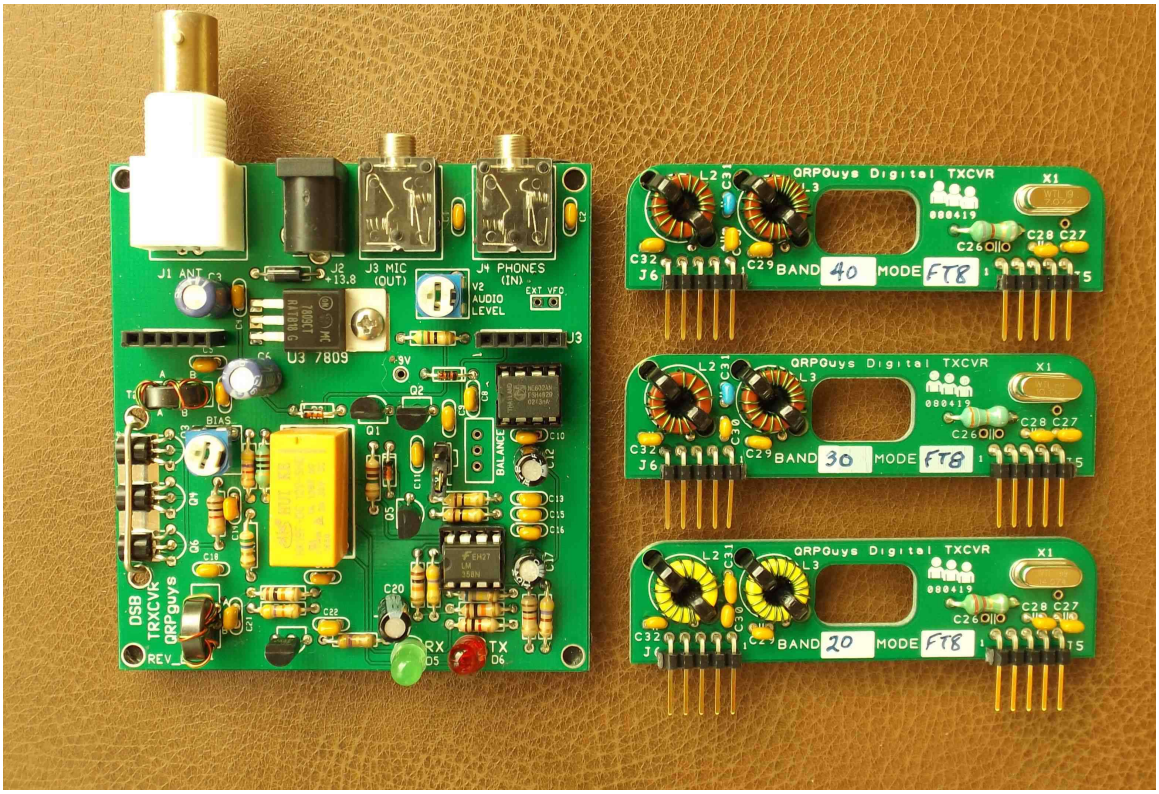
QRPGuys Digital DSB Transceiver Kit



First, familiarize yourself with the parts and check for all the components. If a part is missing, please contact us at *qrpguys.parts@gmail.com* and we will send you one.

Please read all the instructions before starting to assemble the transceiver.

PARTS LIST

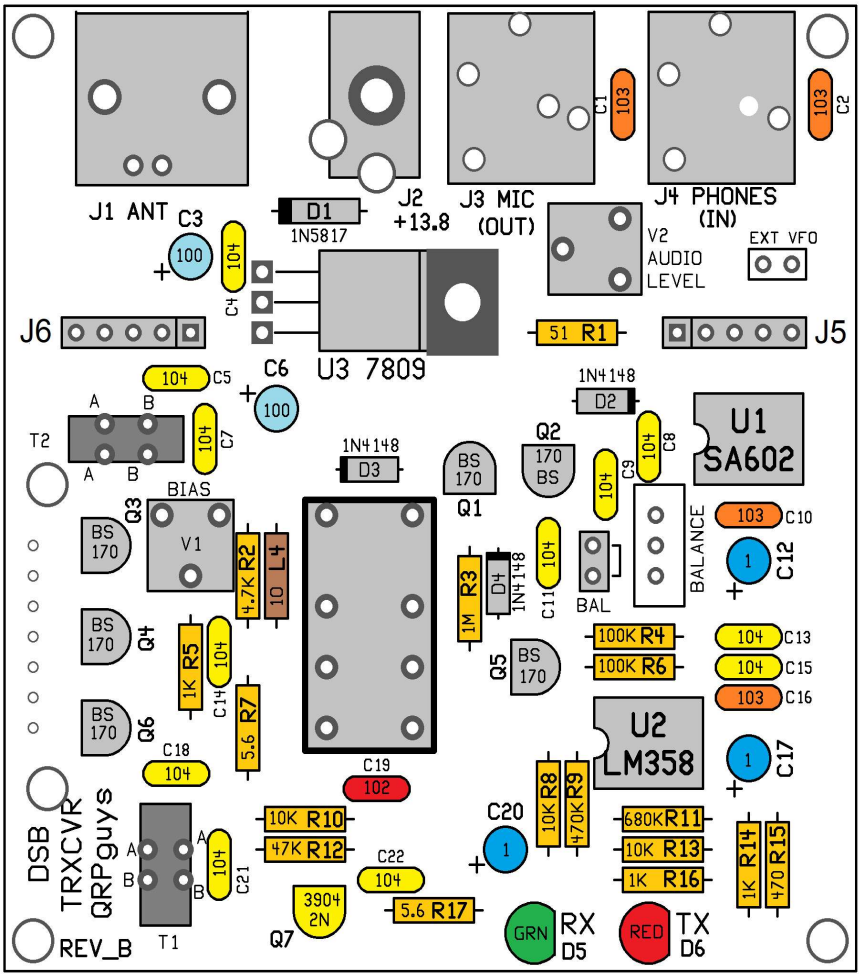
LOCATION	QUANTITY	VALUE	TYPE
C1, C2, C10, C16	4	10 nF - 103	X7R MMLC
C3, C6	2	100 uF /16V	Long lead plus
C4, C5, C7, C8, C9, C11, C13, C14, C15, C18, C21, C22	12	100 nF - 104	X7R MMLC
C12, C17, C20	3	1 uF / 25V	Long lead plus
C19	1	1 nF - 102	
D1	1	1N5817	BLACK PLASTIC
D2, D3, D4	3	1N4148	SMALL GLASS
D5	1	LED Green	May have clear lens
D6	1	LED Red	May have clear lens
J1	1	BNC Jack	PCB MOUNT
J2	1	2.1mm DC Jack	PCB MOUNT

