

# The NorCal BLT Tuner



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Thank you for buying the NorCal BLT antenna tuner. This kit has been around for several years, but recently I repackaged it, doing away with the pc board case and the Manhattan construction style in favor of a pre-drilled custom aluminum case. The case is made from very high quality .063 aluminum, and comes pre-drilled for all controls and connectors. This will make assembly much easier. There are two holes that you will have to locate and drill in the bottom of the case, but this is easy to do. Why didn't I have these holes predrilled? Well, by not doing so, the top and bottom of the case are exactly the same. This resulted in a significant savings on the cost of the case and kept the cost of the kit down.

And you have already found out that the manual is on a CD, instead of paper. This also helps to hold the cost down, and will allow me to make changes as needed. My thanks to Dave Fifield, AD6A, James Bennett, KA5DVS, George Heron, N2APB, Gene Sailsbury, N0MQ, and Paul Maciel, AK1P who all encouraged me to do so. Please check the American QRP Club Web page at [www.amqrp.org](http://www.amqrp.org) for any corrections or additions to the manual.

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After you drill the holes, mount the parts. It should look like the picture below.

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## Background

The tuner was designed by Charlie Lofgren, W6JJZ, who is renowned in the QRP World as a tuner expert. Charlie has built all of the tuners used by the Zuni Loop QRP Expeditionary Force for years, and they all swear by them.

This tuner is a balanced line tuner only, and will not work with coax feedlines unless modified as shown in the mods section at the end of this manual. It works great with open wire feeder, ladder line, zip cord and even computer ribbon cable. As long as you are using balanced line as a feedline, this tuner will work.

Charlie designed this tuner to work specifically with the polyvaricon variable capacitors that used to be available from Mouser. I asked him to design it at first because I wanted a simple tuner for a presentation that I was doing at the Ft. Smith QRP Group Forum, Arkiecon 2000. It turned out so well that everyone who saw it wanted one. Thus the NorCal W6JJZ BLT kit was born. I would like to thank Charlie for his efforts on behalf of NorCal. This one is going to be a classic.

The design is for a classic Z-Match, using inductive coupling with L1, L2 and L3 wound on a single T106-2 toroid. L2 or L3 is switched in and out of the circuit by

Switch 2, located on the back panel of the tuner. The “high” and “low” positions on the switch for the output links may need clarification. The positions are for “high” and “low” in terms of impedance, not frequency. For a given band and antenna, try the High Z link first, and use the Low Z link only if a match can’t be found with the high link. (Often either link will allow a match. In these instances, the High Z link produces better efficiency as a result of loading the tank circuit more heavily.)

The circuit also includes the famous N7VE LED SWR indicator circuit. Dan Tayloe invented this several years ago, and it has proven a great addition to the qrp fraternity. This allows us to have an indication of lowest SWR on the tuner (indicated by the dimming or LED going out at minimum SWR.)

The circuit also is an absorptive bridge, which means that your transmitter sees a 50 ohm load as you are tuning up. This will help to save your final transistors!! This tuner is rated at 5 Watts. I doubt if the polyvaricon caps will take the 100 Watts of your big rig!! Now, lets get started to build the kit. First of all, you will need the following tools: 25 – 30 watt soldering iron, drill, 1/8” bit, small Phillips screw driver, small blade screw driver, pliers, diagonal cutting pliers, needle nose pliers and about 4 feet of #24 solid insulated hookup wire. A Volt/ohm meter is helpful also. Please read the manual in its entirety before you start building. You may want to print out the schematic, parts layout, parts list and wiring diagram.

### Building the BLT PC Board

Fig. 1 below shows the board as it comes in the kit. This type of board is called a Pittsburg Style board because the guy who makes them, Joe Porter, W0MQY, happens to live in Pittsburg, Kanas. Joe is a good friend of mine, and does excellent work. The Pittsburg board is similar to the Manhattan Style made famous by Jim Kortge, K8IQY, with the main difference being that all of the pads and traces have been etched on the board, so there are no pads to glue, and no wires to run. Both styles mount the parts directly to the copper, and use the remaining copper as the ground plane.

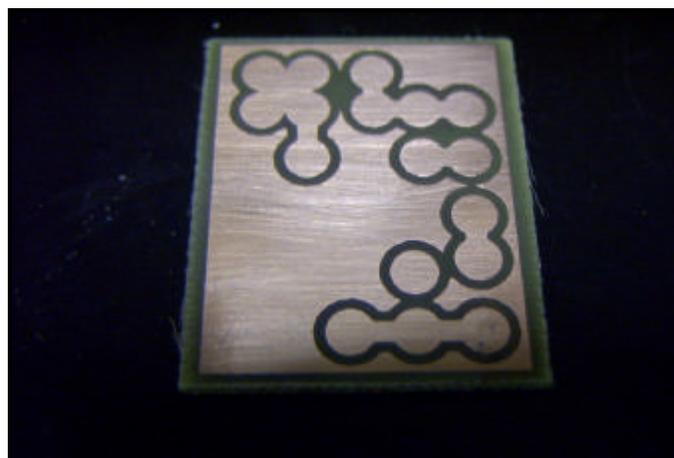


Fig. 1 – The Bare Board

The first thing that you need to do is to tin the pads as shown in Fig. 2. Prepare the board by scrubbing it with fine steel wool, or a scotch brite pad.



