Before the etched-inductor technique brings the inductor down so small that it is no longer fair game for the home constructor, FM fans may find the Interdigital Pre-Amplifier for FM (88–108 MHz) an interesting project.

Such a unit is shown at the beginning of this article. A layout of the complete circuit board, including four etched inductors is in Fig. 2, and Fig. 3 is the schematic plus shield layout.

This is a two-stage pre-amp with active filter elements. In other words, a pre-amplifier with sufficiently high Q that the 3 dB gain-bandwidth product occupies slightly over a megahertz, resulting in much improved selectivity for virtually any FM tuner or receiver in use today.

The preamplifier is designed around the Siliconix E300; a plastic-cased JFET of the 2N5397 family and with most unusual noise-figure and signal handling capabilities at 100 MHz. Operating in the grounded gate (non-neutralized) configuration, the E300 is factory rated at 1.3 dB noise figure, with a signal handling dynamic range of 100 dB.

The E-300 was designed especially for grounded-gate operation. And this makes circuit design using the device simply a matter of putting tuned input and tuned output circuits around the transistor, applying proper voltage, and tuning for max! The *only* adjustment per se is to match the source-to-ground resistor so that the E-300 draws between 4.8 and 5.2 mA (at 10 volts dc).

Looking first at the operational characteristics of the preamplifier, Fig. 4-a shows a spectrum sweep display centered at 100 MHz. The markers on the horizontal line are 1 MHz apart. The center is 100 MHz, and this represents 18 dB gain at frequency. Note that the 3-dB-down points fall at 99.0 and 101.0 MHz. In Fig. 4-b the display has been increased so that now we are looking at the 10-dB down points; 97.3 and 102.6 MHz. Figure 4-c shows the 18-dB down points (the preamplifier has 18 dB gain, so signals within the 18-dB-down points fall at some point between 0 dB and 18 dB gain); 96.2 and 104.7 MHz. You might go back and compare this with the flat-topped curve in Fig. 1, the single-channel TV unit for some idea of the flexibility of the etched inductor passive and active filter combinations.

Construction

Construction of the etched-inductor FM preamplifier is truly straightforward. The usual tricky adjustments for neutralizing, noise figure vs maximum gain and tweeking of the coils are eliminated. The E-300 grounded-gate operation eliminates neutralizing and noise figure/gain adjustments while the etched inductors eliminate tweeking of inductors.

In the schematic (Fig. 3) antenna energy from a 75-ohm antenna downlead or 300-to-75 ohm matching transformer is coupled into Q1 source through C1, a 500-pF disc ceramic capacitor. L1 and C3 comprises the tuned input circuit. L1 is of course an etched inductor (see Fig. 2). C3 is a Philmore type 1952 15-pF variable capacitor. The same network is repeated in the combinations L2, C4; L3, C7 and L4, C9.

The cold end of each inductor is bypassed to ground with a stud mounted uhf bypass capacitor, such as the Sprague BH-105 series or Centralab type MFT. (Note: Do not attempt to use disc ceramics for bypassing in this device.) L1 and L3 are also coupled to ground with ¼-watt resistors (R1, R2), each chosen so that their resistance draws between 4.8 and 5.2 mA current for the respective E300's. (Note: The circuit board is laid out so that the 10 volt dc positive supply voltage from the power supply may be broken at RFC1, and a 0–25-mA meter placed in series with the dc line at this point to monitor E300 current while R1 and R2 are properly balanced.) Typical values for R1 and R2 fall between 91 and 560 ohms.

Coils L2 and L4, in addition to bypassing to ground through the stud mounted 500-pF capacitors are also coupled to the positive voltage line shown in Fig. 3 and in the construction photos. L2 and L4 are "jumped" to the positive supply line with ⅜-inch lengths of number 22 or 24 wire, bent into an inverted "U" to span the ground line between.

Interstage shields (SH1–SH3) shown in the construction photos are constructed from double-sided G-10 copper-clad epoxy-glass board (see Fig. 3). SH1 and SH3 separate the respective input and output sections of Q1 and Q2, and also serve as a convenient ground attachment point for the E300 gate leads. Note that the E300's mount inside of ⅜-inch holes drilled in SH1 and SH3.

Interstage shield SH2 separates the first stage output from the second stage input and it has a ⅜-inch hole drilled to pass C6, the interstage 500-pF coupling capacitor (see Fig. 3).

Mounting shield SH4 serves merely as an anchor on which C3, 4, 7 and 9 are suspended and grounded.