J3, J4	2	3.5mm Phone Jack	STEREO, SWITCHED
J5, J6	2	5 Position SIP Jack	0.1” CENTERS
K1	1	12V DPDT Relay	
L4	1	10 uH choke	Brown-black-black-gold or silver
Q1, Q2, Q3, Q4, Q5, Q6	6	BS170	TO-92 MOSFET
Q7	1	2N3904	TO-92 NPN
R1	1	51 ohms	GRN-BRN-BLK-GLD
R2	1	4.7K	YEL-VIO-RED-GLD
R3	1	1 MEG	BRN-BLK-GRN-GLD
R4, R6	2	100K	BRN-BLK-YEL-GLD
R5, R14, R16	3	1K	BRN-BLK-RED-GLD
R7, R17	2	5.6 ohms	GRN-BLUE-GOLD-GLD
R8, R10, R13	3	10K	BRN-BLK-ORG-GLD
R9	1	470K	YEL-VIO-YEL-GLD
R11	1	680K	BLUE-GRY-YEL-GLD
R12	1	47K	YEL-VIO-ORG-GLD
R15	1	470 ohms	YEL-VIO-BRN-GLD
U1	1	SA602 / SA612A	DIP 8 MIXER/OSC
U2	1	LM358	DIP 8 DUAL OPAMP
U3	1	LM7809	TO-220 9V/1A REG
V1, V2	2	6mm sq. , 2K	TRIMMER RESISTOR
T1, T2	2	FT37-43	FERITE CORE, BLACK
8 PIN DIP SOCKET	2	8 Pin DIP Socket	
PCB	1	Main Circuit Board	
SCREW	1	4-40 1/4”	
NUT	1	4-40 nut	
FEET	4	Rubber Feet	
BAL HEADER	1	2 position SIP pin strip	
SHORTING JUMPER	1	Shorting jumper	

BAND PARTS, SEE TABLE FOR LOCATIONS	**QUANTITY**	**VALUE**	**TYPE**
CAPACITORS	6	22 pF	C0G
	1	33 pF	C0G
	1	47 pF	C0G
	1	68 pF	COG
	2	150 pF – marked 151	C0G
	2	220 pF – marked 221	C0G
	3	330 pF - marked 331	C0G
	1	560 pF – marked 561	C0G
	1	680 pF – marked 681	C0G

INDUCTORS	1	2.2 uH	Red-red-gold-gold or silver
	1	3.9 uH	Orange-white-gold-gold or silver
	1	8.2 uH	Gray-red-gold-gold or silver
	4	T37-2 Red Core	
	2	T37-6 Yellow Core	
CRYSTALS	1	7.074 MHz	HC-49/US
	1	10.136 MHz	HC-49/US
	1	14.074 MHz	HC-49/US
MISCELLANEOUS			
	3	Band module boards	
	12'	#26 magnet wire	
	1'	#26 magnet wire, different color	
	12	3/32" tie wrap	
J5,6	6	5 position 90 ° SIP pin strip	

Parts placement diagram: Print this page for quick reference

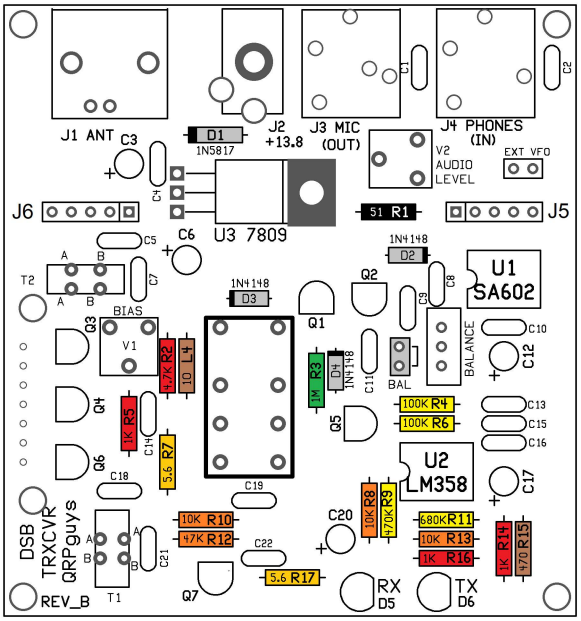


Assembly:

The first step is to sort the parts into groups of similar types. This will make finding the needed part type and value quicker.