Fig. 2 – The Tinned Board

Fig. 3 shows the 2 pieces of #28 magnet wire, one red and one green, plus the small gray toroid. Unwind the wire, and straighten it out by running it between your fingers until the wire is straight.



Fig. 3 – Small Toroid + Wire

We will start the building process by winding a toroid that is used as transformer T1. It is easier to mount the toroid at this time because nothing else is in the way. You will use the red wire and green wire plus the toroid shown in Fig. 3.

Fig. 4 shows the toroid after the 25 turns of red wire have been wound. Start winding the toroid and count every time that the wire goes through the toroid as one turn. This is the secondary winding of T1.

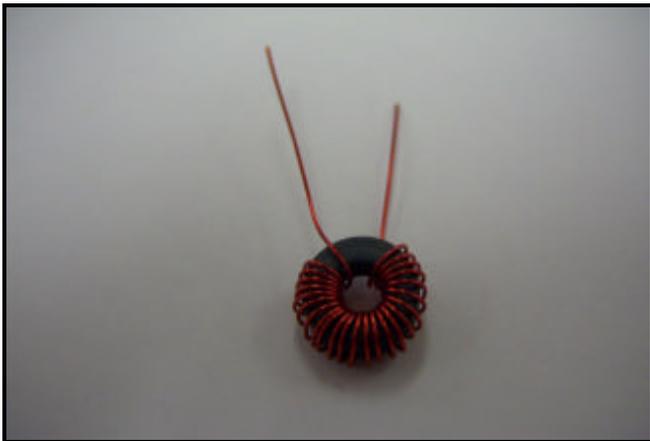


Fig. 4 – Toroid with 25 Turns of Wire

Next, take the strand of green #28 wire, and cut off a piece about 8 inches long. This will be used to wind the 5 turn primary of T1 over the 25 turn secondary. Wind the green wire 5 turns as shown and try to space it so that it is the same distance from the start and finish of the red wire as shown in Fig. 5.

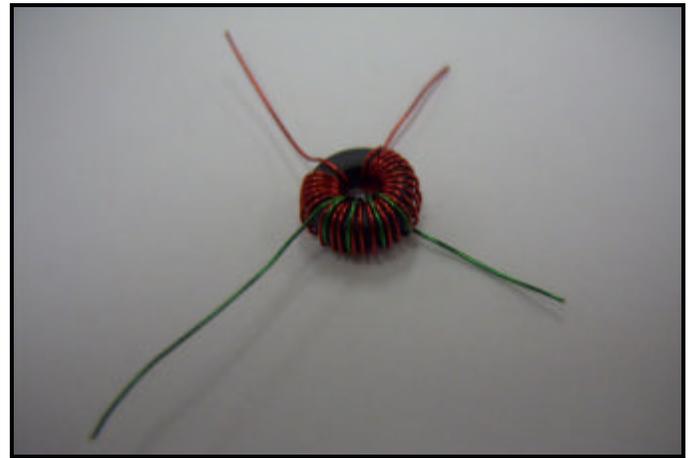


Fig. 5 – T1 with 5T Primary and 25T Secondary windings

The next step is very important. Be careful here, because this is where about 90% of problems with this tuner happen. You must remove the insulation on the four wires of T1 back to within 1/8" of the edge of the toroid. Don't worry it is easily done. Take a match, and burn the insulation off one wire. Be careful and don't get it too close to the toroid. Then, use some steel wool and clean off the burned paint until you see bright, shiny copper. Now, do the rest of the wires the same way. When you have all 4 wires cleaned, tin them using your soldering iron or a solder pot.

Refer to Fig. 6 to get the placement of T1 correct. Solder the green wires first as shown, and then finish with the red wires. Test the solder connections for continuity by using a VOM and placing the probes near the wire connections and seeing if you have continuity. If you do fine, if you don't, find out where the short is and fix it now while it is easy to get to.

When you finish, the toroid should look like Fig. 6 below.



Fig. 6 – Toroid Mounted on Board

Next we will solder on the 6 - 100 ohm resistors. But first we need to prepare them. Take the first two, and prepare them as shown in Fig. 7. You will mount them on the pads for R2 and R2A.



**Fig. 7 – 100 ohm Resistor ready to mount**

Use Fig. 8 to figure out where R2 and R2A go on the board.

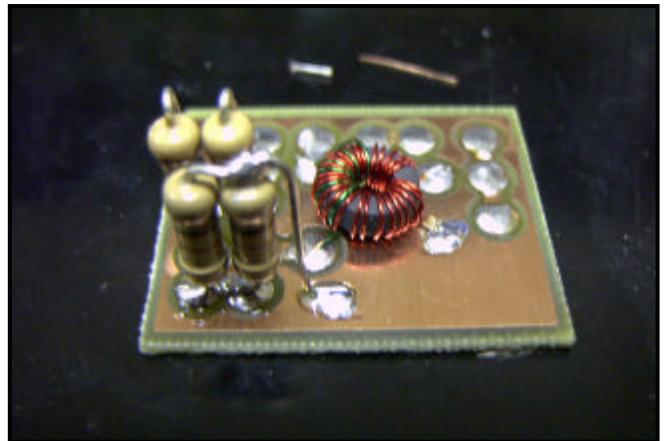


**Fig. 8 – Resistors R2 & R2A Mounted.**

Next we will prepare two more of the 100 ohm resistors, R3 and R3A. They will need to be prepared as in Fig. 9.



