

TJ6-1 High-Performance SSB/CW QRP Transceiver

Construction Guide (Oct. 3)

With the SMD doubly-balanced diode ring mixer as the receiving mixer and HSB88WS as the product detector, **TJ6A** offers excellent low-noise reception and strong signal handling ability. **TJ6A** is used with DDS (AD9850) as LO, offering wider frequency coverage.

Operating Power:

12 – 13.8 V

Output Power:

8 W (15 m: 5W)

Frequency Coverage:

BAND 1: 3.100000 – 4.099999 MHz

BAND 2: 4.100000 – 7.799999 MHz

BAND 3: 9.950000 – 15.099999 MHz

BAND 4: 17.950000 – 21.999999 MHz

Operating Mode:

LSB, USB, CW

IF:

9 MHz

Tuning Rate:

1Hz

10 Hz

100 Hz

1 KHz

10 KHz

100 KHz

Memories with VFO features:

Eight memories with features of VFO's, each memorizing the last operated frequency and mode

Dual System

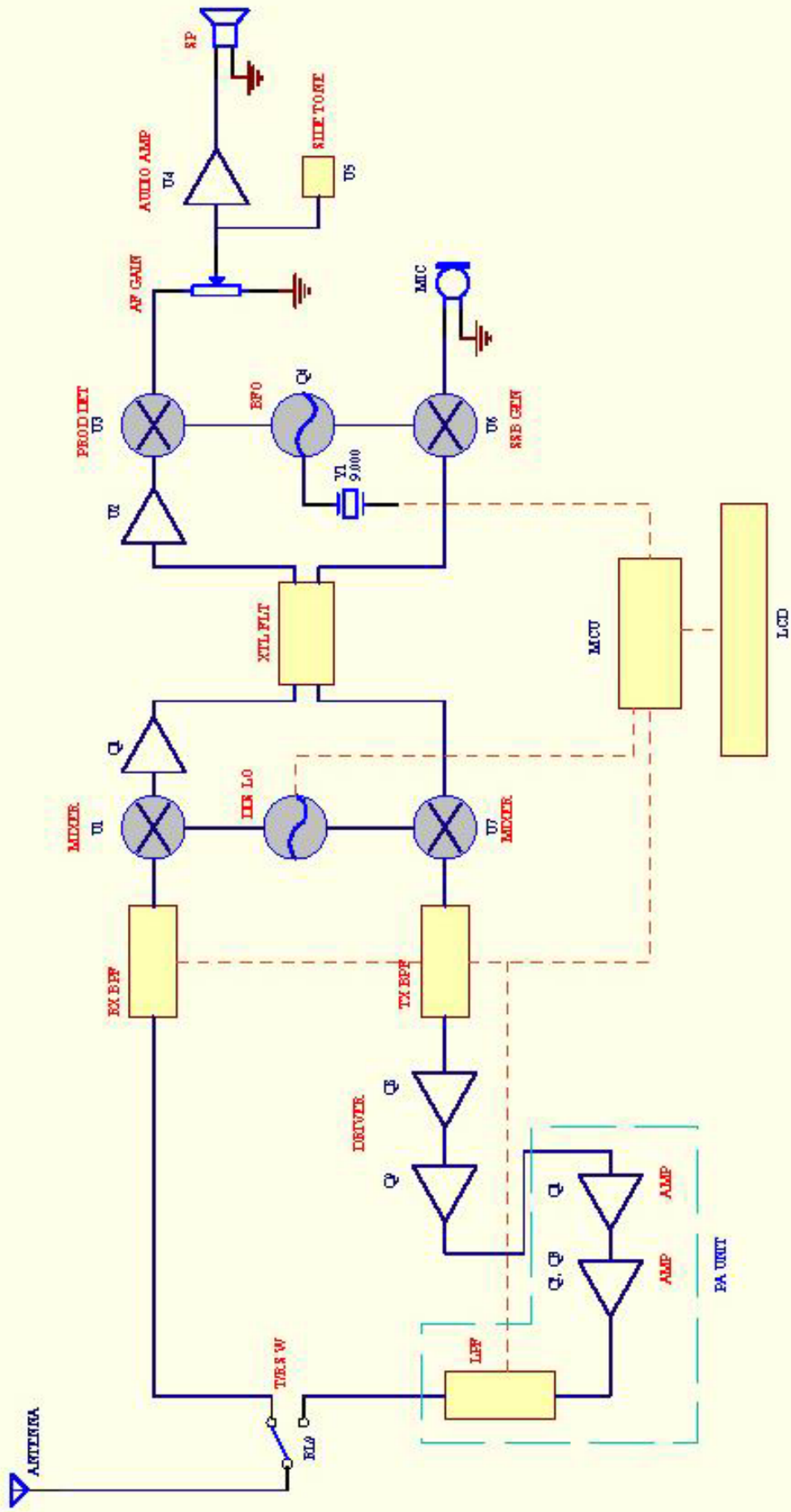
Two separate operating interfaces, covering different frequency range

New Features:

Plug-in RX and TX BPF modules

Plug-in IF XTL filter module

BLOCK DIAGRAM



1. Circuit Description

For better performance, an HSB88WS is employed as the first mixer, and another HSB88WS as the product detector. The signal is first routed through the BPF and then the doubly-balanced diode ring mixer (made up of U1, T1 and T2) which mixes the signal with LO. Q1 compensates the conversion loss. The amplified signal is fed into XTL FLT to remove the unwanted side band, and the amplified by IF amplifier U2. Output from the IF amplifier is fed into product detector U3 (HSB88WS), and mixed with BFO energy to produce audio signal. U4 amplifies the signal to drive the louder speaker.

The input impedance of Q1 is 50 ohms, matching that of the mixer. The 6-dB pad made up of R11, R12, and R13 preserves the input and output match of the stage. The amplifier gain is about 16dB. The loss of the mixer is about 6dB. The net gain of this circuit is about 10dB. The pi net work consisting of C7, C8 and L1 converts the 50-ohm impedance of the amplifier to the impedance required by the XTL filter.

U2 (LA1201), the IF amplifier, provides a gain of 55dB. This IC offers good AGC function and low noise feature.

The detector used here is HSB88WS, the output of which is applied to a net work formed by C23, C24 and R27. This network reduces the RF contents.

U4 (LM386) is the audio amplifier. C26 removes the hiss sound.

Separate BPF units are used in TJ6A: two for receiving purpose, and two for transmitting purpose. The RX BPF modules cover 2.5 – 21.5MHz, offering a wide receiving range with good selectivity. The TX BPF modules are identical with the RX BPF modules for the purpose of simplicity. However, for the best performance, different optional modules could be plugged in.

U6 functions as the modulator, mixing the signal from MIC with the BFO energy. Again, the XTL FLT removes the unwanted side band, and the signal is fed into the TX mixer U7 which mixes the signal with that from LO to produce the TX signal. The Signal is fed into the BPF unit to select the wanted signal and remove the harmonics. The selected signal is fed into Q8 and Q9, and then fed into PA board. The amplified signal is filtered by the LPF to eliminate the harmonics, and fed into the antenna.

RL1 operated by Q10, serves as RX and TX power switch. When PTT is pressed, Q10 conducts and RL1 functions. Q11 serves as CW power switch. When KEY is pressed, Q11 conducts, and 12V operates Q12 which makes Q10 conduct. D13, R69, C72, and R70 form relay holding circuit to extend some hold time after the last character and space, in order to limit the fast back and forth TX-RX cycles. When KEY is pressed, 12 V charges C72 through D13 and R69. During the very short intervals of key up, C72 discharges through R70 to the base of Q12, so that Q10 keeps conducting, avoiding the unnecessary frequent relay operation to save relay service life and avoid the contact noise. Increasing the value of R70 or C72 increases the relay hold time. Reducing the value shortens the hold time.

Q4 forms the BFO circuit. L2 pulls the frequency down to the desired BFO frequency for LSB. Mode control signal from DDS Board conducts Q5, switching in L2. Q6 is the USB switch. In USB mode, the control signal from the DDS unit makes

Q6 conduct, switching in VC2, which increases the frequency to the desired BFO frequency for USB. Q6 is also the CW mode switch. In CW mode, Q6 conducts, switching in VC2. However, in CW transmission, the keyed voltage from Q11 makes Q7 conduct, switching in VC3, lowers the frequency to change the frequency to the desired BFO frequency for CW transmission.

Q3 is the mute circuit, muting U4 during transmission.

U5 functions as the side tone circuit. When KEY is pressed, the keyed voltage is supplied to U4 via R34 and U4 starts working. The 1 KHz-tone is fed into U4 via C33, VR3, R32 and C35. VR3 sets the volume of the side tone. The keyed voltage is also fed into Pin 2 of U6 via D11 and R44, making the IC unbalanced and CW carrier is produced. The value of R44 controls the level of CW signal.

The optional VR1, R16, R17, R18, Q2, and C11 form the automatic bandwidth control circuit. In CW mode, with optional XTL filter unit, this circuit narrows the XTL filter bandwidth for better CW reception. In transmission or SSB mode, the control circuit is disabled.