The power supply is so straightforward that there is no need to elaborate on its components or their functions. A well regulated and heavily filtered 10 volts dc is supplied and total two-stage current drain is 10 mA.

The board master may be duplicated directly from Fig. 2, or the board may be purchased singly or as part of a complete parts kit (see parts list).

The shield sections should be cut and drilled as in Fig. 3 and construction photos. Soldering G-10 board together, as shields, is no trick if you tin mating sides first and use a 35–50-watt iron (Note: Do not use anything over a 50-watt iron on these boards as the etched inductors may lift from the board proper with too much or prolonged heating.)

When the shield composite is completed (see construction photos), it is positioned in place and tack soldered on two opposing corners. When you are sure alignment is correct, as shown in the construction photo, the small-nose iron can be drawn along the two tinned mating sides and the solder will flow together forming a weld between the two sections.

Bypass capacitors C2, 5, 8 and 10 are then soldered into position, from their respective etched inductance "cold" ends to the adjacent shields. Coupling capacitor C6 is mounted next, followed by the two E300's. Note that the E300 gate lead is formed as shown in Fig. 3 and that the leads on the E300 face towards SH4. The gate lead is soldered to SH1 and SH3 on the L1 and L3 sides of the shields.

Variable capacitors C3, 4, 7 and 9 are mounted with their mounting screws with the rotor-grounding strap straight up. The rotor grounding strap is bent back to SH4 as shown in the construction photos and soldered into position, since the capacitor itself is not automatically grounded when mounted.

The source and drain leads of the E300's, if mounted according to instructions and as shown in the construction photos, will connect to the variable-capacitor studs nearest the shields. Before they are attached to the capacitor studs, run a length of number 22 or 24 solid wire from the *inside* connection point of the etched inductor straight up to the stud of the variable capacitor where the E300 lead will attach. Also, run a 5.0-pF disc ceramic (C13) from that same stud on C7 straight to the shield next to it; effectively placing 5 pF in parallel with the 15-pF variable on C7 *only*.

When attaching the E300 leads to the studs, exercise the usual care that you would with any transistor device by placing a heat sink between the JFET proper and the soldering iron tip on the lead. The JFET is quite difficult to damage (unlike the MOSFET) but sustained heat is not advised for any transistor.

Coupling capacitors C1 and C11 may now be attached, and the E300's resistance-matched (R1,R2) as previously outlined.

It is difficult to see, but in our black plastic housing we use "F" series chassis-mounting connectors. A short length of number 22 or 24 wire is run from the center pins on the connectors to the pads where C1 and C11 terminate. And, a piece of braid, removed from a piece of RG-59/U coaxial cable has been tinned, and it provides ground connection between the connector shell and the circuit board proper, just adjacent to the C1 and C11 pads. Unless the body of the connector is grounded in this way to the circuit board proper, you will have no end of problems in making the unit operate properly.

If 300-ohm antenna lead-in and connection to your FM receiver is utilized, use a pair of 75- to 300-ohm matching transformers before and after the preamplifier so it "sees" 75 ohms at both the input and output circuits.

The preamplifier is tuneable over the complete FM band, and for a little ways on either side. With the capacitors fully meshed, the unit tunes down to about 85 MHz, and with the capacitors fully open the unit tunes up to approximately 115 MHz. Alignment is not required.

There is only one no-no associated with the unit. The etched inductances are flush to the bottom of the (plastic) case so the preamp should not be placed directly on top of a metal cabinet. Nor in a metal chassis. If metal surfaces are going to be used, be certain the etched inductor surfaces are 1 inch above these surfaces (i.e. use standoff spacers when mounting in a metal case) so as to not detune the etched circuits.

The front of the unit is easily calibrated with rub-on numbers and while electrical tuning is quite sharp, mechanical bandspread is bunched fairly closely together as the photo shows. In tuning, adjust C4 and C9 (marked 2 and 4 in the front unit photo) first for maximum signal, then C3 and C7 (marked 1 and 3).

Construction hints

If the complete etched-inductor/circuit board is utilized as shown and described here, the power supply components should be mounted first, and the power supply checked out as shown in Fig. 5. At the top of the board, etched inductors L1,2,3 and 4 appear from right to left. Note use of etched link coupling for inductors L2 and L4 output coupling.

Shields SH1, 2, 3 and shield mount SH4 are shown drilled and tinned prior to assembly (see Figs. 3 and 6-a).

