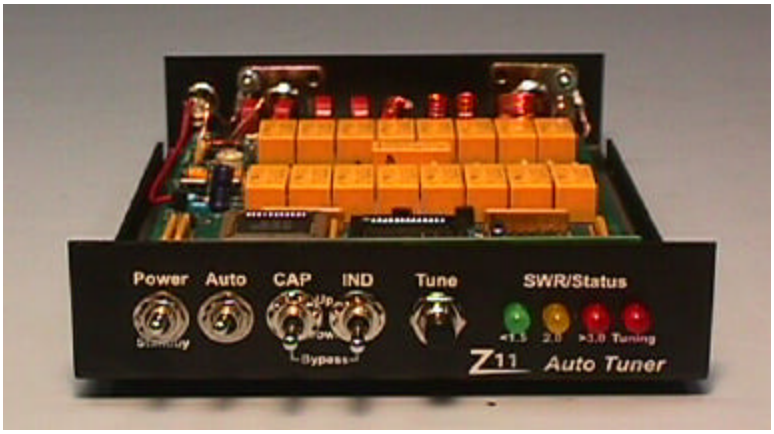
Introduction: The Z11 is a full featured QRP auto or semi automatic antenna tuner designed for HF (1.8 to 30 MHz) transceivers using between 0.1 to 30 watts. The tuner uses a switched "L" configuration with 256 capacitor, 256 inductor and Hi/Lo-Z settings to provide over one hundred and thirty thousand tuning combinations. The tuning range is 0 to 2700 pF and 0 to 20 uH. The "L" network works great with just about any coax fed antenna (dipole, vertical, beam, etc). Users with long wires can install a balun between the tuner and the antenna. Tuning time is between 0.1 and 3.0 seconds with the average being about 1.5 seconds.

Latching relays are used to switch tuning components into and out of the tuning circuit. These relays will hold the tuning configuration even if power is removed from the tuner. Once a tune has been made the tuner enters a low power mode where it only draws 0.008 amps. Placing the tuner into Standby can further reduce this power consumption, where it draws zero amps. During tuning, the tuner may temporarily draw up to 0.4 amps. This current draw usually only last a second or two.

Three LEDs provide an indication of SWR while RF is present. Green indicates SWR of less than 1.5, Green/Yellow is 1.5-2.0, Yellow is 2.0-2.5, Yellow/Red is 2.5-3.0 and Red indicates more than 3.0. The fourth LED is a tuning indicator. It is lit only when the tuner is trying to find a match.



Operation: Turning on the unit with the front panel Power switch will initialize the microprocessor. All four LEDs will flash once to indicate the power up process was initiated. Turning the unit off by the front panel Power switch places the tuner into Standby. The tuning configuration is maintained with the Power switch in either position.

The Auto/Semi switch controls how the tuning process will be envoked. In Auto mode (Auto/Semi toggle switch in Auto), the tuner will seek a 1.5 match (or better) anytime the SWR rises above 3.0. In Semi mode (Auto/Semi toggle switch in Semi), the tuner will seek a match only when the Tune push button is pressed. Both modes require that more than 0.1 watts of RF power be present. If the Tune button is pressed and there is less than 0.1 watts of power, the four front LEDs will flash once to indicate that there was not enough RF to tune properly.

The Capacitor and Inductor Up and Down switches are used for fine tuning the inductors and capacitors and can be used in either, Auto or Semi mode. Pressing either of the Up switches will increment that tuning section until it reaches the maximum range. When the maximum value is reached, all four LEDs will flash. Conversely, pressing either of the Down switches will decrement that tuning section until it reaches the minimum range. When the maximum value is reached, all four LEDs will flash.

Besides envoking the tuning process, the Tune push button has some other functions. Pressing the Tune and Ind Up push buttons at the same time will cause the Hi/Lo-Z relay to move to the Hi-Z position. The Tuning LED (red) will flash to indicate the change. Pressing the Tune and Ind Down push buttons at the same time will cause the Hi/Lo-Z relay to move to the Lo-Z position. The 1.5 SWR LED (green) will flash to indicate the change.

Pressing both Down switches at the same time will reset the processor and place all relays in a bypass position.

The back panel has SO-239s for connecting UHF type connectors to the antenna and transmitter. A coaxial power jack is used to provide DC power to the tuner. Between 11 and 15 volts DC can be used. The power supply must be able to provide up to 0.4 amps for up to two seconds. For portable operation, two rechargeable 9V batteries in series will provide about 14 volts DC at about 0.120 AHr. With the Z11 drawing about 0.0002 AHr per tune, the user should get about 500 tunes on a single charge. Do not use regular alkaline 9-volt batteries without regulating the power to below 15 volts.