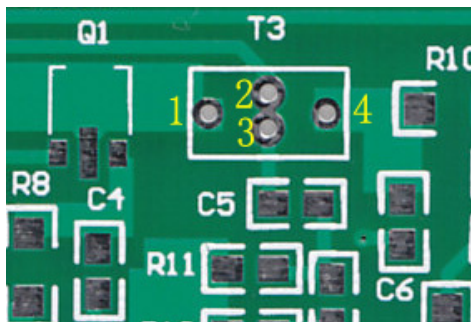
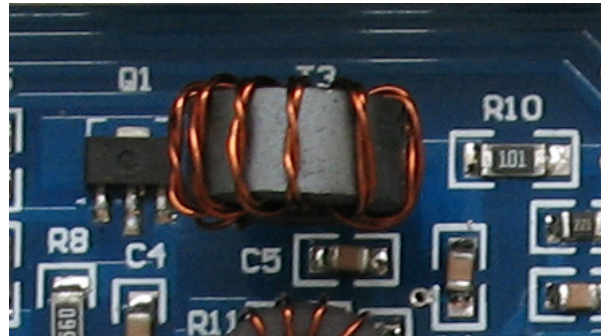
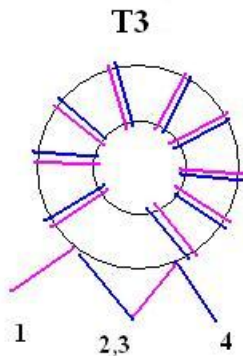
Q14 functions as the key control. When Q14 conducts, the driver Q8 works, and the signal is transmitted. Q13, D14, and D15 disable KEY function in SSB transmission, and disables MIC in CW transmission.

2. Construction

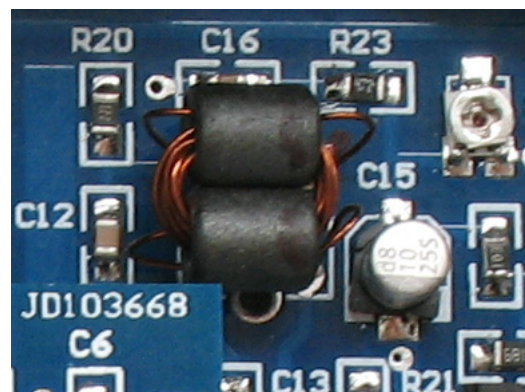
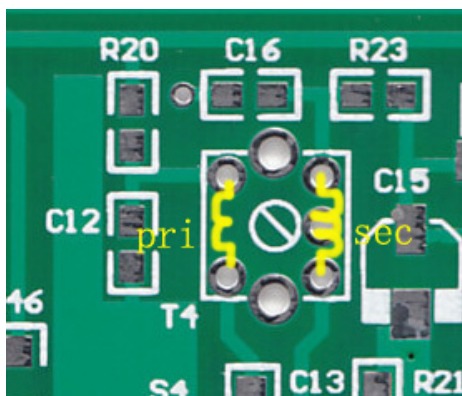
2.1 Winding Transformers and Coils

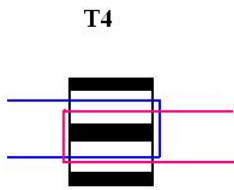
2.1.1 Main Board

T3: Broad-band ferrite transformer, 8 bifilar turns, 0.31 wire, on the broadband core. Cut 2 wires of 18 cm long, and twist them. See photo. Pay attention to the phase. As shown in the picture, red wire is Wire A; black wire is Wire B. The end of Wire A (2) is connected with the start of Wire B (3) as the tap.

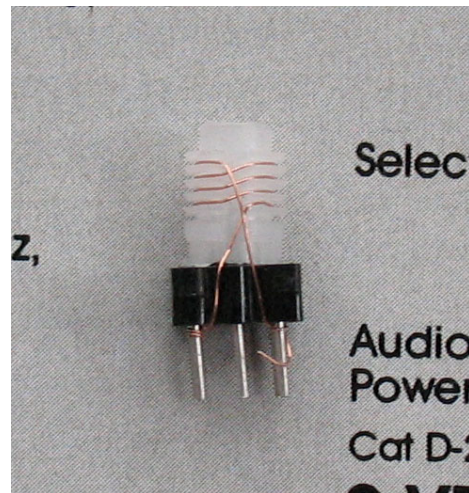
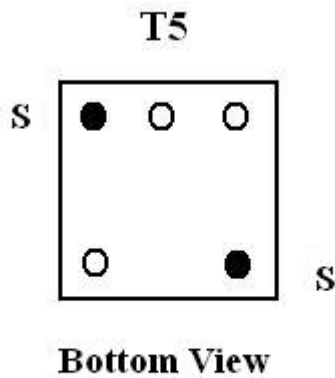


T4: IF transformer. Use 2 sleeves to form a binocular core. 0.31 wire, primary (C12 side) 3 turns, secondary (C15 side) 9 turns. Cut 14 cm of wire for primary; 23 cm for secondary. Mark primary and secondary before winding the transformer, so that you can identify the primary and secondary easily.

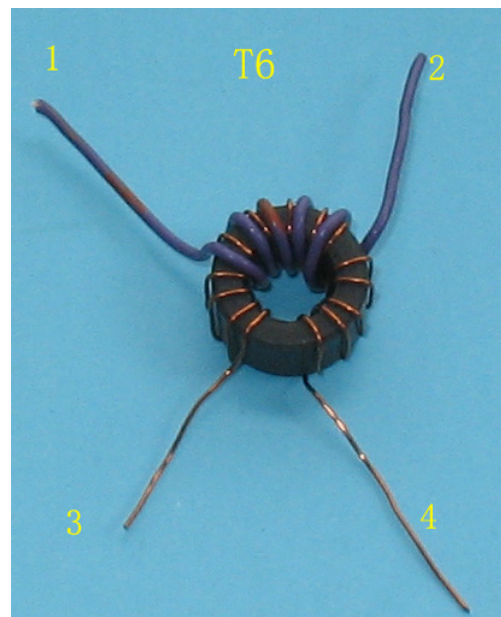
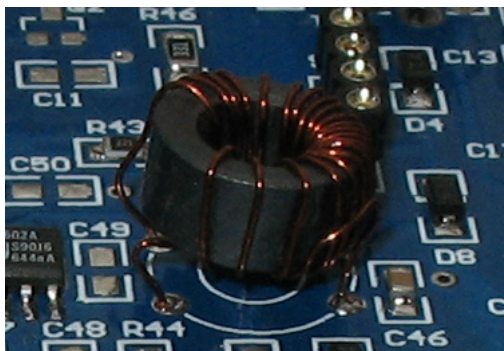


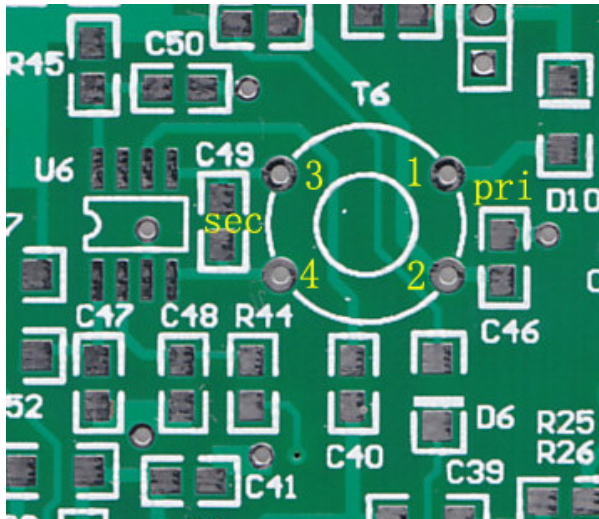


T5: Use the can former (See picture). 0.1 wire, primary (the 3-pin side) 16 turns, counter clockwise, the turns spread in 4 slots. Secondary (2-pin side), 4 turns in the bottom slot, counter clockwise. Wind the 2-pin side first. Pay attention to the start. See the illustration.

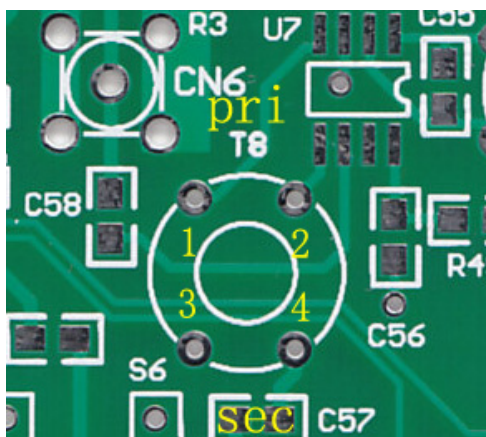
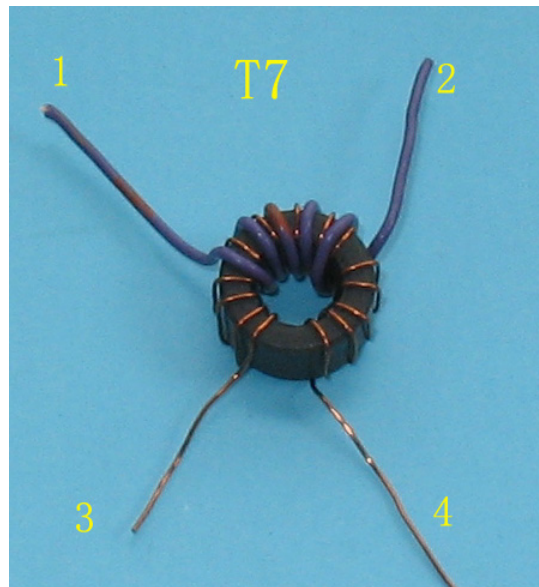
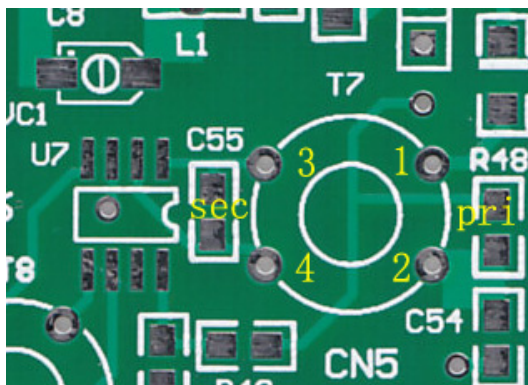


T6: Broad band transformer. 0.31 wire, primary 6 turns, secondary 15 turns on broadband toroid. Wind secondary first. Spread 15 turns evenly on the core. Do not overlap. Place the primary on the middle part of the secondary, see photo. For convenience of illustration, a purple wire is used for the primary.



