HAMTRONICS® LPA 4-35 UHF LINEAR POWER AMPLIFIER CONSTRUCTION, ALIGNMENT, & OPERATION INSTRUCTIONS

GENERAL INFORMATION.

The LPA 4-35 is designed to be used either as a linear amplifier with a transmitting converter or as a class C amplifier with an fm exciter in the 420-450 MHz band. It is a new version of the popular LPA 4-30 Amplifier.

As a linear amplifier, it will take a 1-1/2 Watt p.e.p. output from a transmitting converter, such as the XV4, and provide 30-35W output. In class-C operation, it will amplify the 2W output from an exciter, such as the TA451, to provide 35-40W output. It is designed to match a 50Ω input and output impedance, and it is rated for continuous duty.

In linear mode, the LPA 4-35 may be used for any mode of operation, including ssb, am, cw, atv, and fm. For exclusive use on modes such as fm and cw, where linearity is not required, the bias circuits can be modified for class-C (actually between class-B and class-C) for more efficiency and it can be driven to slightly higher output.

The unit operates on 13.6 Vdc at 8-10 Amp peak. It was designed for the 420-450 MHz ham band, but it may also be tuned to other nearby frequencies with reduced efficiency. It has a 10 MHz bandwidth without retuning; so it is ideal for TV transmissions.

CIRCUIT DESCRIPTION.

Refer to the schematic diagram. Amplifier transistors Q2 and Q3 are the new generation, high gain, emitter ballasted rf power transistors. They are operated well below their full capability to remain in the linear range. Impedance matching is done with high efficiency printed transmission lines (strip lines).

Note that what used to be a pre-driver stage on the pc board is no longer needed with the premium high gain transistors available now. Therefore, only two stages are used, providing better stability and linearity as well as reduced complexity and cost.

The transistors are normally biased slightly above class-B for linearity. However, when the unit is to be used only for fm or cw, greater efficiency and power output is obtained by running the driver stage just on the edge of conduction in class-B and the output stage in class-C (no bias).

Silicon diodes CR2 and CR3 are thermally coupled to the transistor cases to regulate the base bias according to the transistor temperature for a stable idle current over a wide temperature range to prevent thermal runaway. As the transistors warm up, they tend to conduct more; but the diodes reduce the bias accordingly to counteract the drift in idle current.

CONSTRUCTION.

Most of the pertinent construction details are given on the component location and schematic diagrams and in the parts list. Following are details of special procedures and techniques and a general construction sequence to be used. 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. Lay the pc board on a box or hold in a vise horizontally with the etched side of the board up. Using a sharp pick or any other convenient tool, pick up eyelets and place in the small holes. The heads of the eyelets must rest flat against the foil on the etched side of the board. then, using a small amount of solder, solder the heads of the eyelets to the foil. The eyelets connect the pc board front and rear foils together at critical locations. Be sure to solder all around the heads of the eyelets to provide low impedance.

b. Turn the pc board over, and solder the other side of the eyelets to the ground plane. Be sure all are soldered, and check to make sure none have slipped back through the other side. If so, heat eyelet flange on top side of board until solder on both sides melts, and push eyelet gently back in place. Note that it is especially important that the 8 eyelets under the emitter leads of Q3 (see diagram) are properly seated and that no solder blobs protrude above eyelet heads. This is to prevent stress on the transistor leads when it is installed later.

c. Locate the thin brass strip stock. Use scissors to cut two pieces each 5/8 inch long. Form them with pliers to fit pc board as shown in the detail above the component location diagram. The purpose of these straps is to provide a low inductance connection between the emitter leads of Q2 and the bottom side ground plane foil. The strap should be bent so that it fits tightly, with about 1/4 inch on the top and bottom of the board. Refer to component location diagram to determine positions of the emitter leads of Q2; these are the leads under the shield shown on the diagram. Tack solder the straps in place on the bottom of the board only. The straps will not be soldered to the top of the board until after Q2 is installed.

d. Position the heat sink on the bench, oriented so holes align with the pc board as shown in the diagram. *Note that the heatsink is used for several products; so there will be extra holes on the pc board which are not used in this model.* Place five #6 x 1/16 inch thick flat washers over the mounting holes. Carefully set the pc board over the washers, positioning as shown in the diagram. Secure the board to the heatsink with five 6-32 x 3/8 inch thread cutting screws, making sure that the washers stay in place and that transistor holes are aligned over heatsink holes.

