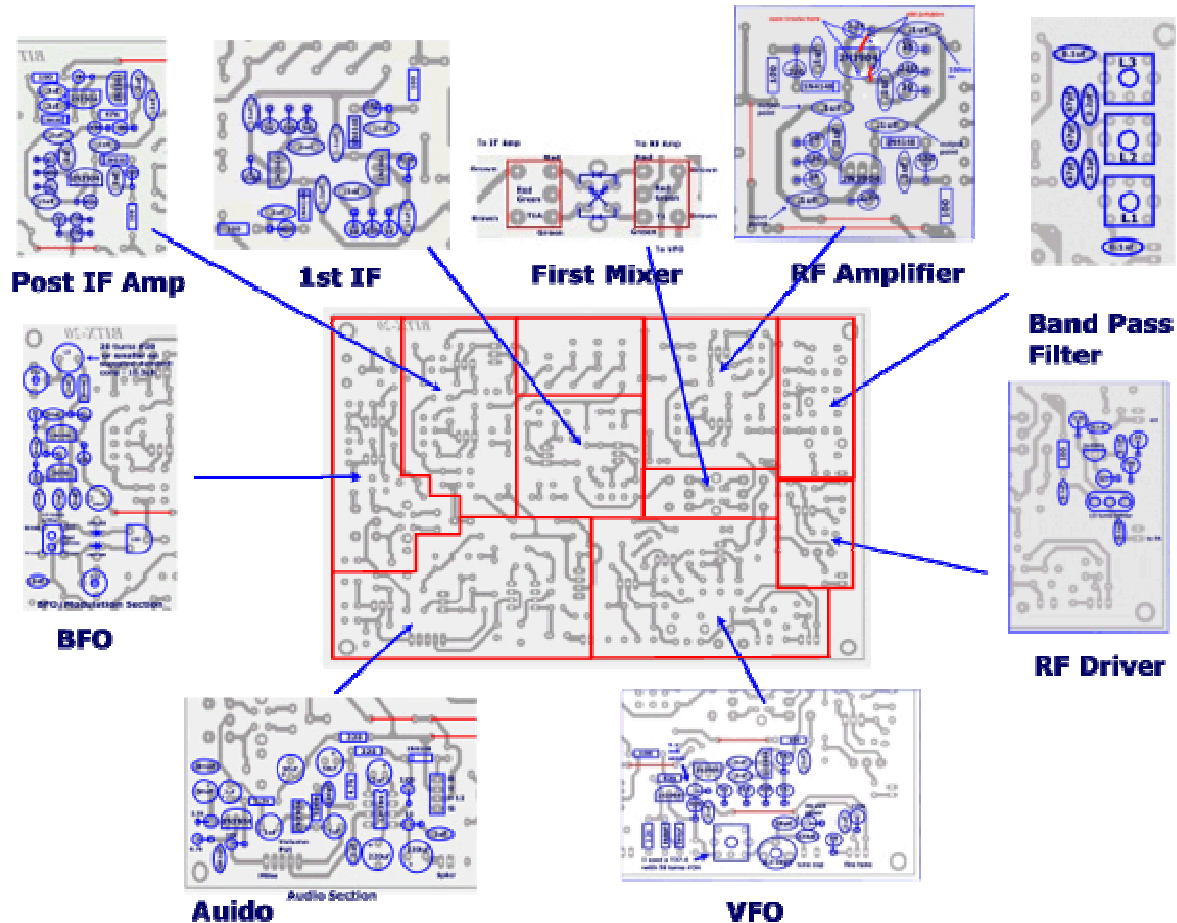
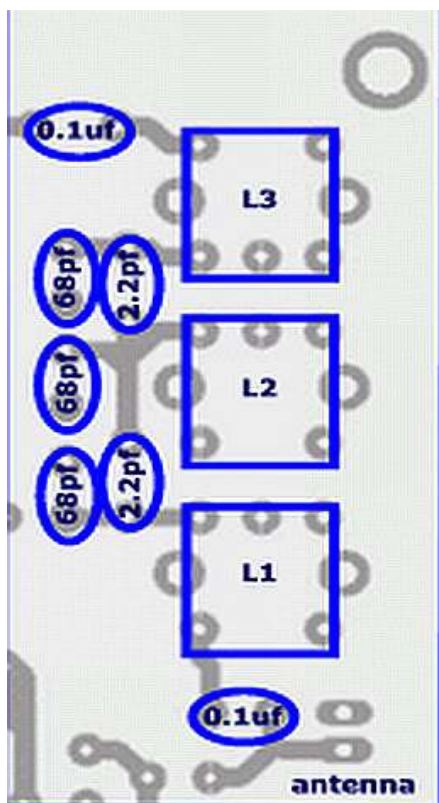


Building a Bitx20 Version 3

The board can be broken into sections and then built and tested one section at a time. This will make troubleshooting easier as any problems will be confined to one small section.



Install all of the wire jumpers onto the board. These can use bare or insulated wire. #22 wire will fit nicely through the holes. Place the jumpers where indicated by the red lines. If you have access to some header pins, it will make testing of the board a little easier as you can plug and unplug the wires between testing steps. We will be applying voltage to different power pins to enable the receiver and transmitter. If you don't have the pins, a spdt switch can be used.



RF Amplifier Section

For the RF amplifier section you will need the following components.

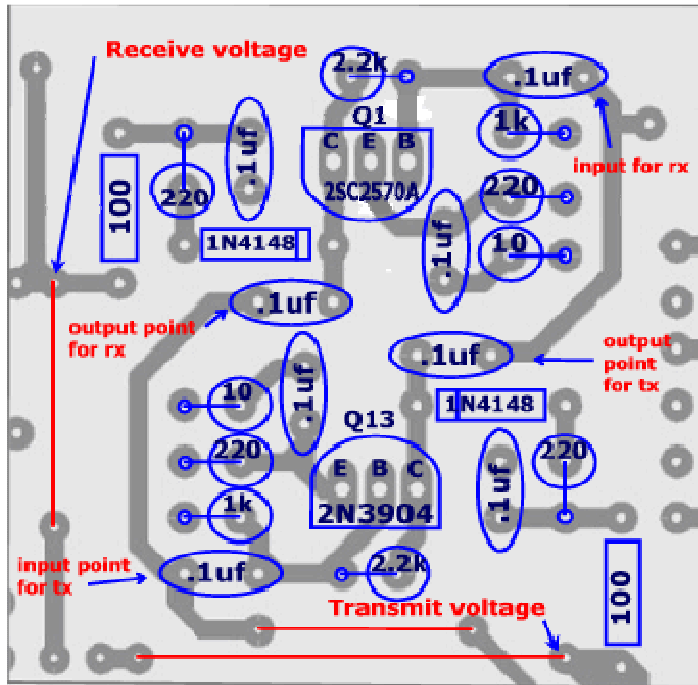
RF Amplifier Components

	quantity	value	description	color code
	2	10 ohm	resistors	brn-blk-blk
	2	100 ohm	resistors	brn-blk-brn
	4	220 ohm	resistors	red-red-brn
	2	1k	resistors	brn-blk-red
	2	2.2k	resistors	red-red-red
	8	.1uf	capacitors	
	2	1N4148	diodes	
	1	2N3904	transistor	
	1	2SC2570A	furnished with boards	

Using the parts placement diagram below, assemble the RF amplifier section.

Note:

Install the transistors with the flat as shown on the drawing. The board silkscreen is not correct for 2N3904's. It is correct, however, for the 2SC2570A. Also, the 2SC2570A pins are not configured the same as the 2N3904's so is not directly interchangeable.



Note:

When setting the power supply voltage to measure the current, if you have 2 meters, hook one up as the ma meter and then measure the voltage using the other where it enters the board. ma meters have an internal voltage drop and if you set the power supply to 13.25 volts, there will be less voltage at the board due to the meters voltage drop.

After assembly, apply 13.25 volts to the Receive voltage test point. The measured current should read approximately 11.7 ma's

Measure the Q1 voltages and compare to the chart below. There is space to document your readings after the standard voltages.

Disconnect the receive voltage line and connect the 13.25 volts to the Transmit voltage point. **Warning! Do not ever have voltage applied to the Receive and Transmit point simultaneously!** The measured current should read approximately 11.9 ma's .

ma's

Measure the Q13 voltages and compare to the chart below.

