HAMTRONICS® LPA 2-15 LINEAR POWER AMPLIFIER: CONSTRUCTION, ALIGNMENT, & OPERATION INSTRUCTIONS

GENERAL INFORMATION.

The LPA 2-15 is designed to amplify the 2W p.e.p. output of the XV-2 Transmitting Converter, an FM Exciter, or any other rf source to about 15W p.e.p., depending on band. Three models are available--for 6M, 2M, or 220 MHz ham bands. As you would expect, the output is somewhat higher on 6M and a little less on 220 MHz.

It is a linear amplifier; so it may be used on any mode of operation, including ssb, am, cw, and fm. It has a 50-ohm input and output impedance. The LPA 2-15 operates on +13.6 Vdc at about 2 Amp. It is designed for continuous duty.

CIRCUIT DESCRIPTION.

Amplifier transistor Q1 is one of the new generation, high gain, emitter ballasted type. It is normally operated well below its full output capability to remain in the linear range. Impedance matching is done with high Q, discrete coil-capacitor tuned circuits to aid signal purity.

The transistor is biased slightly above class B for linearity. Silicon diode CR1 is thermal-coupled to the heatsink to regulate bias according to temperature for a stable idle current over a wide range of operating temperatures. As the transistor warms up, it tends to conduct more, but CR1 reduces the bias, as warm up occurs, to counteract the drift in idle current. L3, C7, and C8 provide feedback to suppress low frequency oscillations, which can occur in vhf pa's due to extremely high low-frequency gain of the transistor.

The LPA 2-15 has a unique T/R switching arrangement, which may be used in several ways if needed. Thus, the unit can be used with separate exciters and receivers or with low-power transceivers as well as with just a simple transmitter.

An rf output detector is built into the LPA 2-15 to allow alignment and monitoring during operation without the need for a separate wattmeter.

CONSTRUCTION.

Most of the pertinent construction details are given on the component location and schematic diagrams. Following are details of coil winding and special parts mounting procedures. Note that 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.

a. Refer to component location diagram. Set heatsink flat on bench, and set #8 nuts over the four holes for screws used to mount board. (Note: In the 220 MHz model, #6 x 1/16 inch thick flat washers are used instead because the should of the transistor is shallower).

b. Carefully set the pc board over nuts. Secure board with four 6-32 thread cutting screws, being careful not to move nuts below board. Align pc board over transistor and diode holes before tightening screws.

c. 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.

d. Set the transistor in place, and orient the notched collector lead to the right as shown. Secure transistor with #8 lockwasher, solder lug, and 8-32 nut. Orient solder lug next to diode hole as shown in detail below component location diagram. 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. Excessive torque can break stud or leads.

e. 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.

f. Cut tabs of the variable mica capacitors as shown in the component location diagram, and solder them to the board in the exact positions shown. Doing so leaves adequate space for coil connections. Mount the capacitors oriented as shown so the rotor screw is connected to the proper side of the circuit.

g. Wind the coils exactly as specified in the component location diagram, and tack solder them to the board. It helps to prestrip the #24 magnet wire by application of heat from the iron and solder before mounting. Note that all pertinent details of coil winding are given in the diagram. Any rod of the proper diameter (such as the shank of a drill bit) can be used as a forming tool for coil winding.

h. Install CR1 through hole provided in the heatsink. Solder cathode (banded end) to solder lug on the fin side of heatsink. Use short, direct lead connection to provide thermal connection to ground lug as well as electrical connection. On the pc board side of the heatsink, bend the anode lead over to the pad provided, and tack solder to the board. Note that the body of the diode should be centered in the thickness of the heatsink for best thermal coupling. Be careful not to short anode lead to ground.

i. Tack solder all other parts to the pc board in the positions shown. Use short, direct lead dressing. Observe polarity of components, such as diodes and electrolytic capacitors. Note that leads may be tack soldered to the top side of power transistor leads if necessary. When the small variable capacitor is mounted, carefully bend leads at right angles at the base of the capacitor.

