5.208 MHz. Then rotate the polyvaricon fully to the right (maximum capacitance) and verify that the VFO is now below 5.108 MHz. This insures full 17 meter band coverage.

3. Align the front-end bandpass filter:

While listening to a signal generator or received carrier beat note, carefully adjust C-14 and C-18 for maximum received signal level.

4. Adjust the transmit driver bias:

Temporarily short the microphone audio input connection. Connect an ammeter capable of measuring approximately 200 ma in series with power to the transceiver. Key the microphone PTT and note the idling current of your transmitter. Now slowly rotate R-8 clockwise until the idling current has increased by 20 ma. Un-key the transmitter and remove the temporary short across the microphone audio input.

5. Adjust the transmit power amplifier bias:

Temporarily short the microphone audio input connection. Connect an ammeter capable of measuring approximately 300 ma in series with power to the transceiver. Key the microphone PTT and note the idling current of your transmitter. Now slowly rotate R-91 clockwise until the idling current has increased by 50 ma. Note the new idling current. Slowly rotate R-2 clockwise until the idling current has increased by another 50 ma. Un-key the transmitter and remove the temporary short across the microphone audio input.

6. Drive level adjustment:

Monitor transmitter output with a 50 ohm termination and watt-meter, or dummy load and scope or diode detector probe and DC voltmeter.

Temporarily connect an audio signal generator to the microphone audio input connection (if R-92 is installed you will need to use capacitive coupling to keep DC out of the signal generator). Adjust the signal generator for 1000 Hz and 40 to 50 mv output level.

***NOTE:** The time honored method of speaking a prolonged "Aaaaaaaaaah" into the microphone will also work if you do not have an audio signal generator.*

Key the transmitter and slowly rotate R-83 to the right while watching the transmitter RF output. An RMS voltage reading of 22.4 volts indicates power output of 10 watts. If your equipment is reading in peak volts, 10 watts will be at an indication of  $1.4 * 22.4 = 31.3$  volts.

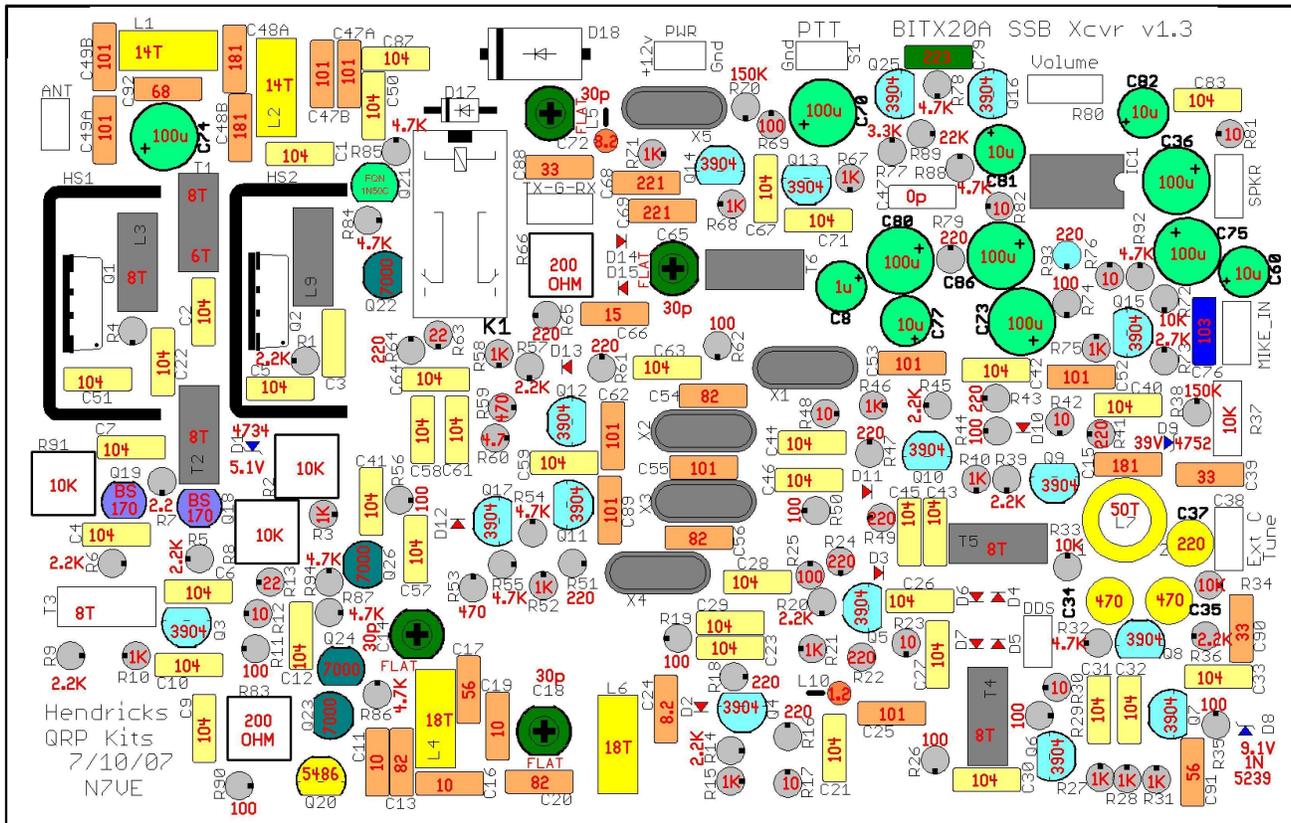
**50 OHM VOLTAGE CHART**

Watts	Volts RMS	Volts PEAK
1	7.07	9.9
2	10	14
3	12.25	17.15
4	14.14	19.8
5	15.81	22.14
6	17.32	24.25
7	18.71	26.19
8	20	28
9	21.21	29.7
10	22.36	31.3
11	23.45	32.83
12	24.49	34.29
13	25.5	35.69
14	26.46	37.04
15	27.39	38.34

This completes the initial adjustment and alignment of your BITX17A transceiver kit.

The following document sections provide additional information for education and for troubleshooting. The parts placement drawing and schematic drawing have been duplicated in this section so you will have a copy to write notes on as a future reference for your particular BITX17A transceiver.

**Parts Placement Drawing:**



Drawing by KD1JV



## **Alignment Method:**

### **BFO/Carrier Oscillator:**

There are several ways to adjust the BFO/Carrier Oscillator frequency.

1. Rough alignment may be made by adjusting C-72 while listening to a received SSB signal on 17 meters. This is a two-handed operation as you have to use the VFO Fine Tuning to keep the VFO frequency set for best intelligibility while searching for the best quality audio with C-72.
2. Instrument alignment is done by monitoring carrier attenuation while adjusting the BFO/Carrier Oscillator relative to the crystal filter sideband shape factor. The oscillator frequency needs to be 24 to 40 db down the lower side of the filter passband.
  - Disconnect the microphone or short it's audio output so that there is no audio coming through the microphone amplifier.
  - Set up an oscilloscope or RF detector and voltmeter to monitor the transmit 2<sup>nd</sup> IF amplifier output (the exposed lead on R-45, near Q-10).
  - Connect a frequency counter to the exposed lead of R-67 to monitor BFO/Carrier Oscillator frequency.
  - Operate the PTT switch and un-balance the balanced modulator by turning R-66 until you have a measurable signal. Un-key the transmitter.
  - Key the transmitter again and adjust the BFO/Carrier Oscillator frequency (C-72) for maximum signal level, note the frequency on the counter, and then adjust C-72 for a lower frequency and a 24 to 40 db decrease in monitored signal level. Un-key the transmitter. The BFO/Carrier Oscillator frequency needs to be just outside the lower frequency edge of the crystal filter for USB operation.
  - Disconnect the frequency counter, key the transmitter and re-check to see that you are still at the same signal attenuation point on your scope or voltmeter. Un-key the transmitter. This checks to make sure that your counter was not pulling the BFO/Carrier Oscillator off frequency by any significant amount.
  - Key your transmitter and adjust the modulator balance (R-66 and C-65) for minimum RF indication. Un-key your transmitter.
  - Re-connect your microphone or remove the short from it's output.

There are several additional ways to adjust the BFO/Carrier Oscillator frequency. If you have the knowledge and equipment it might be an interesting exercise to try these methods as well. However, even the Rough Alignment method outlined above will usually provide adequate setting for good reception and transmission.

### **VFO:**

VFO components provided in the kit have been chosen in an attempt to insure that your tuning

range will be within the 17 meter band. However, this is not guaranteed. You should check the VFO frequency with a counter connected the exposed lead of R-27, or use a well calibrated receiver. Trimmer capacitors on the back of the main tuning capacitor will provide some adjustment but you will need to select which capacitor sections are connected to set the minimum & maximum tuning limits and the tuning range.



