HAMTRONICS® LPA 2-40 220 MHZ LINEAR POWER AMPLIFIER: CONSTRUCTION, OPERATION, AND MAINTENANCE

GENERAL DESCRIPTION.

The LPA 2-40 is designed to amplify the 2W pep output of the XV2 Transmitting Converter or the TA51 Exciter or any other 2W 220 MHz rf source to 30W p.e.p. on ssb (linear mode) or 40W on fm or cw (class-C mode). 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 2-40 operates on +13.6Vdc at 8-10 Amp. It may be tuned to any frequency in the 220-230 MHz range, and has a passband of 5 MHz.

CIRCUIT DESCRIPTION.

Refer to the schematic diagram. Amplifier transistors Q1 and Q2 are of the new high gain, emitter ballasted type. They are both normally operated well below their 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. A low-pass filter is used in the output circuit for harmonic suppression.

The transistors are biased slightly above class B for linearity. However, when the unit is to be used only for fm or cw, slightly greater efficiency and power output is obtained by dc grounding the transistor bases for class-C operation. Both bias circuits (Q1 & Q2) use silicon diodes which are thermally coupled to the heatsink to regulate bias according to temperature for a stable idle current over a wide range of operating temperatures. As the transistors warm up, they tend to conduct more, but CR1 and CR2 reduce the bias, as warm up occurs, to counteract the drift in idle current.

Feedback networks C4/R4 and C18/R8 are employed to spoil the excessive low frequency gain of the transistors to prevent oscillations at low frequencies.

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. Use the shortest possible leads on all bypass capacitors. Be sure to observe polarity on diodes and electrolytic capacitors.

The markings on disc capacitors may be confusing; so some explanation may be helpful. Some larger values may be marked in pf with two significant figures and a multiplier much as resistors are marked. For example, 101 = 100pf and 103 = .01uf (10,000 pf).

a. Refer to component location diagram. Set heatsink flat on bench, and set 1/16 inch thick washers over the six holes for screws used to mount board.

b. Carefully set the pc board over the washers, positioning as shown. Secure board with six 6-32 thread cutting screws, being careful not to move the washers below the 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 stud mount transistor where it contacts the heatsink.

d. Set the stud mount transistor in location Q1, 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. 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. Apply heatsink compound to flange type transistor and set in position Q2. Note that the collector lead is narrower than the base lead. The collector lead should be facing the right hand side. Secure transistor with two 4-40 screws. On the lower screw, install #4 lockwasher and 4-40 nut. On the upper screw, install solder lug and 4-40 nut. Orient solder lug next to diode hole.

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.

g. Install the 40pf and 250pf metal clad mica capacitors in the exact positions shown. The flat side with the part number should face up. The tab contact on each capacitor should be bent down to contact the pc board foil and the tab should be soldered while maintaining correct positioning. With the capacitor firmly held in place by the tab, the case can then be soldered along each side to the ground plane foil with generous amounts of solder. (Exception: C21 tab should be bent upward to form a solder terminal for the junction of Z5 and Z6.) Note that some pc board pads are not used.

h. Solder the tabs of the variable mica capacitors to the board in the exact positions shown. Doing so leaves adequate space for coil connections.

i. Form coils L1, L2, L3, and L4 from #14 (heavy) bus wire exactly as specified in the component location diagram, and tack solder them to the board. Note that all pertinent details of coil winding are given in the details above the schematic diagram.

j. Install the two silicon diodes as shown in the diagram, observing polarity. In each case, position the body of the diode directly resting on the case of the transistor. Place a small amount of heatsink compound between the transistor case and the diode body. Form the cathode lead down to the ground plane foil next to the transistor, and tack solder in place. Reseat the diode in its proper position, and tack solder the anode lead to the insulated bus pad on the pc board.

k. Ferrite chokes Z2, Z4, Z5, and Z6 are wound (threaded) with 2-1/2 turns of #22 bus wire (fine) as shown in the detail diagram, by feeding the wire through adjacent holes and pulling tight. One hole will not be used. Ferrite chokes are mounted flat against the pc board, and their leads are tack soldered to the board.

l. The network formed by Z3/R5 is made by threading 2 turns of #22 (fine) wire through a ferrite choke (4 holes used). Then, one lead of the resistor is passed through a remaining hole and tack soldered to the bus wire to form a junction as shown in the detail. (3.3 ohm resistor is coded org/org/gold.) Be careful that no part of the winding of the choke touches other metal parts.

m. Feedback networks C4/R4 and C18/R8 are tack soldered between the base and collector leads of the transistors, using short leads. The free leads are brought together over the transistor and diode to form a junction and tack soldered together in mid air.

n. Tack solder all other parts to the

pc board in the positions shown, except do not install bias resistors R3 and R7 until directed to do so later in the text. Ground leads are tack soldered to the ground plane. Use short, direct lead dressing, and install parts as close as possible to positions shown so you have enough room for all of them.

