VHF POWER AMPLIFIERS Part 2

High power amplifiers using stripline techniques – by Roger Harrison, VK2ZTB and Phil Wait, VK2ZZQ.

IN THE FIRST PART of this article we covered the ETI 715 series from A to E, with the exception of ETI 715D. This is the 3W 15dB two metre amp, which we shall describe first.

The ETI 716 45W two metre stripline amp follows. This model completes the project series. But, drool, drool, slurp, slurp – this series ends with descriptions of two state of the art stripline power amps which we constructed from CTC evaluation kits kindly supplied by Ampec Engineering. They are not intended as projects as such, but for those hardy souls with oceans of tomato resources and ingenuity (remember the amateurs' code?) who may be interested in borrowing the techniques if not attempting reproduction.

ETI 715D, 3 W 2 m amp.

Homebrewer' delight! From your prissy little 50–100 mW or so output you can start off at the bottom rung of the real power ladder. No matter if you've built yourself an FM driver run by an all-singing, all-dancing you-beaut type synthesizer or a solid state transverter with push-pull, shove-grunt type FET mixer.

The usual construction order prevails Component layout is in figure 12. Mount the transistor first according to the details given earlier. Then mount RFC1. This may be a 0.22 μH moulded choke or 10 turns of 34 or 36 B & S enamel wire wound on a low value ¼W resistor. Follow this by winding L1, L2 and RFC2 and mounting them.

Complete construction by mounting all the trimmers and other components. Diode and stub switching is not used as this is not an 'add-on' amplifier.

Mount the assembly on the chassis/heatsink in the usual manner previously described for the other amps.

Tune-up follows the general procedure previously described.

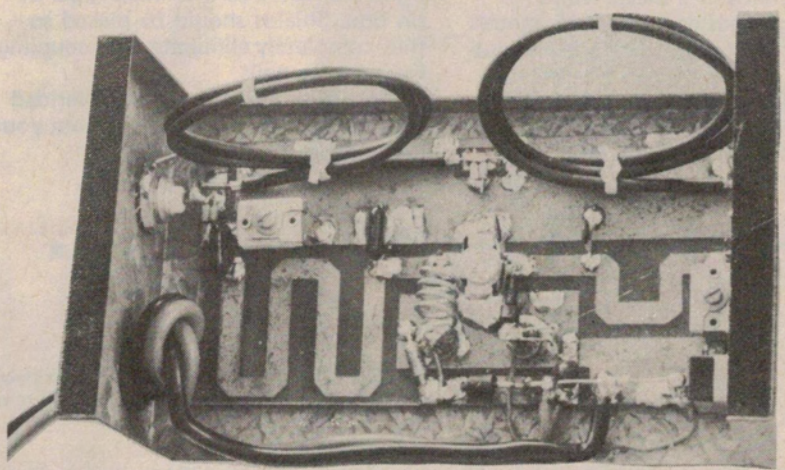
ETI-715D Performance

Yes, well, these little B3-12's have plenty gain! More than you'd expect from your common or garden variety device. Power output of 3 watts was obtained from the prototype with only 80 mW drive. Up to 5 watts can be obtained from most devices. In linear service, the B3-12 has a little less gain than in class C but it seems to produce the same peak power output.

Prototype performance, ?, look at this:–

Power output = 3 watts
Gain = 15.5 dB
Efficiency = 62.5%
Collector current = 400 mA 12.5 volts (class C) (max. Ic = 1A) (max. Vs = 36 V)
Collector dissipation = 1.8 watts (at full carrier)
Maximum recommended voltage = 16 volts
Bandwidth = 7 MHz (to -3 dB points)

In linear mode, quiescent collector current should be around 30–50 mA (class AB) or around 200–250 mA if you want to operate in class A.