Before installing T/R switch circuit components, refer to the INPUT/OUTPUT section which follows.

NOTE: Disc capacitors may be marked with two significant figures and a multiplier much the same as resistors. Thus, for instance, a .01 uf capacitor may be marked "103", a .001 uf capacitor may be marked "102", and a 220 pf capacitor may be marked "221".

INPUT/OUTPUT CONNECTIONS.

The input and output connections are made with lengths of 50 ohm coax cable connected to the appropriate input and output pads and ground (shield) of the pc board. Connect cables by stripping as illustrated and tack-soldering to board. Keep leads short and neat.

Connect the shields by pretinning all around the shield and then tack soldering just the part of the shield which contacts the board. Avoid melting polyethelene insulation on cable by pretinning board and cable and then tacking them together quickly. If desired, light gauge wire can be wrapped around the shield before soldering to make a neater shield termination.

Connectors were deliberately avoided at the pa, since connectors must be used at the other ends of the cable at the Transmitting Converter or Exciter and the rear panel, and short connections to the pa board are desired. RG-174/u cable is convenient to use for short connections to the pa. (See catalog.)

There are many possible connection points which can be used in conjunction with the optional T/R switching circuit as follows. Connection pads are numbered left to

right on the board for reference. (See component location diagram.)

Pad 1 is used as the rf input connection whenever an Exciter or Transmitting Converter separate from a Receiver is used. E.g., using an XV2 Transmitting Converter as the driving source.

Pad 5 is used as the normal direct rf output to the antenna if the same antenna does not need to be switched to a receiver when you are not transmitting. In such a case, none of the T/R switching circuit along the front of the board should be installed.

Pad 4 is used (in place of pad 5) for the antenna connection when T/R switching is necessary. This connects CR3 and CR4 in series with the transmit signal to the antenna. When not transmitting, CR3 and CR4 do not conduct; so the pa is effectively disconnected from the antenna so it does not load down the receiver. When transmitting, CR3 and CR4 have sufficient voltage applied so they conduct, thereby connecting the transmit signal to the antenna. A small signal loss occurs, and the diodes therefore heat up somewhat when transmitting.

Pad 2 is used for the vhf receiver or converter connection when used on the same antenna as the pa. In such a case, the receive signal from the antenna at pad 4 is coupled through series tuned circuit L6/C9 to pad 2. At resonance, L6/C9 presents a low impedance to receive signals. But when transmitting, CR5 and CR6 conduct to shunt any rf to ground, with the impedance of L6 preventing a large amount of power from being coupled to the receiver. Whenever pad 2 is used, pad 4 must be used in place of pad 5 for the antenna connection.

One final case is possible, although it is not often used in linear service. If the LPA 2-15 is used in conjunction with a 1 to 2 Watt transceiver, the transceiver is connected to pad 2 instead of pad 1. Diodes CR7 and CR8 are added to provide isolation from the pa input during receive, and the rest of the T/R circuit is used to provide receive signal switching as is done with a separate receiver. When CR7 and CR8 are used, a small loss in driving power will occur; so the transceiver must provide about 2.5 Watts to drive the pa to full output.

POWER CONNECTIONS.

+13.6Vdc should be connected to the B+ pad at the top of the pc board. A ground return cable should be connected from the power supply to the ground plane of the pc board as shown in the component location diagram. The cable should be #18 or larger wire to minimize voltage drop. A 2 Amp, quick acting fuse should be connected in the positive supply line for protection.

A well regulated power supply should be used for any ssb equipment, including the PA. Current drain of the PA at full output is about 2 Amp. 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.

If the unit is used in a mobile application, or on anything other than a well regulated and protected power supply, a hash filter consisting of a choke and large electrolytic capacitor should be connected in series with the B+ line and a rectifier diode, such as a 1N4001, should be connected across the line with reverse polarity to shunt any reverse voltage transients which may occur on the B+ line. This is in addition to the fuse mentioned above. The rest of the transmitter may also be operated on the same filtered line output if desired.