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.

o. Check to make sure all parts are installed except bias resistors R3 and R7. Several 1/4W and 1/2W resistors will be left for this purpose.

p. Check all connections against diagrams, check all solder connections, and check polarity of diodes and electrolytic capacitors.

CONNECTIONS FOR CLASS-C OPERATION.

If the unit is to be used exclusively on fm or cw, you may wish to change the bias circuit for class-C operation for slightly higher efficiency and output power and for zero idling current. To do that, the cold end of R1 and Z3 should be connected to ground instead of the bias source, and resistors R3 and R7 should not be installed. R5 is not used. If the unit has not been built up, and if you never intend to use linear operation, the other bias circuit components need not even be installed. If you intend to use ssb or other modes requiring linear operation at times, it is best to build the unit up as a linear amplifier as designed and not worry about changing back and forth between linear and class-C. There really isn't much advantage to try to switch modes on the PA.

BIAS RESISTOR CONNECTIONS.

For linear operation, values must be chosen and installed for R3 and R7 to provide the proper bias for the two stages. Each resistor actually is a parallel combination of several resistors to arrive at the correct amount of bias to just begin to turn on the transistor (biased slightly beyond class-B). To install the resistors, proceed as follows.

a. Temporarily unsolder Z2 from the B+ bus on the pc board and reconnect through milliameter (50-100 mA range). Apply 13.6 Vdc and ground from power supply to points on right side of pc board indicated in component location diagram. (As a check, there should be no current drawn from the power supply yet.)

b. Tack solder a 330 ohm, 1/2W resistor in one position indicated for R3. (Temporarily turn off power supply each time a part is soldered in.) Check Q1 collector current on meter. The desired collector current is 20-40 mA. If you have obtained this level of current with the first resistor, stop at this point. If the current is too high, a higher value resistor should be used instead. If the current is too low, which is likely to be the case, add another resistor and check again. First try a 330 ohm, 1/2W resistor. If still not enough, add a 1.2K, 1/4W resistor or a 680 ohm, 1/4W resistor or both until the proper idling current is obtained. Note that as base voltage increases beyond the voltage required to turn on the transistor, the collector current will rise rapidly. At low voltages, though, no collector current will be drawn.

c. When the proper resistor values have been determined, dress the leads neatly, and solder the resistors in permanently. Double check the idling current, and then remove the meter and resolder Z2 to the pc board B+ bus.

d. In similar fashion, lift the lead of Z5 from the B+ bus and connect milliameter in series. Try various combinations of resistors for R7 as done before, using one or two 330 ohm, 1/2W resistors first. Apply B+ and look for 50-100 mA idling current for the collector of Q2. As done before, add or subtract resistors to arrive at the desired idle current. Then, disconnect meter and solder everything together neatly.

e. Connect milliameter in series with B+ line to pc board bus to check overall idling current of the two stages and the bias circuits. This value should be approximately 200-400 mA.

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 as shown on the component location diagram. Connect cables by stripping as illustrated and tack-soldering to board. Keep leads short and neat. Connect the shield 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 Exciter and 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.)

The unit does not have provisions for t/r switching of the antenna. If one antenna is to be used with the pa and a receiver, some form of coax relay must be provided between the pa and the antenna.

Note: The input circuit of the LPA 2-40 is such that bias voltage will be present at the input coax cable. Check to be sure the output circuit of the Exciter is dc blocked by a capacitor so the bias voltage is not shorted to ground.

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 #16 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 for any ssb equipment, including the PA. Current drain of the PA at full output is about 6 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 220 MHz 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. Apply moderate drive and B+. Alternately tune the various pairs of mica trimmer capacitors for maximum output. Continue increasing drive slightly and repeaking capacitors until maximum output is achieved.

At this point, the current drain should not exceed about 6 Amp, and the exciter or transmitting converter should be within proper current limit (i.e., no more than 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 transistors 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.