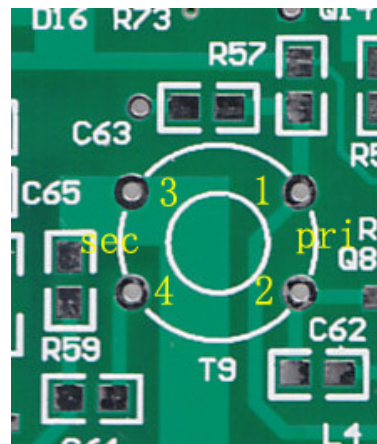
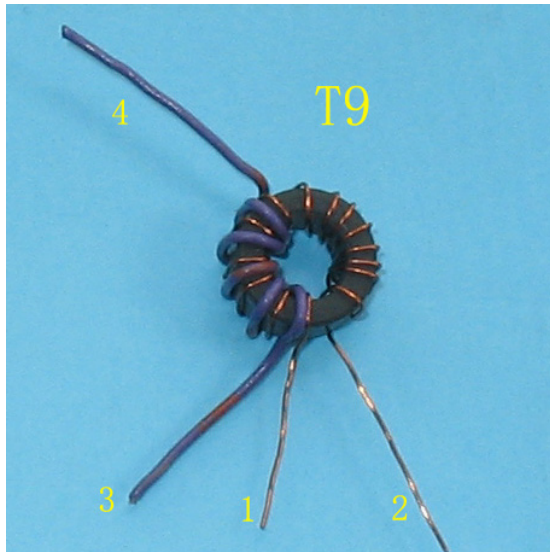


T7: IF transformer. 0.31 wire, primary 8 turns, secondary 22 turns on NXO-10 toroid. Wind secondary first. Spread 22 turns evenly on the core. Do not overlap. Place the primary on the middle part of the secondary.

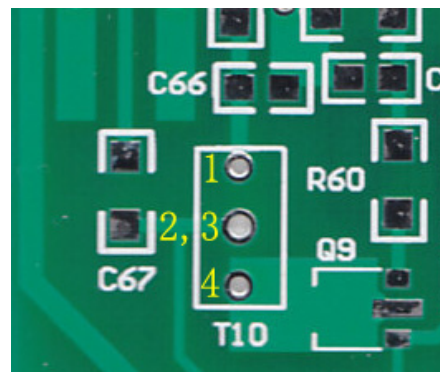
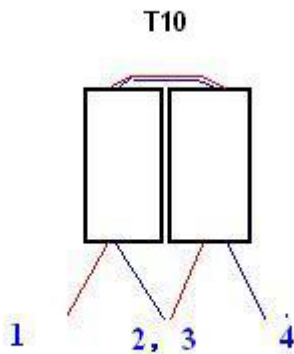


T8: Broad band transformer. 0.31 wire, primary 15 turns, secondary 3 turns on broadband toroid. Wind primary first. Spread 15 turns evenly on the core. Do not overlap. Place the secondary on the middle part of the primary.

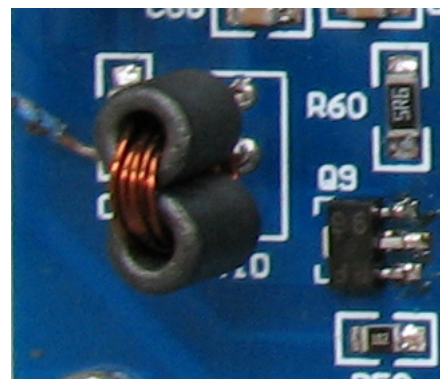
T9: Broad band transformer. 0.31 wire, primary 15 turns, secondary 3 turns on broadband toroid. Wind primary first. Spread 15 turns evenly on the core. Do not overlap. Place the secondary on the cold end (R57 end) of the primary.



T10: Broad band transformer. 5 bifilar turns, 0.31 wire, on the binocular core formed by 2 sleeves. See photo. Pay attention to the phase. As shown in the picture, red wire is Wire A; black wire is Wire B. End of wire A (2) and start of Wire B (3) are connected as the tap.

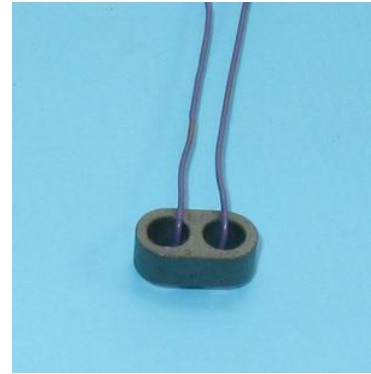
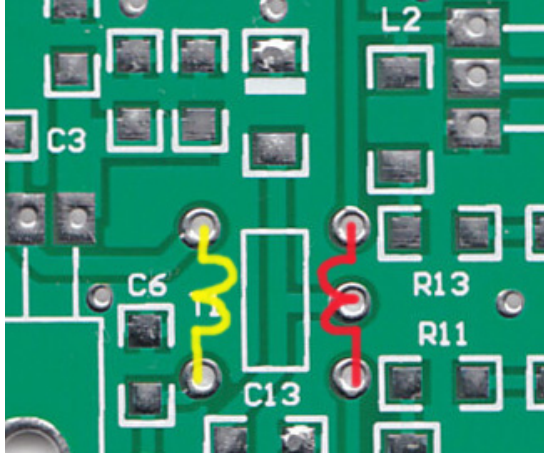


- L1:** 21 turns, 0.31 wire, on NXO-10 toroid core.
- L2:** 26 turns, 0.1 wire on can former, spread in 5 slots.
- L3:** Use the can former. 0.1 wire, 16 turns, (the 3-pin side), spread in 5 slots.



2.1.2 PA Board

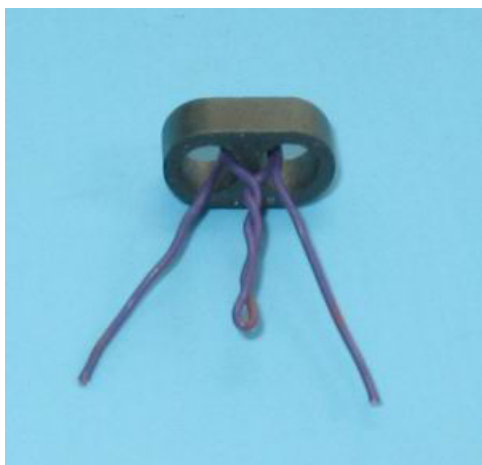
T1: Primary (yellow) 4 turns 0.38 wire or insulated wire on the binocular core; secondary (red) 2 turns, center tapped. See photo. The picture at right shows 1 turn. **Before winding, please use the sharpening stone (oilstone) to hone the sharp edges of the core, because the sharp edges would damage the enamel and cause short circuit between the windings and the core.**



The picture below shows 2 turns.



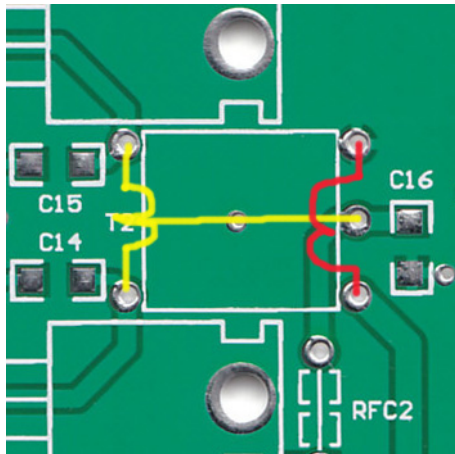
The picture below shows how to tap.



Finished transformer



T2: Use two sleeves to form 1 binocular core. Primary (yellow) 2 turns 0.38 - 0.47 wire or insulated wire, center tapped; secondary (red) 3 turns. See photo.



RFC1, RFC2: 3 turns, 0.47 wire, on the small toroid.

L3, L4: 9 turns, 0.47 wire, on T50-2 toroid.

L5, L6: 11 turns, 0.47 wire, on T50-2 toroid.

L7, L8: 15 turns, 0.47 wire, on T50-2 toroid.

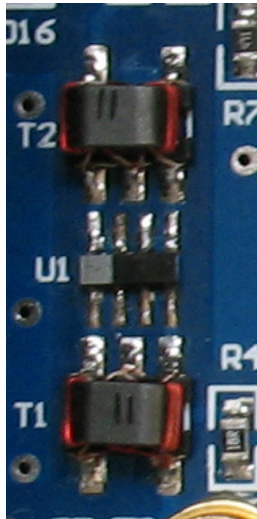
L9, L10: 21 turns, 0.31 wire, on T50-2 toroid.

2.2 Soldering Components

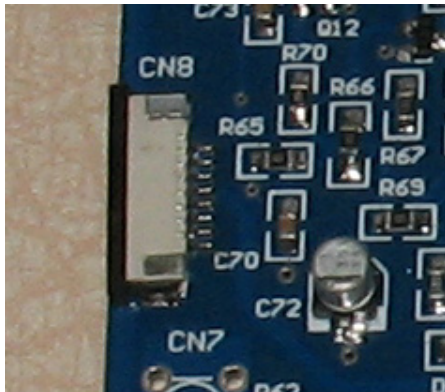
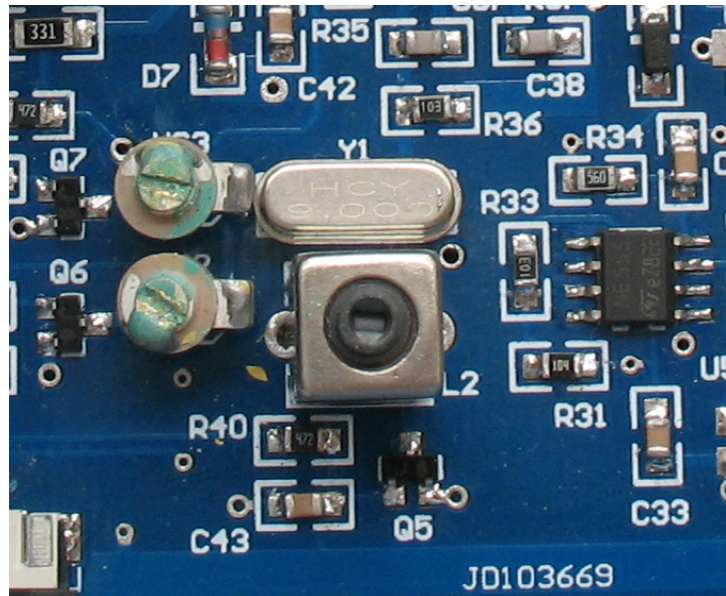
2.2.1 Main Board

Solder the FFC (flexible flat cable) connectors first. Solder also the side pads to the PCB. Use ohm meter to check the FFC pins after all the FFC connectors are soldered. RL1 is the last component to solder. Now, go on to solder other components.