Notes: Most tuning situations with the Z11 is very straightforward. Simply transmit a continuous carrier and press the tune button. The tuner will find the best match and stop tuning.

In either mode (Auto or Semi), if power (either RF or +12) is removed after the tuning cycle starts, but before it finishes, the LEDs will go out and the tuning will stop. The resultant tune will be undetermined; it may or may not be a match.

Performance: The actual performance from the small package will surprise you. It really tunes a lot of antennas to a lot of places! Here are some of the actual test results.

A 40-meter dipole (at 30 feet) would tune just about anywhere from 3.1 to 30 MHz! We had some problems at 19 and 28 MHz finding a 1.5 match. The Z11 usually found a 2.0, and then we had to use the manual switches to get below 1.5.

Next, an Antron-99 (at 40 feet) would again tune just about anywhere from 30 to 5 MHz. The auto mode worked great the whole time. We just dialed down the band and the Z11 would kick in whenever the SWR went over 3.0.

Then we tried out the unit on a 3-element tri-band (20,15,10) at 70 feet. It would tune any of the ham bands (including WARC) except 160 and 80. We had some problems finding a match around 27.200 MHz, but got around it by moving to 27.000, letting the Z11 find a match, then moving back to 27.200.

The 80-meter inverted Vee was next. It tuned everything from 3.1 to 30 MHz. We were hoping that it would tune all of 160 meters, but it only found good matches from 1.900 to 1.800 MHz.

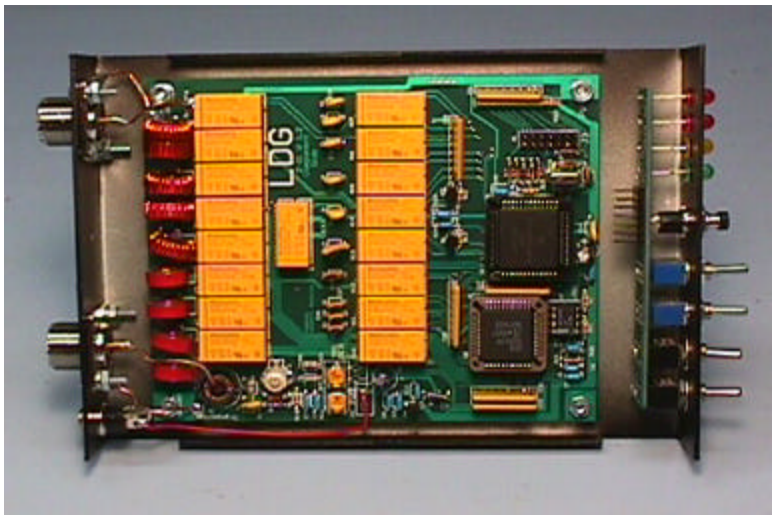
We've tried many other antennas with similar good results. There may be a place or two that your antenna (dipole, inverted-Vee, vertical, beam, etc.) won't tune. Also, the farther away from resonance you try to tune, the harder time the tuner will have. The Z11 will tune a 10 meter vertical to 80 meters, but your performance will not be that great (you can't get something for nothing).

For balanced lines and random wires, you may get better performance by using a 4 to 1 or 6 to 1 balun between the antenna and tuner.

We used the Autek RF-1 analyzer to give us more information about how well the Z11 was working. We found that it would consistently tune impedances from about 6 ohms to about 850 ohms. This corresponds to an SWR of about 10:1.

The SWR bandwidth (usable bandwidth of 1.5 SWR without retuning) averaged about 200 kHz. On the lower frequencies it was smaller (about 75 kHz on 80 meters) and on the higher frequencies it was larger (about 400 kHz on 10), no surprises here.

Tech Support: Telephone technical support at 410-586-2177 is available most days from 8 am to 9pm Eastern Standard Time. Replies by FAX (410-586-8475) are welcome; e-mail (ldg@ldgelectronics.com) is also answered on a daily basis.



Last Resort: As a last resort only, LDG Electronics will attempt to repair any problems. We have a flat fee of $50 plus parts to repair a Z11 (most resistors and capacitors are included in that fee). The 68HC11 chip is the most expensive at $20. Relays are $5 each. The 78L05 is $1.

We will not attempt to repair any unit that has been soldered with acid core. We reserve the right to refuse repair due to excessive problems or damage due to construction.

Before any unit is sent to us, you must first call to get return authorization. All units sent back must be prepaid, either by check, money order or Credit Card unless other arrangements are made. Package the unit carefully and keep in mind that we will use your packaging to return the unit back to you. Include a description of what problem you are having along with your name, address and a phone number that you can be reached at in case we have questions. Repairs average about 2 to 4 weeks, depending on the particular problem.