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 30W p.e.p. output. Do not drive the PA to the saturation point on ssb. For cw or fm operation, up to 2 Watts of drive can be used for 40W output. Of course, avoid drive levels in excess of 2 Watts entirely, as PA transistor damage may occur on severe overdrive (over 2-1/2 to 3 Watts).

TROUBLESHOOTING.

Since the unit has only two simple amplifier stages, there isn't much which can go wrong. It is helpful to know that the Q1 and Q2 base voltages should be about +0.5 to +0.7 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.

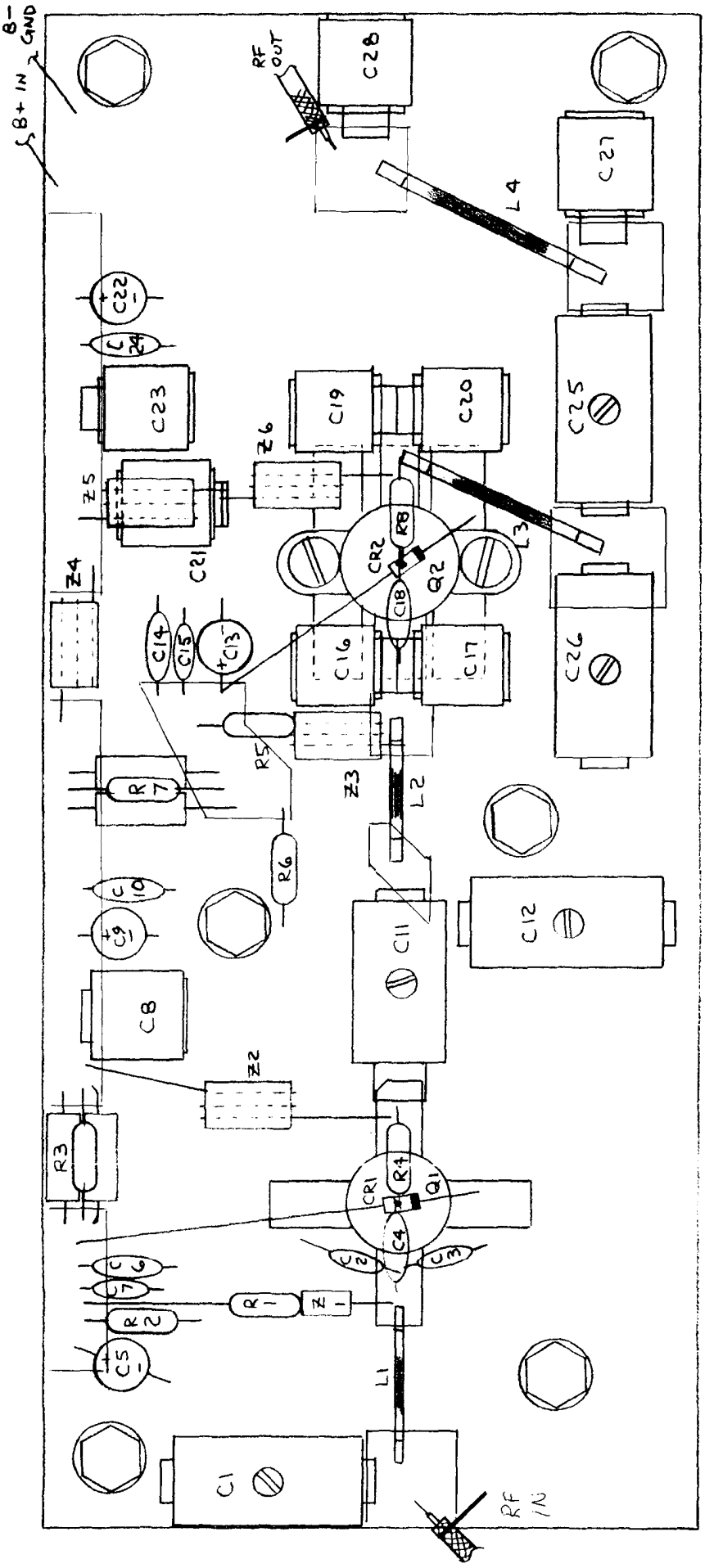
Should it be necessary to replace rf power transistor Q1 or Q2, be sure to use an exact replacement. There are other transistors rated at similar output levels, but they may have lower gain or different impedance characteristics.