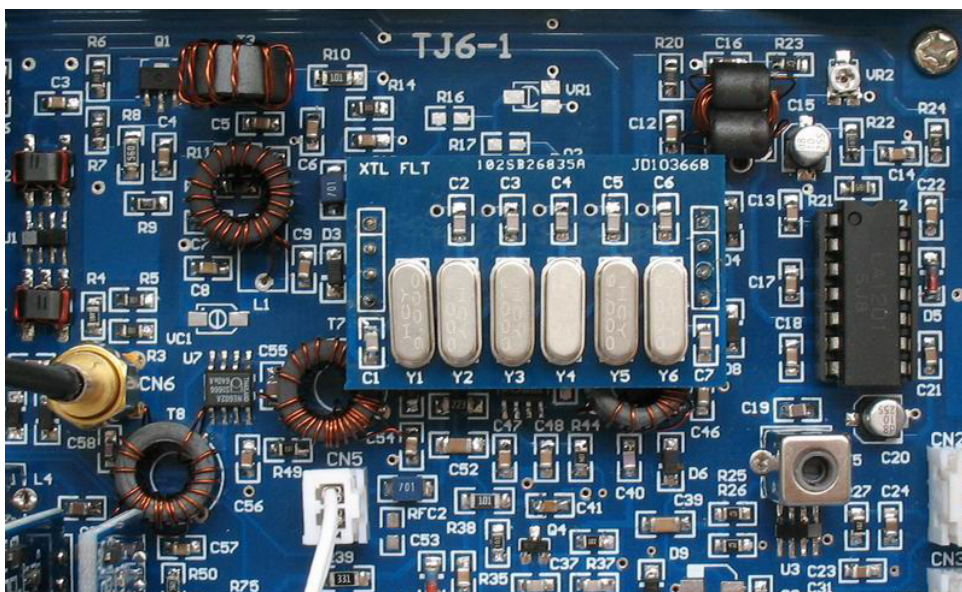
VC2 and VC3 are ceramic variable capacitors. Solder the rotator pin to the left pad.



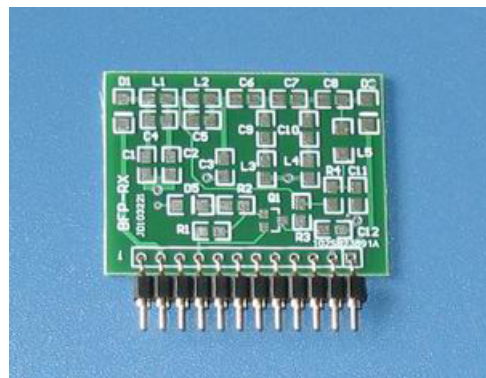
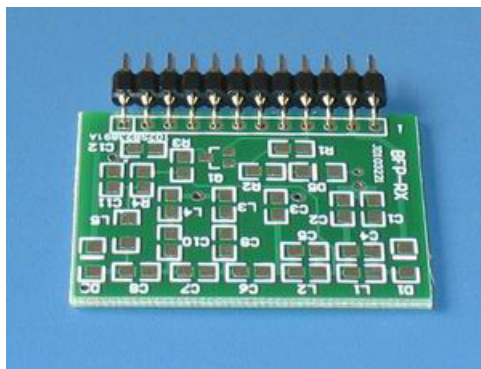
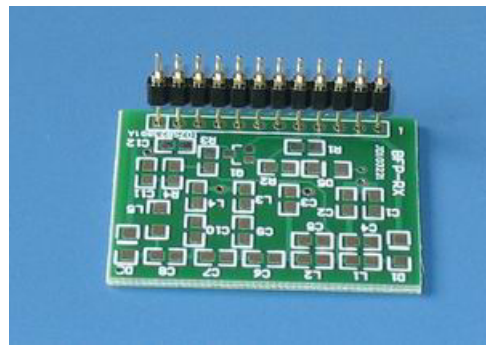
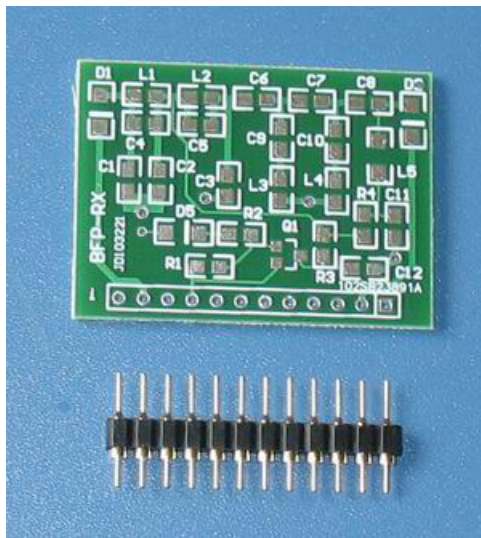
U1 and U2



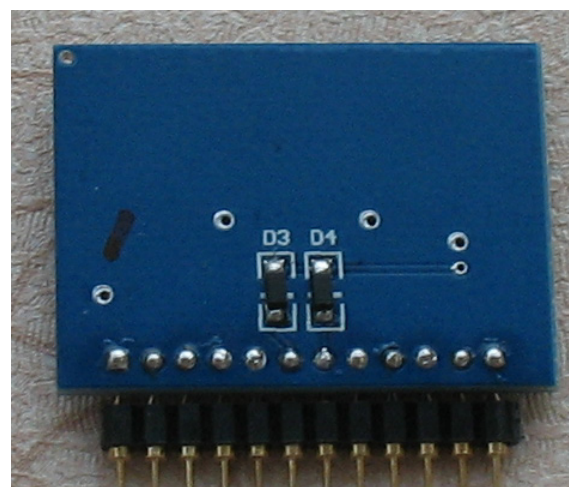
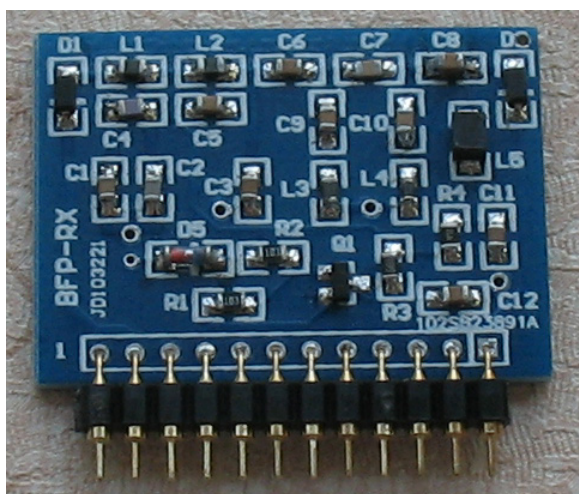
FFC Connector



Bend the headers to make the BPF module legs, see pictures. Place the PCB on a flat surface; put in the headers; push the header plastic bar; the module legs are done. Solder the headers. Do not put the headers on the wrong side. Solder the header sockets to S1, S2, S5, and S6 on the PCB.