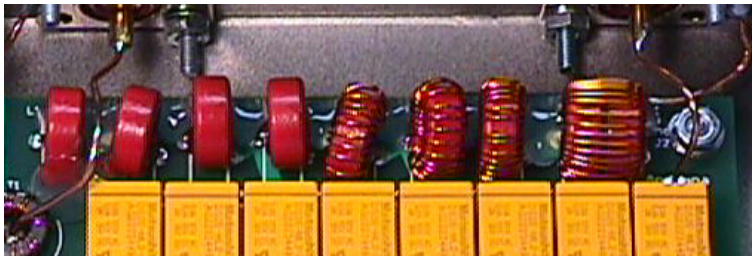
If you have an idea of how the unit can be made better (in software or hardware), please send a description of your upgrade. If we use it for the Z11, we'll send you a free upgrade. Future upgrades will be available for about $10 with 68HC11 chip trade in. If you purchased the kit from LDG, we will notify you when future upgrades and modifications are available through the LDG Newsletter. If you purchased the Z11 through a distributor and would like to be added to our mailing list, just drop us a note by mail, fax or e-mail.

Feedback: We encourage everyone who uses the Z11 kit to drop us a note (card, letter or e-mail preferred) to let us know how well it works for you. We're also always on the lookout for photographs of the Z11 in use. We frequently place pictures that we receive into the LDG Newsletter or on our Web site (www.ldgelectronics.com).

Building the Kit: Before getting the soldering iron out, go through all of the parts in the kit and familiarize yourself with each component and its placement. Most of the parts are common, but a few of them may be new to some builders. There are just over 100 parts and 450 solder connections, so take your time.

You will first wind the inductors on the nine T50-2 toroids (they are red and just over an inch in diameter). Take care not to drop them, they will break. Using the #24 gauge wire provided, you will wind a total of 8 inductors. L8 is two of the toroids placed together and the wire wound around both of them. You can use super glue to hold them together so they will not slip when winding. L1-4 wind in one direction and L5-8 wind in the other. The PC board is laid out with offset solder pads for the toroids. If you wind them backwards, the offset will not match. Trim the wire to about ½ inch and scrape away the insulation from the end. Don't solder them in until later. Save the left over wire for later. It is used for connections on the SO-239s and grounds.

Refer to **figure 1** for winding methods, and to the winding chart for lengths of wire and number of turns. For consistency, we count one turn when the wire passes through the center of the toroid.



Winding Chart

Inductor	uH	Turns	Inches needed
L8 [double]	10.0	33	38
L7	5.0	32	23
L6	2.5	22	17
L5	1.2	15	13
L4	.62	7 bottom	7
L3	.33	5 bottom	6
L2	.16	3 bottom	4.5
L1	.09	2 bottom	2.5

Figure 1 L1-4 Example

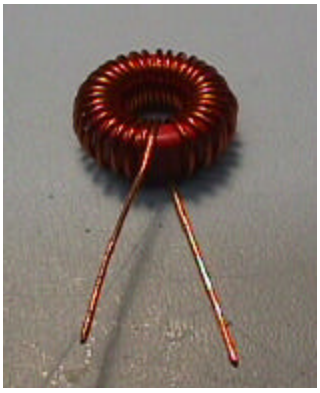


Figure 2 L5 - L8 Example

___ Using the winding chart on page 5, cut a 38 inch length of wire for L8. Hold about one inch in one hand with the toroid and wind the wire around the toroid as shown in figure 1 for 33 turns. You should space the wires evenly around the toroid as you wind them. Once you have completed winding L8, trim both ends to one half inch and scrape away the insulation from them. Do not install L8 until later.

___ In a similar manner, wind L7 through L5, using the winding chart for lengths and turns. Trim and scrape thermaleze coating from #18 wire. The thermaleze wire cannot be soldered unless the thermaleze coating is scraped off.

___ Wind L1 through L4 as shown in **figure 1**. Place all windings of the bottom of the toroid.

___ Wind T1 with 10 turns using the red and green #28 gauge wire. T1 is the small, black toroid just under one half inch in diameter. See figure 2 and wind this in bifiliar fashion by using two lengths of wire and winding them at the same time. It doesn't matter if you twist them or wind them side by side. Note: you must wind this in the direction shown in **figure 3**.

___ After scraping the insulation from the ends of all four wires, connect the green 2 wire to the red 1 wire and twist together. You will now have three leads: the red wire on the left, the twisted pair, and the green wire on the right. Do not install T1 yet.