Transistor voltages with 13.25 volts applied

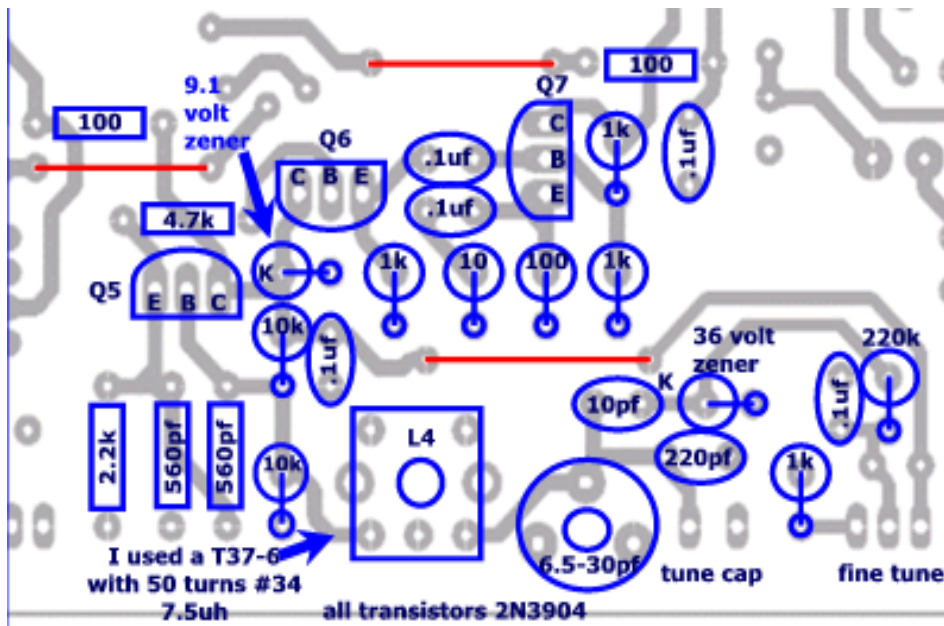
Receive - Q1 voltages			Transmit - Q13 voltages		
Collector	8.76	<input type="text"/>	Emitter	2.008	<input type="text"/>
Emitter	1.995	<input type="text"/>	Base	2.703	<input type="text"/>
Base	2.711	<input type="text"/>	Collector	8.69	<input type="text"/>

For the VFO section you will need the following components.

VFO Components

quantity	value	description	color code
1	10 ohm	resistor	brn-blk-blk
3	100 ohm	resistors	brn-blk-brn
4	1k	resistors	brn-blk-red
1	2.2k	resistor	red-red-red
1	4.7k	resistor	yel-vio-red
2	10k	resistor	brn-blk-orn
1	220k	resistor	red-red-yellow
1	10pf npo	capacitor	
1	220pf npo	capacitor	
2	560pf npo/polystyrene	capacitor	
5	.1uf	capacitors	
1	6.5-30pf	variable capacitor	
3	2N3904	transistor	
1	1N5239A or equiv 9.1 volt	zener diode	
1	1N4752A or equiv 33 volt	zener diode	
1	T37-6 with 50 turns #34 - 7.5 uh	toroid coil	

Using the parts placement diagram below, assemble the VFO section.



After assembly, apply 13.25 volts to the Voltage test point. The measured current should read approximately 44.8 ma's

ma's

Measure Q5, and Q6 voltages and compare to the chart below. Your voltages may be higher as my 9.1 volt zener is only 8.48. You can't measure the Q7 voltages until T1 is installed.

Transistor voltages with 13.25 volts applied

		Q5		Q6
Emitter	7.21	<input type="text"/>	6.36	<input type="text"/>
Base	6.96	<input type="text"/>	7.08	<input type="text"/>
Collector	8.48	<input type="text"/>	8.48	<input type="text"/>

Mixer Section

For the mixer section, you will need the following components.

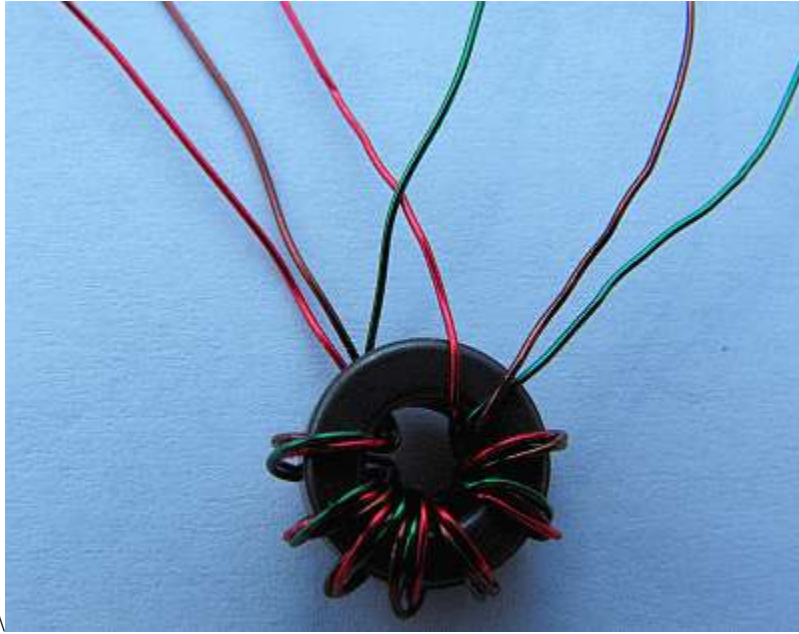
Mixer Components			
	quantity	value	description
<input type="checkbox"/>	4	1N4148	diode
<input type="checkbox"/>	2	FT37-43 cores or supplied binocular cores	T1 and T1a

First we need to wind the trifilar transformers. You can find a video on winding trifilar transformers at

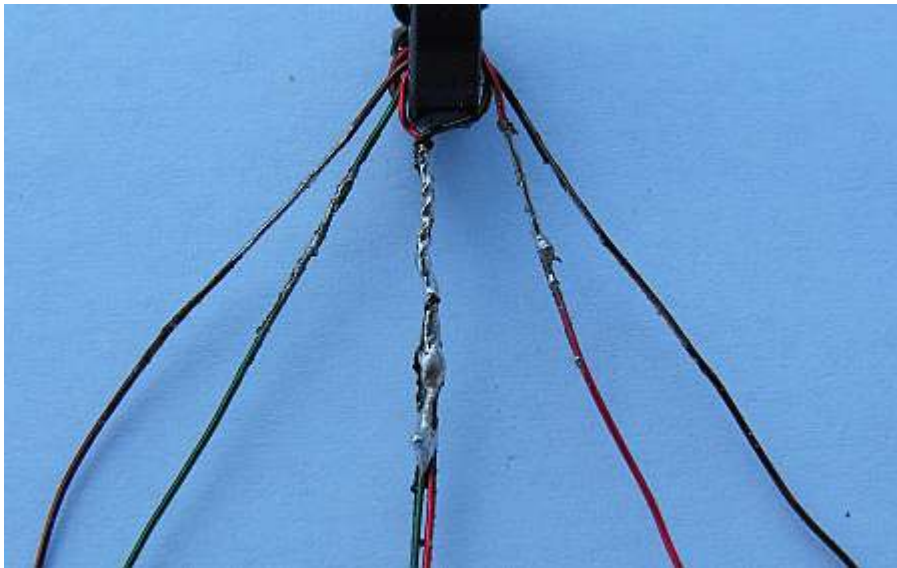
[Winding trifilar transformers](#)

The transformers may be wound using either the supplied binocular cores or FT37-43 cores. You can investigate further by reading [Wide-Band Transformers In the Bitx](#) Instructions are included for both.

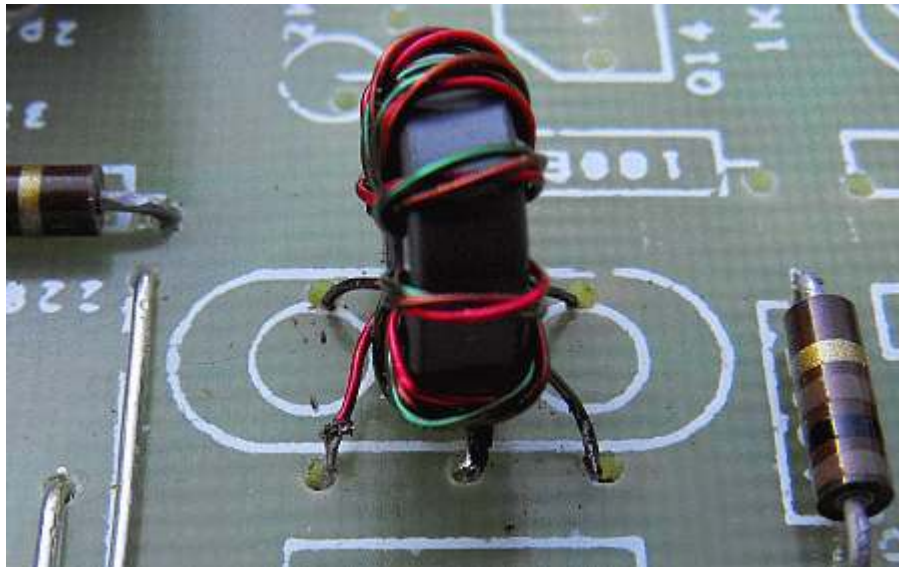
Use FT37-43 cores with 8 turns of trifilar wire. This will take 7" of wire for each transformer. 1 turn is 1 pass thru the center. We need 2 transformers. I used red, green, and brown #28 wire but anything from #26 - #30 should be fine as size doesn't make much difference as long as it will fit into the core. The different colors make keeping the windings straight easier. When pulling the wire through the holes in the cores, be careful not to scrape the insulation off.