In addition, both power lines should be run directly to the battery or power supply. Do not depend on other conductors for a good, low-impedance ground. the battery in a car acts as a huge filter capacitor for the electrical system, and it is the only place good, clean power can be obtained in a vehicle. If ignition switch operation is desired, use a relay to switch the power to the radio.

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 and they want to be sure you get good parts with your kit. 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. Transistors are made to operate in specific circuits. Do not try to check with ohmmeter, etc. Sometimes, you can blow a transistor when you reverse polarity.

2. Observe power and duty cycle ratings in the specifications published in our catalog. some units are not designed for continuous operation. Keep heatsink fins in free air, not closed in, and not upside down on solid surface blocking air circulation. When tuning on bench, allow for cooling periods to avoid overheating.

3. 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 9 or 10 Volts when you first apply power until the unit is tuned. Then, turn up to full 13.6Vdc. Of course, bias adjustments and final tuning should be done at full 13.6V.

4. Never exceed 13.6Vdc, as even a small over-voltage causes strain on transistors.

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

ALIGNMENT.

Alignment is very simple. Connect the input to a vhf transmitting converter or 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.

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

At this point, the current drain should not exceed about 2 Amp, and the exciter or transmitting converter should be within proper current limit (i.e., no more than 400-450 mA). Of course, during normal operation, you would not drive the PA to its limit such as this unless you were running fm or cw; you would stay in the linear region. However, for alignment, you want to tune for absolute maximum output to establish the proper load for the pa transistor for best linearity on ssb.

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

OPERATION.

Operation is quite simple. B+ can be applied either just during

transmit or all the time if desired. Merely apply a signal to the PA when you want to transmit. If the T/R switching circuit is used, the antenna automatically transfers to the receiver when the transmit signal ceases.

It is necessary to avoid overdriving the PA. Moderate overdrive will not damage the unit, but it will cause excessive intermodulation distortion of ssb signals. About 1 to 1-1/2 Watts of drive should be sufficient to obtain full output (about 15W on 2M, 20W on 6M, and 12-15W on 220 MHz). Do not drive the PA to the saturation point on ssb.

Of course, avoid drive levels in excess of 2 Watts entirely, as PA transistor damage may occur on severe overdrive (over 3-4 Watts).

The rf output meter detector circuit may be used during normal operation if desired as an operating aid. A solid-state dc voltmeter or even a sensitive panel microammeter may be used to monitor output. An ammeter in the B+ line is handy too as an operating aid.

Remember, though, that no meter movement can follow sideband peaks; so don't expect to watch the meter "talk" up to full output on ssb. During ssb voice operation, the meter will probably only indicate about 1/5 the level of a full carrier signal because the average power level is much lower, even though the voice peaks are reaching near saturation. Increasing drive to make the meter read "nice" only produces distortion if you drive the PA into flat-topping.

For cw or fm operation, where linear operation is not necessary, the bias to the PA stages can be disconnected and the cold side of L2 can be grounded. This will change the mode of operation from class B to class C for slightly more efficiency. However, it is not recommended that this be done if you will be changing modes. There is very little difference in operation, and it is not worth the inconvenience of switching.

TROUBLESHOOTING.

Since the unit has only one simple amplifier stage, there isn't much which can go wrong. It is helpful to know that the Q1 base voltage should be about +0.5 to +0.7 Vdc and that the regulated voltage at VR1 should be about +6.8 Vdc. The rest of the circuitry is straightforward, with shorted coax cables or incorrect or shorted pc board component connections being the first things to suspect should there be no output.

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.