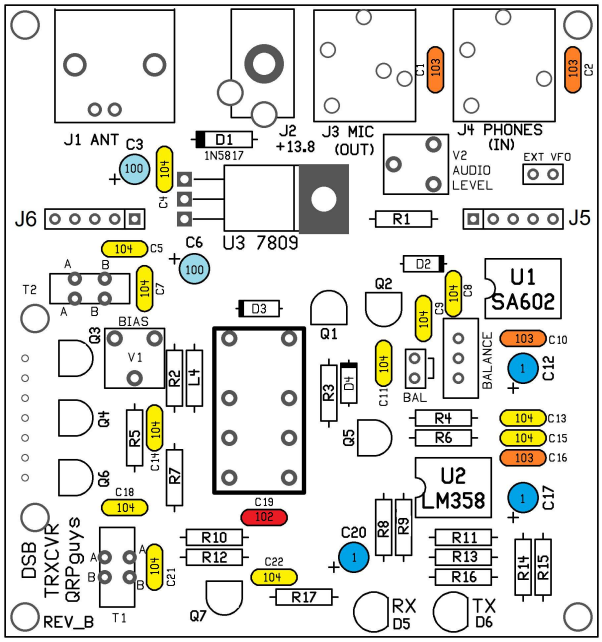
Start with the resistors:

Caution: Several of the values have very similar color codes and differ only by the zero multiplier color. It is also easy to mix up the 51 and 1 Meg resistors as 51 is green/black/brown and 1 meg is brown/black/green. L4 is a RF choke. It looks like a resistor, but is a bit fatter. With an ohm meter, it will read 0 ohms.



[ ] R1 - 51 Green/Brown/Black/Gold
[ ] R2 - 4.7K Yellow/Violet/Red/Gold
[ ] R3 - 1 Meg Brown/Black/Green/Gold
[ ] R4, R6 - 100K Brown/Black/Yellow/Gold
[ ] R5, R14, R16 - 1K Brown/Black/Red/Gold
[ ] R7, R17 - 5.6 ohm Green/Blue/Gold/Gold
[ ] R8, R10, R13 – 10K Brown/Black/Orange/Gold
[ ] R9 – 470K Yellow/Violet/Yellow/Gold
[ ] R11 – 680K Blue/Gray/Yellow/Gold
[ ] R12 – 47K Yellow/Violet/Orange/Gold
[ ] R15 - 470 Yellow/Violet/Brown/Gold
[ ] L4 – 10 uH inductor Brown/Black/Black/Gold, last band can be silver
[ ] D1 – 1N5817 Diode, black plastic body, match band with outline
[ ] D2, D3, D4 – 1N4148 Diode, glass body, match band with outline

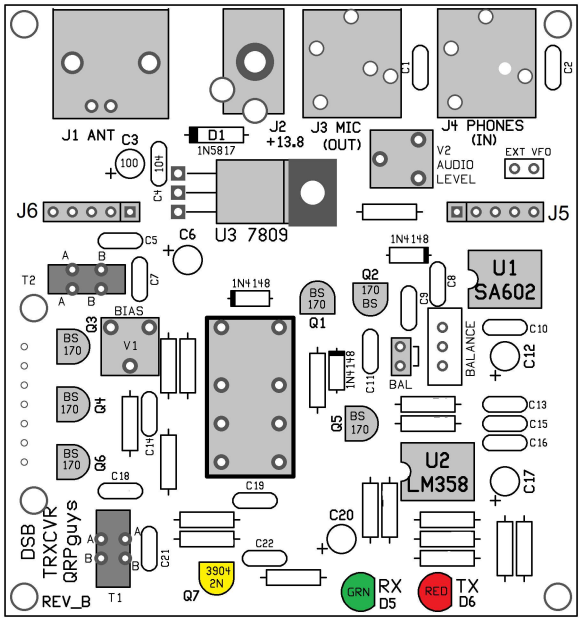
Capacitors:



[ ] C1, C2, C10, C16 – 10 nF, 103 Orange highlight
[ ] C19 – 1 nF, 102 Red highlight
[ ] All others 100 nF, 104 – Yellow highlight 12 places
[ ] C12, C17, C20 – 1 uF – long lead is plus.
[ ] C3, C6- 100 uF – long lead is plus.

Note: When reading capacitor values, do not confuse the manufacturing codes with the component value. If it looks strange it may be a manufacturing code, look on the other side of the component. Also, the value may be followed by a tolerance code - M,K, or J.

Everything else:



[ ] U3 – 7809 Bend the leads so that the U3 hole lines up with the board hole. Secure with 4-40 screw and nut.

[ ] J5, J6 – 5 pins SIP socket. Make sure these are set square and straight to the board before soldering more then one pin.

[ ] U1, U2 - 8 pin DIP socket. Note orientation of notch on socket and match with notch on part board outline. Make sure all the pins are sticking out the solder pads before soldering any!