When you are through winding, it should look like this. Use the red wire from the right side of the picture and take the green wire from the left side of the picture and twist them together. This forms the center-tapped windings. If your wire is not heat strippable, strip of the insulation before twisting them together.



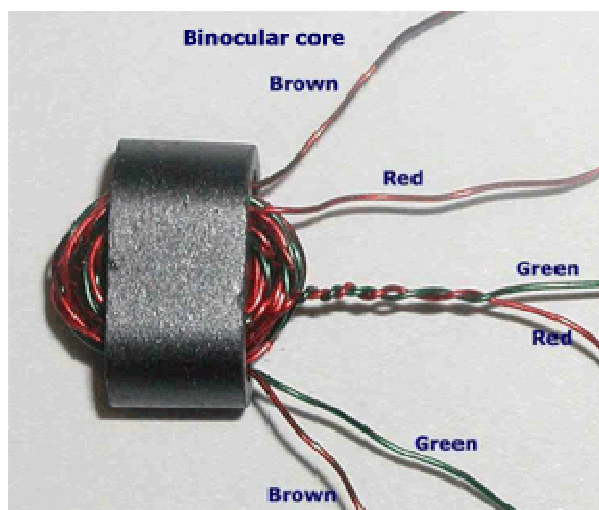
After tinning, it should look like this. Install both transformers. **Do not install the diodes yet.**



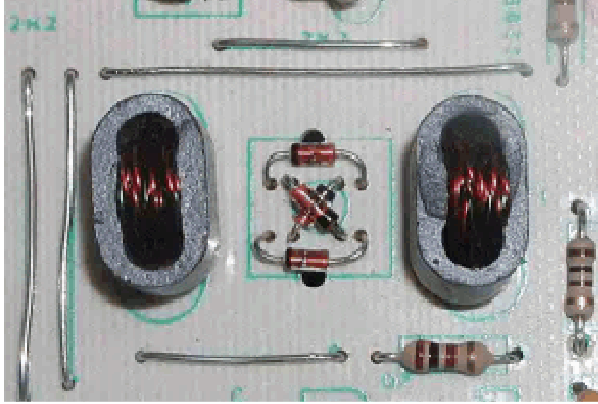
Installed, T1 should look like this.

Using the supplied binocular cores

Use the binocular cores and wind 8 turns of trifilar wire onto the cores. 1 turn is a trip through both holes ending up where you started. We need 2 transformers. I had red, green, and brown #28 wire. The original drawing called for #32 but the size doesn't make much difference as long as it will fit into the core. The different colors make keeping the windings straight easier. When pulling the wire through the holes in the cores, be careful not to scrape the insulation off. The binocular cores can have sharp edges. When you are done, it should look like this.



The completed transformer should look like this. Yours won't look so full as this one actually had 13 turns from an earlier build. Use 8 turns only though.



The installed binocular transformers should look like this. **Do not install the diodes yet.** Wait until after you have performed the test below.

After winding and installing both transformers, verify continuity using an ohmmeter. There should be 0 ohms between the following points for both T1 and T1a. This step insures that the insulation was removed properly and you have good solder connections. Failure to completely remove the insulation may result in a faulty solder joint. This is a common failure item.

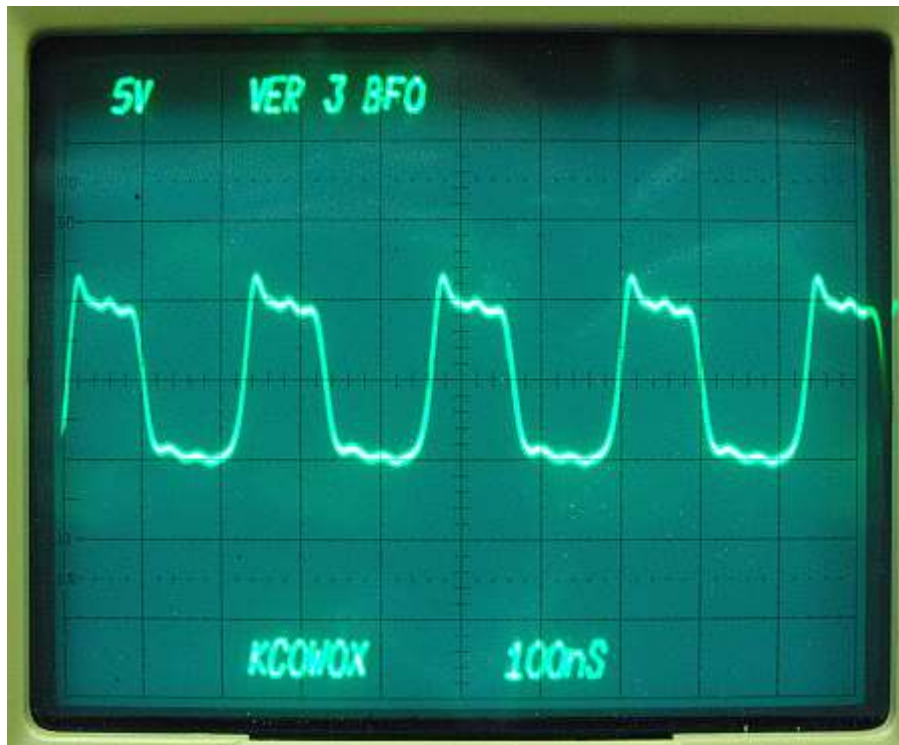
	brown	brown	0 ohms
	green	red-green or center tap	0 ohms
	red-green or center tap	red	0 ohms

Now we can measure the Q7 voltages. Apply 13.25 volts to the Voltage test point. The measured current should read approximately 84 ma's

ma's

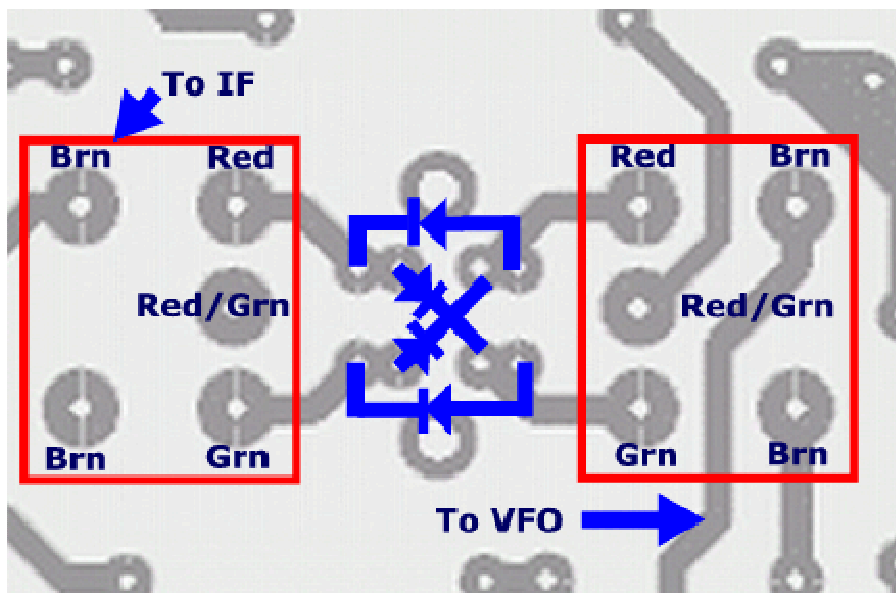
	Q7
3.71	
4.40	
8.85	

If you have an oscilloscope, using a x10 probe, connect to the collector of Q7.