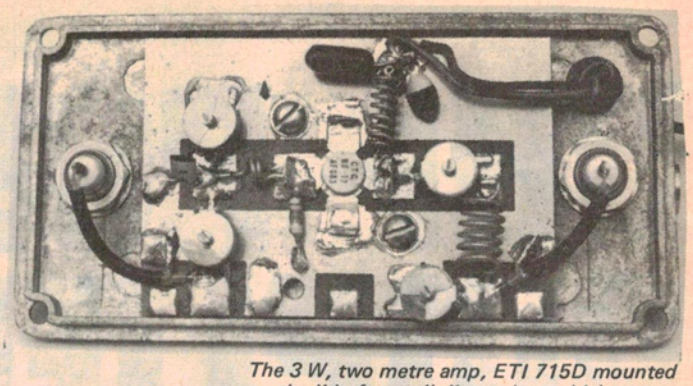


The ETI 716 stripline 45 W 2 m amplifier prototype. Input is on the right, output on the left. Both input and output matching lines are 'folded' to reduce board size. Note the 'dipped mica' capacitors at the beginning and end of the output stripline (C6 and C7). Only two tuning adjustments are required, at the input and the output.

PARTS LIST – ETI 715D

L1	2 turns, 20 g tcw wound on 3 mm dia mandrel, 3 mm long.
L2	6 turns, 20 g tcw wound on 6 mm dia mandrel, 15 mm long.
C1,2,3,4	4-40 p Philips film trimmer or mica compression type.
C5,6,7	as marked
RFC1	10 turns, 36 or 38 g enamel wire wound on low value ¼ W resistor.
RFC2	8 turns, 20 g tcw, wound on 3 mm dia mandrel, 15 mm long with low value ¼ W resistor mounted inside.
Q1	B3-12 (CTC)

Note: 47 pf ceramic or mica capacitor in parallel with C2, as shown above.



The 3 W, two metre amp, ETI 715D mounted on the lid of a small diecast box which serves as a heatsink. The coax leads to the input and output sockets sockets have the braid terminated only to the board groundplane.

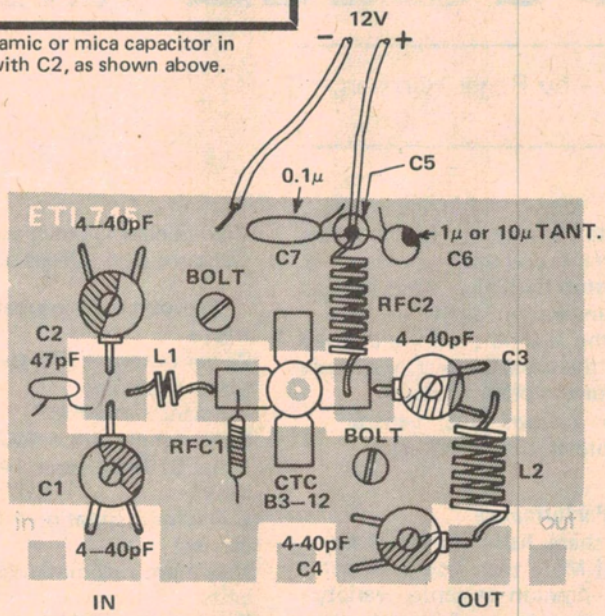


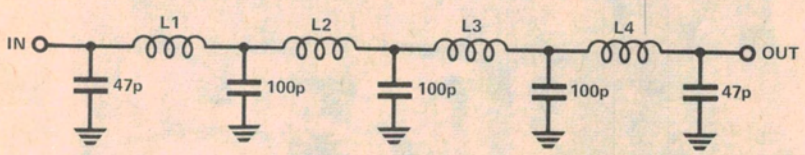
Fig. 12. Construction and component layout of the ETI-715D 3 W two metre amp.

Output Filter For 6 Metre Amps

Anyone who has operated on 6 metres will know the hazards of TVI. The output filter of Fig. 13 can fit into the transmission line to the antenna and provides 48dB/octave attenuation with a cut off frequency of 63 MHz.

The filter can be constructed on a printed circuit board or in a copper or tin box. Shields should be placed so they completely eliminate stray coupling between the coils.

This filter will not reduce overload type TVI but it will make sure that your harmonic output is low.



L1,2,3,4 250 nH, 5 turns 16 g tinned copper or enamel wire, 13 mm i.d., 13 mm long.

Fig 13. Four-section low-pass filter for 6 m power amps described in Nov 77 issue of ETI. Two sections are adequate (input and output capacitors should be 47 p of course) but four sections are better! Each individual coil should be well-shielded and the input kept away from the output to achieve maximum stop-band attenuation. Capacitors should be dipped mica or metal-clad types.

Microstripline

UNLIKE THE PRECEDING amplifiers, which use lumped constant matching networks, the next three use *microstrip transmission line* matching.