Measure VFO Frequency Here  
(top of R-27)

<b>Polyvaricon Section</b>	<b>Capacitance Range</b>	<b>Trimmer Open Tuning Range</b>	<b>Trimmer Closed Tuning Range</b>
Section-A	4 to 80 pf*	60 KHz	58 KHz
Section-B	5 to 160 pf*	124 KHz	120 KHz
Sections A+B	9 to 240 pf*	155 KHz	147 KHz

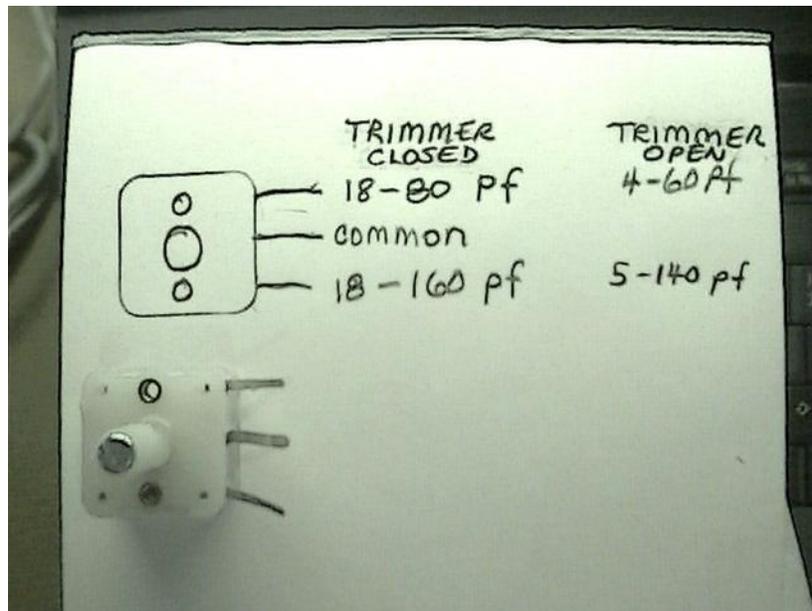
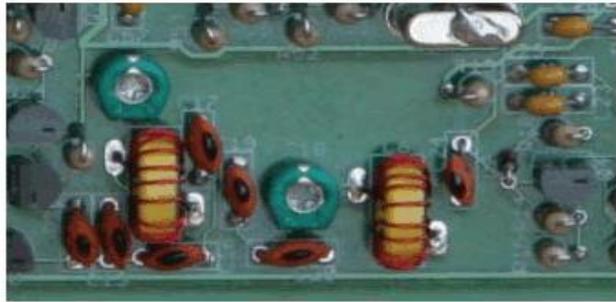


Illustration 28: \*VFO Tuning Capacitor Parameters(K7HKL Photo)

Since the IF frequency is 12.96 MHz, the VFO needs to tune 12.96 MHz below your desired tuning range on 17 meters (18.000 -12.96 = 5.04 MHz). You can use this method to calculate the frequency of the VFO for your particular tuning selection.

### Receiver & Transmitter RF Filter:

The easiest way to tune the RF input filter is to peak C-14 and C-18 in receive mode for loudest signal while listening to a relatively constant carrier from your antenna. This provides both receive and transmit mode alignment of this filter.



### Transmitter Driver

There is no tuning involved in adjusting the transmitter drivers section, but you do have to set the bias adjustment. Drive level adjustment will be done in the RF PA alignment section.

1. Connect a 2 to 3 ampere DC ammeter in series with the +12 volt line to your transceiver.
2. Disconnect the microphone or short it's output so there will be no audio entering the microphone amplifier.
3. Key the transmitter and note the idling current. Un-key the transmitter.
4. Key the transmitter and slowly adjust R-8 for an increase of 20 ma. Un-key the transmitter.

NOTE: You can alternatively monitor the voltage drop across R7 to measure idling current in the PA driver amplifier. This is a 2.2 ohm resistor so 20 ma of current would equal a voltage drop of  $(0.02 \times 2.2 =) 0.044$  volts.

## RF PA

There are no tuning adjustments in the RF PA section, but you do have to adjust the idling current on the two IRF510 MOSFET devices and then set the drive level for best output linearity. To do this you will need an ammeter with a capability of reading 2.5 or 3 amperes.

### PA Idling Current Adjustment:

1. Connect an ammeter in series with the power lead that supplies 12 volts to your transceiver.
2. Disconnect the microphone, or short it's audio output so that no audio is going to the microphone amplifier.
3. Key the transmitter (use a dummy load please) and note the idling current. Unkey the transmitter.
4. Key the transmitter and slowly adjust R-91 until this current increases by 50 ma. Unkey your transmitter. Note the new idling current.
5. Key the transmitter and slowly adjust R-2 until the idling current increases by another 50 ma. Unkey the transmitter.

### Drive Level Adjustment:

RF output level can be adjusted for over 10 watts in some transceivers, but compression of the RF envelope usually starts at about 10 watts. To preserve output linearity you should set the RF output level no higher than the point where RF compression becomes apparent. As you monitor the RF output and simultaneously increase the drive level, you should see the output rise fairly fast, with the rate of rise decreasing after you pass some point on the adjustment. This is the setting where RF compression starts. For best transmitted signal linearity you should set the drive level just below this start of compression point.

1. You can insert an audio tone (approximately 50 mv) via the microphone jack of your transceiver or use the time-honored method of saying a long "Aaaaaaaaaaaaaah" while monitoring the RF output with a scope, diode detector and voltmeter, or watt meter.
2. Key your transmitter and insert the tone while monitoring the RF output and slowly adjusting the RF drive pot (R-83) for an increase in output. Identify the adjustment position where rate of output increase seems to slow. Back the drive level back down by ½ watt or so. This is your position of best output signal quality. Un-key your transmitter.

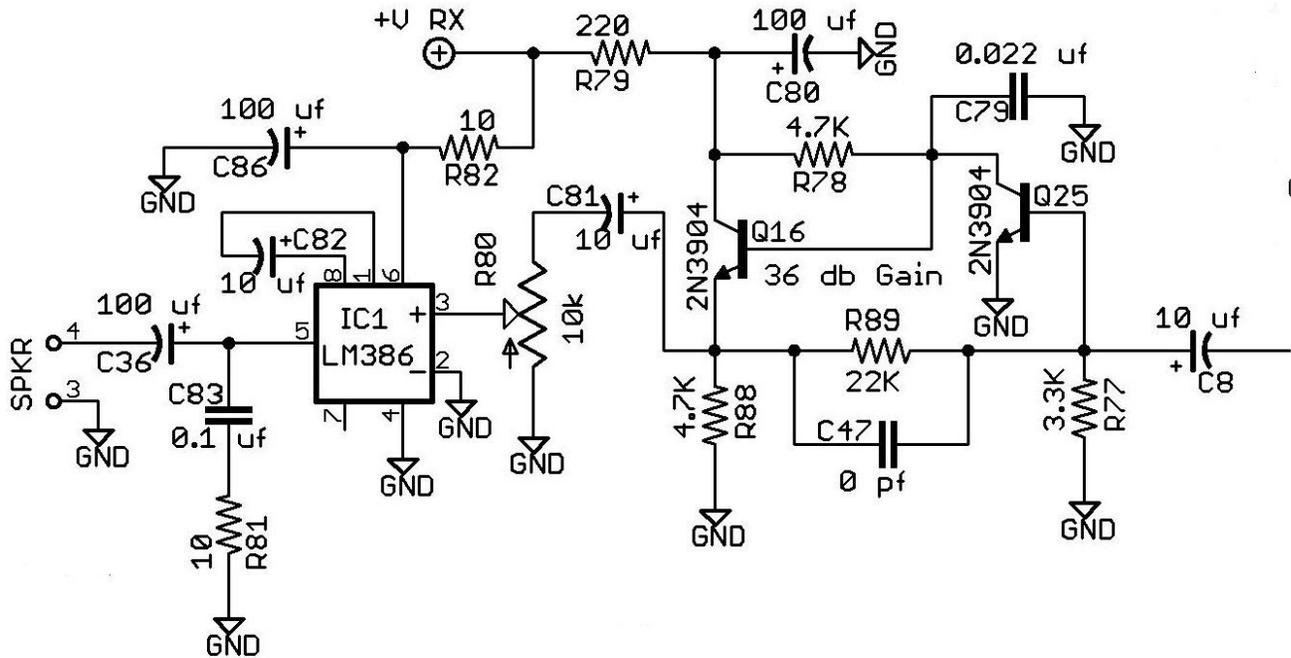
**NOTE:** Do not keep the transmitter keyed for more than a few seconds with a tone input. Steady tones exceed the duty cycle designed into the RF PA amplifiers and their heat sinks, and may damage the IRF510 MOSFETS.