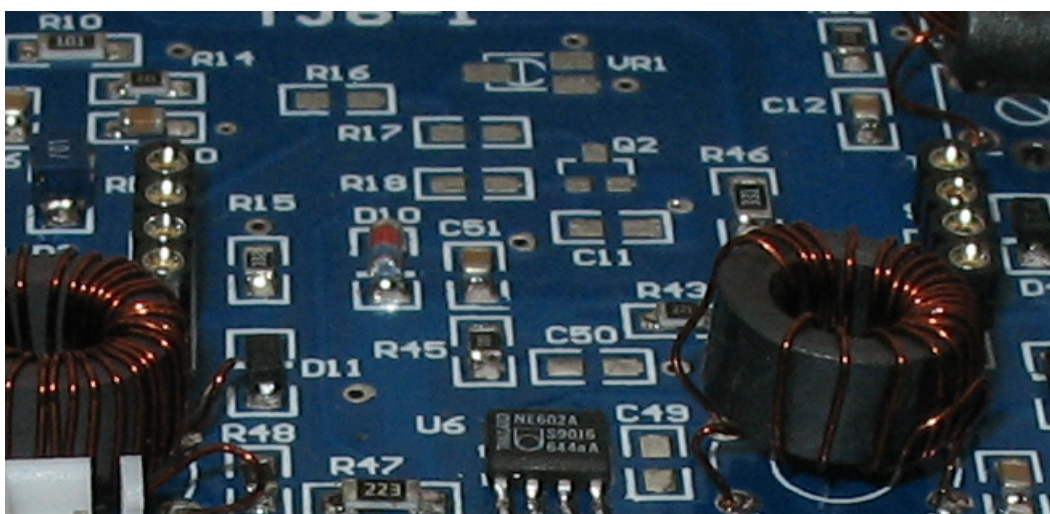
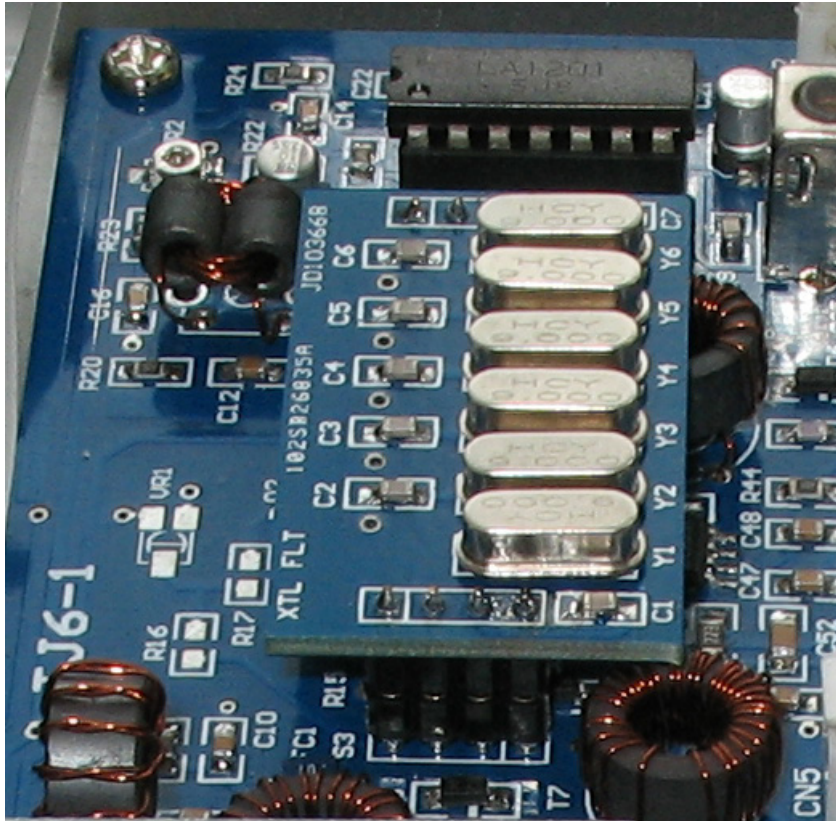
There are 5 modules in the kit, four of them BPF's: 2 for receiving, 2 for transmitting. The modules for S1 and S5 (3.5 – 7.5MHz) are identical, and the modules for S2 and S6 (10 – 21.5MHz) are identical.



The narrow module is XTL filter. Y1 through Y6 are 9.000MHz crystals. C1 through C7 are

47p capacitors. Solder 4-pin headers to the module. Solder header sockets to S3 and S4 on the PCB.

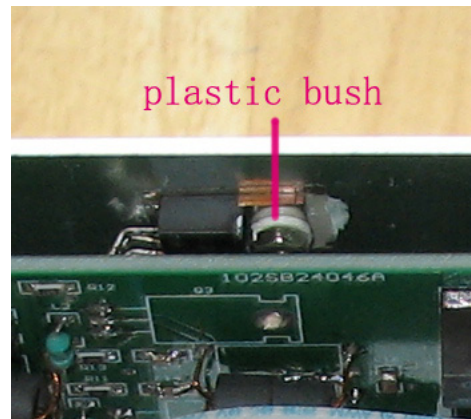
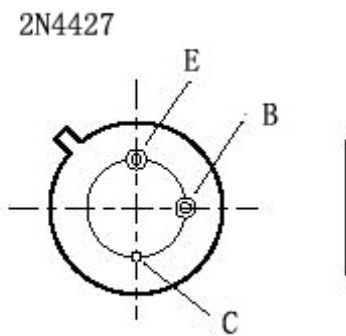
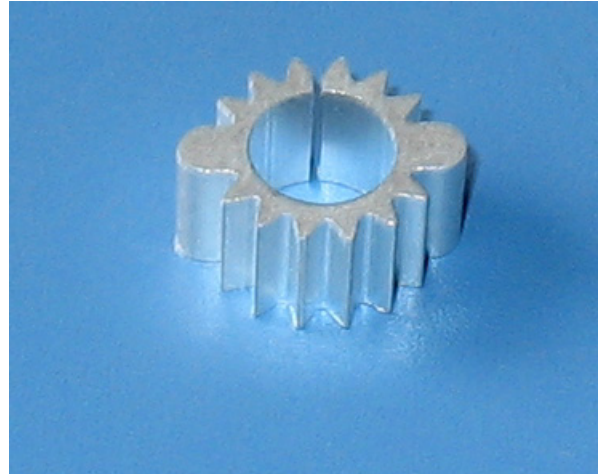
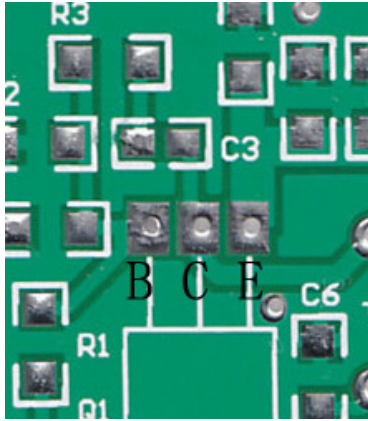
After all the components are soldered, plug in the RX modules into S1 and S2. S1 is for Band 1 and Band 2; S2 for Band 3 and Band 4. Plug XTL Filter module into S3 and S4. Do not plug into the wrong direction. For the BPF modules, the black plastic bar is on the left side. For the XTL filter module, the label “XTL FIL” on the XTL filter PCB is to the upper side of the main PCB.



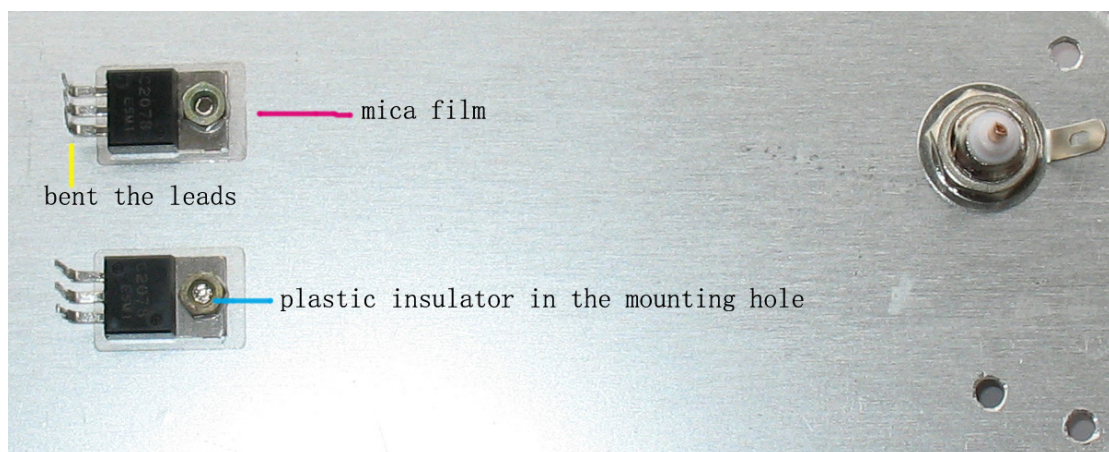
Solder the header sockets for XTL FLT.

2.2.2 PA BOARD

Q1 is 2N4427. Please bend the leads to suit the PCB (See photo). Before soldering 2N4427, press it into the heat sink. If it is very difficult to press it in, please widen the sink slot a little on the side, so that the transistor slides in tightly.

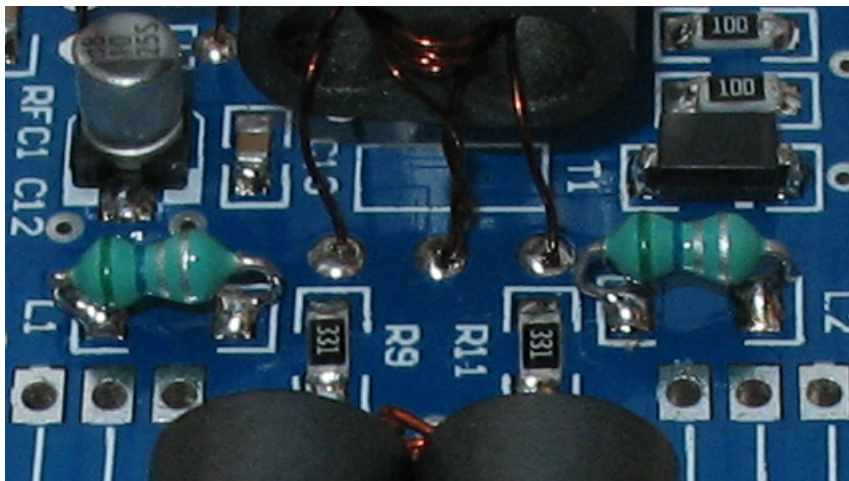
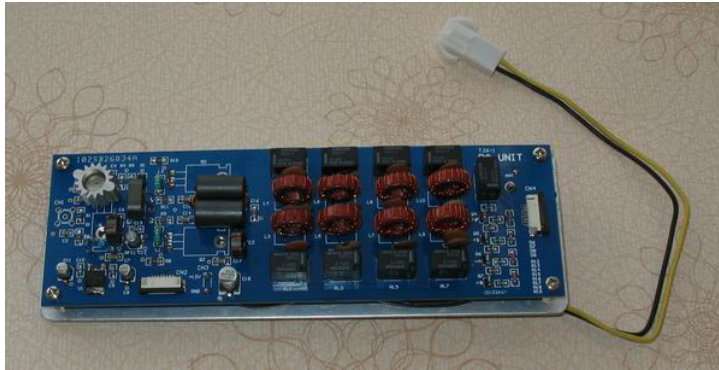


Do not solder Q2 and Q3 until all the components have been soldered. Bend the transistor leads, so that they can go through the pad holes on the PCB. Use the mica film between the



transistor sink and the aluminum back cover. Insert the white plastic bush into the mounting hole of the transistor sink before applying the screw nut. Mount the BNC socket. Mount four 8mm-brass spacers on the 4 corners of the back cover. Place the PA PCB onto the back cover. Align the leads of the transistors and the BNC. Use 4 screws to mount the PCB. Solder the leads of Q2, Q3 and BNC.