Note: If you are building the pa for class-C operation (fm or cw) instead of linear mode, refer to separate paragraph on differences later in this text before beginning construction.

e. Next, mount the transistors as follows. Make sure you know which lead is the collector. Carefully open the package of heatsink compound with scissors. Apply it *sparingly* with a small piece of wire or a toothpick, etc. It is necessary only to use enough compound to make a smooth thermal surface between the heatsink and transistor. Using too much only makes a mess. Be sure not to over tighten the nut on the transistor stud; the gold-plated brass stud could break.

f. Unpack the stud-mount transistor used for Q2. Use scissors to trim each lead to about 1/4 inch. Be careful to note which lead is the collector; it has a notch at the end. Cut a similar notch in the corner of the lead after trimming. Apply a light coat of heatsink compound to the shoulder of the transistor, which is the part that contacts the heatsink surface. Install the transistor in the heatsink, orienting it with the notched collector lead to the right side as shown. Secure the transistor with an 8-32 nut. Do not over torque; tighten nut only to the point where snug. Check first to see that grounding straps are oriented correctly under emitter leads and that no stress is put on the leads. Hold leads from rotating with fingers; if leads still rotate, you a applying too much torque to the stud.

g. Unpack flange-mount transistor used for Q3. Check to be sure eyelets under emitter leads are down flat and solder does not protrude above heads. You don't want the leads stressed when the transistor screws are tightened. Apply heatsink compound to the bottom of the flange base. Set the transistor in place with the narrow collector lead toward the right. Double check this orientation before going further. Fasten with 2 each 4-40 screws, lockwashers, and nuts. Make sure no stress is applied to transistor leads as screws are tightened.

h. Form the leads of both transistors down against the pc board. Solder them to the foil, using sufficient solder to bond the entire surface of the leads to the board and any straps or eyelets under the leads.

i. Locate the sheet metal shield, and observe how it is positioned in the diagram. Hold it above Q2 where it goes, and note the type of notch which must be cut in the edge of the shield to clear the transistor case. Use a scissors to cut a notch as required, and then tack solder the shield in place. (It doesn't have to be a work of art, just functional.)

j. Form the leads of the two small pink ceramic trimmer capacitors as shown in the detail above the component location diagram. Tack solder them to the pc board along the stripline exactly as shown in the diagram. The position and which end of the capacitor is used are both important. One of the capacitors is soldered over the base lead of Q2, not adjacent to the lead. (Remember that the striplines are tuned circuits, not just conductors; so positioning of parts along the striplines is important.)

k. Install seven 250 pF metal clad mica capacitors in the exact positions shown for the following: C15, C17, C21, C26, C24, C34, and C37. The flat side with the part number should face up. For C21 and C37, the tab contact should be bent down enough to touch the pc board, and the tab should be soldered to the board. In the other cases, the tab is used as a free standing terminal; so the tabs should be bent up on a 45° angle. In each case, position the body of the capacitor as shown, and tack solder to the ground plane with generous amounts of solder on the left and right sides of the capacitor case. In many cases, the capacitor will be installed next to or between eyelets, which serve the purpose of carrying the capacitor ground current to the ground plane under the board.

l. In similar fashion, install the two 33 pf and two 24 pf metal clad mica capacitors at the base and collector of Q3. Bend tabs down to touch base and collector leads, and solder the capacitors at first the tab and then the case as done before. *Be sure that the capacitors are as close as possible to the transistor before soldering.* The capacitors should be installed as neatly as possible over the emitter leads, but since the surface is uneven, don't expect a flat fit.