## Troubleshooting Section

This section contains isolated sections of the total schematic, voltage charts, and a few words regarding each section. Voltages shown are based on 12.0 volts supply for the transceiver.

### *Receive Audio Amplifier*

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**NOTE:** The following voltage measurements are made in receive mode

#### LM386 Voltages

Pin-1	1.37 VDC
Pin-2	0.0 VDC
Pin-3	0.0 VDC
Pin-4	0.0 VDC
PIN-5	5.64 VDC
Pin-6	11.43 VDC
Pin-7	5.71 VDC
Pin-8	1.37 VDC

#### Q-16 Voltages

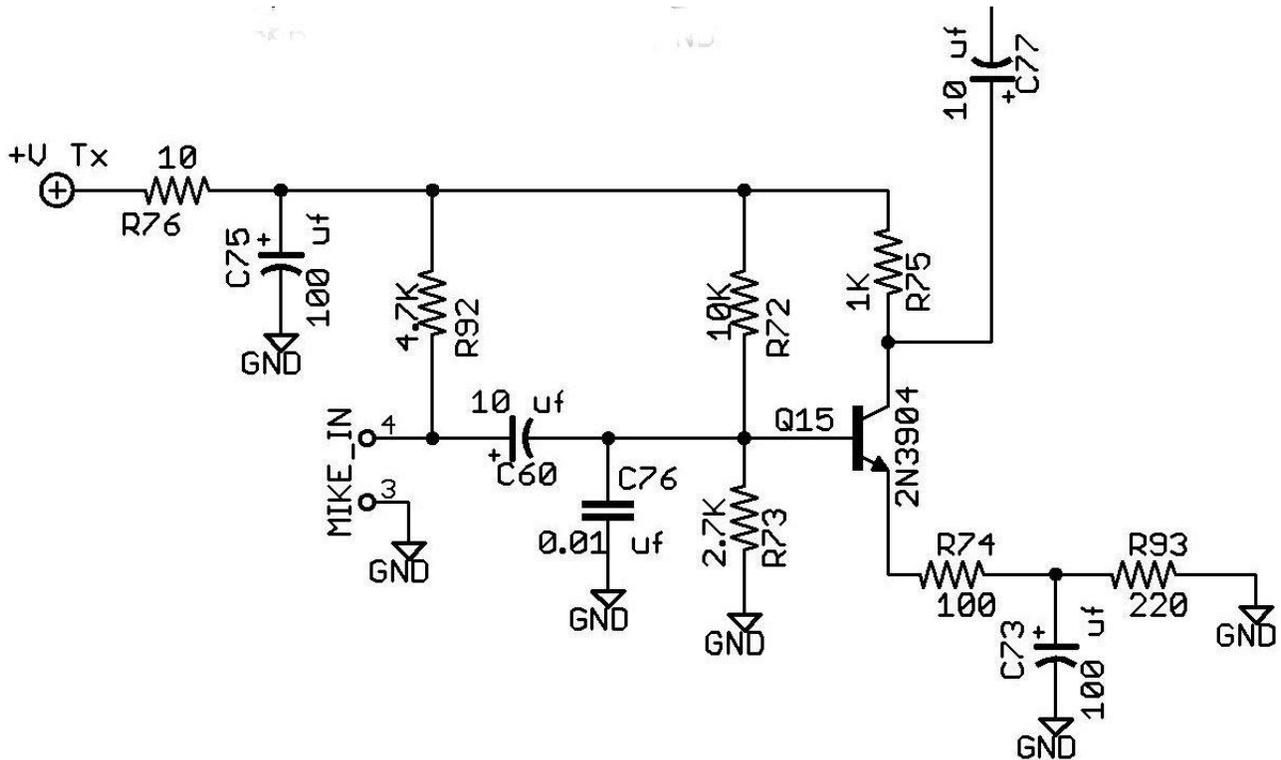
Collector	10.97 VDC
Emitter	5.26 VDC
Base	5.94 VDC

#### Q-25 Voltages

Collector	5.94 VDC
Emitter	0.0 VDC
Base	0.67 VDC

C-47 is an artifact of early PCB layout and testing. No capacitor should be inserted in this position.

## Microphone Amplifier



### Q-15 Voltages (transmit mode)

Collector 6.29 VDC

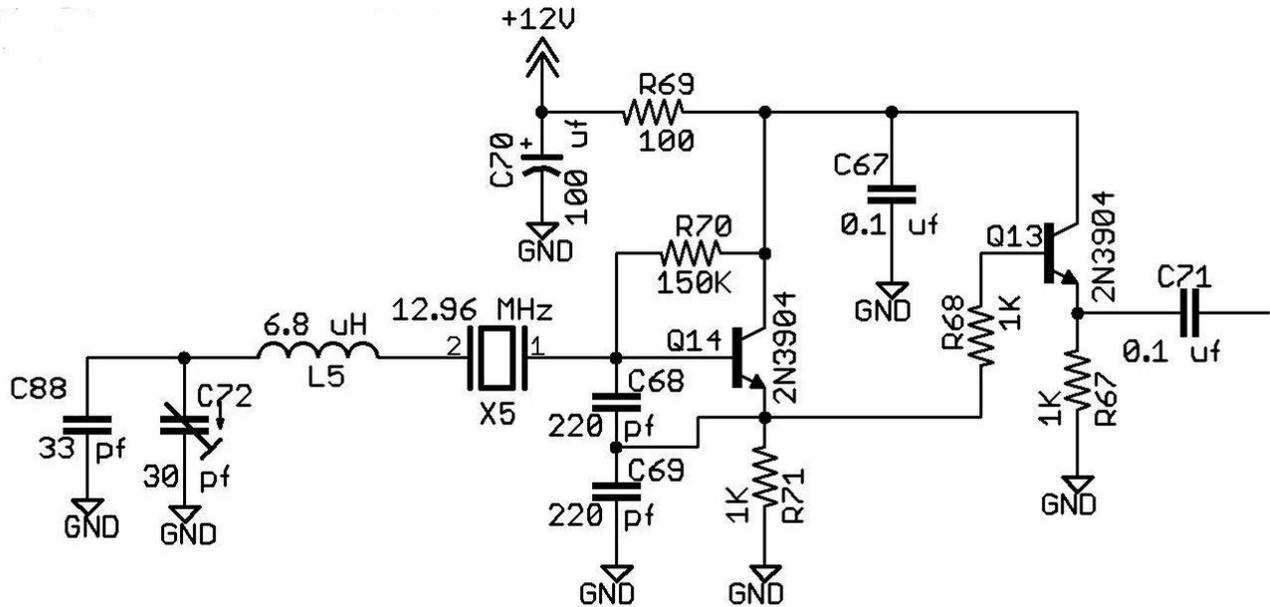
Emitter 1.63 VDC

Base 2.34 VDC

R-92 provides DC voltage to operate an Electret type microphone, which uses a thin metalized Teflon foil capacitive transducer driving an internal FET amplifier. Audio AC voltage is amplified and appears across R-92, where it is coupled through C-60 to the base of Q-15. If you are not using this type of microphone you should not install (or should remove) R-92. Electret microphones are common in inexpensive audio devices (tape recorders, etc.) or can be purchased directly from component suppliers. Most inexpensive computer microphones are Electret types.

Audio input level for transmitter testing should be 50 mv or less. Use capacitive coupling (10 mfd) if R-92 is in place, or temporarily lift one end of R-92 to avoid sending DC power into your test oscillator.

## BFO and Carrier Oscillator



C-88 (33 pf) may not be required to properly set your BFO frequency. It is provided for use in case you need to pull the BFO lower in frequency than can be done with just C-72 (5-30 pf) alone. In this type circuit, the various capacitances C-68, C-69, C-72, C-88, and  $C_{X5}$ , along with inductance L-5 make up a series-tuned circuit which resonates close to the crystal frequency. As C-72 is changed, the crystal is pulled a few KHz from it's normal series-resonance point. This VXO adjustment allows you to set the crystal oscillator to it's proper frequency, which is 12 to 20 db down the lower sideband skirt of the crystal filter.

Because the oscillating waveform will affect DC meter accuracy, it is necessary to stop the oscillator in order to make meaningful DC measurements. This is done by temporarily disconnecting or removing the BFO crystal (X-5). Now you can measure the DC operating parameters of this stage.