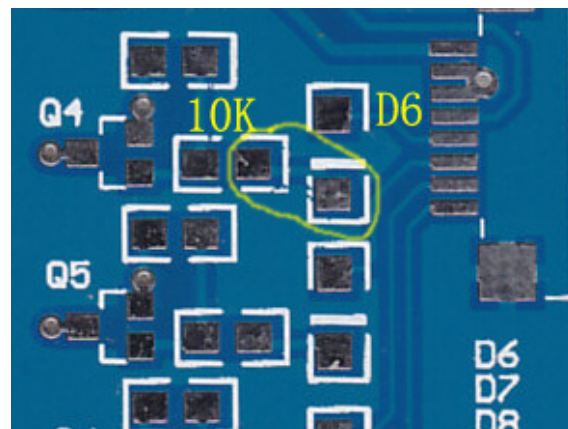
Connect 2 thick wires to CN3. Thread the 2 wires through the POWER lead hole. Connect the power connectors to the power leads.



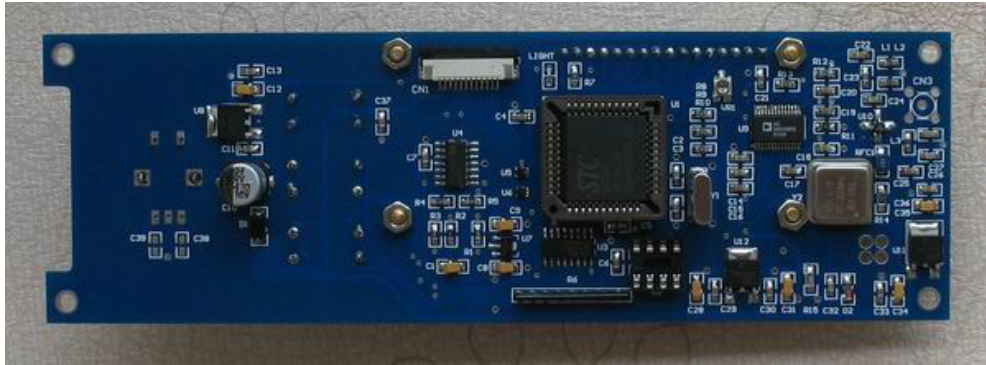
See how L1 and L2 are soldered to the pads. Cut the leads short, and bend the leads to suit the pads.

The bias resistor R7 is made up of one 10-ohm resistor and ONE 68-ohm resistor.

Due to the manufacturing fault, there might be a hair-thin gap between the D1 pad the track connected the to the 10K resistor pad (the circled part in the picture below). Before soldering D6 and the 10K-ohm resistor, please use an ohm meter to check the pads in the yellow circle. If they are not connected, use a knife to remove a little of the paint on the track, and connect the track and the pad with a little solder. After mending, use the ohm meter to check if the two pads are connected.

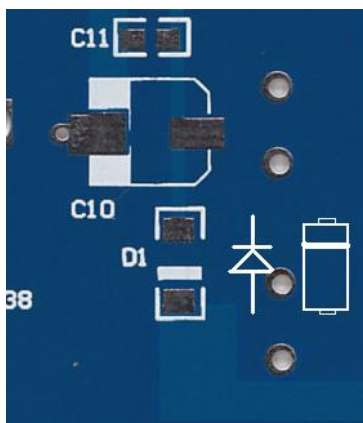
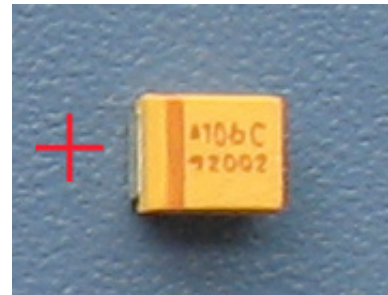
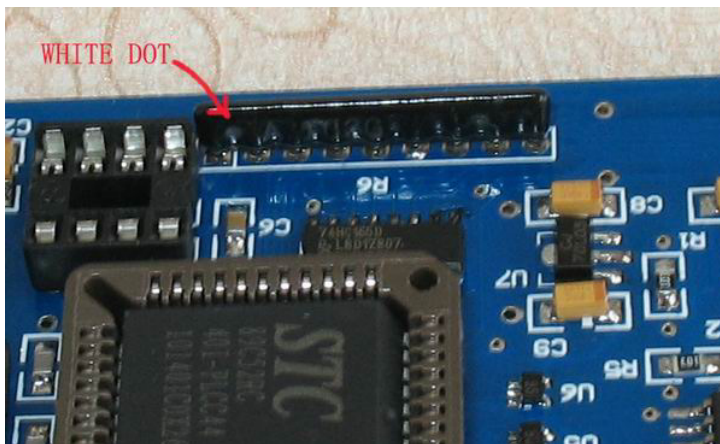


2.2.3 DDS Board



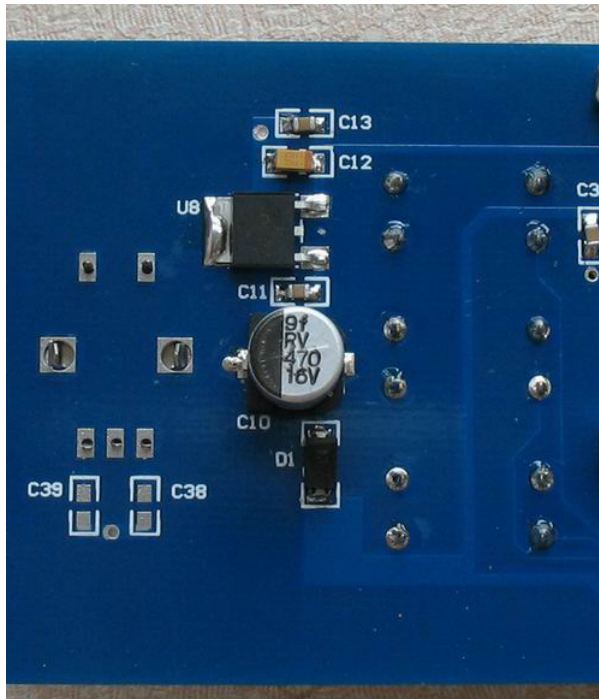
Do not mount MCU socket until all the components have been soldered. Solder the FFC connectors first. Check the connection of the connectors after soldering.

The side with the bar is the + pole of TAN capacitors. Notice the direction the white dot of R6.



The direction of the polar strip of D1 is wrong. Please mount D1 as the above picture indicates.

Solder the heat sink of 78M05 to the pad. As for U7 (78L05), solder the 3 leads to the pads.



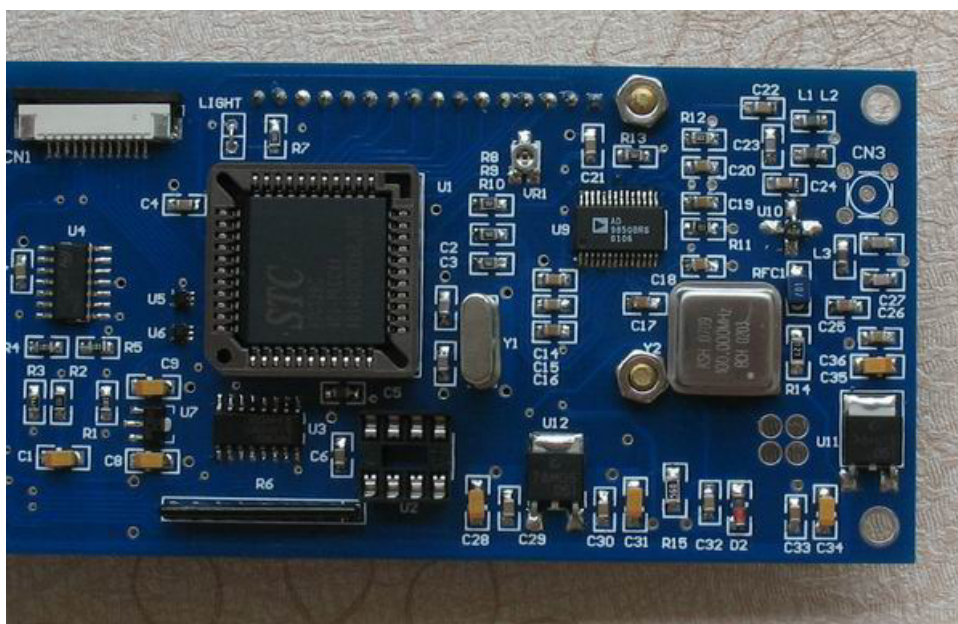
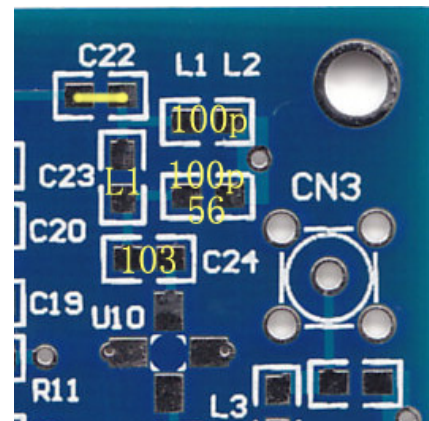
Solder the 0.39uH inductor on the pads of C23.

Solder a 100P cap on the pads of L1 and L2.