m. Install two silicon diodes as shown in diagram. In each case, position the body of the diode directly resting on the case of the transistor. Be sure to observe polarity. 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 connect the anode lead to the tab on the mica capacitor as shown.

n. Install all other parts in the Q2 stage as shown, except do not install resistors called R6 until so directed later in the text. All parts are tack-soldered in place, with ground leads tack soldered to the ground plane. Use the shortest practical leads in all cases and observe polarity on electrolytic capacitors. Z2 is a ferrite bead over R7 lead. The bead is supplied with a wire attached; this wire should be cut off and removed. Z3 is a ferrite bead which uses the wire lead which is already attached. Merely trim the length of the lead and form it down flat on the board before soldering.

Note: L3 and L5 are each five turns of #20 tinned bus wire, spaced one wire diameter between turns, and wound on a 1/8 inch inside diameter. A drill bit makes a good tool for forming coils. L4 is similar, but only 3 turns. (The parts location diagram shows one more turn for each than is actually used.)

o. Z4-Z7 are ferrite chokes wound (threaded actually) with 2-1/2 turns of #22 (fine) bus wire. Refer to detail above component location diagram.

Feed the wire through opposite holes and pull tight. One hole will not be used. Be sure to wind the wire as shown, not in a zig-zag fashion.

p. Bend the leads of the compression mica capacitor as shown in the detail above the component location diagram, and tack solder it exactly in the position shown.

q. On piston capacitors C19 and C31, cut off the narrowest part of the three lugs on the bottom of the capacitors. Tack solder each capacitor in place as shown (2 body lugs and 1 rotor lug each).

r. C32 is the remaining 250 pf metal cased mica capacitor. Tack solder it in the position shown at the end of the stripline next to C31. It should be setting on its side with the center lug facing the top of the pa. (It is not mounted flat on the board as are the others.) C32 acts as a dc blocking capacitor in series with the output to the antenna. The coax cable center conductor will eventually be connected to the center lug on the capacitor.

s. Install the remaining parts in the output stage except bias resistors called R8.

t. Check to make sure all parts are installed except bias resistors R6 and R8. Several 1/4 and 1/2 Watt resistors will be left for this purpose.

u. Check all connections against diagrams and check all solder connections.

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 rf output and near zero idling current.

The next section of the manual describes how to adjust the bias on each stage. For optimum operation on fm and cw, it is best to bias the output stage for class-C, that is, no bias other than that provided by the rf drive. So rather than connect the bias resistors shown as R8, merely connect a wire from the tab of C24 to the ground plane, thereby grounding the right-hand lead of Z6.

The Q2 driver stage has been found to give the best gain if it has enough bias to get it just a the edge of conduction (class-B rather than class-C). For fm or cw service, then, it is best to adjust the values used for R6 so that the collector of Q2 just starts drawing current or is just below the point of conduction with only bias and no signal. Normally, for linear service, Q2 is biased to draw about 15 to 40 mA of collector current. For fm or cw, the desired idling collector current should be less than 15 mA (ideally right at the point where conduction just begins, but it is difficult to set it precisely, and it changes with temperature).

BIAS RESISTOR INSTALLATION.