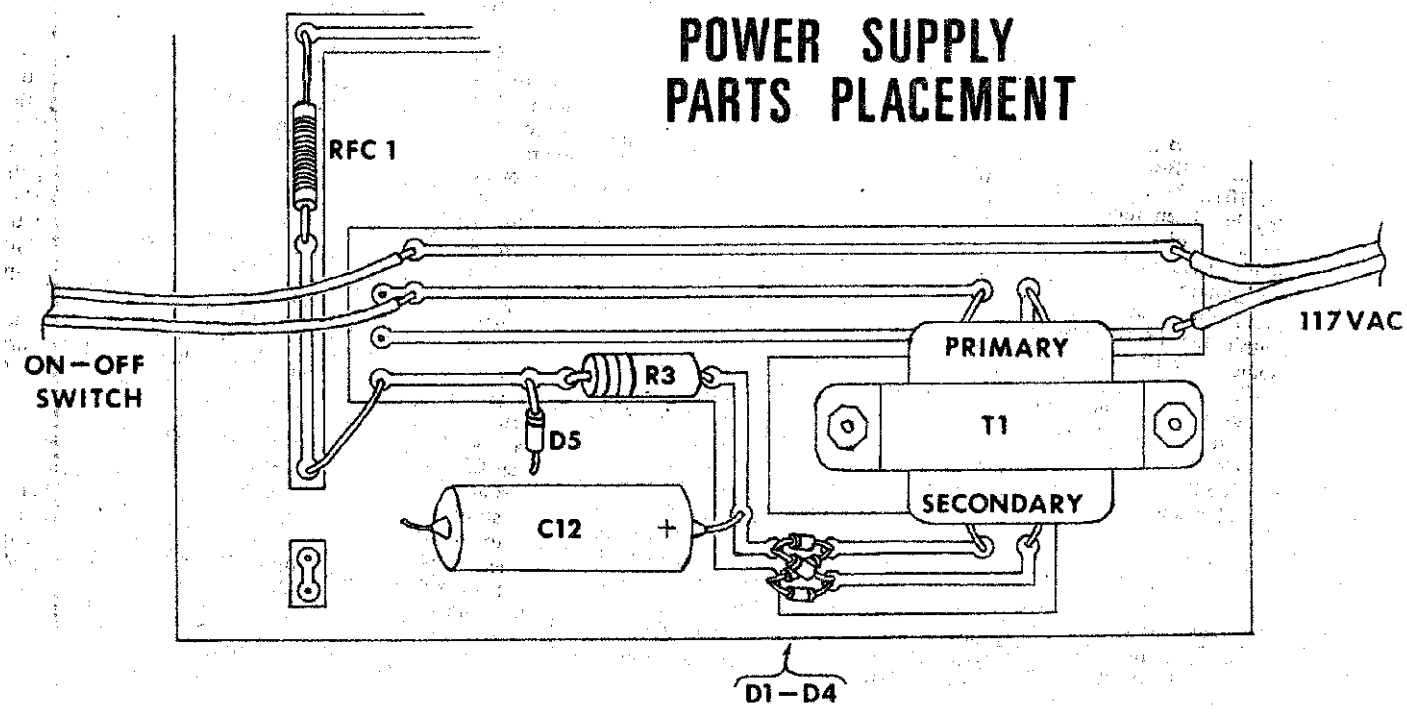
The shield sections are pre-assembled into a complete unit (Fig. 6-b) for soldering onto the etched inductor/circuit board proper. Soldered into place, (Fig. 6-c) the shield subassembly provides mounting plate for capacitors C3, 7 and 9 mounting plates for transistors Q1 and Q2; and ground connection points for bypass capacitors C2, 5, 8 and 10.

Figure 6-d shows how E300 Q2 is soldered to the L1-side of SH3. The source lead of Q1 and the short length of number 22–24 wire coming up from the inside tie point of L1 connect to the inner-most lug on C3. Also note that bypass capacitor C2 is mounted between the shield of SH3 (which is at ground potential) and the outside (cold) end of L1. R1 is in place from the base of C2 to the ground strip between L1 and the positive dc supply line. Note that variable capacitor C3 has it's ground lug bent back and soldered to SH4.

The completed circuit board may be mounted in a plastic equipment box, as shown. SH4 provides a "template" for front panel holes for capacitors C3, 4, 7 and 9 while coaxial connectors J1 and J2 mount directly opposite the pads that C1 and C11 attach to, and one inch above the board proper.