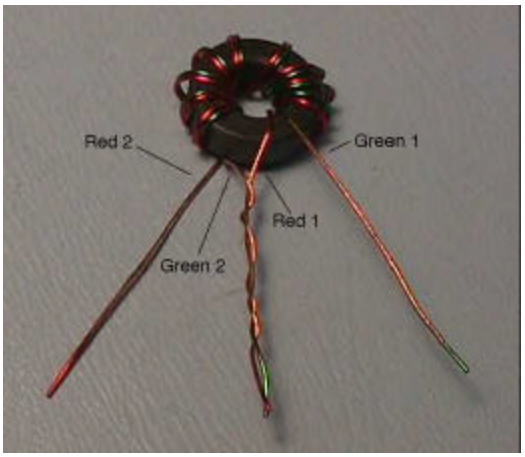


Fig 3. T1 winding example

You will now install (locate, place, and solder in place) the parts on the PC board. Use the silk--screen layout in the back of this manual to assist in locating where parts are to be installed. Parts are installed and soldered in order of height, from shortest to tallest.

___ Install all of the resistors, R1, 11-21. Be sure to check the values with the parts list. Most of the resistors are 1/8 watt and may be hard to read. Use an ohmmeter to verify the values if you have trouble identifying them.

R1, R17, R21 - 100 ohm – brown-black-brown
R18 - 150 ohm - brown-green-brown
R12-13, 15, 20 - 1K ohm – brown-black-red
R19 - 3.3K ohm - orange-orange-red
R11, 14 - 10K ohm – brown-black-orange
R16 - 1M ohm – brown-black-green

___ Install the 1N4148 diodes, D1, 2, 4-9. Note the band polarity.

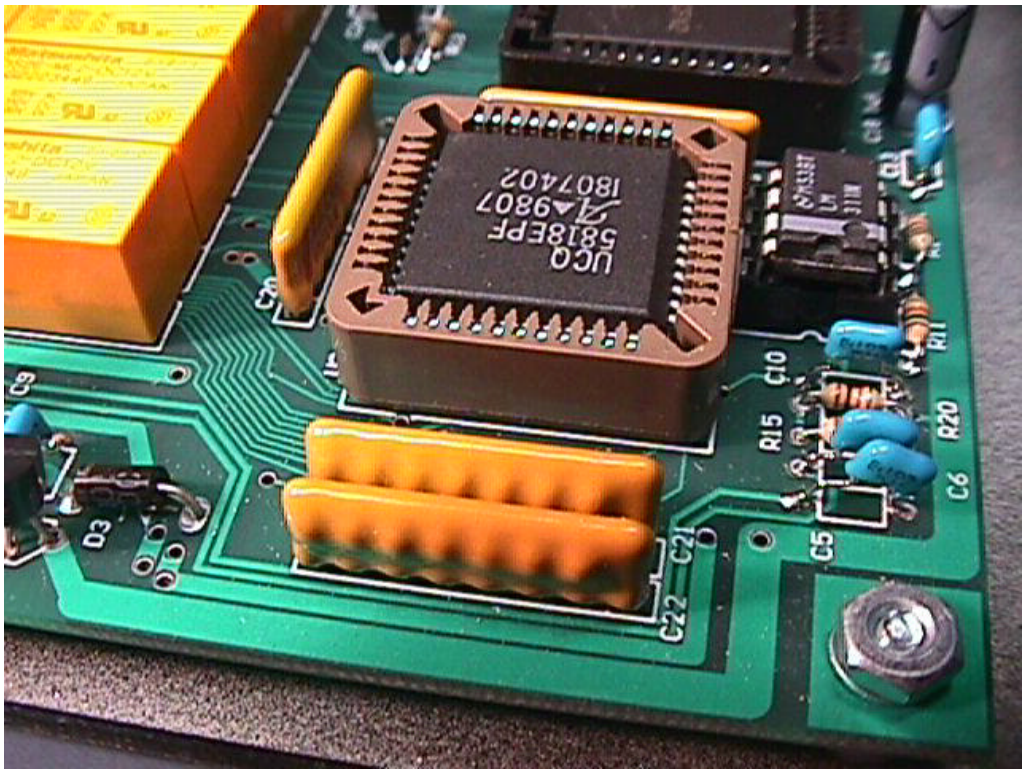
___ Install the larger 1N4001, D3. Note the band polarity.

___ Install the 10K 10 Pin SIP resistor, RSIP1. Be sure to note the orientation of the SIP resistor. A small line (or dot) on the side with writing marks pin 1.

___ Install T1. It lies flat against the PC board and the #18 wire from the SO-239 will pass through the center (you will install this later). You may wish to use a small amount of silicon RTV or hot glue to hold T1 in place, but wait until after the unit is tested before applying it in case there are problems.

___ Install the .01uf monolithic capacitors, C3-8, 10, 12-13, 23-24, 35.

___ Install the .01uf 50v 8 pin SIP Capacitors, C11, 17, 19-22. Pin one is marked on the PC board with a box, and marked on the SIP capacitor with a line.