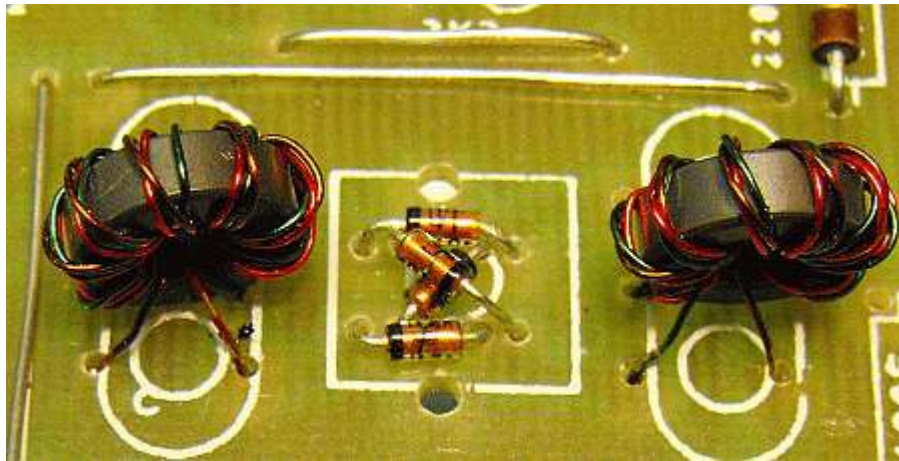


The frequency should be variable using the tuning capacitor. I have a 10-365pfd variable and the frequency will vary from 3.8mhz to 4.8mhz. We will trim the frequency to the proper range later.

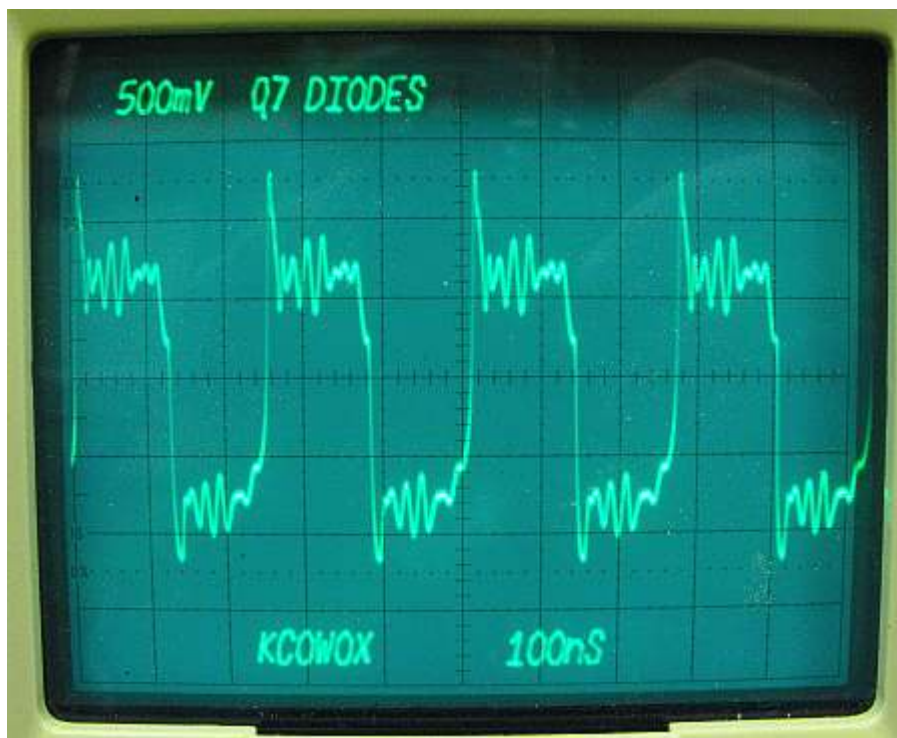
Using the parts placement diagram below, install the 4 diodes observing the proper polarity. The band is the cathode end.



Bend the leads and position them observing the black bands as shown below.



Q7 collector waveform now is:



The signal is clipped to \pm about .7 volts as the diodes bias on. If the waveform wasn't clipped or only clipped on one side, the problem would be an open in the diode circuit or a bad diode.

1st IF Amplifier Section

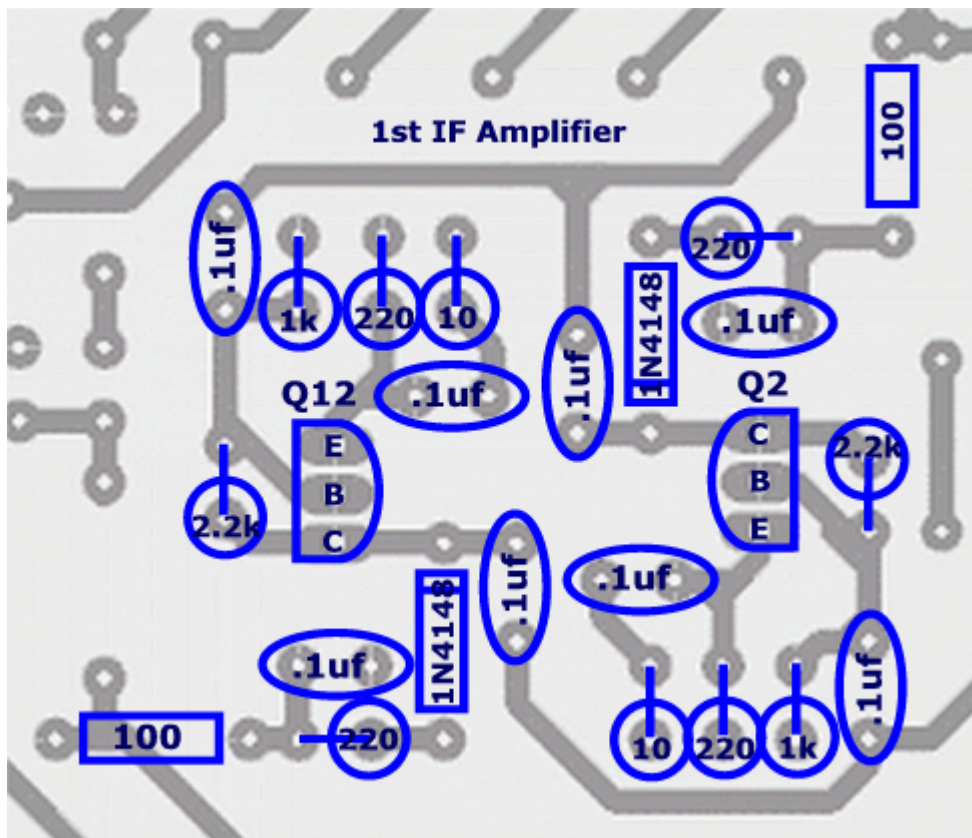
This is almost an exact duplicate of the RF Amplifier section. For the 1st IF Amplifier section you will need the following components.

1st IF Amplifier Components

quantity	value	description	color code
----------	-------	-------------	------------

	2	10 ohm	resistors	brn-blk-blk
	2	100 ohm	resistors	brn-blk-brn
	4	220 ohm	resistors	red-red-brn
	2	1k	resistors	brn-blk-red
	2	2.2k	resistors	red-red-red
	8	.1uf	capacitors	
	2	1N4148	diodes	
	2	2N3904	transistors	

Using the parts placement diagram below assemble the 1st IF amplifier section.



After assembly, apply 13.25 volts to the Receive voltage test point and the voltage test point. The measured current should read approximately 109.2 ma's

ma's

Measure the Q2 voltages and compare to the chart below.

Disconnect the receive voltage line and connect the 13.25 volts to the Transmit voltage point.

Warning! Do not have voltage applied to the Receive and Transmit point simultaneously!

The measured current should read approximately 109.2 ma's

ma's

Measure the Q13 voltages and compare to the chart below.

Transistor voltages with 13.25 volts applied

Q2 voltages

Collector 8.74

Base 2.708

Emitter 1.988

Q12 voltages

Collector 8.76

Base 2.696

Emitter 1.970

Q2 and Q12 circuits are identical so the differences in measured voltages are due to component tolerances.

2nd IF Amplifier

We are going to skip the crystal filter for now. To check our crystals and match them we need an oscillator. We will have one after we complete the BFO section. Also, this is a good spot to leave open to allow easy testing with test equipment later.