[ ] J3, J4 – 3.5mm phone jacks

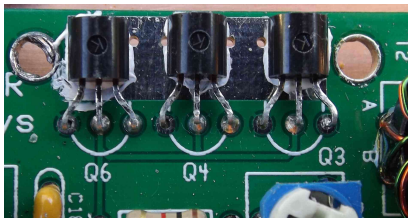
[ ] Q1, Q2, Q5 – BS170 MOSFET Note orientation of the flat side of part. Make sure it matches the board outline.

[ ] Q7 – 2N3904 NPN Make sure it matches the board outline.

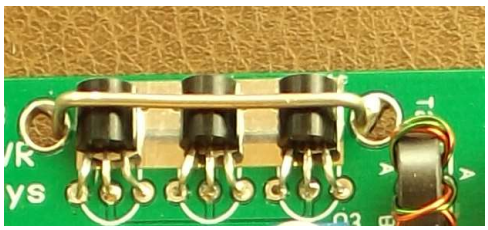
Note: LED's may have clear lenses. Determine which color by touching to a coin battery or similar battery. If when completed you find the intensity is too great, change R16 to 10K or 22K.

[ ] D5 - Green LED – short lead goes into hole on flat side of part outline.
[ ] D6 – Red LED – short lead goes into hole on flat side of part outline.
[ ] V1, V2 – 2K trimmer pots
[ ] Relay – not specifically labeled, but should be obvious where it goes!
[ ] J2 – DC power Jack.
[ ] J1 – BNC antenna jack
[ ] BAL – 2 pin SIP header
[ ] BALANCE – not used. It was found this part is not necessary.

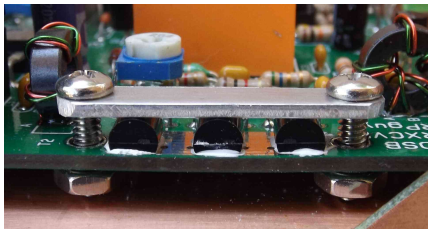
[ ] Q3, Q4, Q6 – These parts require some heat sinking. Therefore, these parts get mounted with the flat side of the package pressed against the large, tinned pad to the left of the board. A stiff piece of paperclip wire can be used to hold the parts down against the pad by soldering it to the two mounting holes on either side. A better method would be to use a piece of aluminum, secured with 4-40 screws, using the mounting holes on either side. If you have some conductive paste, use it.



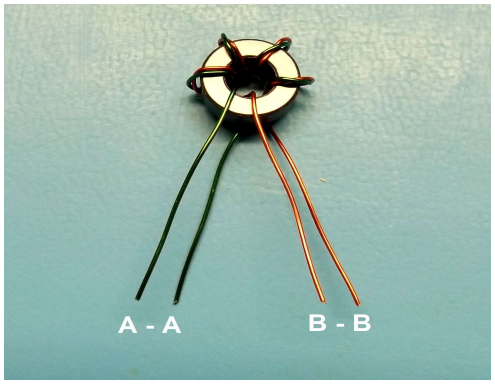
Flat side down



Piece of paperclip wire



Opt. aluminum w/hardware



[ ] T1, T2 – bi-filler wound on T37-43 ferrite core (black).

- Cut 6” length of each color magnet wire
- The two wires can be lightly twisted together, but this is not necessary
- Wind 5 turns on the core as shown.
- **Trim and tin the wire ends.** Either scrape or melt the insulation using a hot iron with a blob of solder.
- Orientate the common wire ends so they are opposite each other on the core.
- The wires will now be in the proper position for inserting into the board.

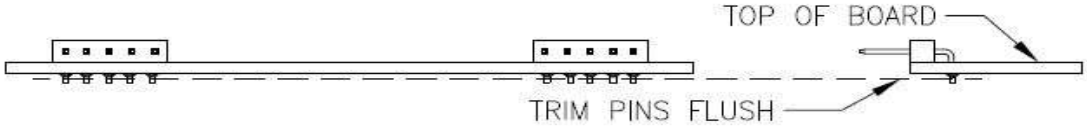
Be sure to tin the wire ends before installing. The transceiver will not work if you do not tin the magnet wire. This is the leading cause of failure.

[ ] Stick the rubber bumper feet on the corners of the board.

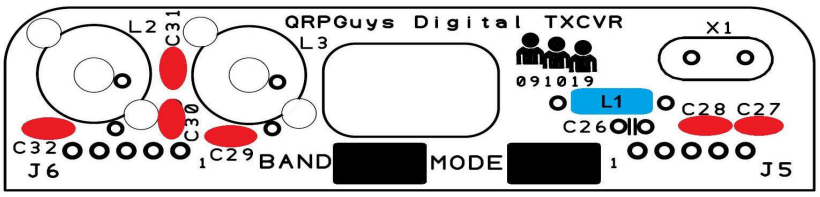
Assembling the band modules

[ ] Before populating with components, ***mark each module with the band and mode in the space provided with a permanent marker*.**

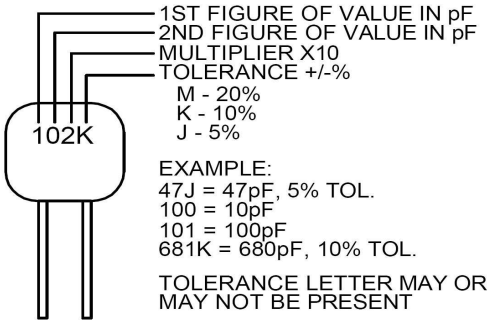
[ ] J5,J6 – 5 pin right angle SIP header strip. Short 90° pins go into board. Mount on the top of the board as shown. Trim the pins flush on the backside.