**Fig. 9, Resistors R3 & R3A ready to solder.**



**Fig. 10, Resistors R3 and R3A soldered on the board.**

Note that Resistors R2 and R2A are directly behind R3 and R3A in Fig. 10. Finally, prepare the last two 100 ohm resistors which will be R1 and R1A. Solder them on the board as in Fig. 11.



**Fig. 11. Resistors R1 and R1A to the right of the toroid.**

Prepare R4, the ¼ watt 1K resistor, brown, black, red, gold as you did the 100 ohm resistors, and solder in place as shown in Fig. 12, and on the parts placement.



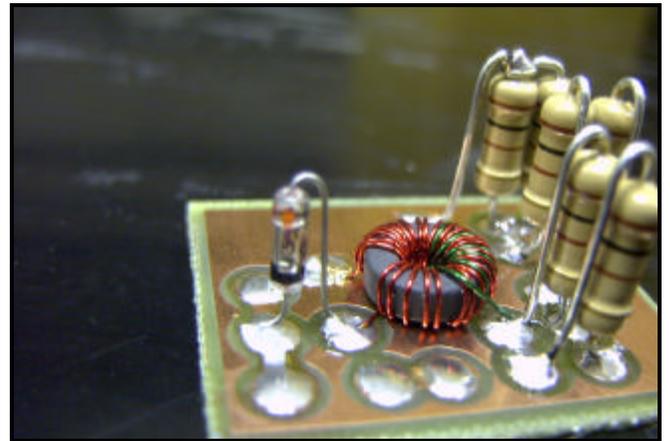
**Fig. 12 – R4 soldered in place just to the left of the toroid.**

We only have 2 more parts to add to the pc board, the 1N34A diode and the .1 capacitor. Fig. 13 shows the diode after it has been prepared for soldering. Note the orientation of the black band and the way that the diode is prepared. Make sure that you do yours exactly the same way, and solder it on the board the exact same way as shown.



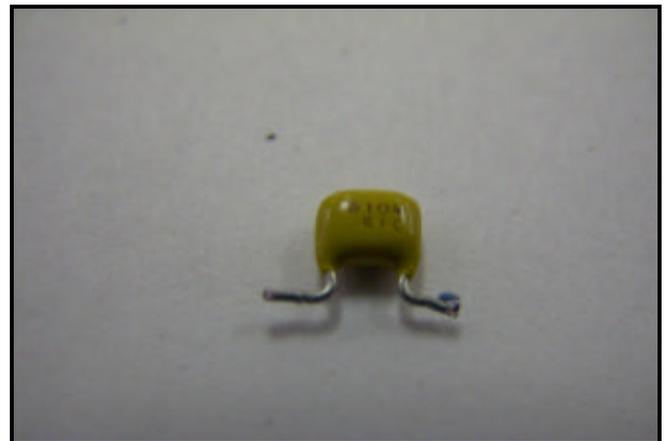
**Fig. 13 – Diode D1 prepared for soldering.**

After you prepare D1, solder it on the board as shown in Fig. 14. Make sure you do it the same way. It is a little bit hard to see in the picture, but the end with the black band goes on the middle pad, and the other end goes to the same pad that the red wire from the toroid goes to.



**Fig. 14 – Mounting D1.**

The last part to put on the pc board is the .1 capacitor, C1. Prepare C1 as shown in Fig. 15.



**Fig. 15 – C1 prepared to solder.**

Solder C1 on the board as shown in Fig. 16. Note that one end goes to the pad to the left of D1, and the other end goes to the ground plane.



**Fig. 16 – Placement of C1.**

Fig. 17 shows what the board should look like now.



Fig. 17 – The board after all parts are mounted.

Next drill a 1/8" hole as shown to be used to mount the board to the metal standoff. This is how ground is connected to the case, and you should make sure that you tighten the screws down tight. When you locate the hole be careful to not interfere with any parts on the board.



Fig. 18 – The board mounted on standoff.

Put the board aside for now, as we will assemble the case next.

#### Case Assembly and Parts Preparation

The case comes in four parts, a front panel, rear panel, top and bottom. The top and bottom connect to the front and rear panels by the 1/4" x 4-40 flat head screws. Find the case and set it aside for now.

The first step is to prepare the two capacitors to mount to the front panel. Take one of the nylon spacers, and a 12 x 2.6 mm screw and attach the nylon spacer to the capacitor as shown in Fig. 19. The nylon spacer will become the "shaft" of the capacitor. I use a small drop

of super glue between the nylon spacer and the capacitor to keep it from turning. Make sure that you don't get any on the capacitor shaft if you do this.