Conclusion

Etched inductances, in one or several forms, are about to become a way of life for every user/servicer of vhf and possibly uhf equipment. The FM preamplifier described here, with a 1.3 dB noise figure, 18 dB gain and good selectivity, will give everyone associated with the vhf-uhf industry an opportunity to find out what makes them tick, while providing a real state-of-the-art FM receiving system as a bonus! **R-E**



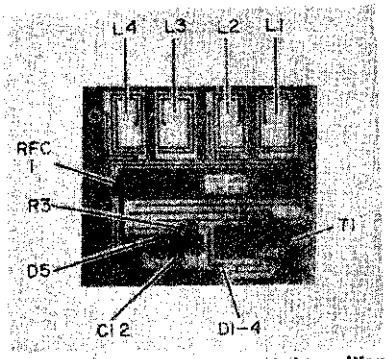
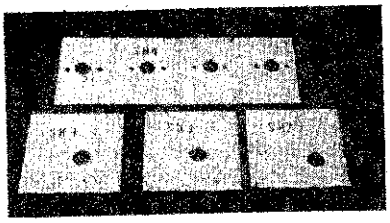
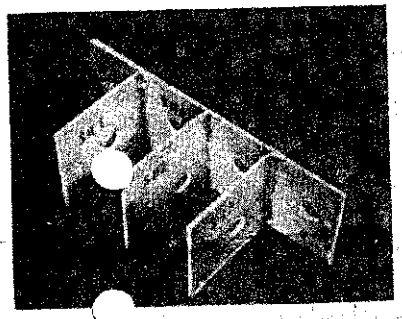
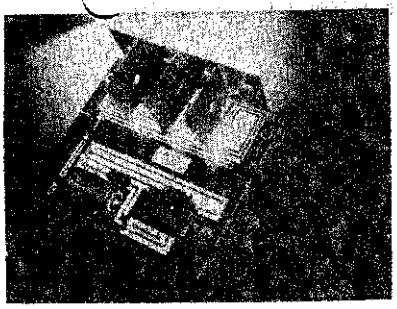


FIG. 5—POWER SUPPLY parts in position on the main circuit board.







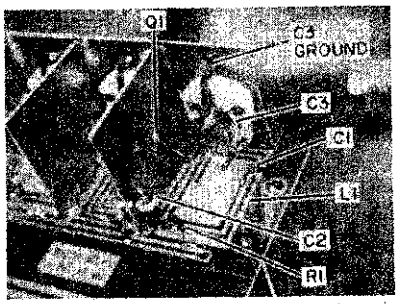


FIG. 6—ASSEMBLING the FM circuitry. (Top to bottom). (a)—SHIELDS are cut, drilled and then tinned along mating edges, (b) SOLDERED TOGETHER and then (c) MOUNTED on the etched board. (d) LAYOUT OF PARTS in the antenna input circuit. A lead from J1 goes to the pad for the right-hand lead of C1.

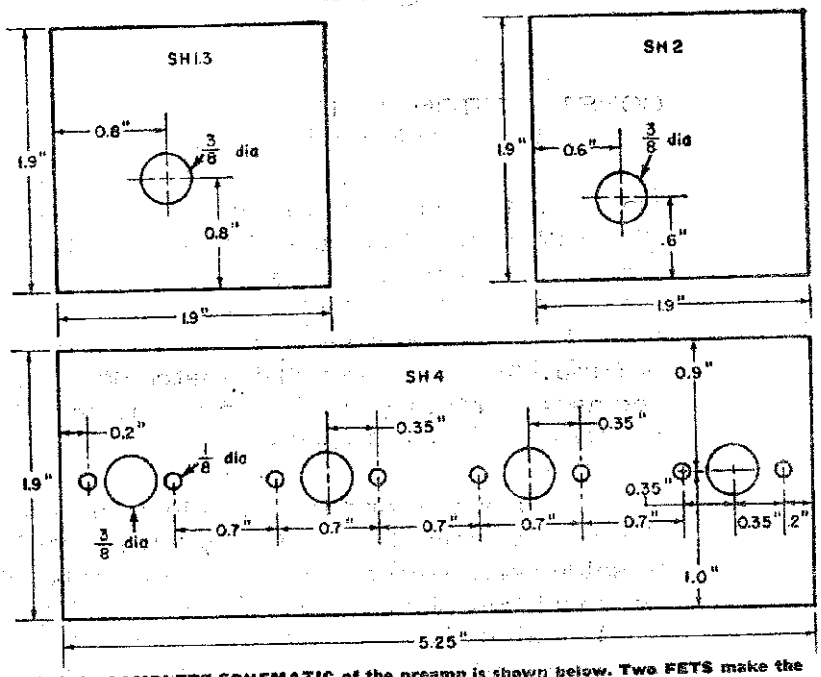
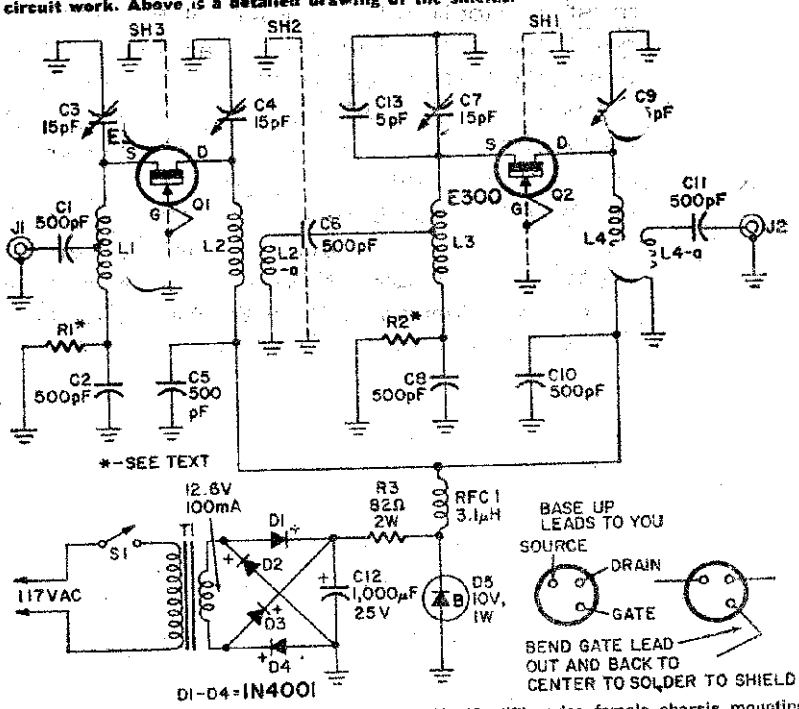