Use the placement graphic and tables below to install the capacitors, crystals, and inductors.



Note: When reading module capacitor values, do not confuse the manufacturing codes with the component value. If it looks strange, it may be a manufacturing code, look on the other side of the component.



Be sure you have read the values correctly. Sort all the capacitors out before you start assembling them onto the modules. They are difficult to remove and correct.

40M
[ ] L1 – 8.2 uH – Gray-red-gold-gold, last band can be silver
[ ] C26 – not used
[ ] C27 – 22 pfd – marked 22, it may be followed by a letter
[ ] C28 – 22 pfd – marked 22, it may be followed by a letter
[ ] C29 – 330 pfd – marked 331
[ ] C30 – 680 pfd – marked 681
[ ] C31 – 68 pfd – marked 68, it may be followed by a letter, (don't mix up the 681 and 68 values!)
[ ] C32 – 330 pfd – marked 331
[ ] L2 – 20 turns on T37-2 RED core – make sure turns are snug to the core and more or less evenly spaced around the core. Loose winding does not work well.
[ ] L3 – 18 turns on T37-2 RED core
[ ] X1 – 7.074 MHz crystal

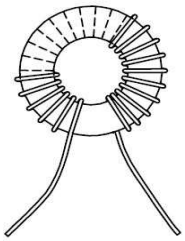
30M
[ ] L1 – 3.9 uH – Orange-white-gold-gold, last band can be silver
[ ] C26 – not used
[ ] C27 – 22 pfd – marked 22, it may be followed by a letter
[ ] C28 – 22 pfd – marked 22, it may be followed by a letter
[ ] C29 – 220 pfd – marked 221
[ ] C30 – 560 pfd – marked 561
[ ] C31 – 47 pfd – marked 47, it may be followed by a letter
[ ] C32 – 220 pfd – marked 221, (don't mix up the 221 and 22 values!)
[ ] L2 – 18 turns on T37-2 RED core – make sure turns are snug to the core and more or less evenly spaced around the core. Loose winding does not work well.
[ ] L3 – 13 turns on T37-2 RED core
[ ] X1 – 10.136 MHz crystal

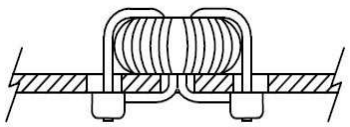
20M
[ ] L1 – 2.2 uH – Red-red-gold-gold, last band can be silver
[ ] C26 – not used
[ ] C27 – 22 pfd – marked 22, it may be followed by a letter
[ ] C28 – 22 pfd – marked 22, it may be followed by a letter
[ ] C29 – 150 pfd – marked 151
[ ] C30 – 330 pfd – marked 331
[ ] C31 – 33 pfd – marked 33, it may be followed by a letter (don't mix up the 331 and 33 values!)
[ ] C32 – 150 pfd – marked 151
[ ] L2 – 17 turns on T37-6 YELLOW core – make sure turns are snug to the core and more or less evenly spaced around the core. Loose winding does not work well.
[ ] L3 – 15 turns on T37-6 YELLOW core
[ ] X1 – 14.074 MHz crystal

Winding the toroids

[ ] Wind each of the L2 and L3 toroids using 12” of the supplied magnet wire. Use the tables above and wind them in the direction shown in the graphic below and they will align with the pcb holes. When you are certain of the turn count, trim the leads ~1/2” and ***tin them*** before installing the toroids flat on the top of the board, centered on the silkscreen outline. Secure each toroid to the pcb using two of the supplied plastic zip ties, as shown below.

Be sure to tin the wire ends before installing. The transceiver will not work if you do not tin the magnet wire. This is the leading cause of failure.





Test and set up:

[ ] Apply 12V to 13.8V to the board. The GREEN LED should light.
[ ] Verify 9V (+/- 0.25) between pins 8 and 4 of U2. (Optional)
[ ] Remove power
[ ] Install SA602 IC into U1 socket. Observe orientation, notch on chip matches notch on IC socket.
[ ] Install LM358 IC into U2 socket. Observe orientation, notch on chip matches notch on IC socket.

[ ] Connect your DMM in series with the positive power supply lead and set the meter to measure current. To be safe, use the 10A scale.
[ ] Set the V1 (BIAS) trimmer to fully *CLOCKWISE*.
[ ] Apply power to the board again.
[ ] Insert the shorting plug into the [BAL] SIP pins. This will force the board into transmit mode. The RED LED should now be on and the GREEN LED off.
[ ] Note the amount of current the board is drawing.
[ ] Slowly adjust the V1 trimmer *COUNTERCLOCKWISE* while watching the current meter. Adjust until the current goes up by about 15 ma. This is just enough to put the PA into linear mode.
[ ] Remove power.
[ ] Remove the shorting plug for the BAL pins.

If the current does not rise on counterclockwise rotation, check the connections of T2.

Operating or testing into a bad SWR or no antenna will permanently damage the three power amplifier BS170's. Be careful...

You are now ready for on-air testing.

[ ] Start the WSJT-X program on your PC or Laptop.
[ ] Set up your computer to look for inputs and outputs at the auxiliary sound connections if needed.
[ ] Make the required MIC and Headphone connections between the PC and DSB board. MIC to MIC and PHONES to PHONES. (I found nice stereo jumper cables at the Dollar Store).
[ ] Plug in the desired band module. The toroid side of the module faces you, the end with the LEDs.
[ ] Connect up your antenna.
[ ] Power up the board.