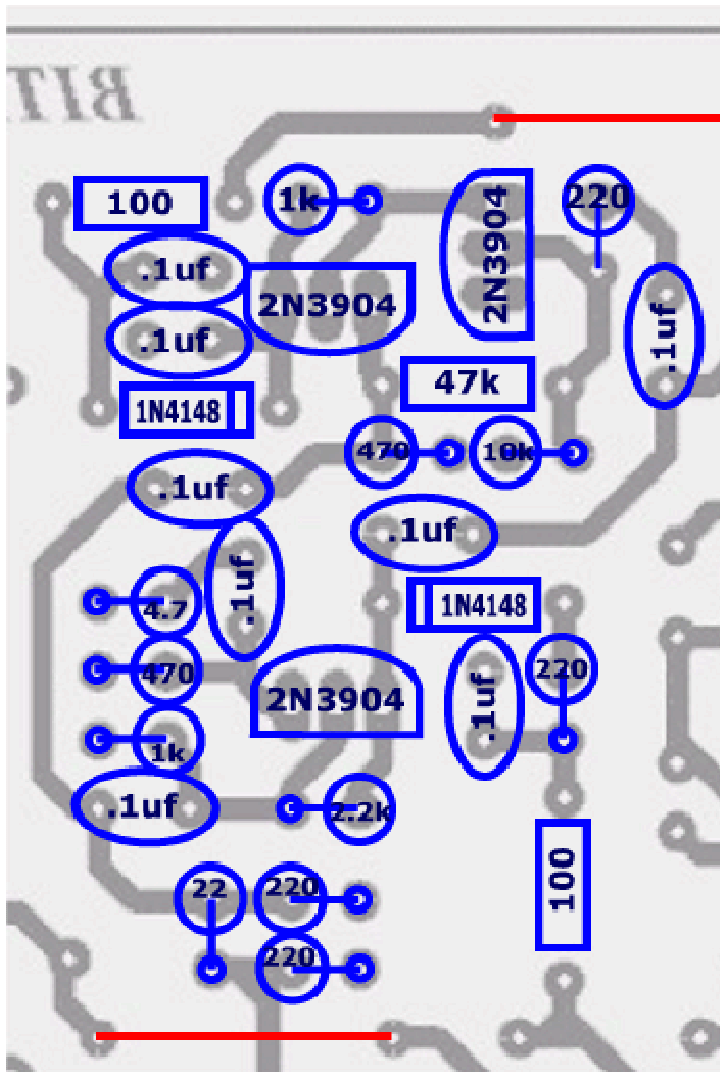
We will need the following components for the 2nd IF Amplifier.

2nd IF Amplifier Components

	quantity	value	description	color code
<input type="text"/>	1	4.7 ohm	resistor	yel-vio-gld
<input type="text"/>	1	22 ohm	resistor	red-red-blk
<input type="text"/>	2	100 ohm	resistors	brn-blk-brn
<input type="text"/>	4	220 ohm	resistors	red-red-brn
<input type="text"/>	2	470 ohm	resistor	yel-vio-brn
<input type="text"/>	2	1k	resistors	brn-blk-red
<input type="text"/>	1	2.2k	resistors	red-red-red
<input type="text"/>	1	10k	resistor	brn-blk-org
<input type="text"/>	1	47k	resistor	yel-vio-org
<input type="text"/>	8	.1uf	capacitors	
<input type="text"/>	2	1N4148	diodes	
<input type="text"/>	3	2N3904	transistors	

Using the parts placement diagram below assemble the 2nd IF amplifier section.

Note: The 4.7 ohm resistor in the drawing below is correct. The silkscreen on the board may show 10e. Use a 4.7 ohm here.



Apply 13.25 volts to the receive line and the voltage line. The measured current should be approximately 124.7 ma's.

ma's

Measure and verify the voltages in the chart below for Q3 and Q3A.

Receive transistor voltages with 13.25 volts applied

Q3			Q3A		
Collector	6.08	<input type="text"/>	Collector	10.78	<input type="text"/>
Base	.71	<input type="text"/>	Base	6.07	<input type="text"/>
Emitter	0	<input type="text"/>	Emitter	5.35	<input type="text"/>

Remove the voltage from the receive line and apply it to the transmit line The measured current should be approximately 117 ma's. Measure and verify the voltages in the chart for Q11.

Transmit transistor voltages with 13.25
volts applied

Q11

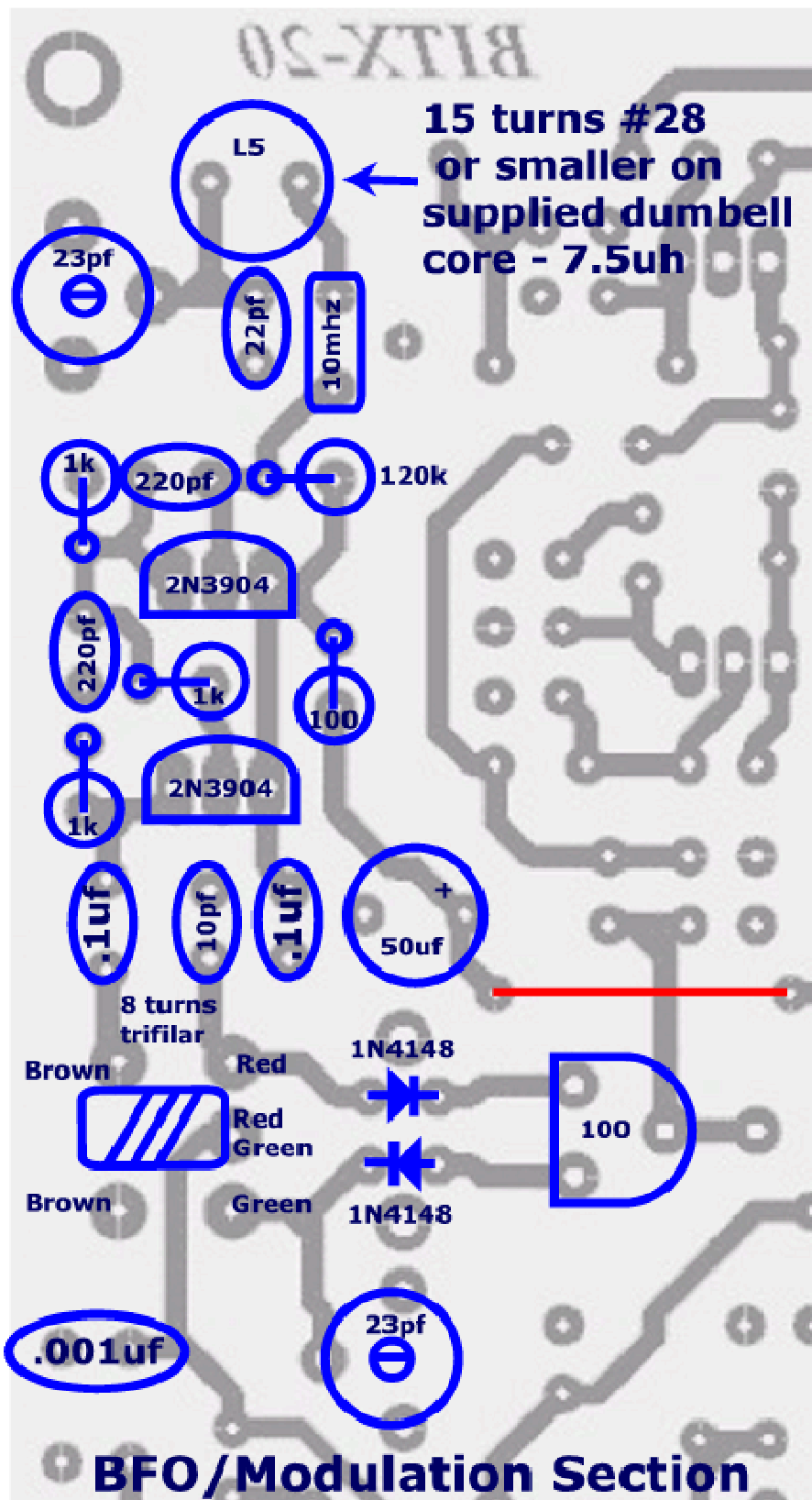
Collector	9.90	
Base	3.118	
Emitter	2.405	

BFO Section

We will need the following components for the BFO section.

BFO Section Components				
	quantity	value	description	
	1	100 ohm	resistor	brn-blk-brn
	3	1k	resistors	brn-blk-red
	1	120k	resistor	brn-red-org
	1	10pf	capacitor - npo	
	1	22pf	capacitor - npo	
	2	23pf	variable capacitors	
	2	220pf	capacitor - npo	
	1	.001uf	capacitor	
	2	.1uf	capacitors	
	1	50uf	capacitor	
	1	10 mhz	crystal	
	1	7.5uh	inductor (see text)	L5
	1	100 ohm	potentiometer	
	1	T2	transformer (see text)	
	2	1N4148	diodes	
	2	2N3904	transistors	
	2	socket pins		

Using the parts placement diagram below assemble the BFO section. If you can obtain 2 plug in socket pins for the crystal, we will use the bfo oscillator to help match the crystal filter crystals frequency before we build the crystal filter.



