HAMTRONICS® LPA 2-15R, LPA 3-15R, & LPA 6-25R REPEATER POWER AMPLIFIERS: ASSEMBLY, INSTALLATION, & MAINTENANCE

GENERAL INFORMATION.

The Power Amplifier is a class C device designed to be installed as an integral part of a transmitter enclosure in a repeater installation with a 2 Watt exciter module.

This PA comes in models for several vhf bands and power levels as follows:

LPA 2-15R	140-175 MHz	17-20W
LPA 3-15R	213-233 MHz	17-23W
LPA 6-25R	50-54 MHz	20-25W

The Power Amplifier operates on +13.6 Vdc at about 4 to 5 Amp, depending on output power level. It has a 50-ohm input and output impedance and is designed for continuous duty.

A low-pass filter reduces harmonic output to very low levels. The unit is FCC type accepted for commercial operation in the 150-175 MHz band.

CONSTRUCTION.

General.

Most of the pertinent construction details are given in the component location and schematic diagrams and parts list.

All parts are tack soldered to the pc board; so it is necessary to cut and form leads so that they seat properly on the board and be sure to keep leads as short and direct as possible. This is especially true of the disc capacitors. Figure 1 shows how to trim and form the leads of capacitors.

PCB, Transistor, and Heatsinking.

This series of power amplifiers is designed to be mounted in an rf tight enclosure with the exciter in such applications as our REP-200 Repeater. The unit is supplied less heatsink and mounting hardware, since the enclosure acts as a heatsink and the hardware normally is provided with the repeater kit.

If you have purchased the PA for some other use or mounting method, it is important to assemble and use the unit as we do in the repeater to avoid damage to the transistor by pulling the leads off the ceramic case. The pa is designed to have the thickness of a standard 4-40 nut (about 0.100 inch) as a spacer between the pc board and the chassis on which the transistor is mounted.

a. If you are supplying your own enclosure, mark and drill four clearance holes for mounting the board with 4-40 screws and one 8-32 clearance hole to mount the transistor in the center of the cutout in the board. The latter hole must be close to the diameter of the xstr stud to provide maximum surface for the shoulder of the transistor to contact the chassis for heatsinking; so do not make this hole oversize.

b. Install four 4-40 x 3/8 inch screws from the bottom of the enclosure and secure with 4-40 nuts.

c. Set pc board over screws, and align so cutout for transistor is centered over hole in enclosure. Secure the board with 4-40 nuts and lockwashers.

d. Carefully open the package of heatsink compound with scissors. Use a toothpick or small piece of wire to apply a small amount of compound to the shoulder of the transistor where it contacts the heatsink.

e. Set the transistor in place, and orient the notched collector lead to the right as shown. Secure transistor with #8 lockwasher and 8-32 nut. Do not overtighten nut; tighten only to the point of being snug. Hold transistor leads with fingers to prevent rotation. If leads still rotate, you are probably applying too much torque.

Note: Since heatsink compound is used, it is unnecessary to use a lot of torque, which could break the stud.

f. Form the transistor leads down against the board. Then, tack solder them to the foil, using sufficient solder so that a bond is formed under the full length of the leads. Note that other parts will be soldered on top of the base and collector leads; so it helps to thoroughly flood those leads with solder.

Installing Capacitors.

a. Solder variable mica capacitors C8 and C9 to the board in the exact positions shown in figure 2. Mount the capacitors oriented as shown so the rotor screw is connected to the proper side of the circuit (as shown in fig. 2).

b. Bend the leads of C2 and C3 gently at a 90° angle, and solder them as shown. Make sure the round end of C2 goes to ground.

c. Form the leads of C1 and C15 (if used) close to the body, as shown in figure 1, and tack solder on the board.

d. Tack solder C4-C5 and C6-C7 (if used) as shown, bending the leads at right angles, and keeping them as short as possible, as shown in figure 1. It is important to angle the capacitors as shown in figure 2 and position them as close as possible to the body of the transistor. The idea is to connect them electrically as close as possible to the emitter and base terminals or the emitter and collector terminals. In fact, they should be soldered on top of those leads.

e. Tack solder C13 and C14 as shown, bending the leads at right angles, and keeping them as short as possible. Position the capacitors as shown in figure 2.

f. Tack solder chip capacitors C10 and C11 as follows. Position the capacitors as shown in figure 2 or 5. They are installed between the B+ pad and ground. Use small tweezers to handle them. *Be careful not to drop them; they are difficult to find. Since they have no markings, be sure to leave them in the package until installled so you can tell the values apart.*

Apply a little solder to the B+ pads adjacent to where each capacitor will be positioned. Do not apply solder to the ground plane yet.