For linear operation, values must be chosen and installed for R6 and R8 to provide the proper nominal idling current for the two stages. Each "resistor" actually is a parallel combination of several resistors to arrive at the right amount of bias to just begin to turn on the transistor (biased slightly beyond class-B). To install the resistors, proceed as follows. (If you will be operating only in fm or cw service, modify the bias resistor connection procedure as described above.)

a. Temporarily unsolder the lead of Z4 from the B+ bus, and connect a 100 mA meter in series between Z4 and the B+ bus to measure the collector current of Q2. Apply regulated +13.6 Vdc and ground from power supply to points indicated on diagram at right side of pc board. As a check, there should be no current drawn from the power supply yet. *Remember to turn off the power supply whenever you make a connection in the following steps.*

b. Tack solder a 330Ω, 1/2W resistor in one position indicated for R6. Check Q2 collector current on ammeter. 20-60 mA is the desired current. If you have obtained this current with the first resistor, then stop at this point. If current is too high, a higher value resistor must be used instead. If current is too low, which it probably will be at this point, add another resistor and try again: first a 1.2K 1/4W resistor, if necessary, a 680Ω resistor, and if still necessary, both the 1.2K and 680Ω resistors. If this still doesn't do it, remove the 1/4W resistors, and try another 330Ω, 1/2W resistor.

Some combination of resistors will be found to bias the transistor for the desired collector current. Note that as the base voltage increases beyond the voltage required to turn on the transistor, the collector current will rise rapidly. At lower voltages, though, no collector current will be drawn. An extra 2.2K resistor has been provided for fine adjustment should the 1.2K resistor make too coarse a change in collector current.

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 ammeter and resolder Z4 to the pc board bus.

d. For Q3 stage, lift the lead of Z7 from the B+ bus on the pc board, and connect ammeter in series. Start by tacking three each 330Ω 1/2W resistors in place for R8. Apply B+, and look for 50-100 mA idling current for the collector of Q3. Add or subtract resistance, as done before, to arrive at the correct idling current as done in step (c). When done, disconnect ammeter, and solder everything neatly.

e. Connect ammeter in series with B+ line to pc board to check overall idling current and bias current of both stages. This value should be in the range of 150-400 mA. Remember that the bias circuits draw a considerable amount of current too; this measurement won't just be the sum of the two collector currents.

INPUT AND OUTPUT CONNECTIONS.

The rf input and output connections are made by soldering 50 Ω coax cables directly to the pc board as shown in the parts location diagram. This is done to minimize the number of connectors in your system in order to avoid unnecessary losses. The center conductor of the input cable should be soldered to the left end of the strip line next to C11. The shield should be soldered to the adjacent ground plane. The center conductor of the output cable should be soldered to the center tab on dc blocking capacitor C32 as shown, and its shield should be soldered to the adjacent ground plane.

Keep stripped leads as short as possible for best efficiency. The importance of using good quality, low loss cable cannot be over stressed. Teflon cables are ideal for short runs with small diameter cables. If an antenna relay must be used, a high-quality coax relay should be used to avoid losses.

Caution:

The input circuit in the LPA 4-35 is such that bias voltage will be present on the input coax. Check to be sure that the output circuit of the exciter or transmitting converter is dc blocked by a capacitor so the bias voltage is not grounded. Hamtronicsâ units are so configured; but if you have another type, check it out.

POWER CONNECTIONS.

+13.6 Vdc 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 10 Amp, quick-acting fuse should be connected in the positive supply line for protection.

A well regulated power supply should be used for any radio equipment, including this PA. Current drain of the PA at full output is 8-9 Amp. Idle current is about 150-400 mA in linear service or less than 50 mA in fm/cw service, depending on how you set up the bias. Note that the output capability of the PA drops rapidly as the voltage is reduced below 13.6 Vdc; 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.

ALIGNMENT.

Caution:

Because it is easy to damage rf power transistors in the field due to abuse, transistor manufacturers do not provide any warranty to cover replacement in such cases. They do not honor claims that "the transistor must have been bad from the factory". They are careful to fully check each transistor before it is shipped so you can be sure that they are good when received. The following precautions should be observed.