FIG. 3—COMPLETE SCHEMATIC of the preamp is shown below. Two FETS make the circuit work. Above is a detailed drawing of the shields.



Capacitors

C1, C6, C11—500 pF disc ceramic

C2, 5, 8, 10—500 pF stud mounting uhf bypass (Sprague BH-105 series, Centralab type MFT or equal)

C3, 4, 7, 9—15 pF (maximum) variable (Philmore model 1952)

C12—1,000 mF 25 volt dc electrolytic

C13—5.0 pF disc ceramic

Resistors

R1, R2—1/4 watt between 91 and 560 ohms typically—see text

R3—82 ohm, 2 watt

Semiconductors

Q1, Q2—Siliconix E300

Miscellaneous

RFC1—3.1 μH rf choke (Ohmite Z144 adequate substitution)

D1, 2, 3, 4—50 V, 1A, power supply diodes (1N4001)

J1, J2—"f" series female chassis mounting coaxial connector (Amphenol 461-6005 or equal)

D5—10-volt, 1-watt zener

S1—Spst toggle switch

T1—12.6 volt 100mA secondary, 117 Vac primary power transformer (Westcom TF-121, or Stancor P8390)

117 Vac line cord, 440 hardware

Circuit Board

Inductances L1, 2, 3, 4 are etched onto the master circuit board as shown in Fig. 5. The complete circuit board alone is available from PAIA ELECTRONICS, P.O. Box 14359, Oklahoma City, Oklahoma 73114; price $8.00. Specify item 2712PC. The same source will supply a complete kit of all parts including the circuit board, but less the case and knobs, for $27.50 plus postage for 3 pounds. Specify item 2712K.

CONSTRUCTION NOTES

Note that 1,000 pf ceramic disks have been substituted for the 500 pf. disk called out in the parts list as C1, C6 and C11. No other parts substitutions have been made.

E-300's have been pre-matched for an optimum gain/noise compromise of 5 ma. drain current. The matching resistor is supplied in the same bag as the FET. Be careful that matched FET-resistor pairs are used together.

You will probably find it advisable to pre-tin the edges of the shields prior to fastening them to one another or to the circuit board. A dot of solder placed on the circuit board at the outermost edge of the shield will assist in tacking the assembly in place during final soldering.

The E-300 FET's are exceptionally sensitive to heat and heat sinks must be applied to the leads of the device between its body and the point being soldered while heat is supplied and a minimum of 5 seconds thereafter. Use only a 35 - 40 watt soldering iron while assembling the device. The electric field associated with soldering guns can destroy the gate/channel junction. Do not under any circumstances use acid core solder.

In the event of difficulty, a repair service is available. Write for repair address and shipping instructions. Units returned to PAIA Electronics cannot be accepted for repair.