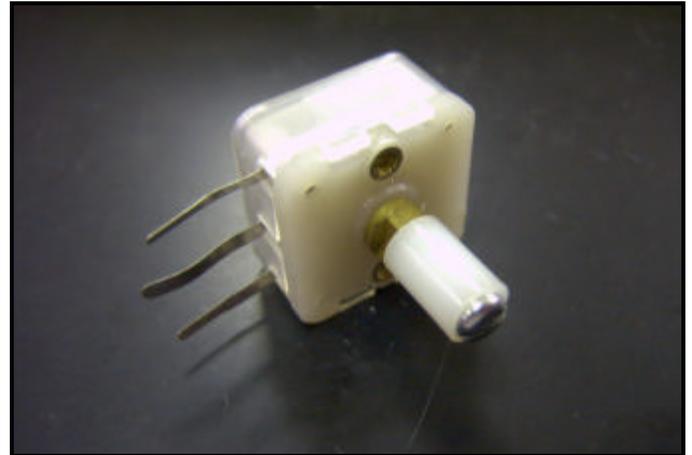


Fig. 19 – Variable capacitor with nylon spacer attached.

Find the other variable capacitor and prepare it the same way. Now find the 4 screws that fit the caps. They are small, round headed screws. Try one for a fit to make sure that you have the right ones. Attach both C2 and C3 to the front panel.

Now let's prepare the 2 switches. You will find 2 dpdt switches in the kit. Switch 1 goes on the front panel, and Switch 2 goes on the back. Find a resistor lead and use it to short the two pins of switch 1 as shown in Fig. 20.

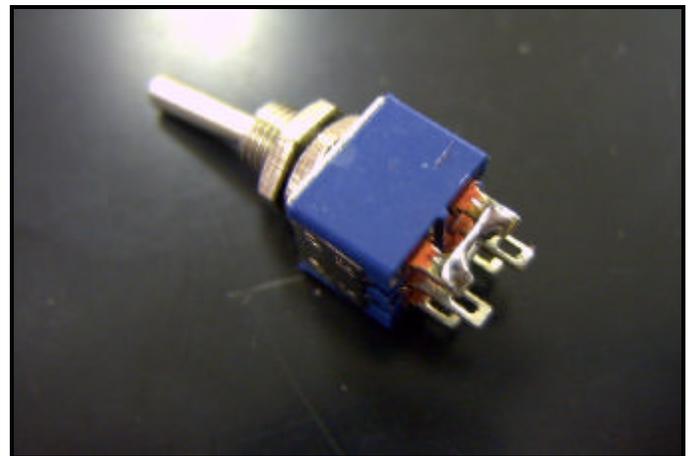
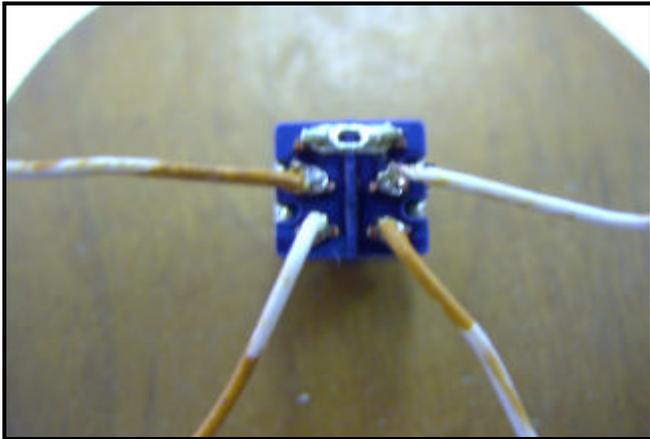


Fig. 20. – Switch one with the two pins shorted.

Be sure to solder the connections. Make sure that you don't hold the iron on the pins any longer than needed, as the pins are fragile and can melt.

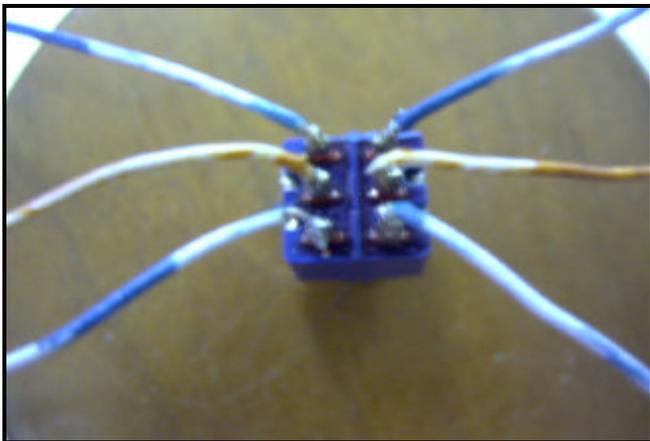
Cut 4 pieces of solid insulated wire 4" long. I used some wire out of telephone cable. Connect them to the four remaining pins of Switch 1 as in Fig. 21.



**Fig. 21 – Switch 1 ready to mount on the front panel.**

Mount Switch 1 on the front panel, making sure that the “jumper” is on the bottom. This completes the assembly of the front panel except for the LED, which we will do later. Lay it aside for now.

Prepare 6 more 4" leads of solid insulated copper wire. Attach them to Switch 2 as shown.