Pick up one capacitor at a time. Set the capacitor in place. Then, heat the solder on the pc board pad, and allow the solder to bond to the electrode on the capacitor. When the solder melts, the capacitor will seat down on the board in the molten solder. It is essential that this process be done relatively quickly so the solder doesn't oxidize and so there is still a little flux left where the capacitor electrode sits.

After one end of each capacitor is soldered and the positions have been checked, solder the ground plane end of each capacitor.

g. Tack solder electrolytic capacitor C12. Bend the leads at right angles, and observe polarity.

RF Choke, Ferrite Beads, and Resistors.

a. Ferrite choke Z2 is threaded with 2½ turns of #22 bus wire, as shown in the detail, by feeding the wire through opposite holes and pulling tight. One hole will not be used. Be sure to wind the wire around and around through the holes as shown. Do not thread the wire through in a zig-zag fashion. The choke is mounted flat against the pc board, and the leads are tack soldered to the board.

b. Install resistor R2 across Z2 as shown.

c. Cut the bus wire off the ferrite bead close to one end of the bead and discard the leads.

d. The following procedure installs a power lead of the proper length for our repeater. If you have a different installation, you can do something similar. Cut a 3 inch length of red hookup wire. Strip one end ¼ inch and the other end 5/8 inch. Tack solder the ¼inch end to the pc board power trace as shown. Be careful to apply fresh solder over the wire so you don't get a cold solder joint from simply reheating solder already on the trace. Slide the ferrite bead over the long end, and bend the wire at a slight angle to hold the bead in place until you solder the lead to the feedthrough capacitor in the repeater.

e. Twist together and tack solder one lead each of rf choke L2 and resistor R1. Trim the other lead of each part to about ¼ inch and form down to reach the board. Then, tack solder these leads to the board as shown, with the lead of L2 to the pad area for the base of the transistor and the lead of R1 to the ground plane.

f. For 220 MHz, install R3 and R4 with very short leads exactly as shown. Tack solder to traces and ground plane.

Coil Forming and Placement.

Figures 2 & 3 and 5 & 6 show exactly how coils are formed for the 144 and 220 MHz versions of the PA, respectively. If you have the 6 meter version, separate drawings are provided for that unit.

You need to form the coils exactly as specified, using #18 bus wire supplied. Tack solder them to the board in the positions shown.

Any rod of the proper diameter (such as the shank of a drill bit) can be used as a forming tool for coil winding. It is important that they not only be wound the proper inside diameter but that the leads be the proper length. Any extra lead length adds to the inductance and will affect performance. You don't need to be super precise, but do form them to resemble the detailed drawings as closely as you can.

Remember that the finished coils should fit on the pc traces as shown; so that will help you check that you formed the coils properly.

For 144 MHz, the coils are all either 1/8 or 1/4 inch inside diameter. Spacing between turns of the coils should be minimal, with turns separated just enough to prevent shorting together.

L1 is 1/8 inch i.d. and 1-1/4 turns. The feet are formed just so the bottom wire of the coil doesn't short to the ground plane. The feet should be only about 1/16 inch high. The other three coils are 1/4 inch i.d. L3 is 1-1/4 turns. L4 is 3-3/4 turns. L5 is 1-3/4 turns.

For 220 MHz, L1 and L3 actually are jumpers formed with legs so that the *top* of the jumpers are 1/8 inch above the board, as shown in figure 6. L4 is 1-3/4 turns on 1/4 inch i.d. L5 is 1-1/4 turns on 1/8 inch i.d. Spacing between turns of the coils should be minimal, with turns separated just enough to prevent shorting together. The feet are formed on L5 just so the bottom wire of the coil doesn't short to the ground plane. (Note that L1 and L3 are shown in figure 5 at a smaller scale than the rest of the coils.)

Inspection.

This completes assembly. Check to be sure all parts are installed according to parts list. Look for any short circuits or bad solder joints. RF power transistors are expensive to replace; so now is the time to find problems, before power is applied.

RF INPUT/OUTPUT CONNECTIONS.

The input and output connections are made with RG-174/u 50-ohm coax cable connected to the appropriate input and output pads and ground plane of the pc board.