After assembly, apply 13.25 volts to the Voltage test point and ground to the ground point. We don't need any voltage on the Rx or Tx as the BFO runs all of the time.

The measured current should read approximately 98.6 ma's

ma's

Measure Q8 and Q9 voltages and compare to the chart below.

Transistor voltages with 13.25 volts applied

Q8 voltages

Collector 11.99

Base 6.41

Emitter 6.32

Q9 voltages

Collector 11.99

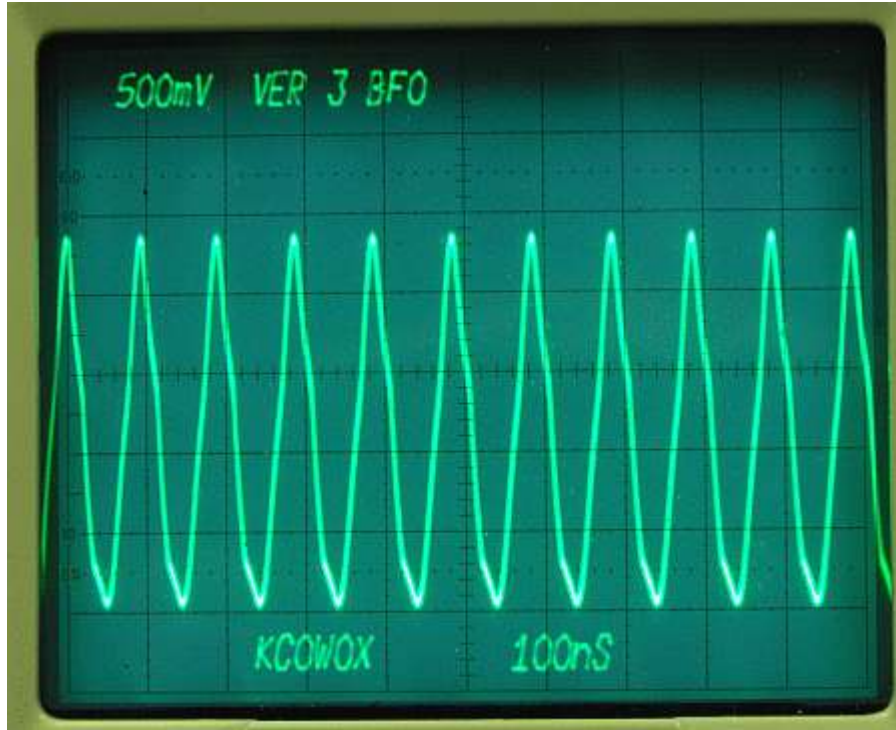
Base 6.30

Emitter 5.81

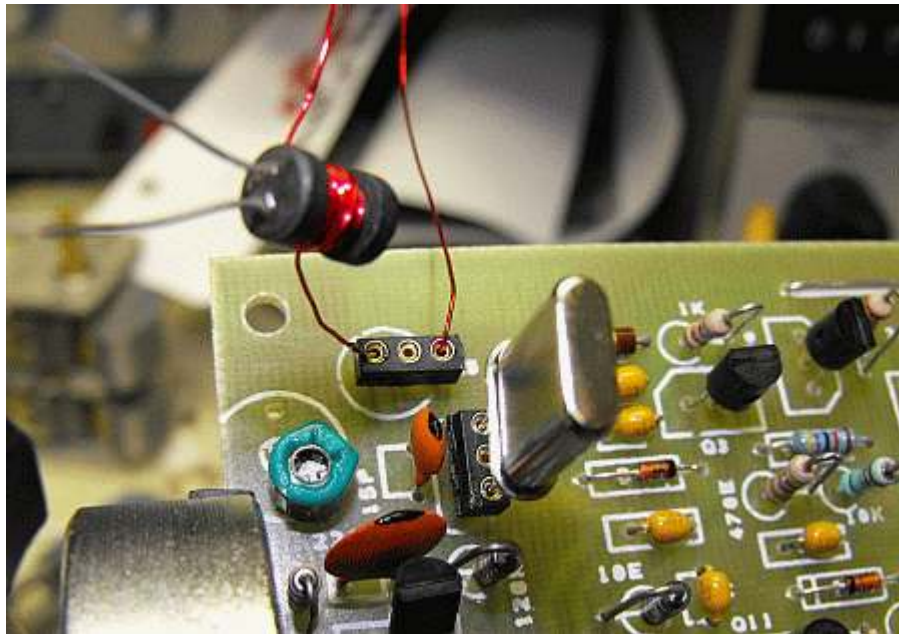
If you have an oscilloscope, connect as shown below to see the bfo output waveform.



You should see the waveform below.



If you have a frequency counter, an easy way to get the correct frequency range is a test hookup shown below. Using this method, wind a couple of extra windings on the dumbbell core and install it using a test plug made from an cut up IC socket. This will prevent damaging the board with repeated soldering/desoldering operations. A good place to connect the counter is at the junction of T2 and the 0.1uf cap as shown in the picture above. Apply power and adjust the variable cap to the middle of it's range. Remove a turn or two until the frequency is near 9,995,268 hz. This should be close enough that it should adjust properly later.



My BFO frequency, when adjusted properly for the filter on my board, was 9,995,268 hz.

If you don't have access to a counter, just wind the 15 turns on the core.

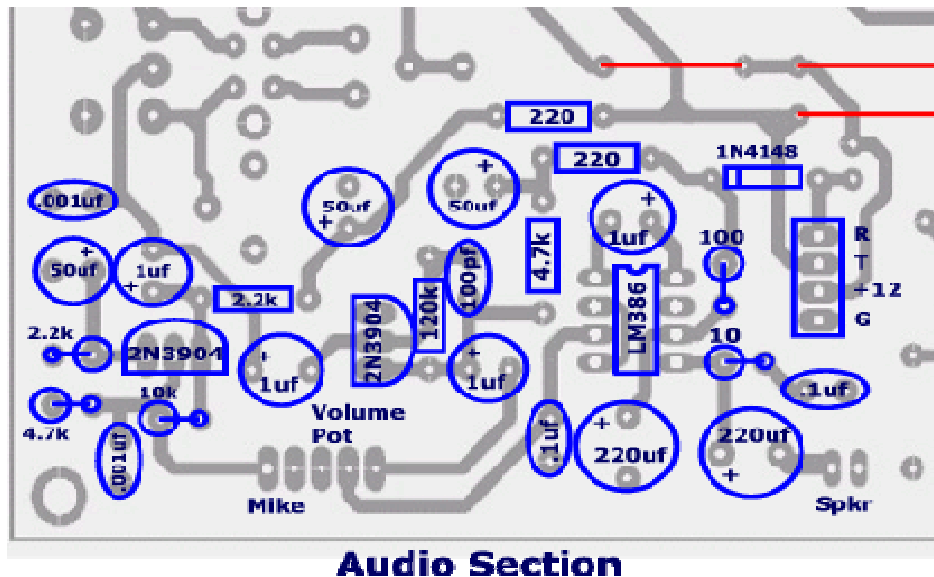
Audio Section

We will need the following components for the Audio Section.

Audio Section Components				
	quantity	value	description	
	1	10 ohm	resistor	brn-blk-blk
	1	100 ohm	resistor	brn-blk-brn
	2	220 ohm	resistors	red-red-brn
	2	2.2k	resistors	red-red-red
	2	4.7k	resistors	yel-vio-red
	1	10k	resistor	brn-blk-org
	1	120k	resistor	brn-red-yel
	1	100pf	capacitor	
	2	.001uf	capacitors	
	2	.1uf	capacitors	
	4	1uf	capacitors	
	3	50uf	capacitor	
	2	220uf	capacitors	
	1	LM386	audio amp IC	

1	1N4148	diode
2	2N3904	transistors

Using the parts placement diagram below assemble the audio amplifier section.



After assembly, apply 13.25 volts to the Voltage test point, the Rx test point, and ground to the ground point. Do not connect the volume control pot or the speaker. The measured current should read approximately 146 ma's

ma's

Measure the Q4 voltages and compare to the chart below.

Transistor voltages with 13.25 volts applied					
Q4 voltages			Q10 voltages		
Collector	2.234		Collector	9.16	
Base	.709		Base	4.18	
Emitter	0		Emitter	3.50	

Remove the voltage from the RX test point and apply it to the TX test point. Leave the voltage applied to the V test point and measure the Q10 voltages and compare to the chart above.