### Q-14 Voltages (receive mode)

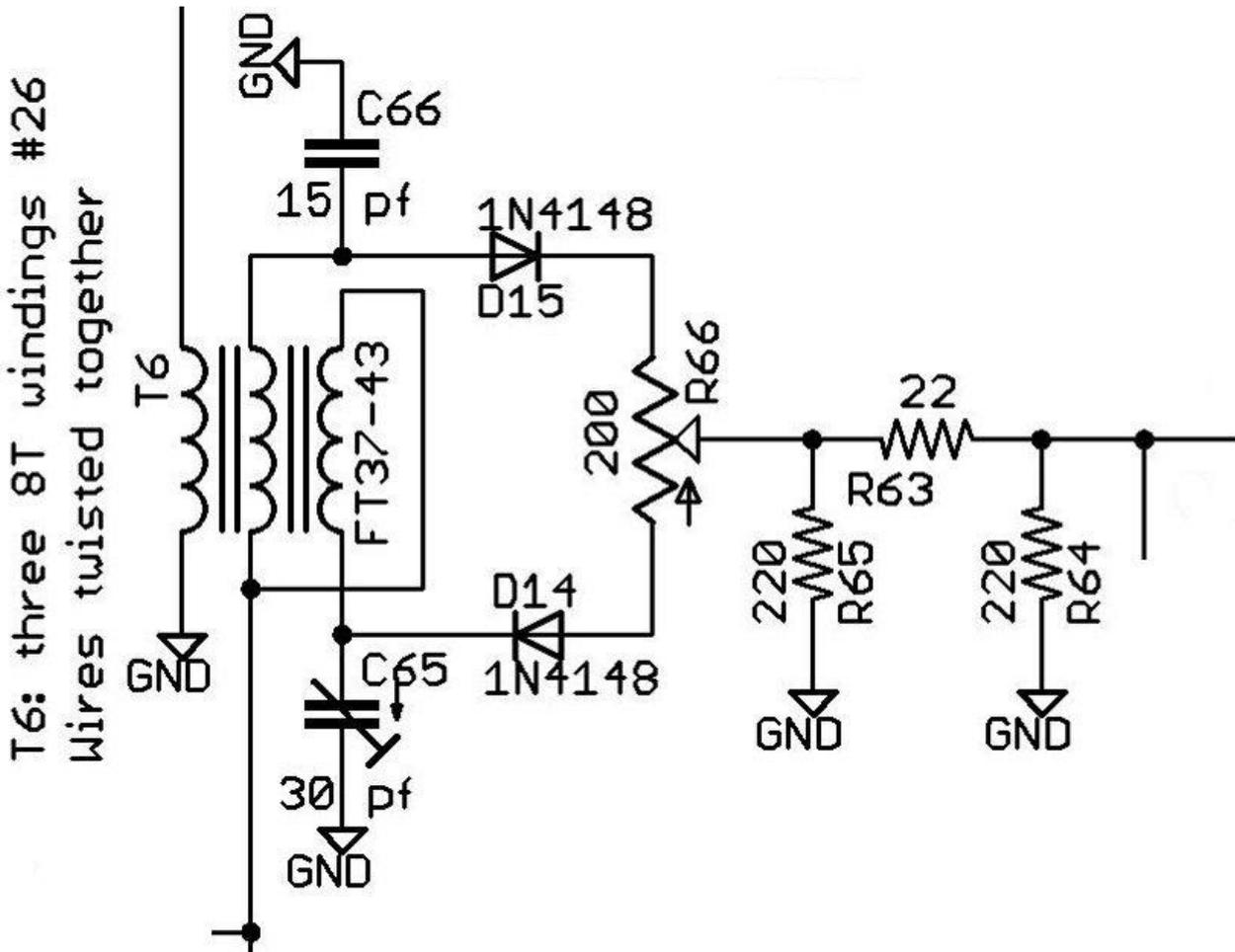
Collector 10.55 VDC  
 Emitter 5.35 VDC  
 Base 5.50 VDC

### Q-13 Voltages (receive mode)

Collector 10.55 VDC  
 Emitter 4.63 VDC  
 Base 5.31 VDC

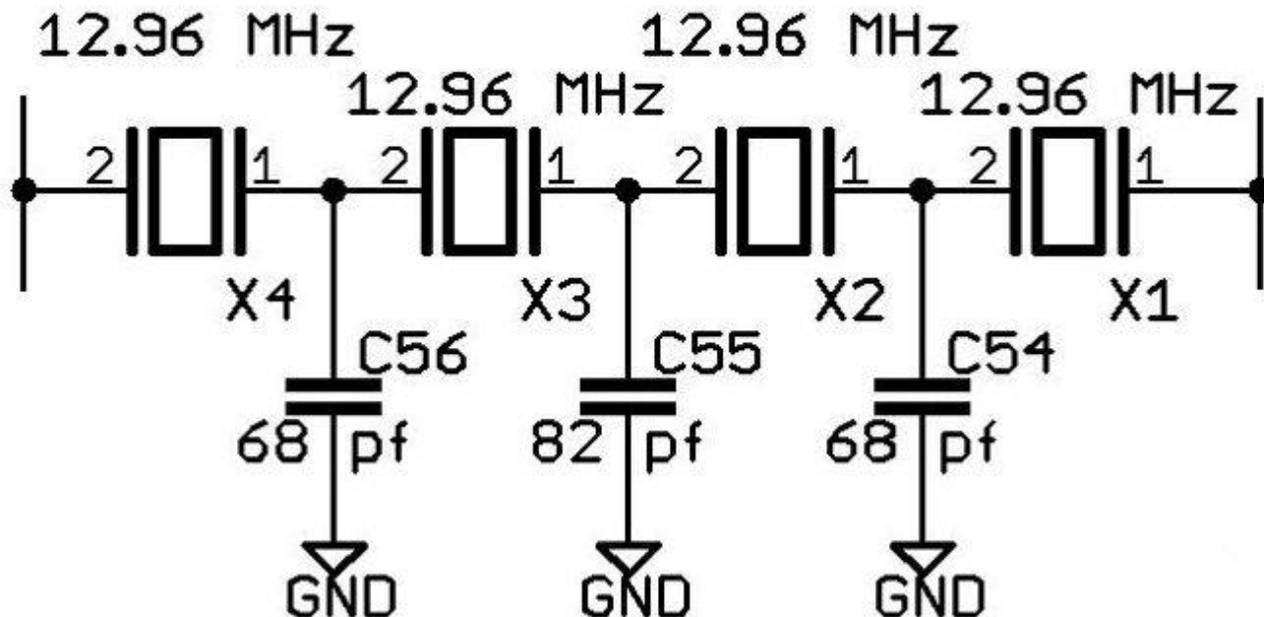
*(Remember to reinstall the crystal that was removed for making these measurements.)*

*Balanced Modulator*



You can adjust the balanced modulator in receive mode. Connect an oscilloscope or diode probe and DC voltmeter across R-64. Then adjust C-65 and R-66 for minimum output. There should be two points on C-65 where the R-64 voltage is at minimum (this verifies that you are not at the end of the adjustment range). The dip in voltage across R-64 should occur at approximately mid-point on R-66. There is some interaction between these two adjustments so you need to re-adjust each several times to obtain the best dip.

## Crystal Filter



The crystal filter appears quite simple and easy to build. Testing it to verify performance though is a bit more complex. To determine the passband characteristic for your crystal filter it should be tested in the circuit where it will be operated. In the BITX designs this means that you need to have the IF amplifiers on each side of the filter wired and working properly.

Insert a low level signal at the input of the receiver 1<sup>st</sup> IF amplifier. Monitor the output at the top of R-64 which is located at the output side of the 2<sup>nd</sup> receive IF amplifier. Decrease input signal until the output decreases as you decrease input (this avoids working through a saturated amplifier).

As you tune very slowly across the IF passband, note and record R-64 signal levels at every 200 Hz frequency step. For a rather crude looking chart you can simply plot the voltage readings on graph paper to determine your filter passband, but the graph will not look like the classic ones in radio handbooks. To improve your chart's appearance and to look like the commercial diagrams, you need to convert each reading into decibels and then plot the response with DB as the vertical axis of your graph.