❶ *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 of meter.*

❷ *Observe power and duty cycle ratings in the specifications published in our catalog. Keep heatsink fins in free air, not closed in, and not upside-down on solid surface. When tuning on bench, allow for cooling periods to avoid overheating while mis-tuned.*

❸ *Sometimes, transistors may be destroyed by parasitic oscillations occurring during tuning because of the extremes of capacitors settings, etc. or due to accidental shorting of components. To protect against such damage, turn power supply voltage down to 9 or 10 Vdc when you first apply rf until the unit is tuned. Of course, bias adjustments and final tuning should be done with full voltage applied.*

❹ *Never exceed 13.6 Vdc. Be sure you have a low-impedance connection to power supply, i.e., short, heavy cable.*

❺ *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.*

❻ *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.*

Alignment is very simple. Connect the input to a uhf exciter or transmitting converter which has previously been tuned into a 50Ω load of sufficient power rating through a power meter.

Preset variable capacitors as follows:

- Small red ceramic trimmers, midrange (1/4 turn from factory setting).
- Mica compression capacitor, mid range
- Piston trimmers, 3/8 inch of piston exposed at top.

Apply moderate drive and B+. Tune all trimmers alternately for maximum output. Be careful not to bottom out the tuning screw on the piston capacitors.

Continue increasing drive slightly and repeaking capacitors until maximum output is achieved. At this point, the current drain should not exceed 8-9 Amp. Of course, during ssb operation, you would not drive the PA to its limit such as this, 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. The exception is that the input circuit of the first stage, C11 and C12, should be repeaked with drive reduced to just under full output (25W output or so) to avoid saturation effects from masking the peak when tuning.

Mica compression trimmer C18 is a loading capacitor, which normally peaks near or at fully tight position. Do not be concerned if it is all the way tight when you are done tuning.

Full power output normally is 30-35W in linear service for 1-1/2W of drive, which is the normal full output level of the XV4 Transmitting Converter. In fm or cw mode, full output should be about 35-40W with 2W of drive from an exciter, such as the TA451.

Notes:

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

❷ *A small plastic tuning tool with a metal bit is required to adjust the miniature ceramic variable capacitors and the piston capacitors. See the A2 Tool in the catalog. A larger plastic tool with a screwdriver bit should be used to adjust the mica variable capacitor, but the A2 Tool can be used if you are careful not to apply too much torque.*

❸ *Never leave the B+ applied to the PA if you suspect it is oscillating or if an arc occurs somewhere. An audio or low-frequency rf oscillation could destroy a transistor or a capacitor if sustained for any length of time. If the unit draws excessive current, or there is an output indication with no input, or if you hear a high frequency frying sound, turn off the power until you discover the problem.*

MOUNTING.

If desired, the PA can be mounted to a panel or enclosure with angle brackets at the left and right hand edges of the heatsink. However the unit is mounted, the fins should be in free air to allow for good convection cooling. Do not mount the PA with the fins inside a cabinet. If the exciter or transmitting converter is adjacent to the PA, some shielding should be provided between them to avoid feedback.

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 1-1/2W of drive should be sufficient to obtain the rated 30-35W p.e.p. ssb output. Do not drive the PA to the saturation point on ssb to avoid flat-topping.

For cw or fm operation, 2W of drive can be used for 35-40W output. Drive levels over 2W should be avoided, as severe overdrive might cause transistor damage from overheating.

Note that exciters and power amplifiers both run cleanest when operated at full output. That is, if drive is reduced considerably, spurious levels may increase due to under driving the unit. This is especially true of class-C devices. When the drive is reduced to the point where the transistor is not fully conducting, spurious outputs may result. It is a common error to think that running a PA at reduced drive levels improves problems of this nature.

TROUBLESHOOTING.

Since the unit has only two stages, there isn't much which can go wrong. It is helpful to know that the base voltage in linear service should be about +0.6 to +0.7 Vdc. Idle current to each stage can be checked by connecting an ammeter in series with the choke for each stage as done in the bias setup procedure earlier in the manual. 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.

REPAIR.