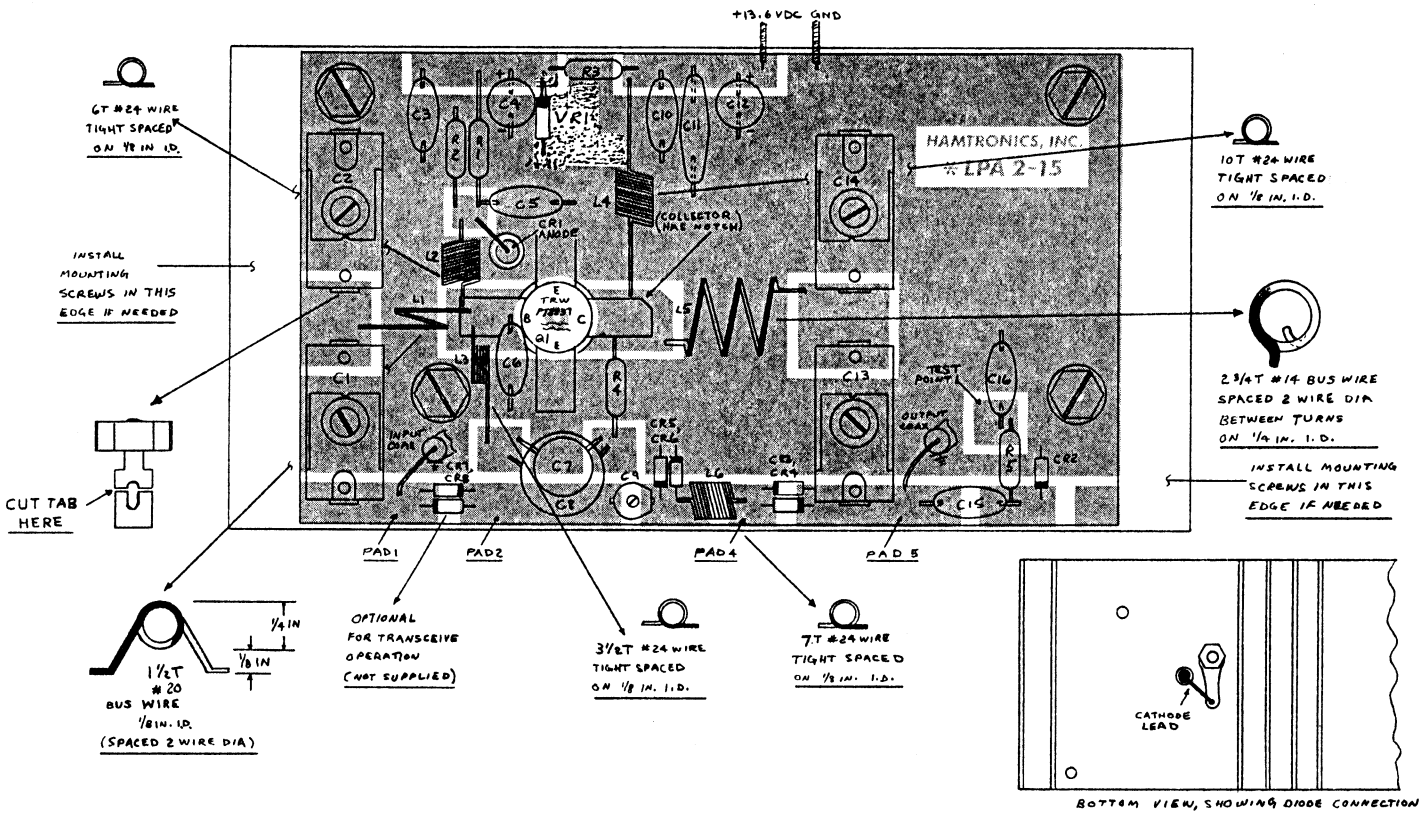
To replace the transistor, carefully peel each lead away from the pc board while melting the solder. Then, remove the mounting hardware and gently push the old transistor out of the heatsink. Clean all the old solder off the pc board. Add new heatsink compound, and install new transistor with collector 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.