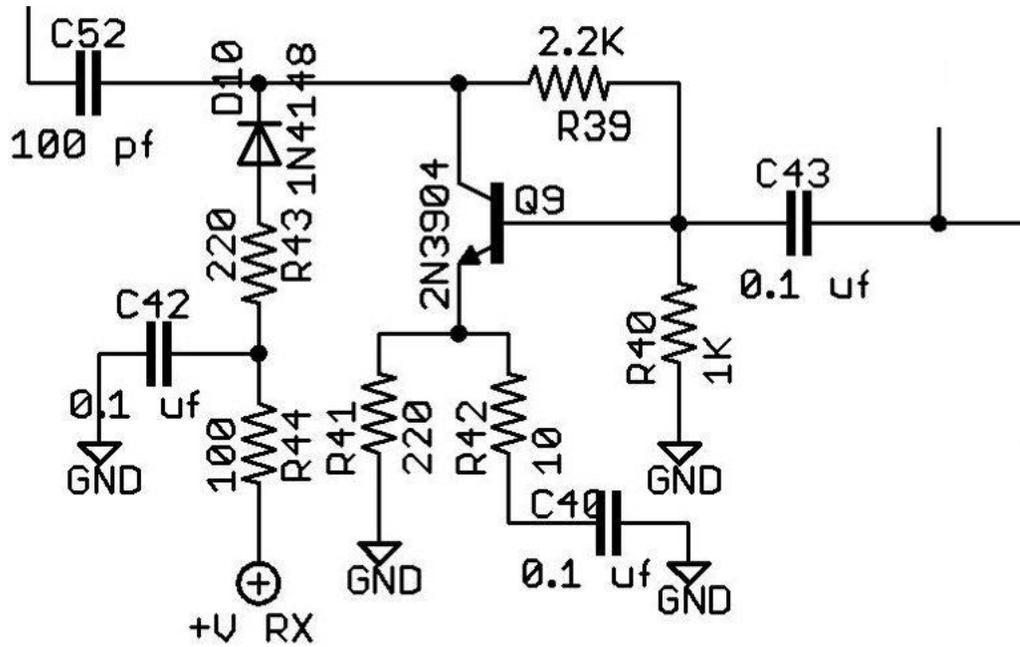
Mark the -6 db points (or half-voltage points if you are plotting raw voltage readings) on upper and lower skirts of the filter response curve. The frequency range between these points is your filter 6-db bandwidth.

Note the points of -12 and -20 db down the lower sideband skirt of filter response. Somewhere between these points is where you should set the BFO frequency for best audio and good LSB and carrier suppression.

The bandwidth and response curve of a crystal filter can be adjusted to some extent. In building your filter you may have picked the 4 crystals which were closest in frequency and used these for the filter. This will give you the steepest sideband skirts. The capacitors to ground inside the filter diagram (C-54, C-55, and C-56) may be changed to alter the overall filter bandwidth. While it may seem counter-intuitive, increasing capacitance decreases the filter bandwidth. The value of C-55 should equal approximately twice the value of C-54 or C-56, but there is some room to experiment to see how changes affect the ripple factor across the passband and steepness of sideband skirts.

There are several mechanized ways to monitor your crystal filter passband, including use of a Spectrum Analyzer, a swept frequency source with RF detector and oscilloscope display, or using a PC sound card with one of the AF Spectrum Analysis software packages. These have the advantage over manual measurement and manual production of graphs because they allow you to see a real-time result from any changes you might make.

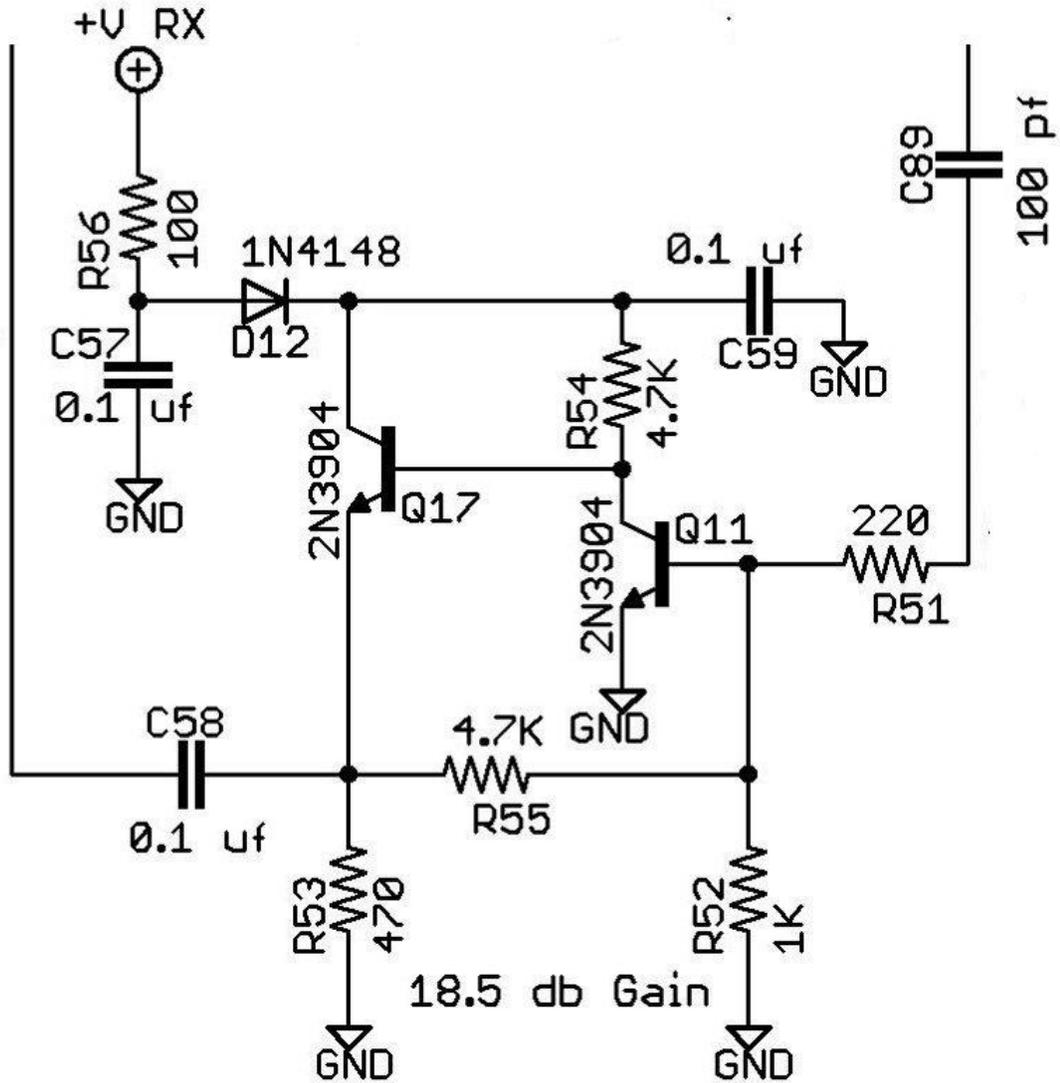
*Receive 1<sup>st</sup> IF Amplifier*



Q-9 Voltages (voltage measurements are made in receive mode)