**Fig. 22 – Switch 2 prepared for installation.**

Find the back panel and install Switch 2 at this time. Then mount the BNC and the two binding posts as shown in Fig. 23. Make sure that you use a wrench or a pair of pliers to tighten the BNC and the Binding Posts. It is difficult to do after you have done the wiring. Note: If you intend to put in the unbalanced tuner mods, you should drill your holes in the back panel as indicated before you assemble it. See the mods section at the end of the manual. When you finish with the back panel assembly, set it aside.



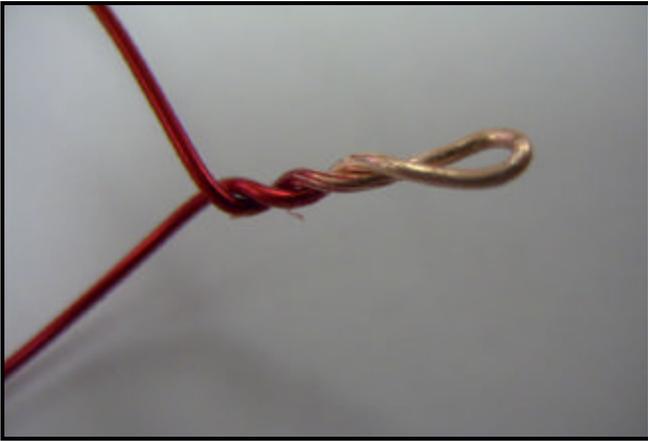
**Fig. 23 – Back Panel**

The last part to do is the big red toroid. It is really easy to do. Just follow the pictures. Remember that a winding or turn on a toroid is counted every time the wire goes through the hole in the center.



**Fig. 24 – Red Toroid and Heavy Wire.**

Start by taking a 30" piece of the red heavy wire. Fold it in half, and scrape the insulation off for a half an inch on either side of the fold. Then, twist the wires together as shown in Fig. 25.



**Fig. 25 – Twist in heavy wire.**

First we will wind L1. Use the wire with the twist that you have just prepared to wind the 16 turns on the red core, starting in the middle with the twist against the core, and wind 8 turns in one direction and 8 turns in the other. Keep the same “sense” while winding, and you should end up with a core that looks like Fig. 25 after you have scraped the insulation off the ends of the wire.



**Fig. 26 - L1 wound on the red core.**

Now take another piece of the heavy wire, cut it 24” long and wind 12 turns, with six on a side of the tap in the middle. When you finish, scrape off the insulation and make a loop as shown. This winding is represented by the blue wire in this color version of the manual. You may chose to use different colored wire as I have, but you may also use the red wire provided in the kit. I used the different colors to show the windings better for this manual. See Fig. 27.



**Fig. 27 – L2 and L1 both wound on the red toroid.**

Note that the lighter wire is wound between the windings of L1. Our final winding is L3. Cut a piece of wire 18” long and wind 6 windings around L2 and L1, with 3 windings on each side of the tap. It is represented by the orange wire in the color version. Be sure to scrape off the insulation and make the connecting loops.



**Fig. 28 – The finished Toroid, note the tap on the right side.**

Find the solder lug and solder it to the tap of L1 as shown in Fig. 29.



**Fig. 29 – The large toroid prepared for mounting.**

Put the toroid aside, and prepare to assemble the tuner.

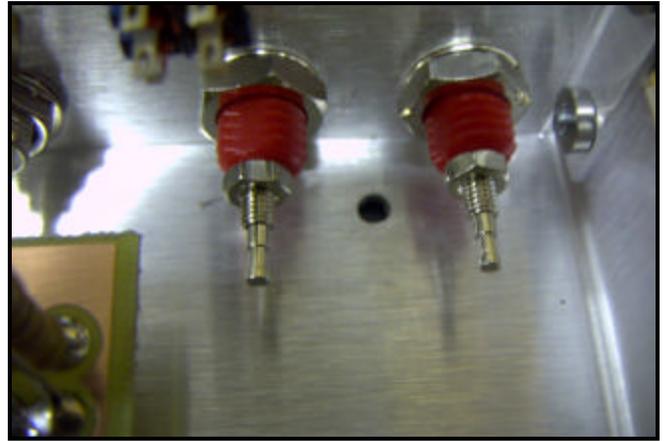
Get the pc board. Locate it on the left side of the bottom of the case, mark a hole to mount the standoff.

Put the front and back on the case, so you will have plenty of clearance from the connectors and controls. Place the pc board as close to the left side as you can, but leave a gap of about 1/8" between the board and the side. My hole was 3/16" from the side and 1 3/8" from the front edge. Use the hole in the pcboard to mark where the hole needs to be drilled. Next, use a drill to drill a 1/8" hole in the bottom of the case. Do not mount the pcboard yet.