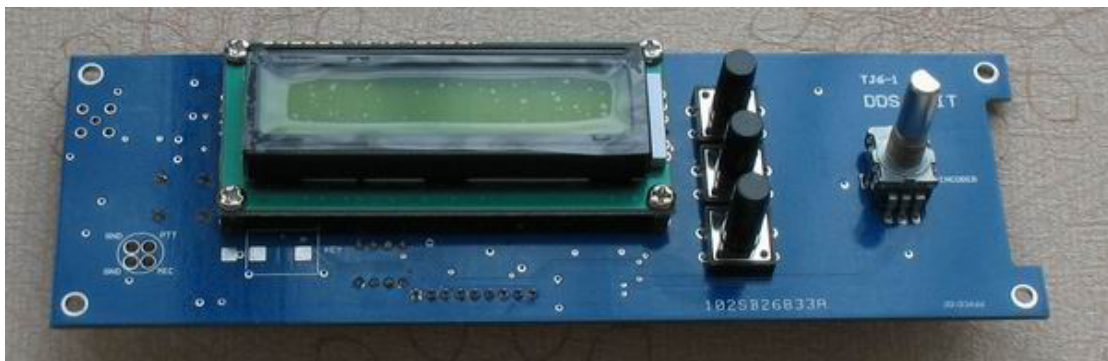
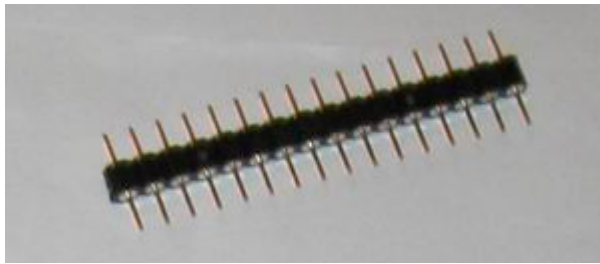
After a 100P cap is soldered on the pads of L2, solder a 51-ohm (or 56-ohm) resistor in parallel with the 100p, i.e., stack the resistor on top of the cap.

Bridge the pads of C22 with solder.

Solder a 103 cap to the pads of C24.



Use 16-pin header to connect the LCD. Use the 5 mm long brass spacers to connect LCD and PCB.

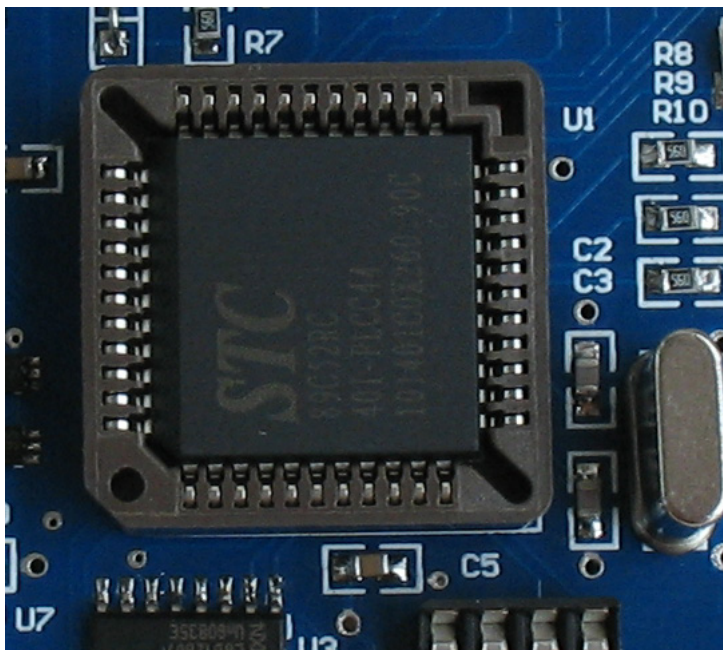


It is suggested the encoder be mounted on the front cover. In this case the encoder leads have to be extended.

The MIC socket leads have to be extended since they are not long enough.

Bridge LIGHT connector.

Plug in MCU and U2. Do not plug in the MCU in the wrong direction.



Use the 15mm long brass spacer and screws to connect the front face and DDS Unit.

DDS unit is completed.

2.3 Connecting the Assemblies

The assemblies are connected by FFC. The FFC connector has locking device (brown plastic). Pull out the lock before inserting the FFC. After inserting the FFC, push in the lock. The blue side of the FFC is always up.

Lock is pulled out



FFC is locked



The 12-pin FFC is used to connect DDS and CN4 of Main Board.

The 16 cm long 8-pin FFC is used to connect CN8 of Main Board to CN2 of PA Board.

The 20 cm long 8-pin FFC is used to connect CN1 of Main Board to CN4 of PA Board.

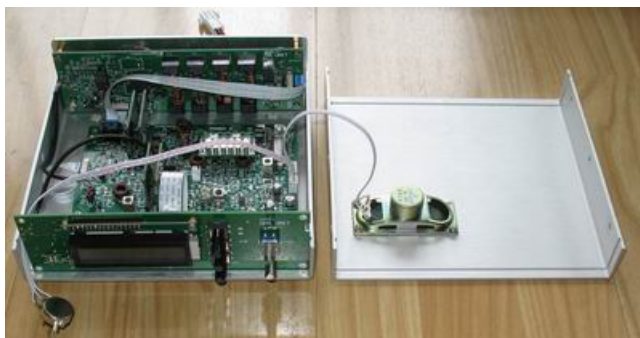
CN3 of DDS Board is connected through the coaxial cable to CN6 of Main Board. The SMA connector is soldered on the Main Board.

CN7 of Main Board is connected through the coaxial cable to CN1 of PA Board. The SMA connector is soldered on the Main Board.

CN2 of Main Board is connected to AF GAIN port. The thick white line indicates GND.

CN3 of Main Board is connected to Speaker. The Speaker is mounted on the casing. The thick white line indicates GND.

CN5 of Main Board is connected to MIC socket of the DDS Unit. The thick white line indicates GND.



3. Setup and Alignment

3.1 DDS Unit

Turn on the power. LCD lights up. Display appears in about 2 seconds. For the first time to turn on the power, DDS Unit works at Band 1. If there is no display, adjust the contrast control VR1.

Connect a frequency counter to CN3 of DDS Unit. The measured frequency is 9 MHz higher than that of the DDS LCD. For example: LCD displays 3.500.00, the measured frequency is 12.5MHz.

Press STEP to change tuning rate (1Hz, 10Hz, 100Hz, 1KHz, 10KHz, 100KHz). This feature allows the operator to move to different parts of the band quickly.

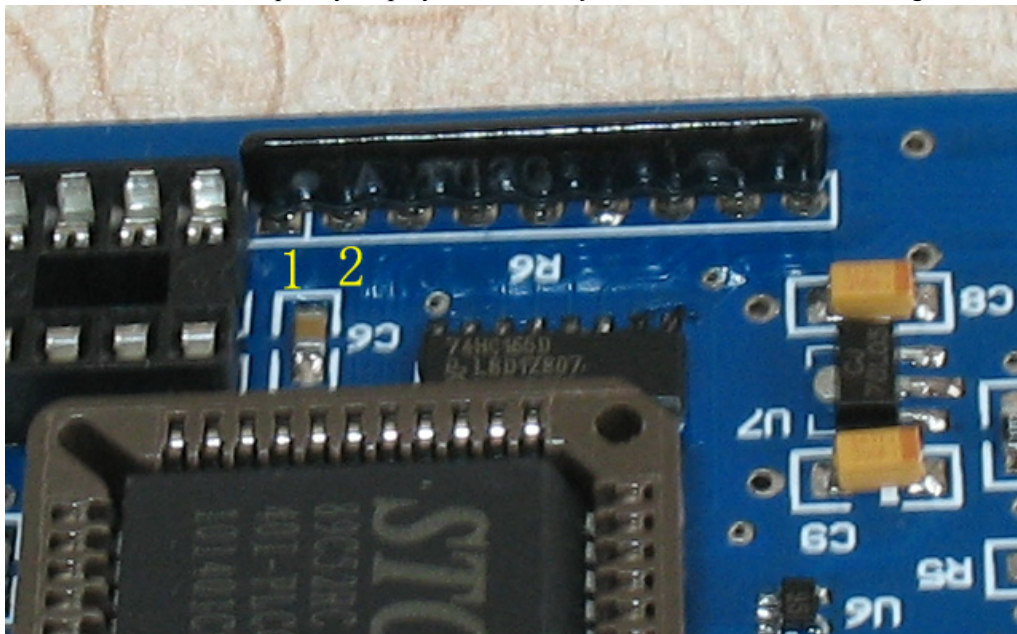
Press MODE to change the operation mode (USB, LSB, CW).

Press MEM to call the memorized frequencies (MEM 0 – MEM 7). The default frequencies of the 8 MEM's are the starting frequency of Band 1 (3.1MHz). The operator can use any of them to operate. The operator may use MEM 0 to operate 80m., use MEM 1 to listen to the beacon at 5 MHz, use MEM 2 to operate 40m, etc. Press MEM, until MEM 0 appears on the screen. Press the big knob (Tuning Knob) to change band, until 3100000 appears (Band 1 starts from 3.1 MHz). Now MEM 0 is set to 3.1MHz. Press tuning knob to change the band.

Turn the tuning knob to tune the frequency.

In USB mode, DDS frequency is 3 KHz higher than that displayed in LCD. In CW mode, DDS frequency is 2 KHz higher (with new MCU, 1 KHz higher).

The center frequency f_c of the DIY crystal filter is not that accurate, and calibration should be made to have correct frequency display. For this kit, f_c is about 1800 - 2200 Hz higher.



Short-circuit 1 and 2 pins of the 9-pin 10K resistor (R6) to the ground simultaneously (Use a piece of hookup wire, with one end connected to the ground of the DDS Unit or to the casing). IFS (IF setup) appears on the lower left corner of the LCD. DDS Unit is ready to be calibrated. In this mode, DDS Unit works at Band 1. The frequency displayed on the lower right corner indicates Band 1 frequency. The 0 in the middle refers to the IF default setting.