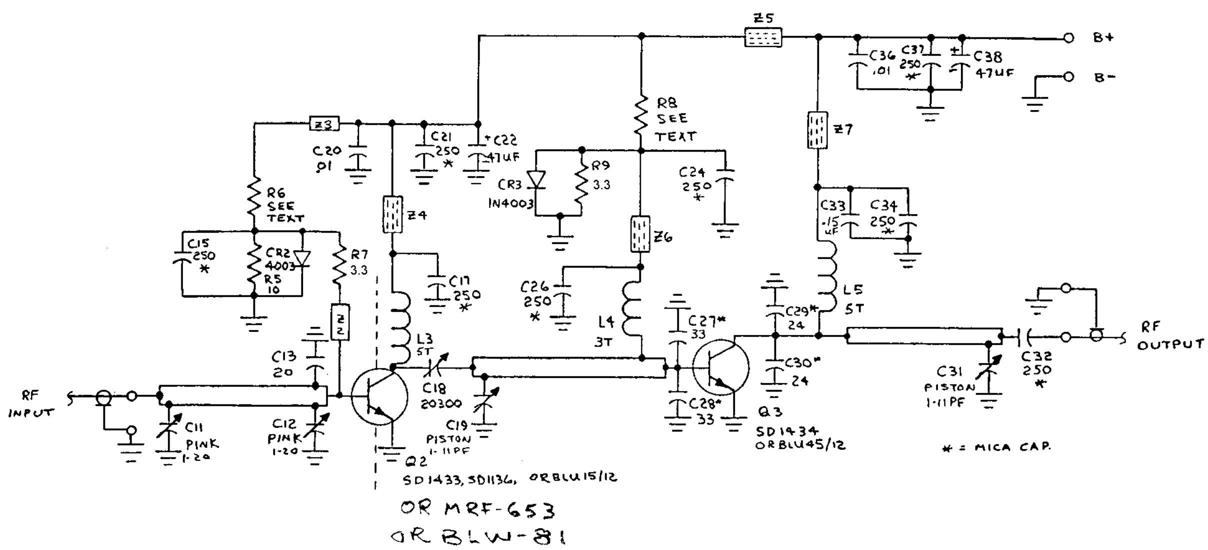
Should it be necessary to replace an rf power transistor, be sure to use an exact replacement. See parts list for types we have tested. There are all sorts of transistors available on the market which cost less or may be easier to obtain, but they may not operate properly in a uhf circuit, especially in linear operation.