The following lengths assume that PA will be installed in REP-200 Repeater. The input cable should be 5½ inches long and the output cable should be 3 inches long, measured before stripping the ends.

Connect cables by stripping and tack-soldering to board as illustrated. Note that stripped length of coax is inductive; so keep pigtail leads as short as possible.

Connect the shields by pretinning the shield and then tack soldering the end which contacts the board. Avoid melting polyethylene insulation on cable by pretinning board and cable and then tacking them together quickly.

POWER CONNECTIONS.

+13.6Vdc should be connected to the B+ pad at the top of the pc board. When installed in an REP-200 Repeater, a hookup wire should be attached to the B+ pad as shown, using a ferrite bead on the far end, which attaches to the feedthrough capacitor in the PA compartment. The ground return normally is connected to the pc board through the mounting hardware.

The cable should be #18 or larger wire to minimize voltage drop. A 6 Amp, quick acting fuse should be connected in the positive supply line for protection.

A well regulated power supply should be used. Current drain of the PA at full output is about 4 to 5 Amp, sometimes slightly higher (but no more than 6 Amp), depending on power level.

Note that the output capability of the PA drops rapidly as the voltage is reduced below 13.6Vdc; therefore, you should try to use a power source of sufficient voltage and minimize cable losses so that you have full B+ available at the PA.

CAUTIONS TO PROTECT TRANSISTORS.

Because it is so easy to damage rf power transistors in the field due to accidents and abuse, transistor manufacturers do not provide any warranty to cover replacements once a transistor is installed in the unit. They test them thoroughly at the factory because they are expensive parts. Therefore, they do not honor claims that "the transistor must have been bad from the factory". ☹ *For your protection, please be sure to observe the following precautions:*

1. Sometimes, transistors may be destroyed by parasitic oscillations occurring during tuning because of the extremes of capacitor settings, or due to accidental shorting of components. To protect against such damage as

much as possible, turn power supply voltage down to about 10 Volts when you first apply power until the unit is tuned. Then, turn up to full 13.6Vdc. Of course, final tuning should be done at full 13.6V.

2. Never exceed 13.6Vdc, as even a small over-voltage causes strain on transistors because of additional heat.

3. Be sure you have a low impedance connection to the power supply, i.e., short, heavy cable.

4. Do not attempt to operate PA until exciter has been properly aligned by itself, operating into a 50-ohm load.

ALIGNMENT.

Alignment is very simple. Connect the input to an exciter which has already been tuned into a 50-ohm dummy load. Connect the output to a 50-ohm load of sufficient power rating. Use an in-line power meter, or monitor output with a dc voltmeter connected to rf detector test point pad on pc board.

Preset variable capacitors as follows if this is the first time tuning from a kit; otherwise, they should be left where previously tuned. The large mica variable capacitors should be screwed down tight and then backed off about three turns. The small ceramic variable capacitors should be rotated 90° from where they are set from the factory.

Apply B+ and moderate rf drive. Alternately tune the four variable capacitors for maximum output. Continue increasing drive slightly and repeaking capacitors until maximum output is achieved and all interactions between capacitors are worked out.

Note: Do not retune exciter with PA connected. Once the exciter is tuned into a 50Ω load, it should never be tuned again. Tuning the input of the PA takes care of matching the PA to the exciter.

With 13.6Vdc power applied and 2W drive, the 144 MHz unit should put out about 17-20W or 25-30W, depending on model, the 220 MHz unit should put out about 17-23W, and the 50 MHz unit should put out about 20-25W. Current drain should be about 4-5 Amp.

To minimize stress on the transistor, avoid running the pa over these maximum levels. A good way to reduce the output power and the current drain is to tighten loading capacitor C9 slightly and repeaking tuning capacitor C8. It is usually possible to reduce both the power level and the current drain that way. Watch both meters while tuning to be sure that is what is happening.

You can tell if the transistor is overheating by watching the output power and current drain as the unit heats up. Neither should change much. If the output power sags by more than a few watts as the transistor heats up, there is insufficient heatsinking. Either the heatsink is too small or the thermal interface between the transistor and heatsink is deficient. There should be heatsink compound between the two surfaces and the nut on the transistor stud should be tight (but not strained to the breaking point).

OPERATION.

Operation is quite simple. B+ can be applied all the time if desired. Merely apply an rf signal to the PA when you want to transmit.

TROUBLESHOOTING.