___ Install the 78L05, U4. Note the orientation.

___ Install the 2N3904 transistor, Q1-2. Note the correct orientation.

___ Install the variable resistors, 100K pots, R22-23.

___ Install the trimmer capacitor C1. Note that C1 has two pins that are common (connected). They should line up with the two holes on the PC board that are connected together with a trace on the bottom.

___ Install the socket for U1, 52 Pin PLCC socket. Note the orientation of the socket. The flattened corner on the socket matches silk screen. Do not install U1 (the 68HC11) until later.

___ Install the socket for U2, 44 Pin PLCC socket. Note the orientation of the socket. The flattened corner on the socket matches silk screen. Do not install U2 (the UCNQ5818) until later.

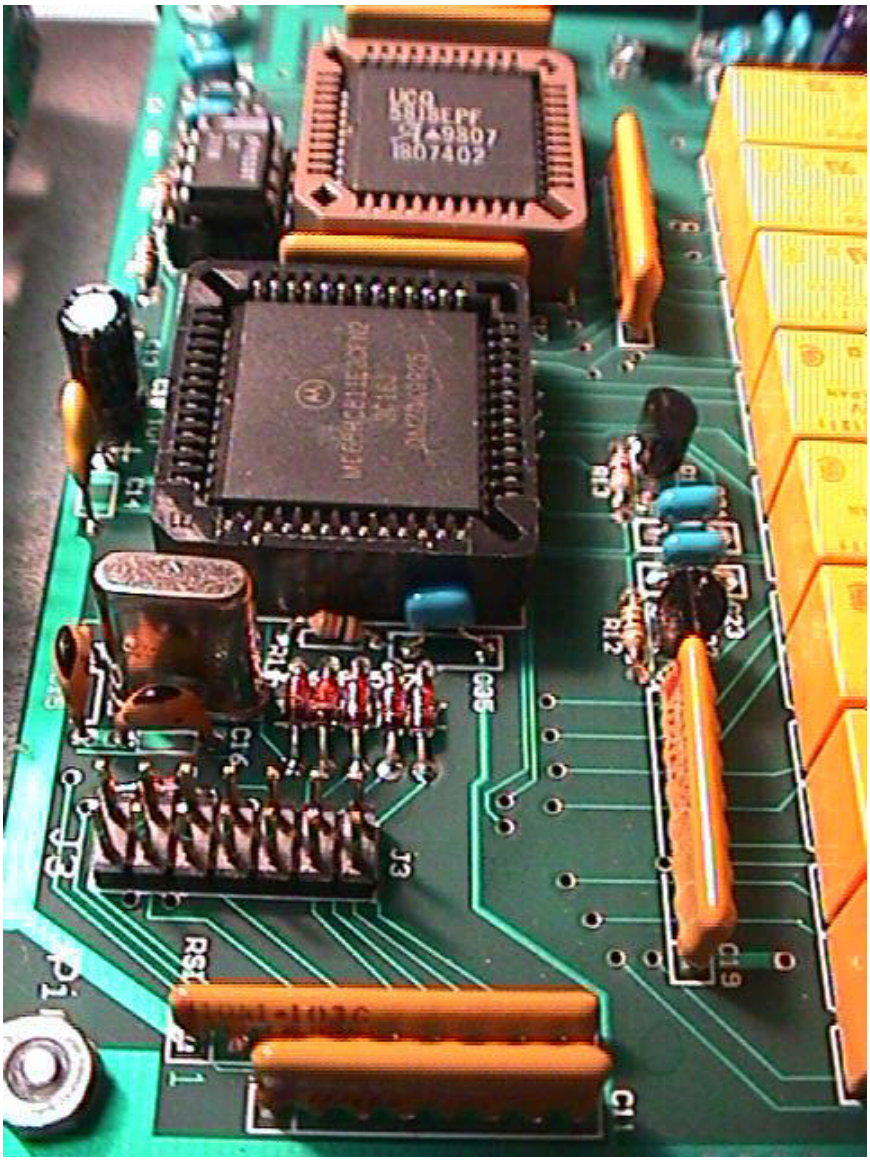
___ Install the socket for U3, 8 Pin DIP socket. Note the orientation of the socket. The notched edge on the socket matches silk screen. Do not install U3 (the LN311) until later.

___ Install the ceramic capacitors, C2 and 14 100pf 1KV, C15-16 & C25-27 10pf 500V, C28 39pf 500V, C29 82pf 500V, C30 150pf 1KV, C31 330pf 1KV, C32-34 680pf 1KV.