**Fig. 30 – Placement of the pcboard on left side of case to locate mounting hole.**

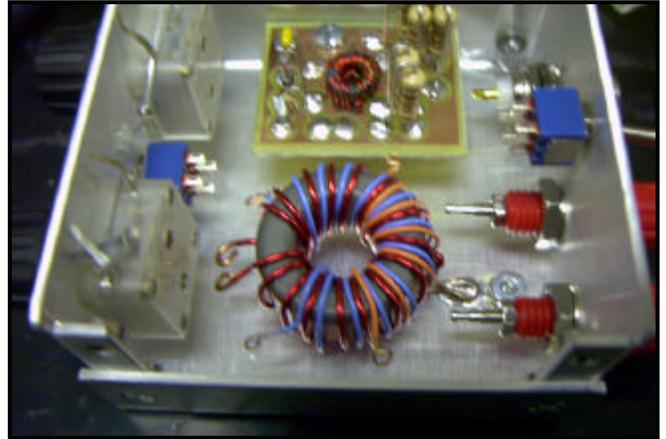
Next, with the back panel on, find and locate the hole for the big toroid ground lug. Mine was 3/8" from the back and right in the middle between the two holes for the binding posts.



**Fig. 31 – Location of hole for big toroid ground lug.**

After you locate the hole, drill a 1/8" hole as shown in Fig. 31 above.

Next, use a 4-40 x 1/4" screw and 4-40 nut to mount the toroid as shown in Fig. 32.



**Fig. 32 – Large Toroid mounted by lug.**

Use the mounting standoff, 2 star washers and 2 4-40 x 1/4" screws to mount the pcboard. It is important to maintain a good ground connection between the board and the case. Assemble in this order.

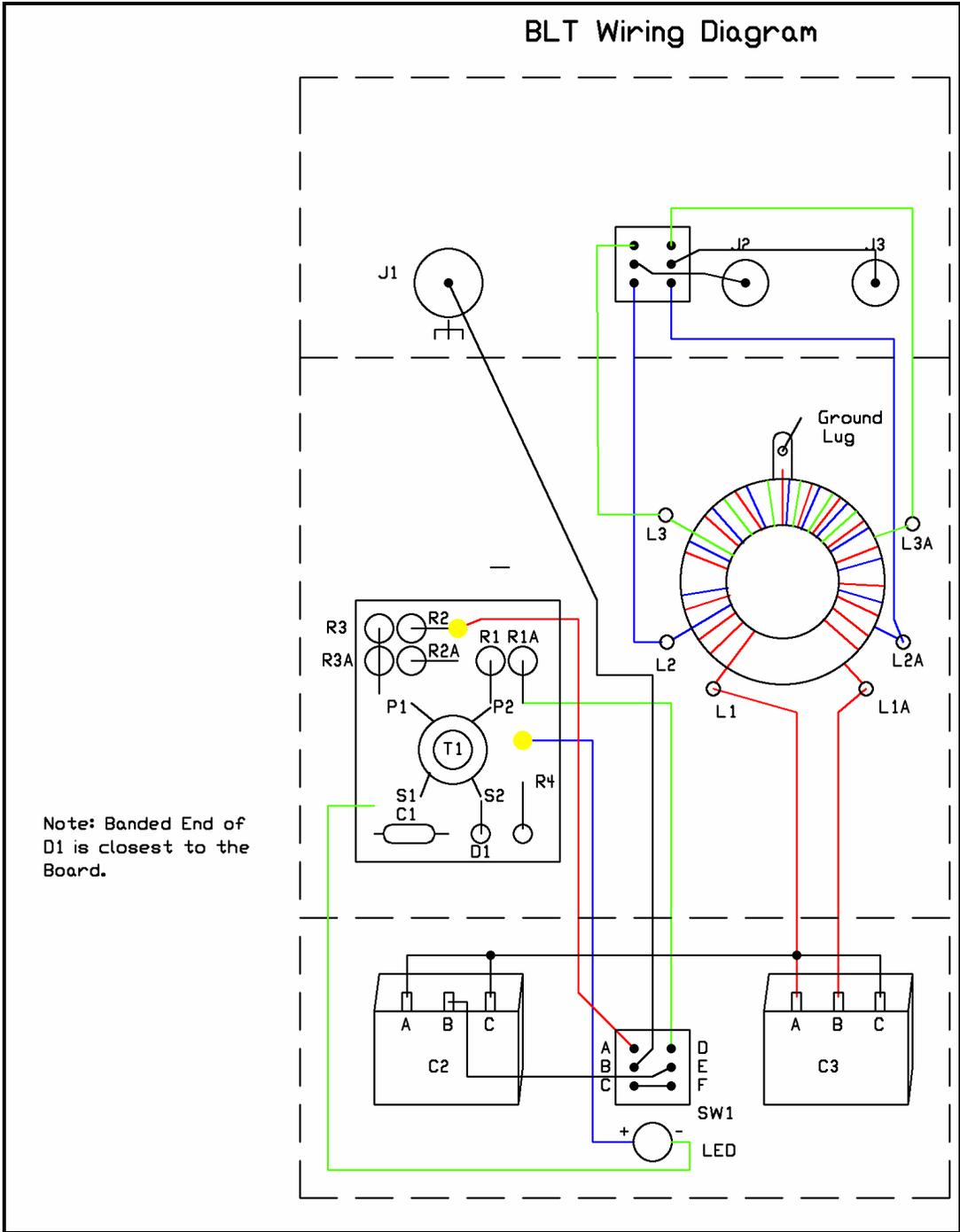
1. Place screw through bottom of case.
2. Put star washer on screw.
3. Put standoff on screw and tighten.
4. Put PC Board on standoff.
5. Put star washer on board centered over hole.
6. Put screw through star washer and pc board assembly to attach to standoff. Make sure that both screws are tightened securely.