Since the unit has only one simple amplifier stage, there isn't much which can go wrong. The circuitry is straightforward. The first things to suspect should there be no output are shorted coax cables or incorrect or shorted pc board component connections.

Should it be necessary to replace rf power transistor Q1, be sure to use an exact replacement. There are other transistors rated at similar output level, but they may have lower gain or different impedance characteristics.

To replace the transistor, carefully peel each lead away from the pc board while melting the solder. Then, remove the mounting hardware and gently push the old transistor out of the heatsink. Clean all the old solder off the pc board and remove the old heatsink compound. Add new heatsink compound, and install new transistor with collector lead in correct location. Carefully tighten nut on transistor without over-torquing. Then, flatten leads against the board, and sweat solder them to the board. Remember to resolder any components removed for access to the transistor leads.

☹ A word about relay coils. Any relay coil connected to the same B+ line as solid state equipment should have a reverse diode connected across it to absorb the inductive kickback which occurs when the coil is de-energized. Relay coils and similar inductors can cause transients up to several hundred volts. This is the most common problem related to damaged semiconductors. You should also be sure that your power supply does not have an inductive surge when you turn it on or off. If in doubt, borrow an oscilloscope and watch the B+ line when you turn the switch on and off.

PARTS LIST.

(See separate sheet for 6M version.)

Ref Desig	Description
C1	39 pf disc capacitor *[22 pf for 220 MHz band]*
C2	20 pf (pink) ceramic var.
C3	20 pf (pink) ceramic var. *[.001 disc cap for 220 MHz band, marked 102 or 1n]*
C4-C5	For LPA 2-15R: 47pf for C4, none for C5 *[For 220 MHz: 110 pf disc marked "111"]*
C6-C7	not used
C8-C9	mica variable marked "703"
C10	.001 uf chip capacitor
C11	.047 uf chip capacitor
C12	47 uf electrolytic cap
C13-C14	56 pf disc capacitor *[33 pf for 220 MHz band]*
C15	5pf disc capacitor *[not used on 220 MHz]*
L1, L3-L5	wind per text
L2	0.22 uh rf choke marked red-red-silver-red
Q1	2N6081 (Motorola) or BLY-88C (Philips) *[BLW-40 for 220 band]*
R1	3.3Ω, ¼W resistor
R2	10Ω, ¼W resistor
R3, R4	27Ω, ¼W resistor
Z1	Ferrite bead over B+ lead
Z2	2½ turn ferrite choke

Chip Capacitors taped here for kit:

1 ea .001 uF ------

1 ea .047 uF ------

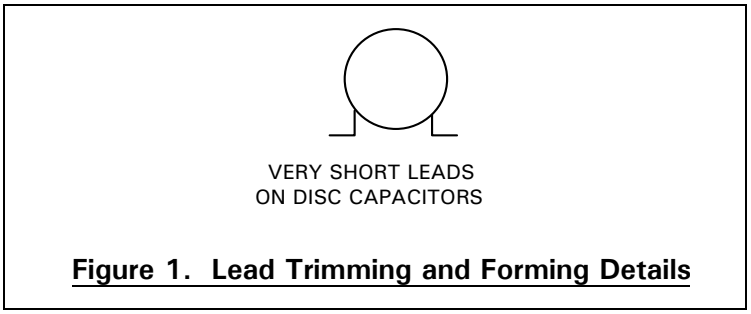

Figure 1. Lead Trimming and Forming Details

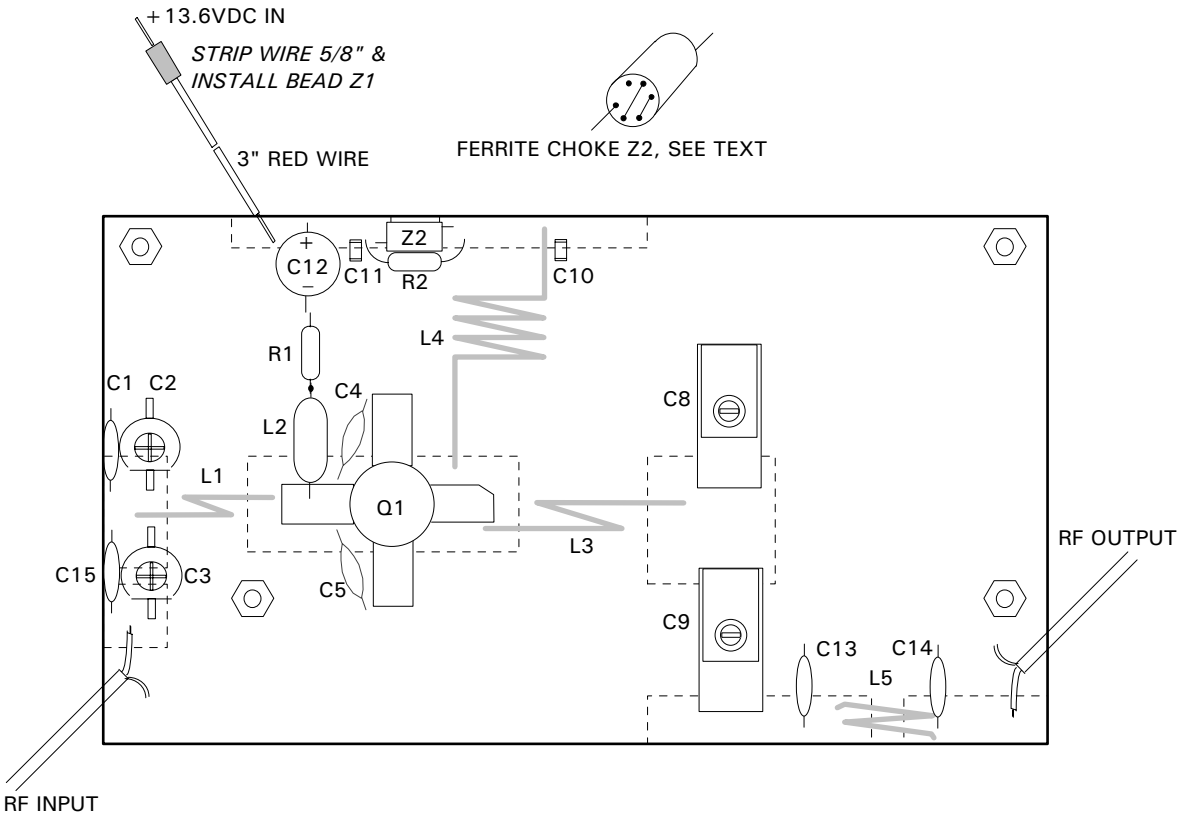

Figure 2. LPA 2-15R for 144 MHz, Component Location Diagram

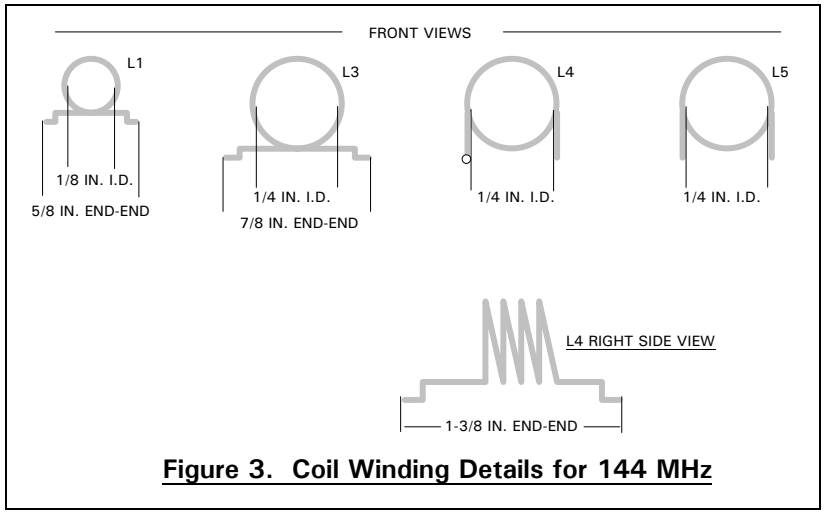