___ Install the relays K1-K17. Be careful not to bend the pins over pushing them in.

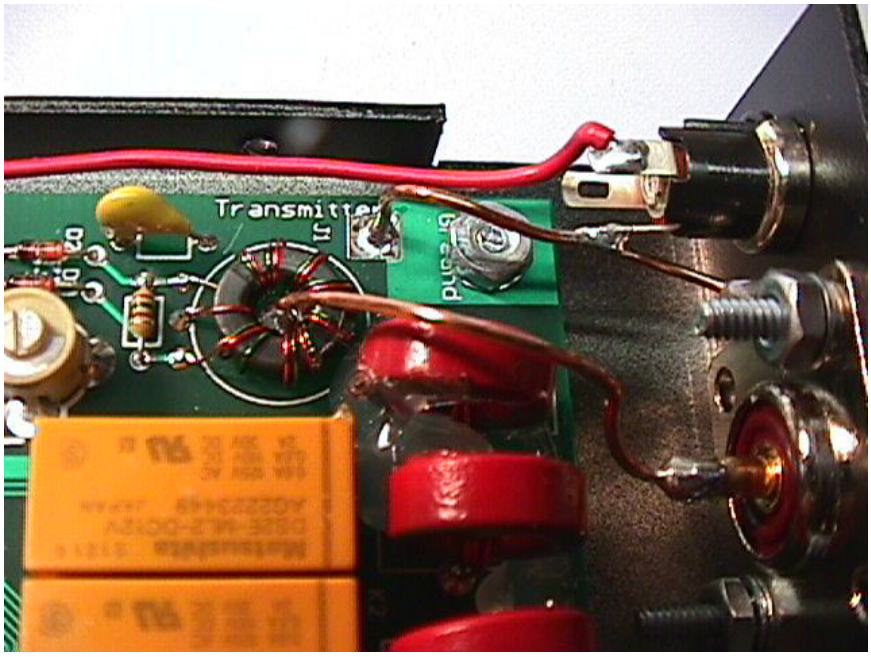
___ Install the 4.5 MHz crystal, X1.

___ Install the electrolytic capacitors, C9 10 uf radial and C18 1 uf radial. Note the polarity.



___ Install the 14 Pin header, J3. Solder the shorter ends of the pins to the PC board.

___ Install inductors L1-L8 on the PC board. Note that the mounting holes are offset slightly to help keep the inductors straight after installation. Make sure the insulation is scraped off the ends of the wires on each inductor. Push in each inductor until the windings touch the PC board. The #18 wire is stiff enough to support L5-L8, but RTV or hot melt glue may be needed for L1-L4 to hold them in place. In you plan to use the unit in a mobile application, you should use the RTV or hot melt glue on all inductors.



___ Install a two inch length of left over #24 wire left over from winding the inductors through the hole in T1. Be sure to scrape the thermaleze coating off of the ends of the wire before soldering. Solder this from beneath the circuit board. Attach one SO-239 to the other end of this wire. Cut another 1 ½ inch length of wire for the antenna connection. Solder one end to the PC board next to L8, and then attach one SO-239 to the other end.

___ Using left over pieces of #24 gauge wire, cut one piece 1 ¾ inches – for J1, and one 1 ¼ inches long – for J2. Crimp the terminal lugs onto one end of each of the wire, and attach the other ends to the PC board at J1 & J2. At this time go ahead and solder the terminal lug to the wires to insure a good ground. Be sure to scrape the insulation off the wires so they can be soldered.

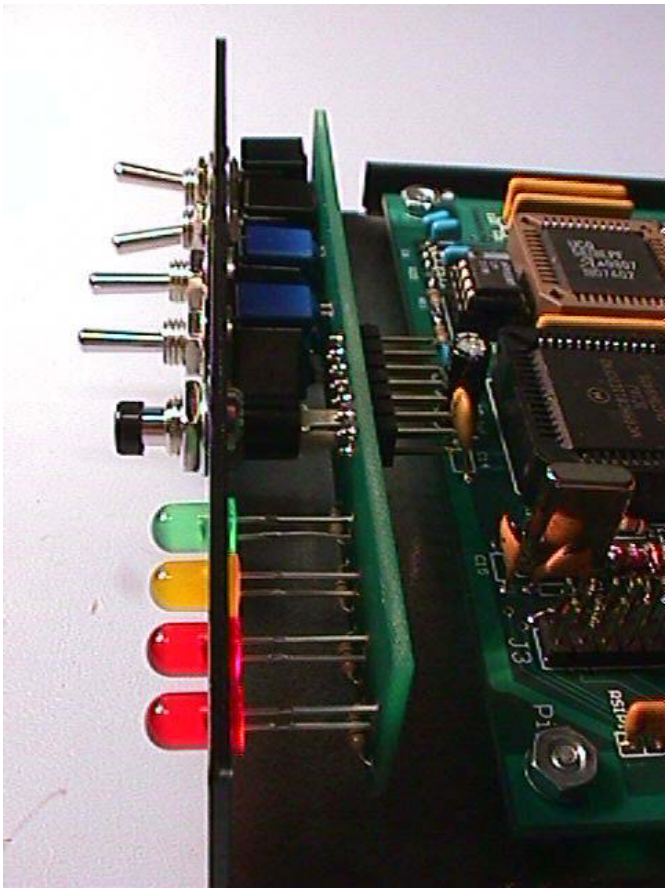
You are finished with the assembly of the main PC board. Proceed with the assembly of the front panel PC board.