Collector	7.62 VDC
Emitter	1.62 VDC
Base	2.35 VDC

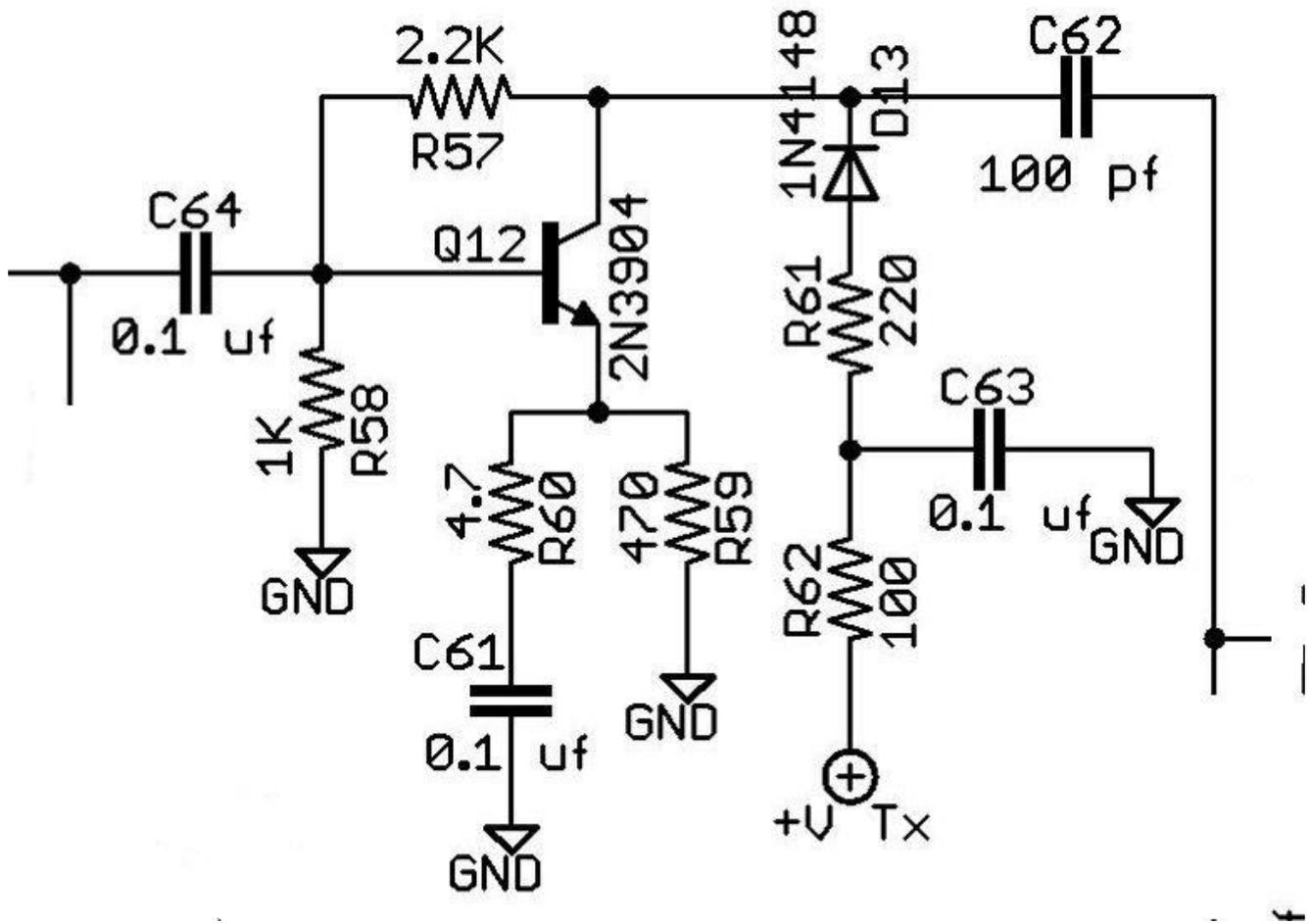
Receive 2<sup>nd</sup> IF Amplifier



This section is a compound amplifier with Q-11 providing voltage gain and Q-17 providing current gain. Overall amplification is controlled by feedback divider made up of R-52 and R-55.

<u>Q-11 voltages</u>		<u>Q-17 voltages</u> (voltage measurements are made in receive mode)	
Collector	4.61 VDC	Collector	9.77 VDC
Emitter	0.0 VDC	Emitter	3.88 VDC
Base	0.68 VDC	Base	4.60 VDC

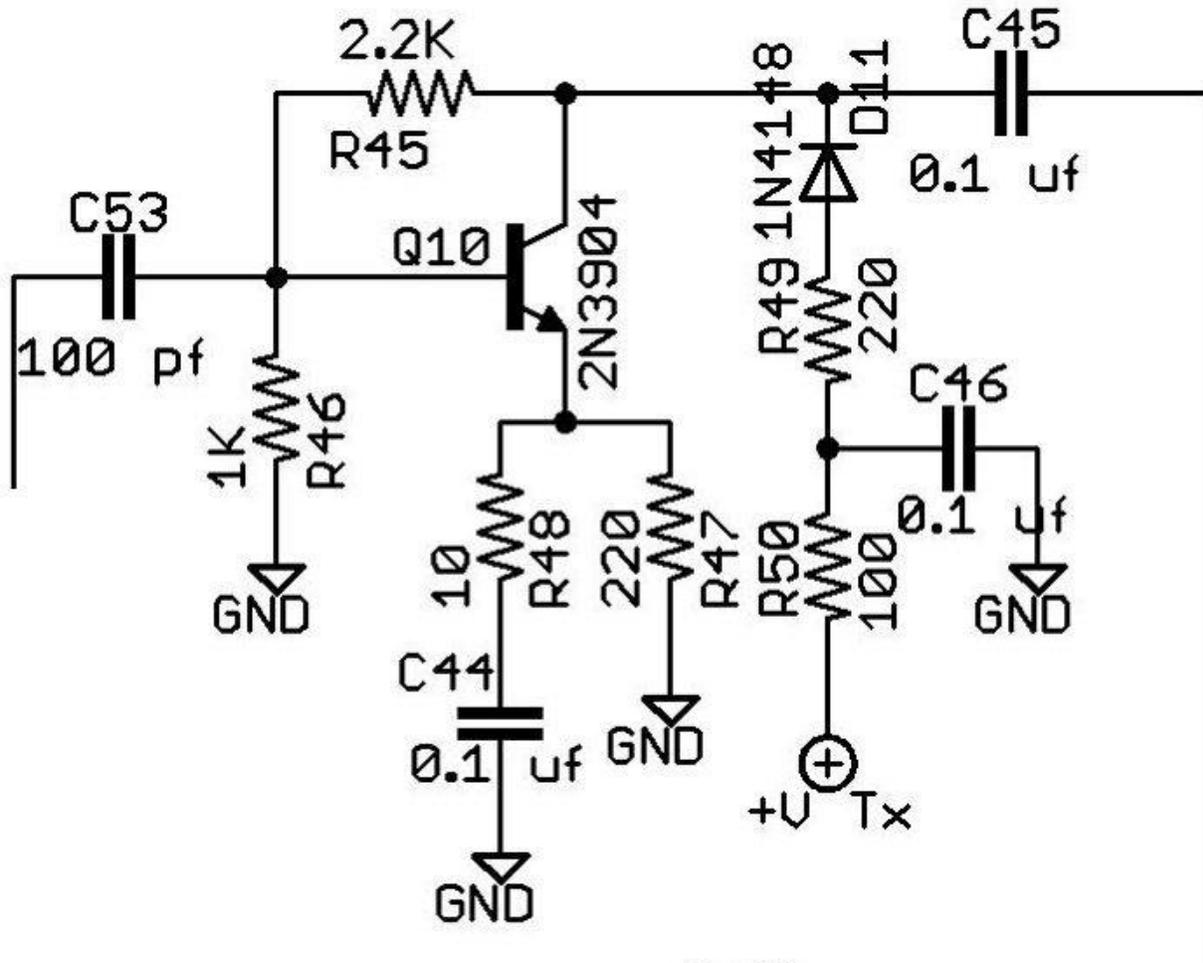
*Transmit 1st IF Amplifier*



Q-12 Voltages (measured in transmit mode)

Collector	8.57 VDC
Emitter	1.93 VDC
Base	2.65 VDC

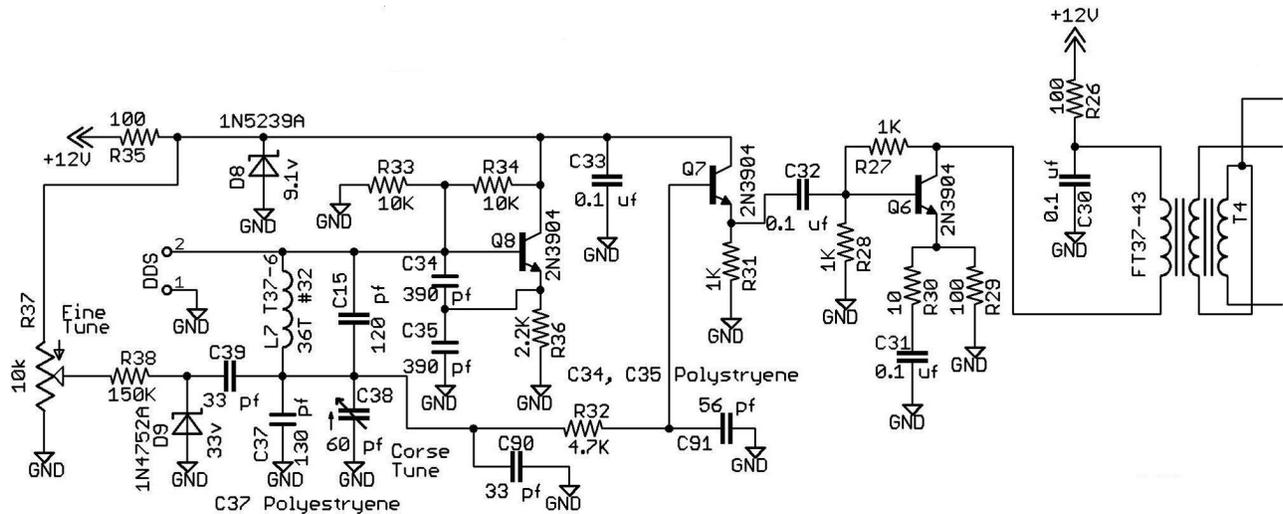
*Transmit 2nd IF Amplifier*



Q-10 Voltages (measured in transmit mode)

Collector	7.59 VDC
Emitter	1.63 VDC
Base	2.35 VDC

## VFO Circuit



Bias for Q-7 is developed from the same two resistors (R-33 and R-34) that provide bias for Q-8.