Note: While testing for operation, you can temporarily plug some earbuds into J3 MIC (OUT). This is the audio out to your computer or tablet. If the particular band is open, you should hear received signal tones in one of the earbuds. If you are not hearing any signals, determine the cause and correct before continuing.

[ ] You should start to see signals. Adjust the Sound card input level and the V2 audio output level to appropriate settings for your conditions.
[ ] Replace the antenna with a 50 ohm dummy load.
[ ] Set the sound card output level to minimum.
[ ] Activate "TUNE" on the WSJT-X to manually transmit.
[ ] Increase sound card output level until the board switches into Transmit. (RED LED goes on) you can continue to increase the output level a little bit to ensure reliable triggering of the VOX circuit.
[ ] Press "TUNE" again to stop the manual transmitting mode.

If you have a watt meter in line with the antenna, you will notice the power will continue to increase as the audio input continues to increase. ***Do not do this.*** *The apparent increase in power is due to overloading the mixer and amplifier stages, putting them into a non-linear region.*

If you look at the RF output with an Oscilloscope, it should look like a string of pearls. This is the result of the two side bands mixing. Increasing the drive will turn the string of pearls into more of a picket fence and then approach being a wall. This is the result of the amplifier stages saturating resulting in the signal flat topping. At this point your creating spurious outputs to the annoyance of others in the band. Keep it clean. It's bad enough we're transmitting two side bands.

[ ] Reconnect your antenna and you are good to go.

Refer to the WSJT-X documentation and our website links for the details on operation.

Theory of operation:

The F8 DSB transceiver is built around the ubiquitous SA602/612A mixer-oscillator chip. It provides both the receive and transmit functions.

Receiver:

The antenna is first routed through the transmitter's Low Pass Filter (LPF) and then into the T/R relay. The received signal is bottom coupled into the tuned circuit comprised of L1 and C26. C26 is actually the stray capacitance of the band module and SIP connectors. Although this does not peak L1 at exactly the desired input frequency, it's close enough as the single L/C tank circuit is pretty broad.

The received input signal is mixed with the internal oscillator, to produce the base line audio output. The audio output is coupled to a high gain audio amplifier through two 0.1 ufd caps (C15+C13) in series. The MOSFET Q5 is connected to the common point of C15 and C13 provides audio muting during transmit by shunting the junction to ground.

U2b, one half of a LM358 op amp, provides audio gain for decent sensitivity. A non-inverting configuration is used so that the input can be high impedance, allowing for reasonably small value input coupling caps. The gain is set to 47. The amplifier then drives an audio level pot so the audio level can be adjusted to a level suitable for your PC sound card.

Transmitter:

The SA602 requires very little input signal to saturate. Therefore a resistor divider is placed between the audio input from the sound card to the mixer input. This allows you to set the audio output from the sound card to a reasonable level and not overdrive the mixer.

The other half of the LM358 (U2a) is used as a VOX circuit. The peak detector circuit of D4 and C11 isn't required for FT8 operation, but is include if one wishes to add a VFO and microphone to use the rig as a DSB voice transceiver or possibly try PSK31. This prevents the relay from chattering.