___ Install the 14 pin header with 0.1 inch spacing to the side of the front panel PC board that has the white silk screen. Solder the shorter ends of the pins to the PC board.

___ Install the resistors on the opposite side of the PC board as the header (either side will actually work). R1 & 2 are 470 ohm 1/8 watt resistors (yellow-violet-violet). R3 & 4 are 100 ohm 1/8 watt resistors (brown-black-brown).

___ Unwrap the chassis of the enclosure (the one with the white silk screen writing on it) and put the 4 rubber feet on the bottom. Take care not to cover the wholes that are there. These are used when mounting the PC board in the chassis.

___ Install the 2 SPST toggle switches (S1 & S2) in the chassis in the power and the auto positions. Remove the nut and one washer from the switch. Place the switch in the hole with the 2 prongs toward the bottom. Then replace the lock washer and nut on the switch. You may need to re-align the switches later, so don't tighten yet.



___ Install the 2 SPDT momentary switches (S3 & S4) in the chassis in the CAP and the IND positions. Remove the nut and one washer from the switch. Place the switch in the hole. Then replace the lock washer and nut on the switch. You may need to re-align the switches later, so don't tighten yet.

___ Install the 1 push-button switch (S5) in the tune position. Remove the nut and washer from the switch. Place the switch in the hole and replace the washer and nut on the switch. Be sure the solder terminals of the switch are aligned one on top of the other. You may need to realign the switches later, so don't tighten yet.

___ Place the LEDs in the front panel board, LED1 Green, LED2 Yellow, LED3 & 4 Red. Be sure to place ground leg down. The ground leg of the LED is the one with the notched plastic next to it. Do not solder them at this time.

___ Install the Front Panel PC Board on the switches. The side without the white silk screen will be placed on the solder terminals of the switches. Gently push the PC board onto the switches. The LEDs should slide into the holes in the chassis. They should be in this order -- Tune Switch, Green, Yellow, Red and Red. Once you have checked the alignment, then solder the switches to

the PC board. Tighten nuts on switches at this time. Next, slide the LEDs into the chassis and solder the legs to the PC board. Then clip the legs of the LEDs.

___ Install the panel mount power jack. Place the jack so the middle pin is facing the S0-239 Holes. Pin 1 will be towards top and Pin 3 will be towards the bottom. You can also attach the ground wire from J1 to Pin 2 of the power jack. See picture on page 10.

You are now ready to mount the Z11 PC board in the chassis.

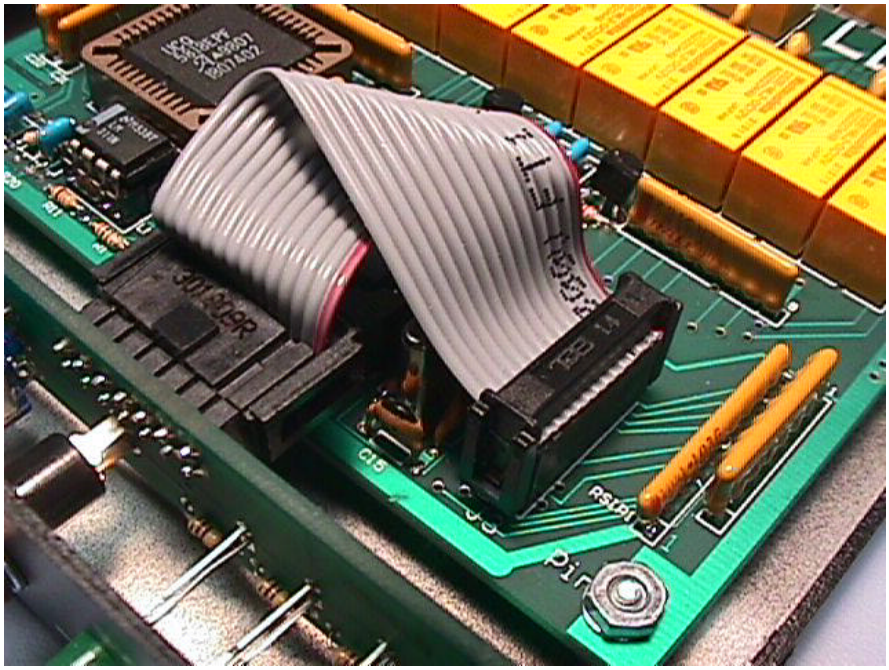
___ Install the Z11 PC board in the chassis using four screws, nylon spacers, washers and nuts. Do not drill out the holes in the PC board. Insert the four screws through the bottom of the chassis with the head on the outside next to the rubber feet you installed previously. Then place a nylon spacer on each screw. Set the PC board on top of the spacers with the toroids toward the back and the microprocessor sockets and header toward the front panel. Next place the lock washers and nuts on next. Tighten down gently, taking care not to damage PC board.