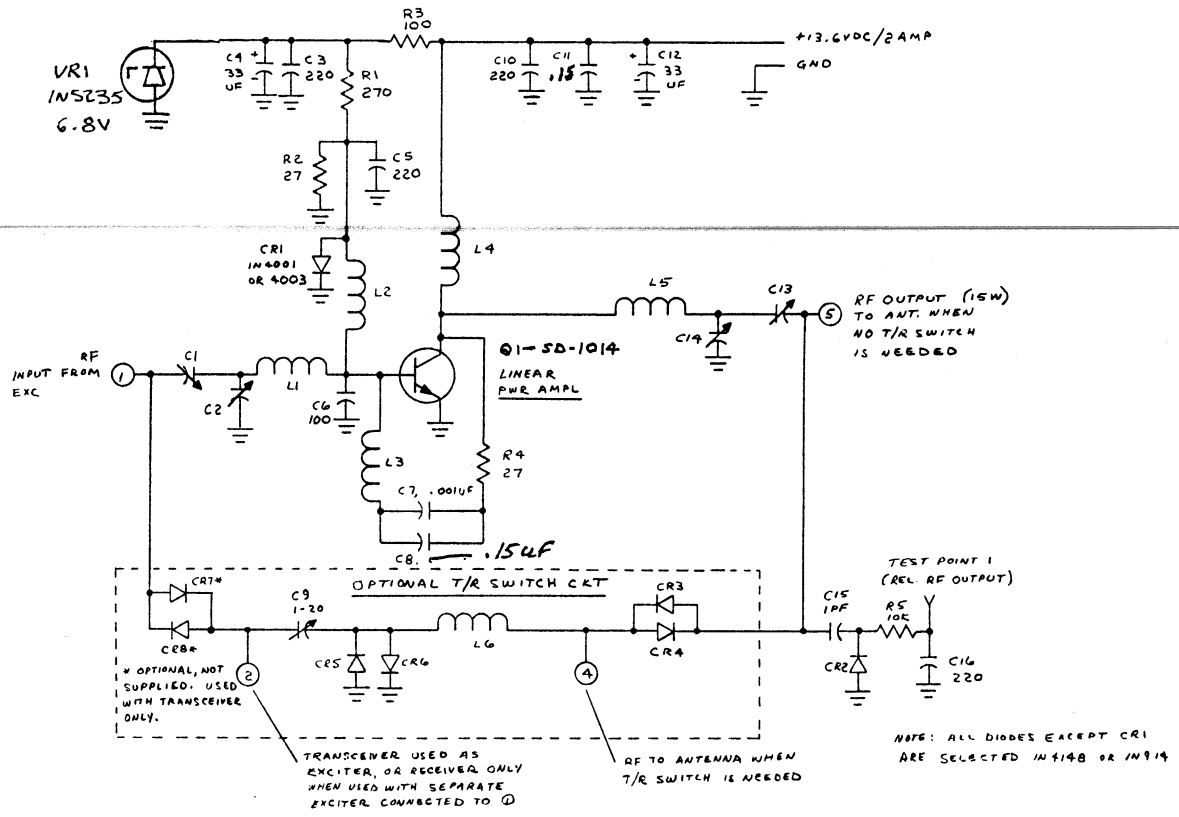
MOUNTING.

If desired, the PA can be mounted to a panel with screws in the left and right hand edges of the heatsink as indicated in the component location diagram. It can be mounted with standoffs to clear the components, or a cutout can be made in the rear panel to clear the pc board and the heatsink can then be mounted flush to the panel. Standard 6-32 or #6 self-threading screws can be threaded into the aluminum heatsink if 1/8-inch pilot holes are drilled, or screws can be used with nuts if you are careful to clear the fins.

However the unit is mounted, the fins should be in free air to allow for good convection cooling and keep the heat away from the oscillator on the Exciter or Transmitting Converter board. Do not mount the PA with the fins inside a cabinet.