**Fig. 33 – Stand off , screws and star washers.**

Now we are ready to wire the tuner. Please refer to the wiring diagram in Fig. 34. I have drawn it in color to make it easier to follow. Wire as shown.

When you are wiring the LED, remember that the shorter leg of the LED is the one that goes to ground. Solder 2 wires about 3" long to the LED. You may use a spot of super glue to mount the LED in the case, but make sure that you don't get any on the lens. Mount the LED in the front panel, and then follow the wiring diagram to connect the LED to the proper places on the PC Board.



**Fig. 34 - BLT Wiring Diagram**

## NorCal W6JJZ "BLT" Tuner

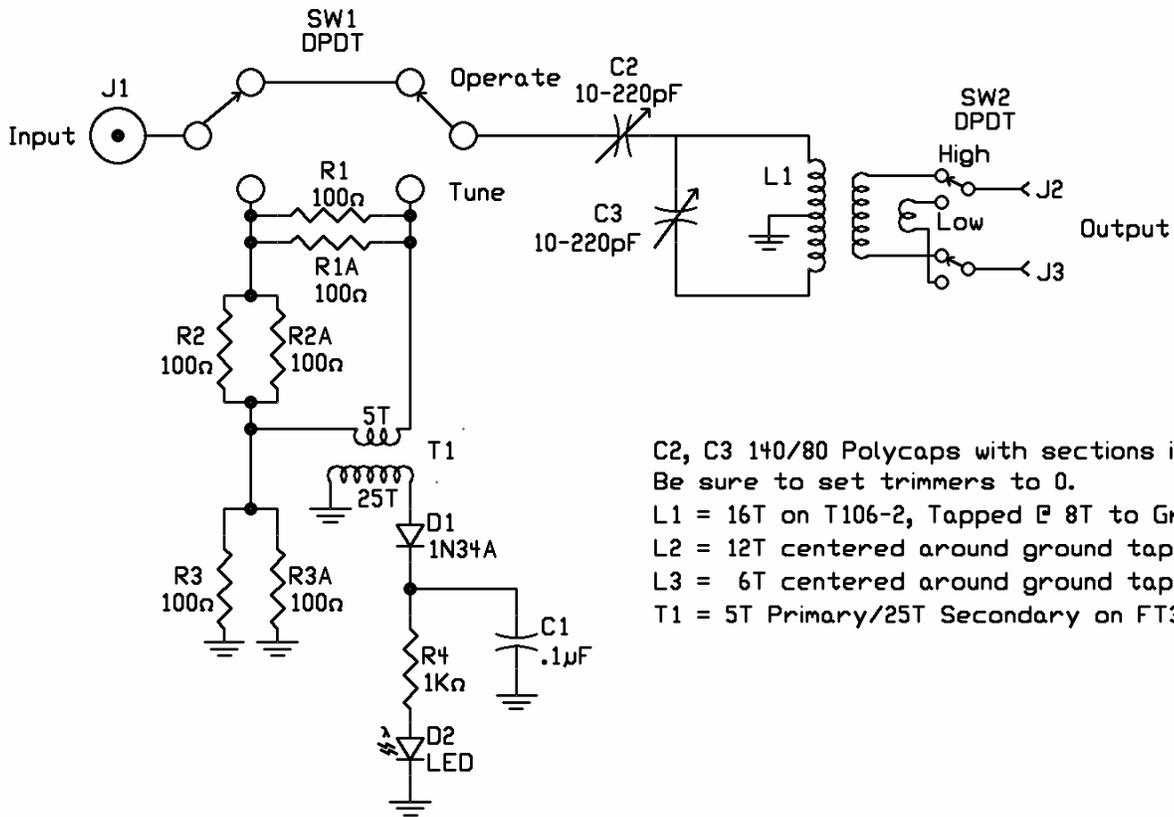


Fig. 35 – BLT Schematic

### PCBoard Parts Layout

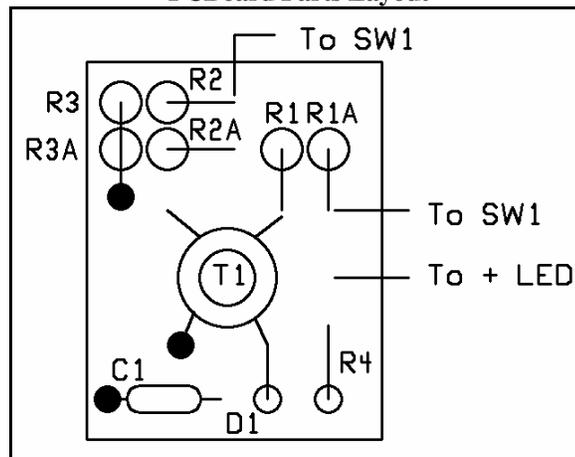


Fig. 36 – Parts Placement Diagram

## Parts List

C1 = .1uF  
C2, C3 = 140/80 Polyvaricons  
D1 = 1N34A  
D2 = Super Bright Clear Red LED  
R1, R1A, R2, R2A, R3, R3A = 100 ohms/ 1 Watt  
R4 = 1K/ ¼ Watt  
SW1, SW2 = DPDT Toggle  
J1 = Chassis Mount BNC  
J2, J3 = 5Way Binding Post  
L1, L2, L3 all wound on one T106-2 Core  
T1 = 5T Primary/25T Secondary on FT37-61  
4 x 4x2.6mm pan head screws  
2 x 12x2.6mm pan head screws  
2 x 3/8 Nylon Bushing  
18" #26 Red Wire  
18" #26 Green Wire  
6' #22 Red Wire  
2 Black Knobs  
1 #4 Solder Lug  
1 ½" Standoff  
3 ¼" x #4 Panhead screws  
1 - 4-40 Nut  
8 ¼" x 4-40 undercut flathead screws  
2 4-40 star washers  
4 rubber feet