___ Install the SO-239s in the holes on the back panel of the chassis. Attach the terminal lugs to the top mounting screws of both the SO-239s.

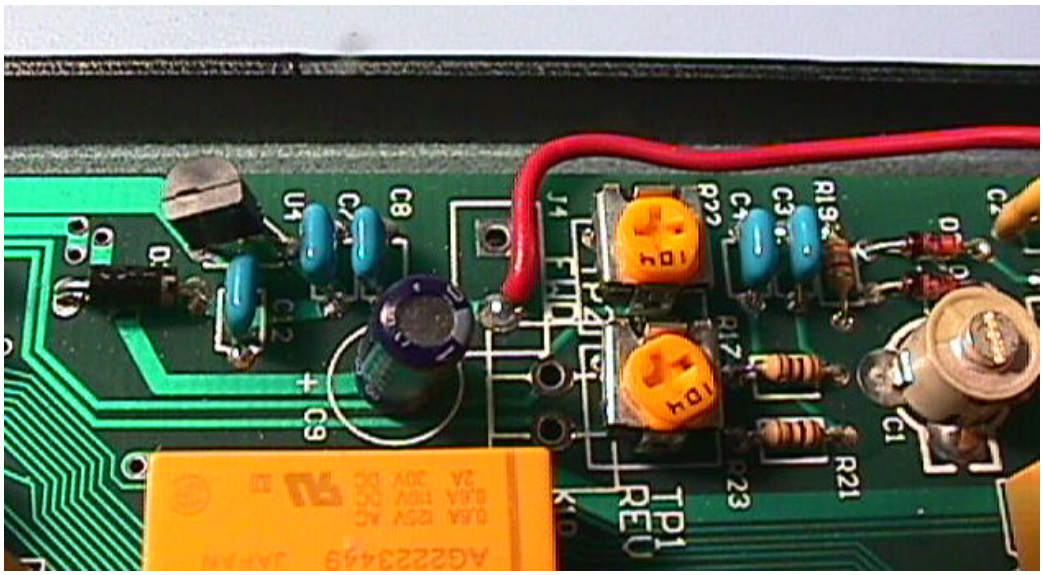
___ Install U1 (the 68HC11) by carefully pressing it into place in its socket. Note that U1 has a flattened corner that should match the socket.

___ Install U2 (the UNCQ5818) by carefully pressing it into place in its socket. Note that U2 has a notch that should match the socket.

___ Install the ribbon cable with the connecting pin 1 of J3 to pin 1 on the 2 x 7 header on the front panel.



___ Install a piece of insulated wire from J4 – Pin 2 – to Pin 1 of the panel mount power jack. (J4 Pin 1 is square…Pin 2 is round)



___ Apply 11 to 14 volts DC to the power input. The center pin is positive. Turn the unit on. The LEDs should all flash once simultaneously.

___ Check for +5.0 volts on the output of U2 (the 78L05). The output is the pin closest to the oscillator.

___ Current draw should be around 8 mA (anything from 5 to 10 mA is acceptable).

___ Set R23 (REV) and R22 (FWD) to the center position.

___ Connect the transmitter and antenna (or dummy load) to the proper ports. With a voltmeter on test point REV and about 5 watts applied and a dummy load or resonant antenna on the output, tune C1 for minimum DC voltage. The voltage should be just about 0.0 volts (0.1 is OK). You MUST use a 50 ohm load (either dummy or resonant antenna) to properly do the alignment.

___ Again with 5 watts and with your voltmeter now on test point FWD, adjust R22 for 2.5 volts (2.0 to 2.5 is OK). This is a fairly course adjustment, so you do not need to be exact.

___ Reverse the coax cables for the transmitter and antenna ports. With 5 watts and with your voltmeter on test point REF, adjust R23 for 2.5 volts (2.0 to 2.5 is OK). This is a fairly course adjustment, so you do not need to be exact.

If you cannot get 5 watts out of your transmitter, use 2 to 3 watts and adjust for 1.5 volts. Once calibrated, the tuner is now ready to be placed on the air.