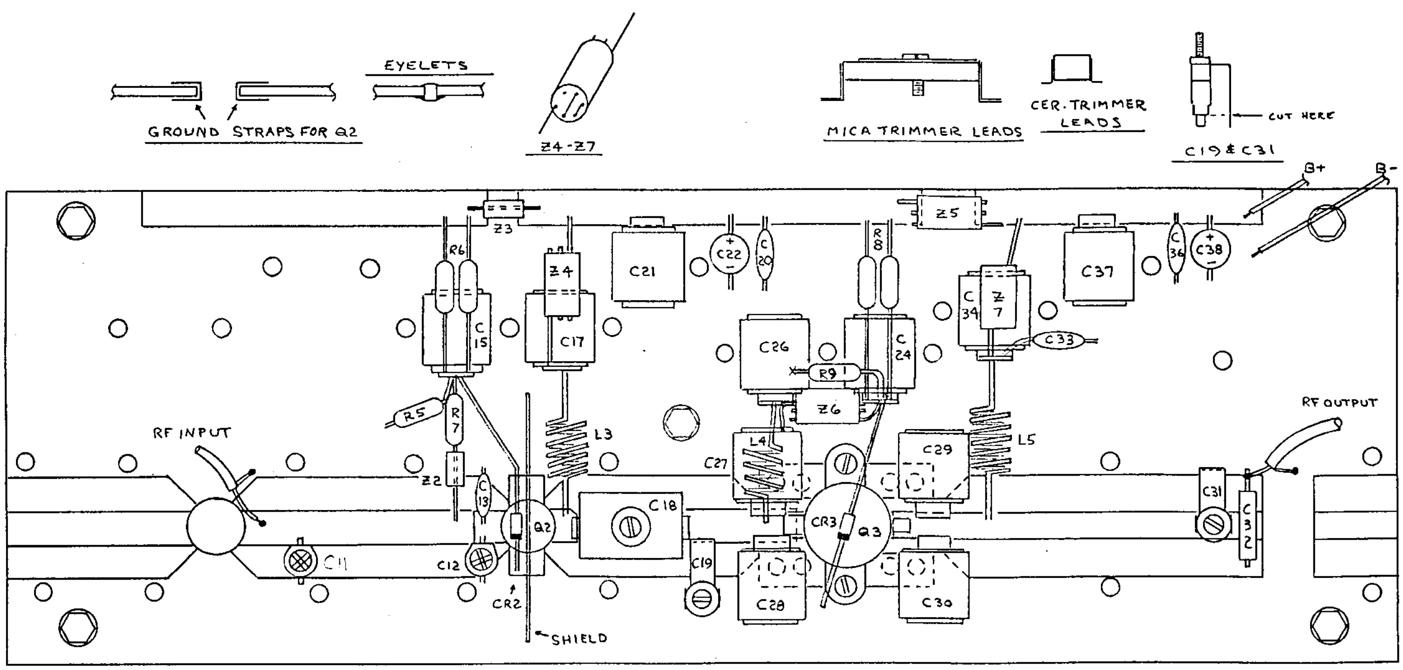
When replacing a transistor, remove any parts that are on top of the leads, and then carefully peel each lead away from the pc board while melting the solder. Then remove the mounting hardware and gently push the old transistor out of the heatsink. Clean all the old solder off the pc board to avoid stressing the leads when the new transistor is mounted. Add new heatsink compound, and install new transistor with collector lead (has notch) oriented properly. Tighten mounting hardware carefully; avoid over-torquing the brass stud of Q2. Then, flatten leads against the board, and sweat solder them to the foil. Remember to resolder any parts removed for access to the transistor leads.

PARTS LIST.

Ref Desig	Description (marking)
C1-C10	n/a
C11-C12	1-20 pF ceramic variable cap. (pink)
C13	20 pF disc ceramic
C14	n/a
C15	250 pF metal-cased mica
C16	n/a
C17	250 pF metal-cased mica
C18	compression mica cap. #703
C19	1-11 pF piston trimmer
C20	.01 uF disc cap (103)
C21	250 pF metal-cased mica
C22	47 uF electrolytic
C23	n/a
C24	250 pF metal-cased mica
C25	n/a
C26	250 pF metal-cased mica
C27-C28	33 pF metal-cased mica
C29-C30	24 pF metal-cased mica
C31	1-11 pF piston trimmer
C32	250 pF metal-cased mica
C33	0.15 uF polyester (red)
C34	250 pF metal-cased mica
C35	n/a
C36	.01 uF disc cap (103)
C37	250 pF metal-cased mica
C38	47 uF electrolytic
CR1	n/a
CR2-CR3	1N4003 silicon diode
L1-L2	n/a
L3-L5	Air wound coils, see text
Q1	n/a
Q2	Motorola MRF653 or Thomson SD-1433 or SD-1136
Q3	Philips BLU45/12 or Thomson SD-1434
R1-R4	n/a
R5	10Ω, 1/4W
R6	Combination of several resistors, see text for bias adjustment
R7	3.3Ω, 1/4W
R8	Combination of several resistors, see text for bias adjustment

R9	3.3Ω, 1/4W
Z1	n/a
Z2	Ferrite bead on lead of R7
Z3	Ferrite bead on bus wire
Z4-Z7	6-hole ferrite core with 2-1/2 T #22 bus wire





Caution: Keep mica capacitors C27-C30 as close as possible to the body of the transistor.

LPA 4-35