Crystal Filter

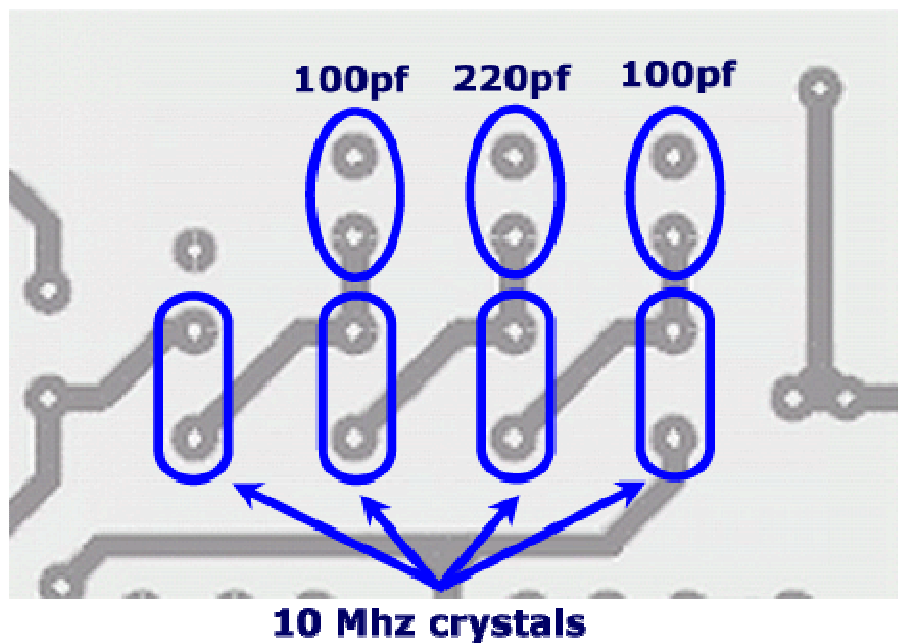
We will need the following components for the crystal filter.

Crystal Filter Components

	quantity	value	description	
	2	100pf	capacitors	
	1	220pf	capacitor	
	4	10 mhz	crystals	

If you have access to a frequency counter, the crystals should be matched as close as possible in frequency. This is done by inserting them into the BFO circuit and counting the frequency. This is best done using at least 10 crystals.

Assemble the crystal filter using the drawing below.

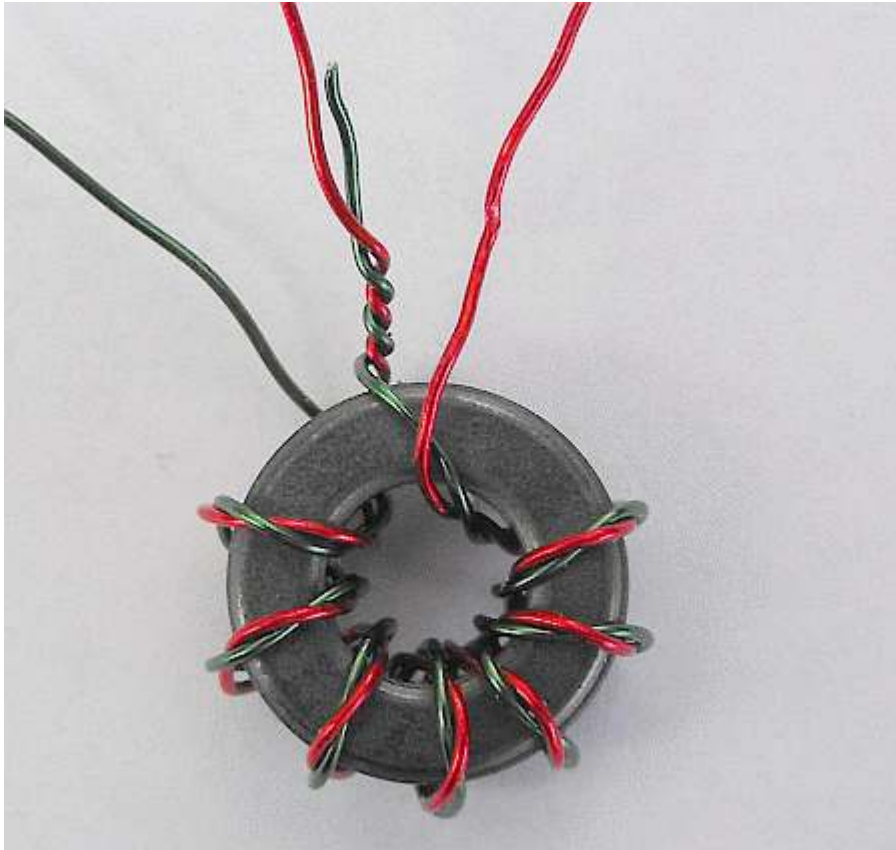


Output Driver

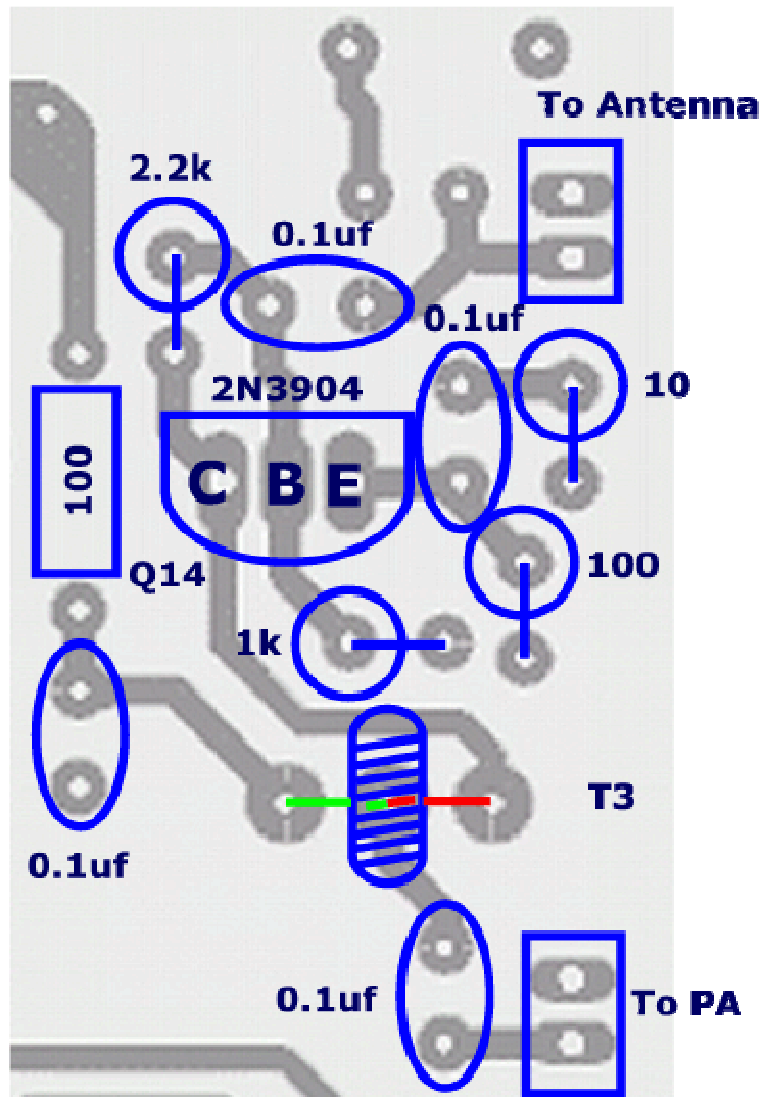
We will need the following components for the output driver.

Output Driver Components				
	quantity	value	description	
	1	10 ohm	resistor	brn-blk-blk
	2	100 ohm	resistors	brn-blk-brn
	1	1k	resistor	brn-blk-red
	1	2.2k	resistor	red-red-red
	4	.1uf	capacitors	
	1	2N3904	transistor	
	1	transformer	FT37-43	

The transformer may be made using a FT37-43 core. Wind 8 bifilar turns on the core . This will take 6" of wire. Take the left side red and the right side green and twist together to form the center tap.



Assemble the components as shown below.



After assembly, apply 13.25 volts to the Voltage test point the Tx test point, and ground to the ground point. The measured current should read approximately 159 ma's

ma's

Measure the Q44 voltages and compare to the chart below.

Q14

Collector 10.58

Base 3.19

Emitter 2.47

Test and alignment

Connect the variable tuning capacitor to the board. Apply power to the voltage connection. Do not apply to the Rx or Tx connector.

The following readings will confirm operation of the BFO and the VFO.

Communications receiver method::

BFO

Move the wire near Q9 and Q9 and tune the receiver around 9.996 mhz. Verify that the signal you are receiving is your board by turning off the power to your board.