Main frequency determining components of the VFO include L-7, C-34 & C-35, C-15, C-37, C-90, and C-38. D9 acts as a voltage variable capacitor in series with C-39 to provide Fine Tuning control. For adequate VFO stability C-34, C-37, and C-35 should be polystyrene types (these are semi-transparent plastic). C-15, C-39, and C-90 should be NPO types (they have a black band on the top section).

For operation on 17 meters, the VFO operates 12.96 MHz below the desired frequency (18.068 – 12.96 = 5.108 MHz and 18.168 - 12.96 = 5.208 MHz) so the VFO needs to tune over the range of 5.108 to 5.208 MHz. VFO alignment steps are:

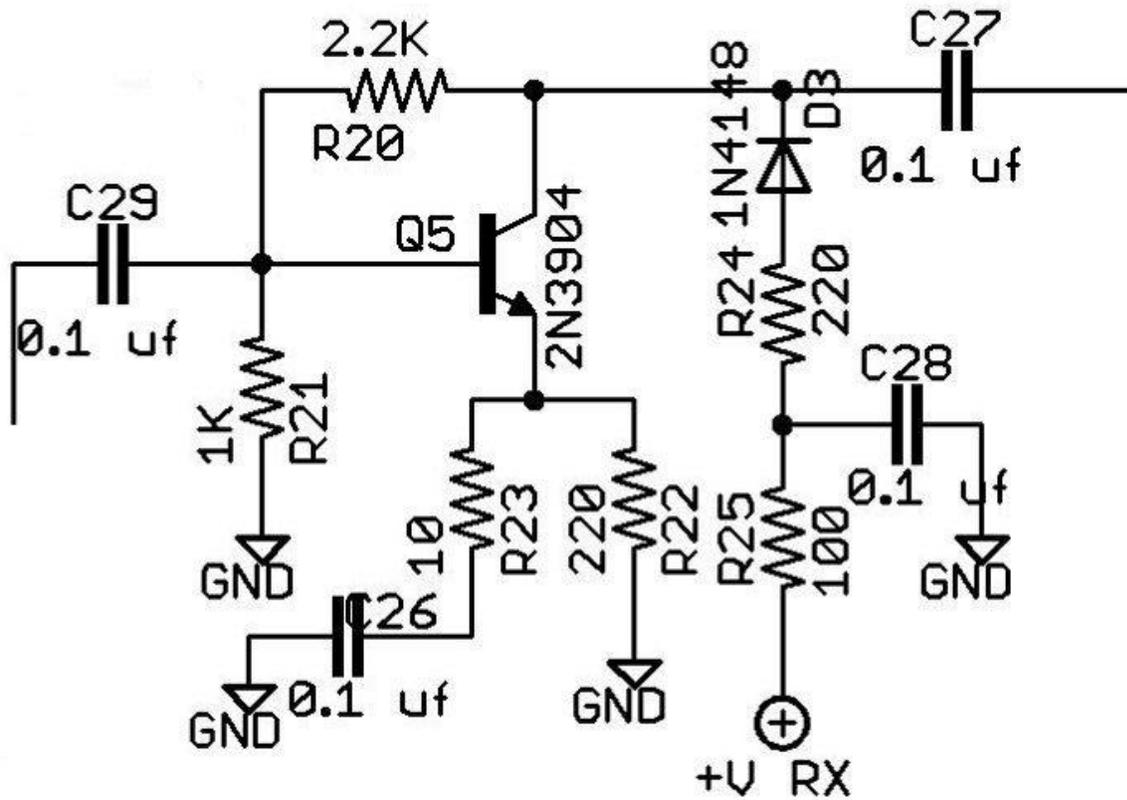
1. Set the Fine Tune potentiometer to mid-point.
2. Open C-38 (the polyvaricon) to minimum capacitance.
3. Adjust C-38 trimmer capacitor so the VFO is operating at or just above 5.208 MHz. If you cannot reach that frequency, try changing the values of C-90, then C-37, and lastly C-15.
4. Close C-38 (the polyvaricon) to maximum capacitance and verify that your VFO frequency is now below 5.108 MHz.

Waveforms present in this oscillator will affect the accuracy of DC voltmeters. In order to measure these potentials you should stop the oscillator by temporarily connecting a 0.1 mfd capacitor across R-36.

<u>Q-8 Voltages</u>	<u>Q-7 Voltages</u>	<u>Q-6 Voltages</u>
Collector 9.13 VDC	Collector 9.13 VDC	Collector 7.98 VDC
Emitter 3.75 VDC	Emitter 3.64 VDC	Emitter 3.16 VDC
Base 4.40 VDC	Base 4.29 VDC	Base 3.88 VDC

(Remember to remove the 0.1 that was installed to stop the oscillator)

*Receive RF Amplifier*



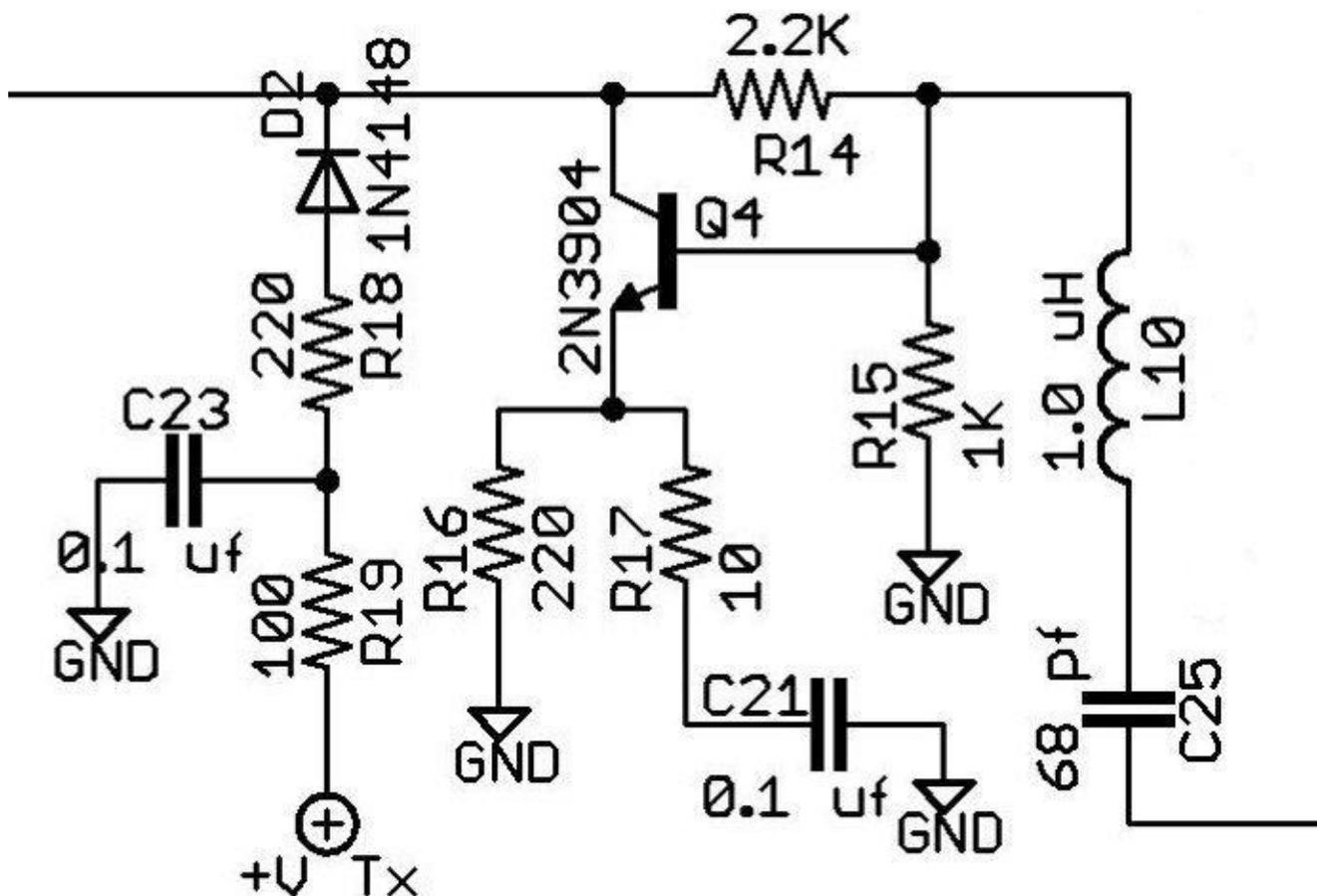
Q-5 Voltages (measured in receive mode)