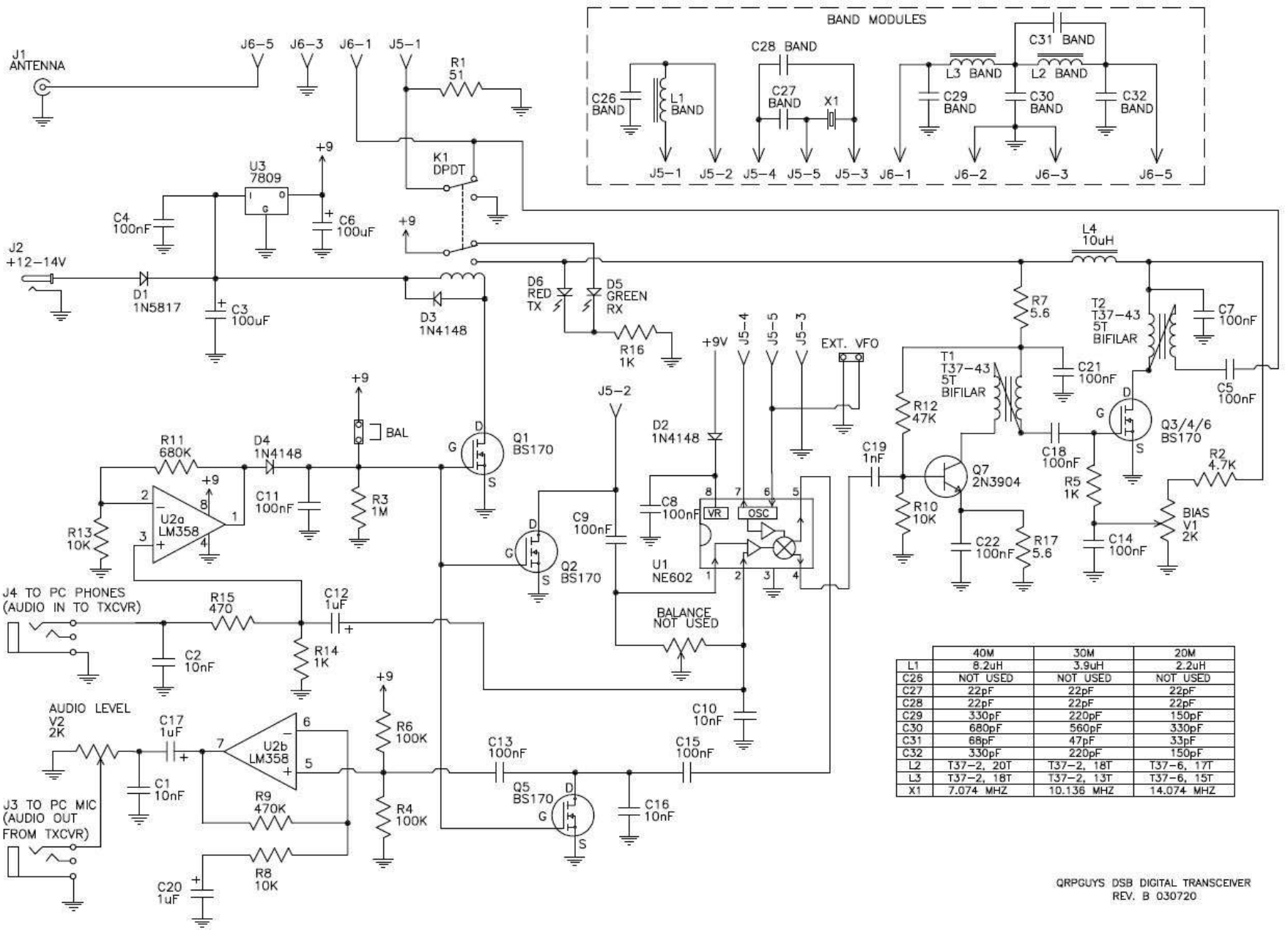
The output of the peak detector drives three BS170 MOSFETs. Q1 activates the T/R relay. Q2 shorts out the antenna input to the mixer, along with connecting C9 to ground to by pass the antenna input side of the mixer input to ground. Q5 shorts the C15/C13 junction to ground for audio muting as described earlier.

One section of the DPDT T/R relay is also used to short the receiver input to ground. Keeping as much of the transmit signal out of the mixer input as possible is important to prevent unwanted spurious outputs. The other half of the relay routes power to the transmitter amplifiers and lights the transmit LED.

Q7 amplifies the RF output from the mixer to a level sufficient to drive the PA. The PA is comprised of three BS170 MOSFETS in parallel. Bias is applied to the gates to place the amplifier into liner mode. This also reduces the amount of drive needed since the input signal does not have to first exceed the ~2.5V it takes to start to turn on the MOSFETS.

Power to the circuits is supplied by a 9V, 1A regulator. This ensures the power output remains in a safe operating area and if there is a problem, the internal over current protection will shut down the regulator. Since the maximum operating voltage of the SA602/612 is 9V, a diode is placed in series with the 9V supply insure the voltage to the chip does not exceed the maximum recommended supply voltage.

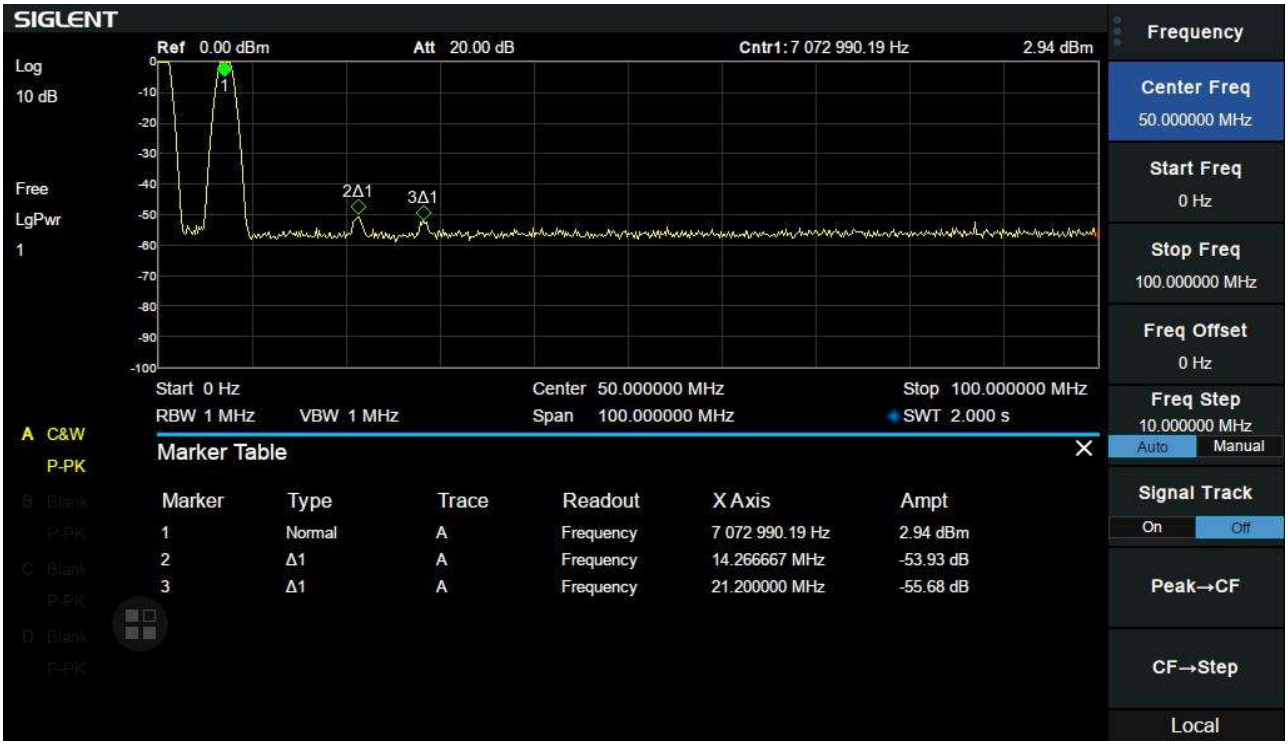
Notes:



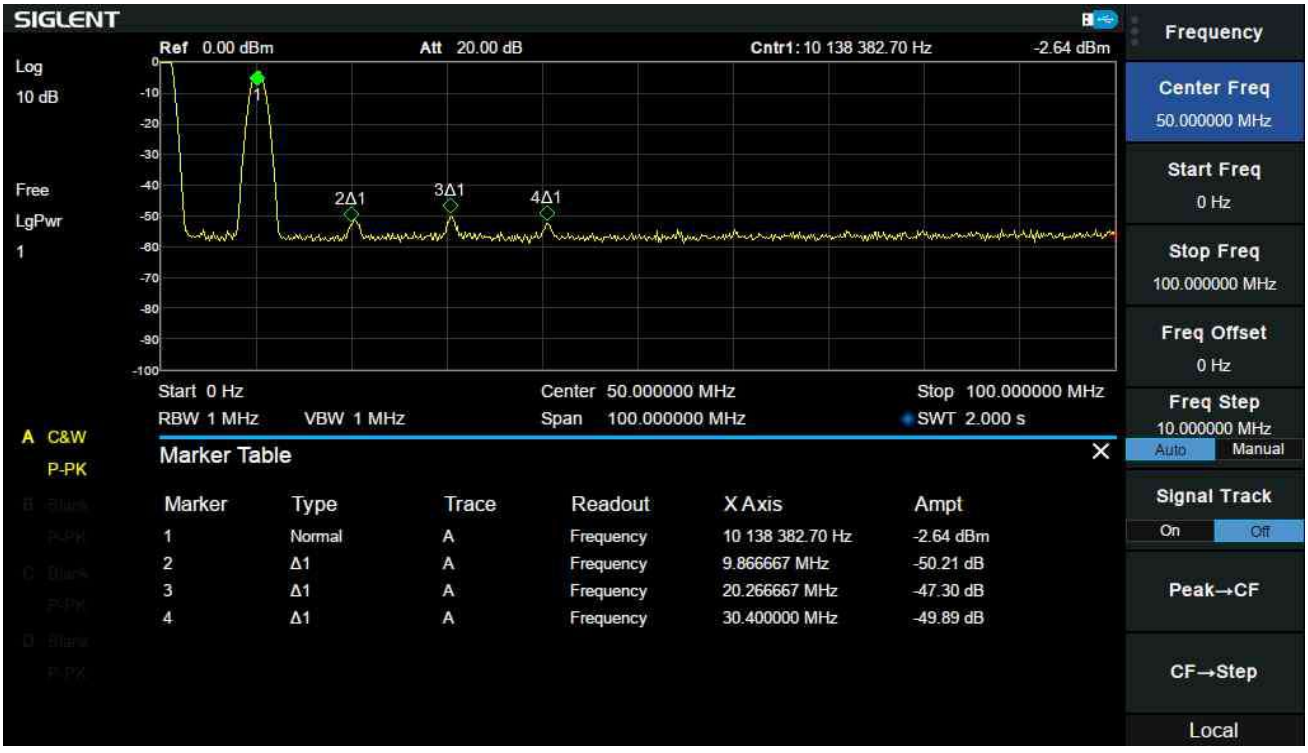
	40M	30M	20M
L1	8.2uH	3.9uH	2.2uH
C26	NOT USED	NOT USED	NOT USED
C27	22pF	22pF	22pF
C28	22pF	22pF	22pF
C29	330pF	220pF	150pF
C30	680pF	560pF	330pF
C31	68pF	47pF	33pF
C32	330pF	220pF	150pF
L2	T37-2, 20T	T37-2, 18T	T37-6, 17T
L3	T37-2, 18T	T37-2, 13T	T37-6, 15T
X1	7.074 MHZ	10.136 MHZ	14.074 MHZ

Reference:

The following are the results for the harmonics measured on a Siglent SVA1015X.



40m



30m

20m

Typical voltages for troubleshooting

IC's								
	Pin 1	2	3	4	5	6	7	8
U1	1.3	1.3	0	6.8	6.8	8.2	7.9	8.33
U2/Rx	0	0	0	0	4.5	4.5	4.5	9
Mosfets and transistors								
	Drain	Gate	Source			Collector	Base	Emitter
Q1/Rx	13	0	0		Q7/Rx	0	0	0
Q1/Tx	0	3 to 8	0		Q7/Tx	8.9	0.8	0.1
Q2/Rx	0	0	0					
Q2/Tx	0	3 to 8	0					
Q3/4/6	0	0	0					
Tx	9	~2.3	0					
Q5/Rx	0	0	0					
Q5/Tx	0	3 to 8	0