VFO

Move the wire near Q6 and Q7. Tune the receiver in the 4.150 to 4.350 range. Verify that the signal you are receiving is your board by turning off the power to your board.

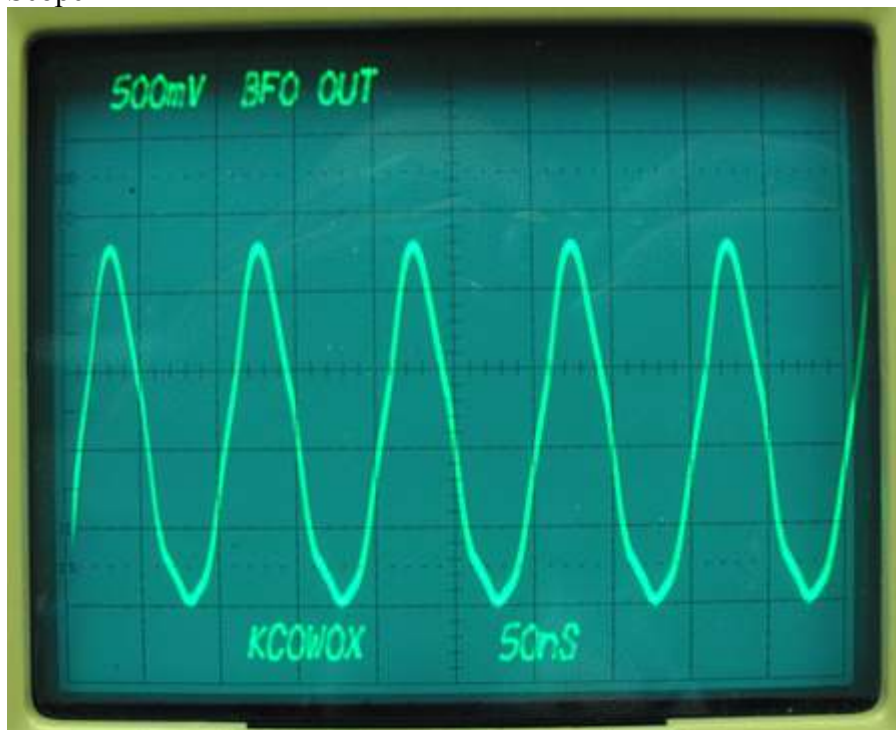
Using a "Sharpie" RF probe or scope:

Using a "Sharpie" RF Probe as detailed at <http://golddredgervideo.com/kc0wox/rfprobe.htm> you should get the following readings. These readings will be very approximate as the RF Probe readings are more of a presence and magnitude reading.:

RF Probe

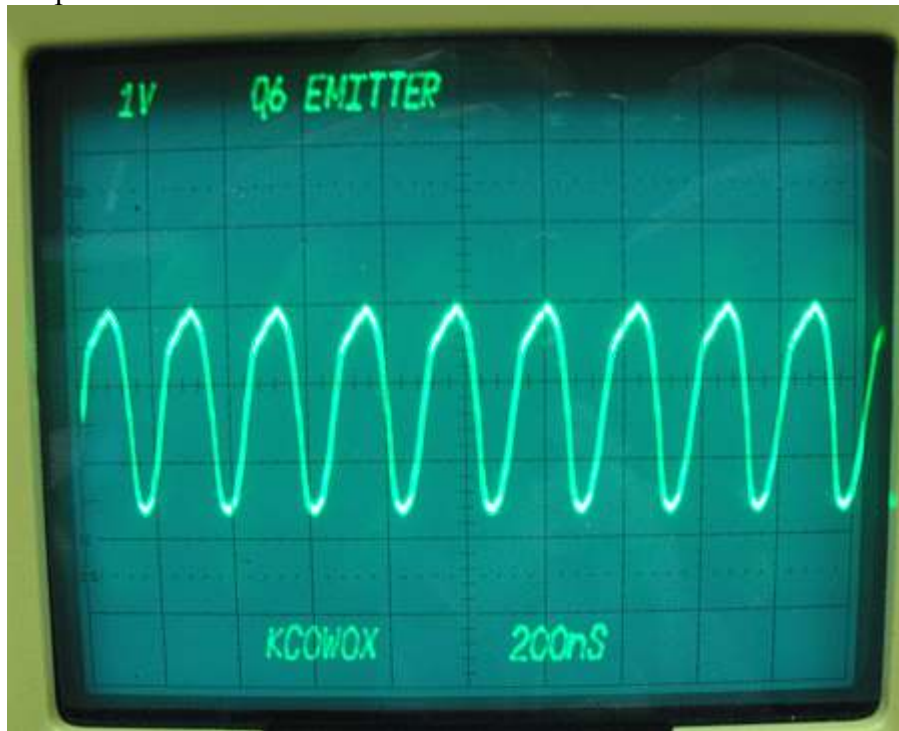
BFO junction of primary T2 and capacitor - .674 volts

Scope



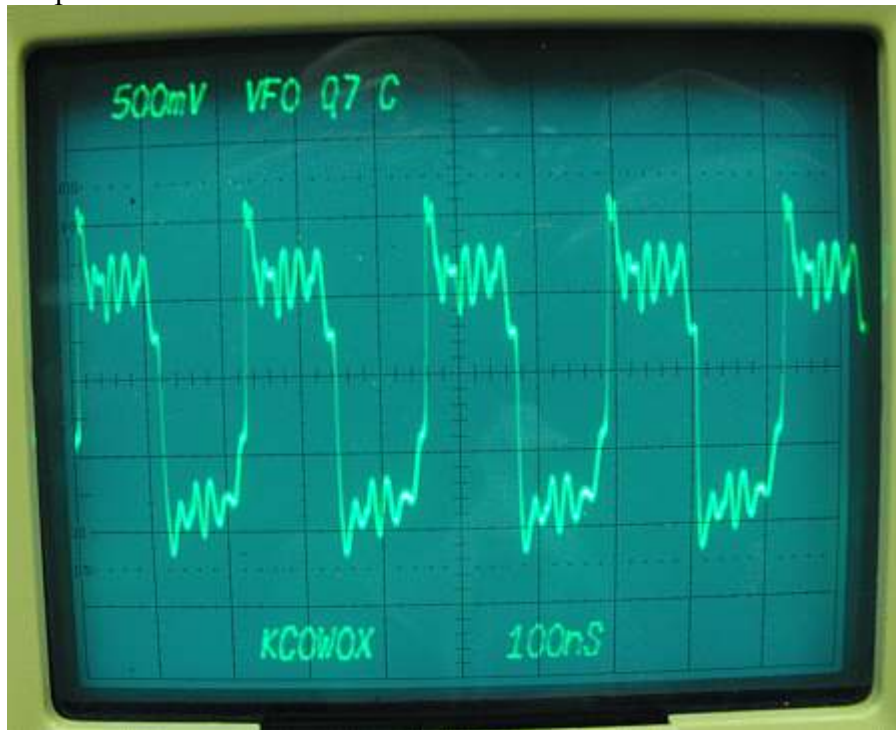
RF Probe
VFO junction of Q6 emitter and 1k resistor - 1 volt

Scope



RF Probe
VFO collector of Q7 - .59 volts.

Scope



Aligning the BFO

The proper BFO frequency will end up around 9.9953mhz. Connect the frequency counter to the emitter of Q9. You should have a tuning range of around 15khz. You can raise the frequency by removing turns from L5. If your frequency is too high, you can add capacitance in parallel with the trimmer capacitor. Once you get the frequency close, verify it this way.

Connect your "sharpie" RF probe to the PA output point.

Connect power to the transmit point.

Adjust the carrier balance pot to one end and note the reading.

Adjust it to the other end.

Set it to the end that gave the most voltage out.

Adjust the BFO frequency while watching the voltage reading until a peak is reached.

At this point the BFO is adjusted to the top of the lower skirt of the filter.

Note the reading and then adjust the BFO frequency back down until it reads about 0.45 of the maximum reading. This will set it about 7-8 db down the filter skirt.

This setting is as close as we can get until we add modulation.

Aligning the VFO

Connect the counter to the emitter of Q6. Verify the tuning range of the VFO. If it is too low, remove turns from L4. If it is too high, add capacitance in parallel with the 220pf capacitor. If it

has too wide a tuning range, add capacitance in series with the variable tuning capacitor. Use only npo capacitors or the VFO may drift excessively.

Aligning the Bandpass Filter

Adjust the VFO frequency to 4.250mhz.

Adjust the 3 transformers for the maximum displayed voltage.

While monitoring the PA Output voltage, adjust the carrier balance and the balance capacitor for minimum voltage reading. We will refine this setting after the linear is connected.

The alignment of the exciter is now done.