Figure 3. Coil Winding Details for 144 MHz

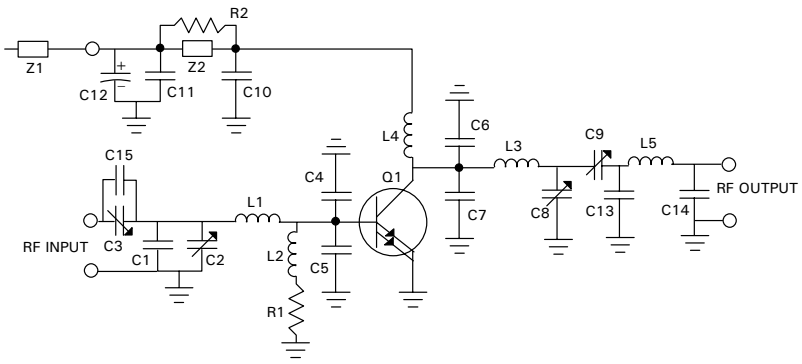

Figure 4. Schematic Diagram

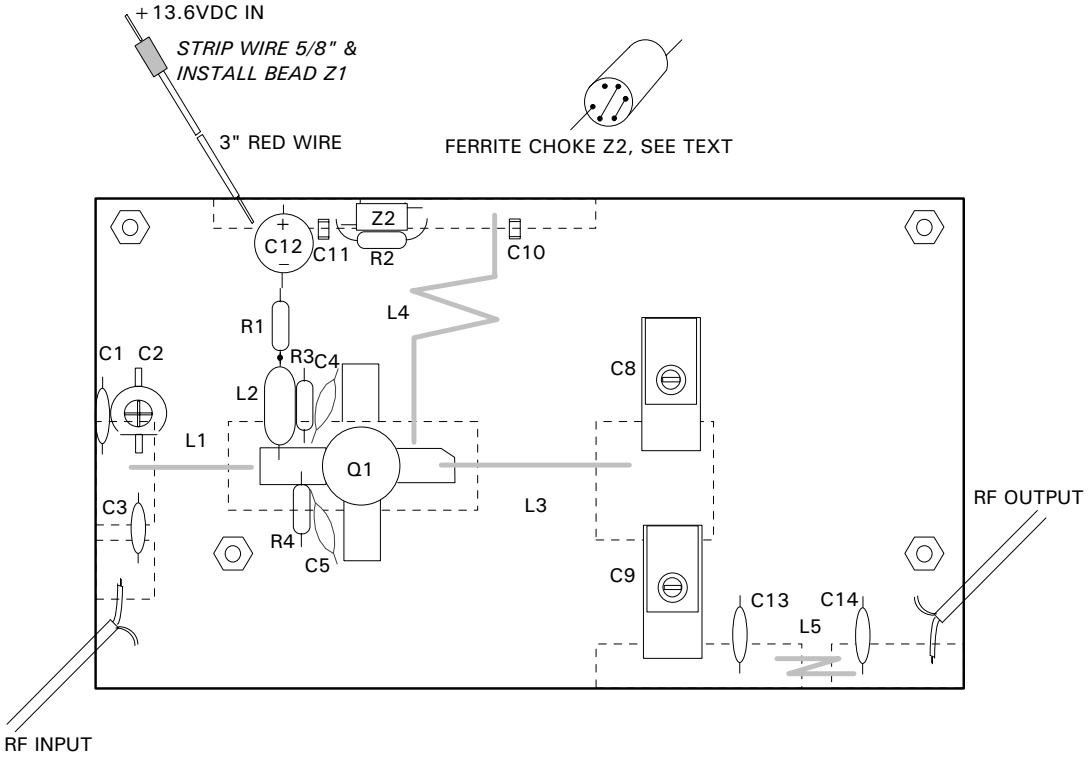

Figure 5. LPA 3-15R for 220 MHz, Component Location Diagram

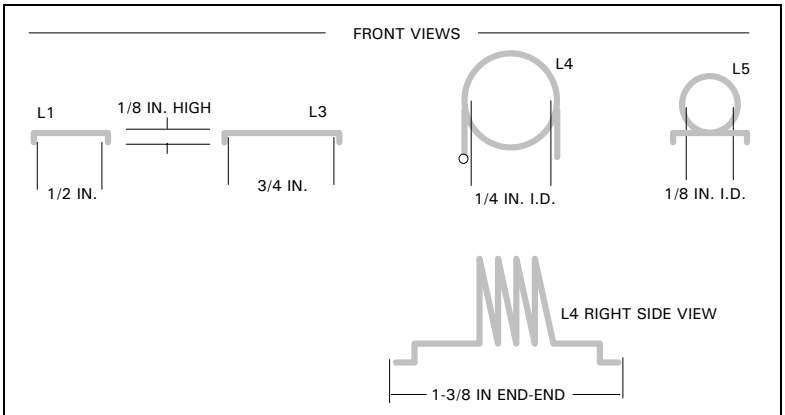

Figure 6. Coil Winding Details for 220 MHz