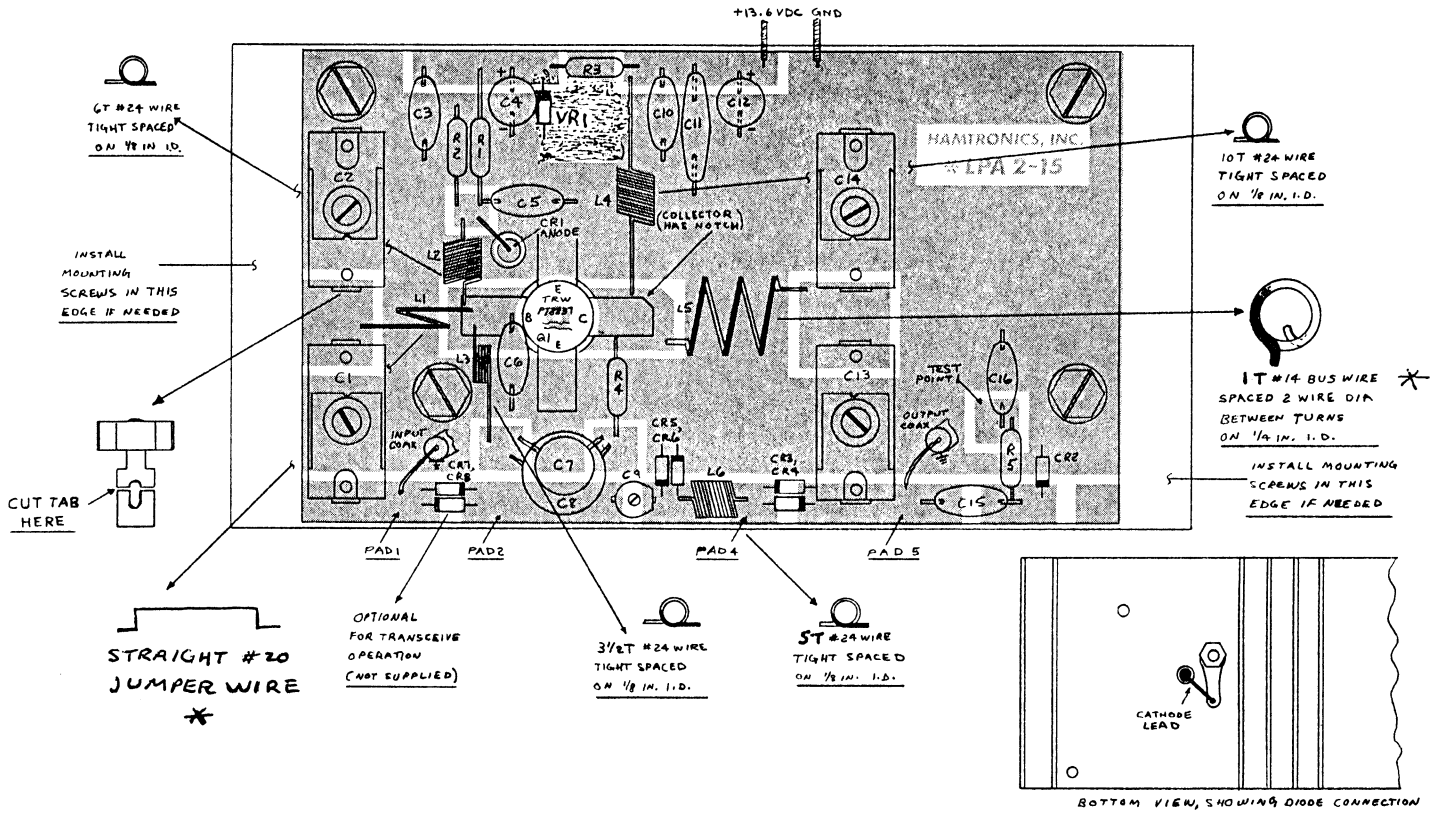


LPA 2-15 PA, COMPONENT LOCATION DIAGRAM

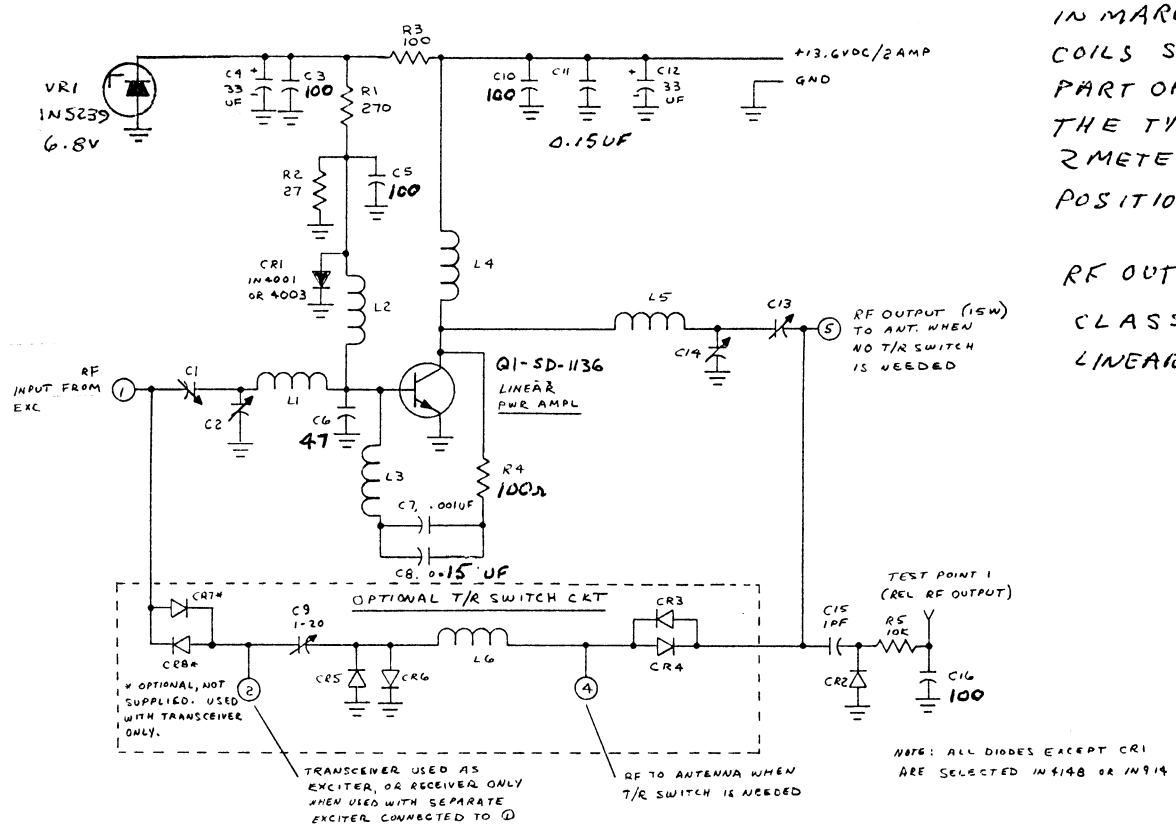


LPA 2-15 POWER AMPLIFIER, SCHEMATIC DIAGRAM

144 MHZ



LPA 2-15 PA, COMPONENT LOCATION DIAGRAM



* NOTE COILS L1 & L5 SHOULD BE AS SHOWN IN MARGINAL NOTES. COILS SHOWN ON MAIN PART OF BOARD ARE THE TYPE USED FOR 2 METERS. THEY SHOW POSITION ONLY.

RF OUTPUT ON 220 MHz

CLASS C = 15-18W

LINEAR = 12-15W

LPA 2-15 POWER AMPLIFIER, SCHEMATIC DIAGRAM - 220 MHZ