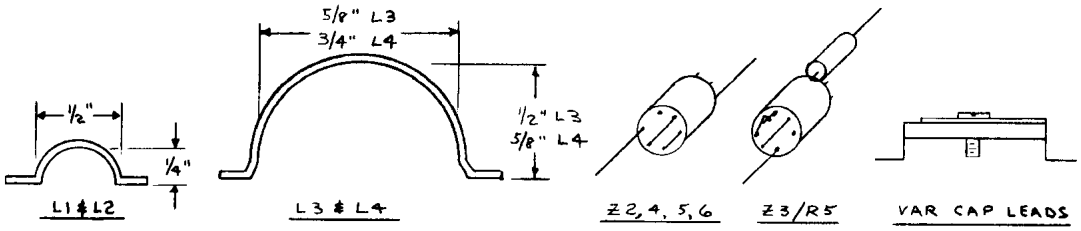
To replace a transistor, carefully peel each lead away from the pc board while melting the solder. Then, remove the mounting hardware and gently push the old transistor out of the heatsink. Clean all the old solder off the pc board. Add new heatsink compound, and install new transistor with collector lead in correct location. Carefully tighten nut on Q1 transistor without over-torquing or tighten the screws on Q2. 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.

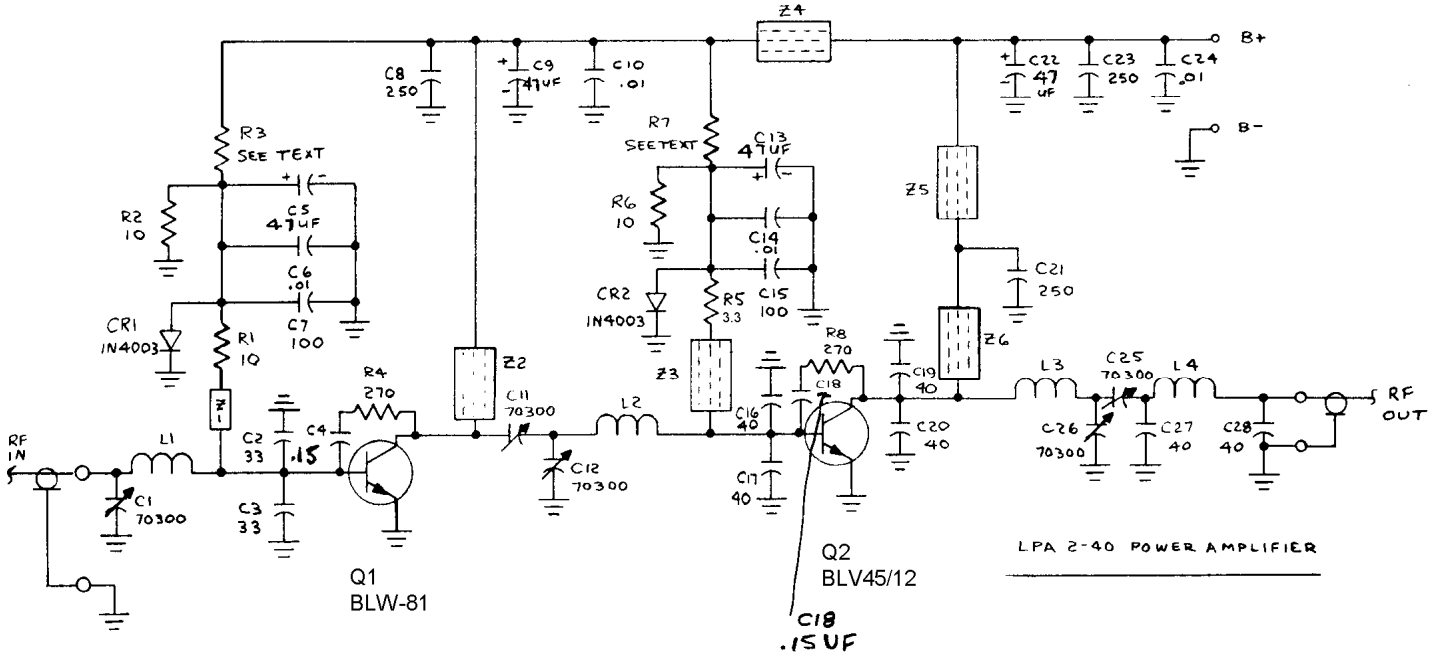
A word about relay coils. Any relay coil connected to the same B+ line as solid state equipment should have a reverse diode connected across it to absorb the inductive kickback which occurs when the coil is de-energized. Relay coils and similar inductors can cause transients up to several hundred volts. 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.







 Revised: 5/3/04