## Mods:

If you want to use your tuner with a coax fed or long wire antenna, a simple mod makes it possible. It involves drilling 2 new holes in the back panel, and adding a single pole switch and another BNC. Here is a picture of the back panel with the new holes drilled. I drilled mine 3/8" to fit the BNC, and you will have to determine the size for the switch based on the switch that you use. By the way, the parts are available at Radio Shack if you don't have them in your junk box.

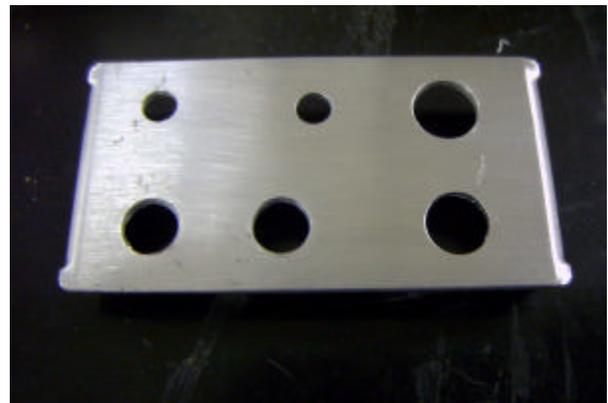
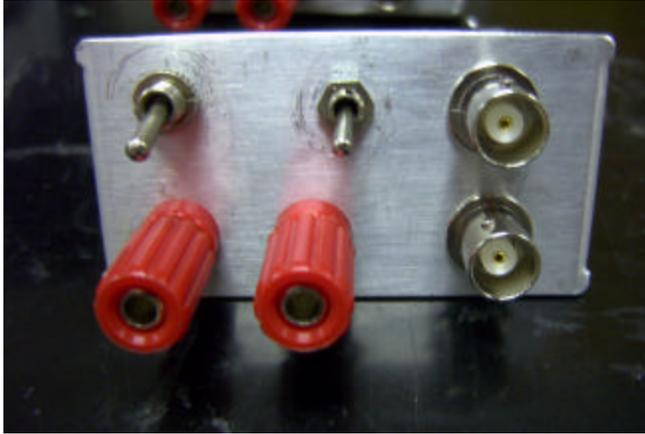
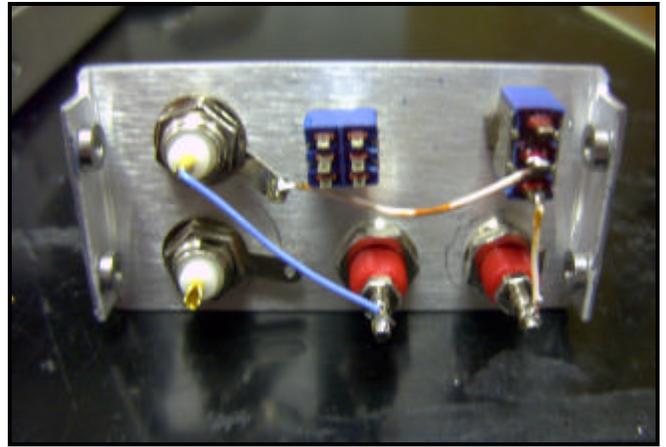


Fig. 37 – Back Panel with mod holes drilled. After you drill the holes, mount the parts. It should look like the picture below.



**Fig. 38 – Back Panel with mod parts added.**

The wiring is simple. The photo below shows the additional wiring that you have to do for the mod. You still have to wire the tuner as per the main wiring diagram, but I have left those wires off to illustrate the added wiring for the mod. Note that you may also go to the solder lug of the big coil for ground, I chose to use the solder lug on the BNC.



**Fig. 39 – Wiring diagram of additional wiring needed for mod. Note that the normal wiring is not shown in the picture for clarity.**

To operate the tuner as a long wire or Coax fed tuner, all that you have to do is switch the added switch in, which will ground one of the binding posts. Now the tuner will work with either coax or long wire. Be sure to connect the long wire to the center binding post, and the counter poise if used to the outside binding post. Also, don't forget to return the switch to normal off position when you are using the tuner in the balanced configuration

Created by Jerry Haigwood W5JH