Set STEP to 100 Hz. Turn the tuning knob counter-clockwise, until LCD displays 2200. Press MEM to save the setting and exit.

3.2 Main Board

3.2.1 BFO

Set the mode to LSB. Connect a frequency counter to C39 or C40. Turn the slug of L2, until the reading is around 8.99778 MHz.

Set the mode to USB. Adjust VC2 until the reading is around 9.0008, i.e. 3 KHz higher than that of LSB.

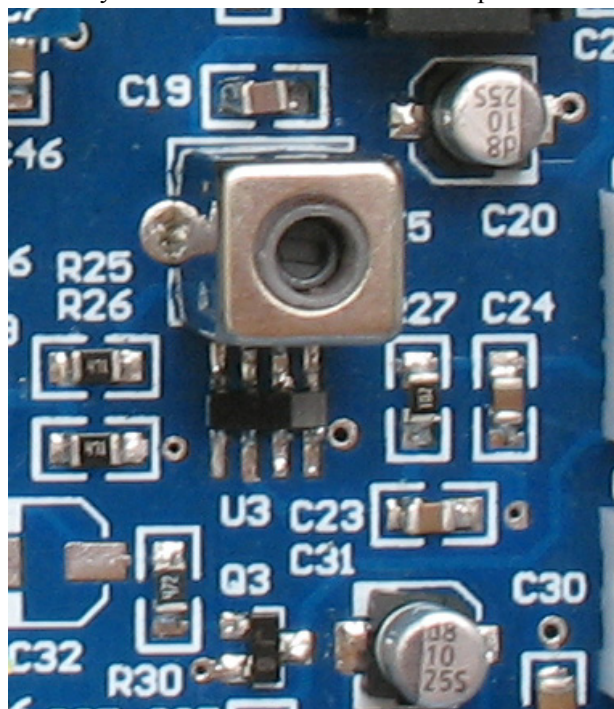
Now switch to LSB, see if the BFO frequency is correct. If the frequency is change, repeat the adjustment.

3.2.2 U2

Do not connect the antenna. Use a digital meter to measure the voltage of pins 4 and 6 of U2. Adjust VR2 until voltage of pin 4 is around 1.19V, pin 6 around 0.65, or $V4 - V6 = 0.5V$. Now AGC works at the best condition. **Never short-circuit pins 2 and 3.** This would damage the IC.

Another simple way to adjust U2 is to wear earphones, adjust VR2, until you hear a relatively louder hiss sound.

Adjust T5. Listen the carefully. Turn the slug, peak the weak hiss sound until you hear a relatively louder hiss sound. Notice the position of the slug of T5. The slug is about half way



inside the shielding case.

Connect the antenna. Select band 2, tune the frequency to 7.000 – 7.060 and try to get a signal. Or use a signal generator to generate a 7.000MHz signal. Adjust T5 to peak the received signals.

The BPF's are of broadband, and no adjustment is needed. If no signal is received, connect the antenna to C1 of the Main Board. If the kit receives the signal with antenna connected in this position, check the connection of CN1 of Main Board to CN4 of PA Board. If no signal is received, move the antenna to C2. If no signal is received, check if the XTL FIL module is plugged in the wrong direction. If the kit receives the

signal, please check the BPF module. Forgot to solder some component? Check the band voltage:

At Band 1, Pin 7 of S1 is 0V. At other bands, 3.8 – 4.5V.

At Band 2, Pin 6 of S1 is 0V. At other bands, 3.8 – 4.5V.

At Band 3, Pin 7 of S2 is 0V. At other bands, 3.8 – 4.5V.

At Band 4, Pin 6 of S2 is 0V. At other bands, 3.8 – 4.5V.

The band control voltage is from MCU via FFC of CN1 of DDS Unit and CN4 of the Main Board.

The kit's background noise is very low. Receiving sensitivity is around -100 dbm,

with good selectivity.

Plug in TX BPF modules in S5 and S6. Disconnect CN7. Connect a 47 - 51 ohm resistor between CN7 and GND as the load. Press KEY (short KEY to GND). Side tone can be heard. Side tone is not controlled by AF GAIN. Adjust VR3 to get comfortable volume.

Set the mode to CW. Set the frequency to 7010. Connect frequency counter to CN7. Press KEY (short KEY to GND), and frequency reading should be around 7010. If the reading is not stable, adjust L3, until a stable frequency reading is measured (with the slug around 2 mm higher than the shielding case). This frequency is around 7010 (possibly 1 or 2 KHz lower than 7010, but very stable).

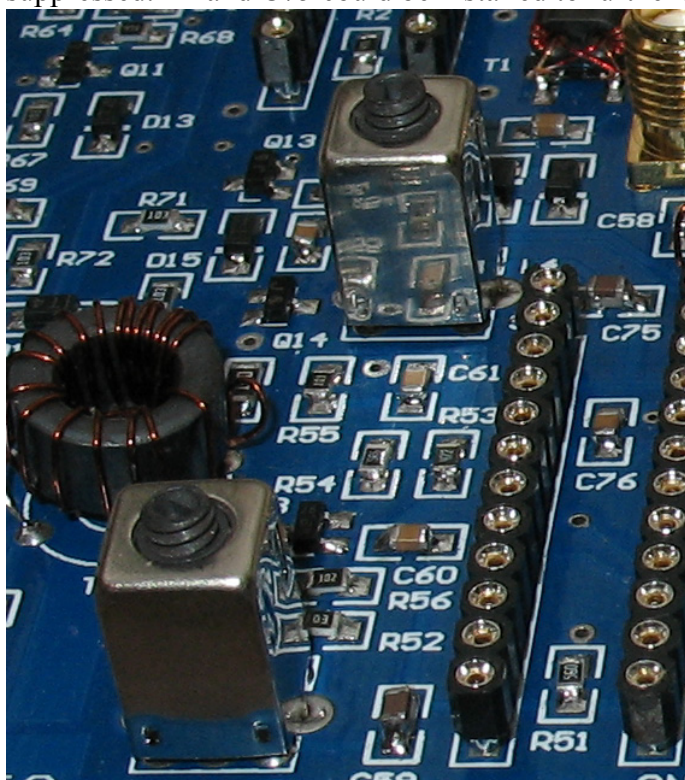
Adjust VC3, until the reading is 7010 (Not that precise. Around 100 Hz difference is allowed). This is the CW transmitting frequency. This adjustment may cause changes to LSB and USB. If it does, please slightly adjust L2 and VC2. **With the new MCU, this procedure is not needed because VC3 is not installed.**

If no frequency is detected at CN7, check the BPF modules of S5 and S6.

T7 and C55 (100P) are resonant at 9MHz roughly. For better resonance, trim the capacitance of C55. One extra 20P - 33P cap can be soldered on the pads in parallel to achieve better resonance. With an oscilloscope, an RF voltage around 300 – 400mV p-p can be measured at either pad of C55 when the CW key is down.

3.2.3 9 MHz Trap

L3 and C59 work as 9MHz trap to remove the possibly leaked 9MHz IF signal. Through the above mentioned adjustment, the IF leakage is suppressed. However, the advanced DIYER could further adjust L4 to achieve the best performance. At CW mode, connect a RF volt meter to CN7. Adjust L3, until a slight dip appears on the volt meter. Or, use an oscilloscope in LSB mode. Adjust L3, until 9MHz signal is suppressed. L4 and C75 could be installed to further suppress the IF leakage.



If you do not have an RF volt meter or oscilloscope, adjust the slug of L3 and L4 to the position as the following picture indicates: the slug is about 2 mm higher than the shielding case. This position is about to trap the 9MHz signal.

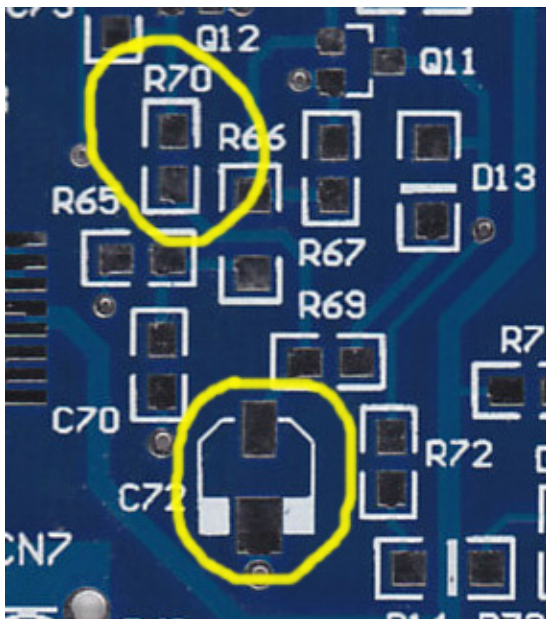
3.2.4 Increasing Output Power

To increase output power, R60 (5.6ohms) could be reduced slightly, say, use a 2.2- ohm resistor. However, do not short-circuit R60 to squeeze out more power.

If PA becomes too hot in 20meter, please increase R44 (100K) to 470K – 820K to reduce CW power output.

3.2.5 Adjusting Hold Time in CW Mode

The relay hold time after the last character and space can be extended by increasing either the value of R70 (100K) or C72 (1uF). However, changing the value of R70 is easier. The hold time can be shortened by reducing either the value of R70 or C72. Reducing the value of the resistor is more convenient. Solder a 100K resistor in parallel with R70, the hold time will be shortened.



3.3 PA Board

Now, remove the load resistor from CN7. Connect CN7 to CN1 of the PA. Connect a 50-ohm dummy load to ANT. Connect a RF volt meter to ANT. At CW mode, press KEY, 60V p-p could be read at 80m, 40m and 20m. 40 V p-p could be read at 15m. Switch to SSB mode; talk to the microphone, and almost the same level could be measured.

4. Use TJ6A

Remove the dummy load. Connect the antenna. You can try your luck with this kit.