Here, sections of transmission line are used to match the transistor impedance to the input and output impedance, in the same way as sections of transmission line and stubs are used to match a line to a complex load impedance. The stubs are replaced by fixed capacitors (C3, C6, Fig. 14) in circuits up to a few hundred MHz.

A microstrip line is formed with a conductor etched onto one side of a double sided pc board, the opposite side being left as a copper plane. Characteristic impedance is determined by strip width, thickness of the board and type of material used, so the type of pc board used is critical. Only use the type and grade specified.

Stripline matching in power amplifiers usually involves several sections of line in series, with one or more intermediate impedance points selected. The ETI 716 uses two sections in each network while the 140 W amp uses three.

ETI 716 45 watt 2 Meter Amplifier

This amplifier was designed as a replacement for the ETI 710 booster amplifier (April 1976 issue). A CTC B40-12 transistor is used to give an output of around 40 watts with 5.5 dB gain. This makes it ideally suited for use with most of the 10 watt transceivers around.

Linear operation is possible using one of the bias circuits described in the Nov. 1977 issue and in this circuit the diode switching can be retained without any noticable distortion of the output.

Refer to Fig. 15. After the hole has

been drilled for the transistor base, the earth planes on each side of the board must be connected together at several places around the edge of the board and under each emitter lead. Suitable lengths of shim stock or tinplate about 5mm wide can be folded around the edge of the board and soldered in place. The transistor hole will have to be filed to accomodate the transistor and the thickness of the shim.

All other components are assembled in position as in Fig. 15 using *absolute minimum* (none if you can manage it!) lead lengths on all components.

The base choke RFC1 is made up of a 0.22μH choke with an F14 suppression bead slipped over the earthy end. This choke can be of the moulded type or made by winding 15 turns of 34 B & S wire around any suitable medium value 1/4 W resistor.

A metal clad mica capacitor is shown for C6 in Fig. 14. This is a difficult component for hobbyists to obtain and can be replaced with a mica dipped type. Ceramics or any other type of capacitor will very quickly self-destruct.

C9 and C10 are standoff or feed-through capacitors used as standoffs. Be careful when mounting the assembled amplifier in a box to drill a clearance hole in the metalwork if a feedthrough is used.

ETI 716 Performance

A maximum output of 50 watts CW or 40 W SSB was achieved with this amplifier.

Peak output power – 50 watts
Gain – 6.5dB
Efficiency – 65%
Withstands infinite VSWR at 40 W output

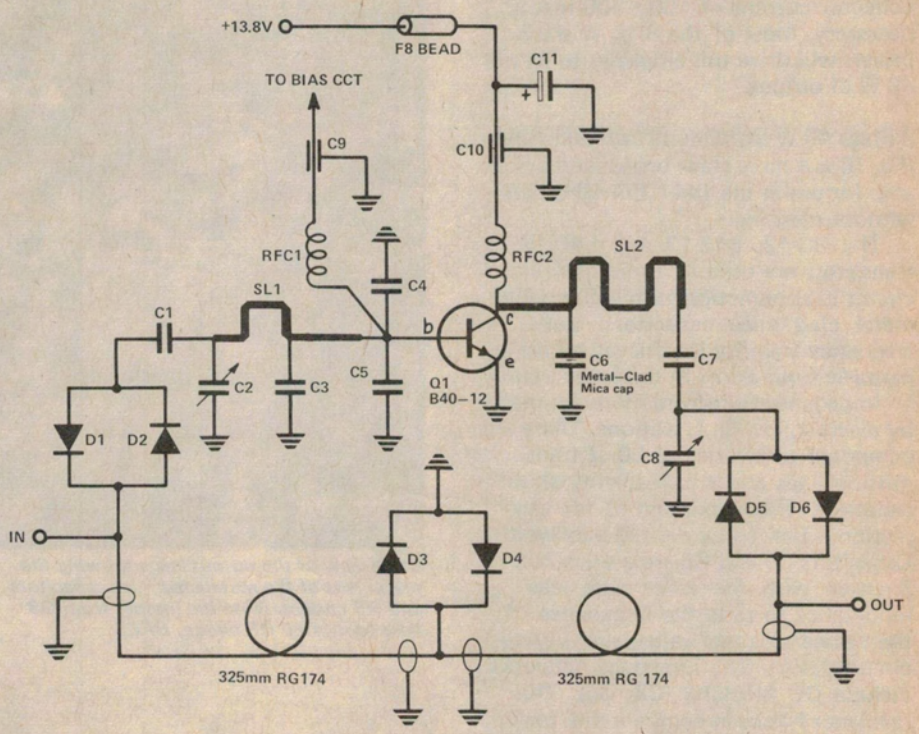


Fig. 14. Circuit of the ETI 716 45W 2m power amplifier. The diode switching is omitted for SSB linear operation. Suitable bias circuits were given in the Nov. '77 issue of ETI. Diode stub switching details were also included in that issue. See text and overlay for notes on C6.