Collector 7.62 VDC

Emitter 1.65 VDC

Base 2.36 VDC

*Transmit RF Amplifier*

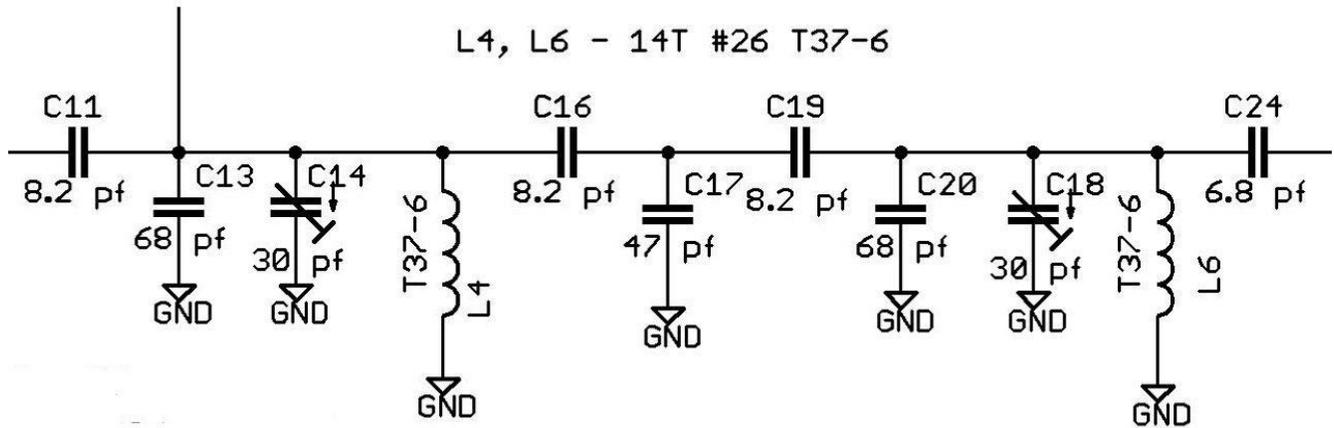


C-68 and L-10 form a series resonant bandpass filter to block VFO and IF energy from reaching the transmit amplifier stages.

Q-4 Voltages (measure in transmit mode)

Collector	7.60 VDC
Emitter	1.61 VDC
Base	2.33 VDC

## RF Filter



The RF filter is critical and must be correctly tuned for the transceiver to perform properly.

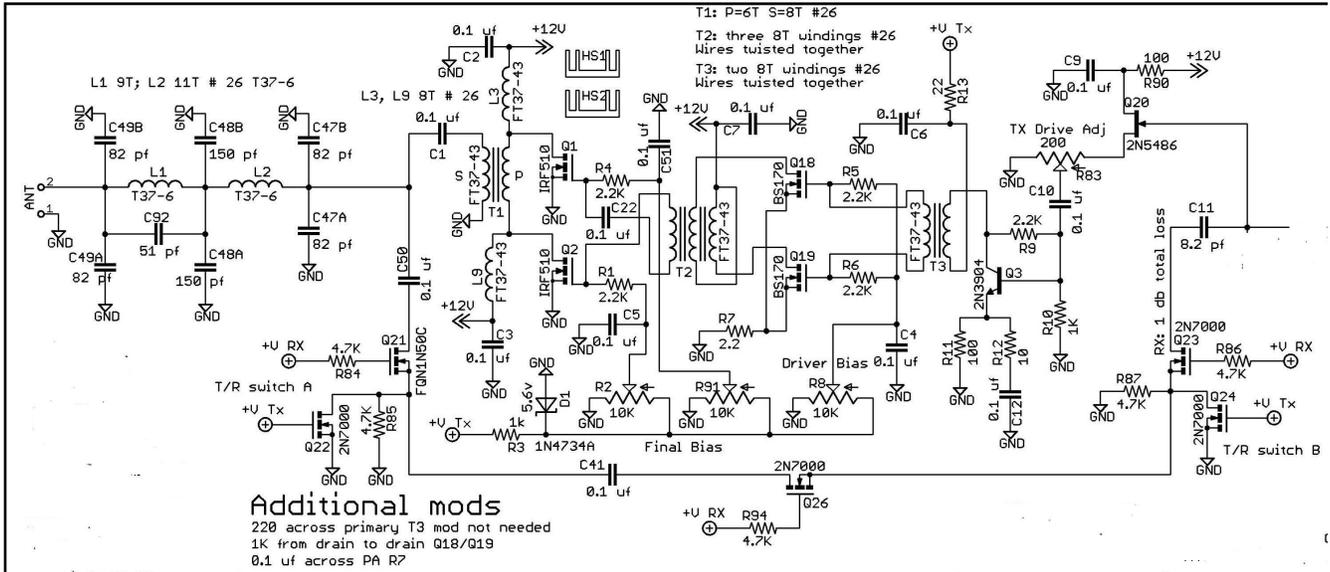
C-16, C-17, and C-19 form an impedance transformation that was used to avoid using very tiny capacitance coupling between L-4 and L-6.

If C-13, C-14, and L-4 will not tune to midpoint in the 17 meter band, adjustment should be made by adding or subtracting turns on L4.

If C-20, C-18, and L-6 will not tune to midpoint in the 17 meter band, adjustment should be made by adding or subtracting turns on L-6.

When adjusting C-14 or C-18, you should find 2 rotation positions which peak the signal. This is to insure that you are not at an extreme end of rotation and not really at a peaking point.

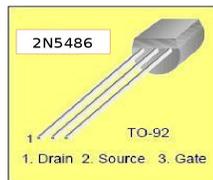
# Transmit RF PA, T/R Switching, and Antenna LPF



Voltagess (Transmit Mode)

**Q-20 (2N5486)**

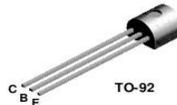
- Drain 10.77 VDC
- Source 1.27 VDC
- Gate 0.0 VDC



**Q-3 (2N3904)**

- Collector 10.83 VDC
- Emitter 2.52 VDC
- Base 3.27 VDC

**2N3904**

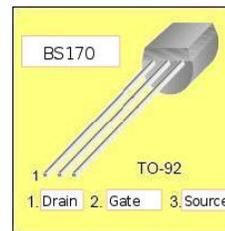


**Q-18 (BS170)**

- Drain 11.46 VDC
- Source \*\*0.044 VDC
- Gate (adjust) VDC

**Q-19 (BS170)**

- Drain 11.46 VDC
- Source \*\*0.044 VDC
- Gate (adjust)VDC



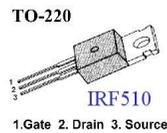
\*\* 20 ma = 0.044 volts DC across R-7

**Q-1 (IRF510)**

- Drain 11.46 VDC
- Source 0.0 VDC
- Gate (adjust)VDC

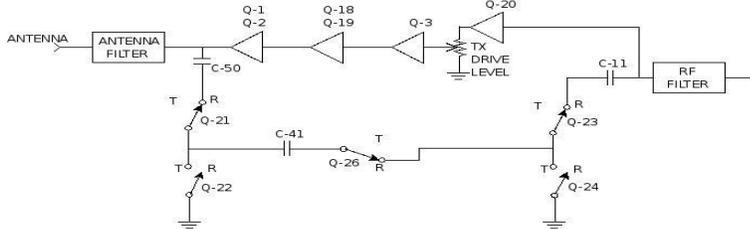
**Q-2 (IRF510)**

- Drain 11.46 VDC
- Source 0.0 VDC
- Gate (adjust)VDC



**Transmit/Receive Antenna Switch:**

This part of the circuit is a set of on/off switches implemented using MOSFET transistors. Q-21 (FQN1N50C) has a 450 volt breakdown capability and is in OFF mode during transmit. Q-22 (2N7000) is ON during transmit and shunts RF to ground during that period. Q-26 (2N7000) is in OFF mode during transmit and blocks RF during transmit. Q-24 (2N7000) is in ON mode during transmit and shunts RF to ground during that period. Q-23 (2N7000) is in OFF mode during transmit and blocks RF when transmitting. Together these switches pass received signals around the RF PA section during receive and block high power RF feedback from entering the RF PA input side during transmit.



*Illustration 29: Antenna T/R Switching Arrangement*