PARTS LIST – ETI 716

C1,7	220 to 1000 pF ceramic or dipped mica cap.
C2	4-40 p mica compression trimmer (Elmenco)
C3	47 p NPO ceramic or dipped mica cap.
C4,5	100 p NPO ceramic or dipped mica cap.
C6	100 p metal-clad mica or dipped mica cap.
C8	4-40 p or 4-60 p mica comp. trimmer (Elmenco)
C9,10	680-1000 p button ceramic stand-off or feedthrough cap. used as component standoff.
C11	1 μ to 10 μ tantalum cap.
D1 – 6	1N914, 1N916, BAX13 or BAV10 (recommended)
Q1	CTC B40-12
SL1,2	50 ohm *stripline* on pc board
F8 bead	4 x 1.5 x 9.5/F8 Neosid suppression bead
RFC1	see text. F14 bead obtainable from Neosid suppliers.
RFC2	4 turns, 18 g tinned copper or enamel wire, 6 mm i.d., 15 mm long.

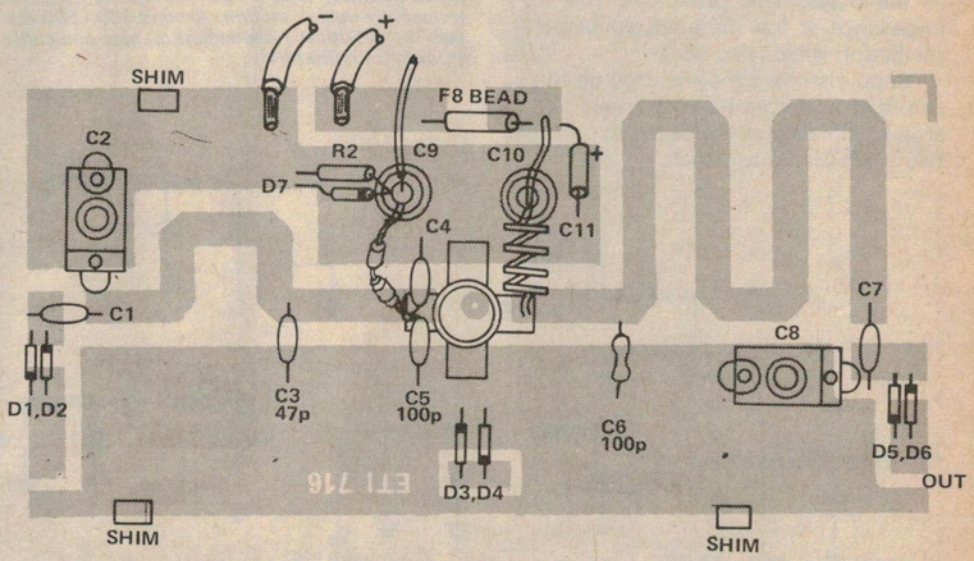
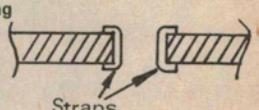


Fig. 15. Component overlay for ETI 716 45W 2m power amplifier. Note the use of shim grounding straps and their location. Two straps are used, one each under the transistor emitter leads as illustrated, as well as three around the board edge. A metal-clad mica or dipped mica capacitor may be used for C6. Pay careful attention to the location of all the components, particularly the capacitors.

Emitter Grounding



These are made by folding the straps over the edge of the board. Two to four mil copper shim stock will make excellent ground straps.

supply voltage – 12.5V
Maximum supply voltage – 16 V
Maximum collector current – 7 A

For linear operation a quiescent collector current of 100 - 300 mA is necessary. Most of the 8-10 W transceivers will drive this amplifier to its full 40 W of output.

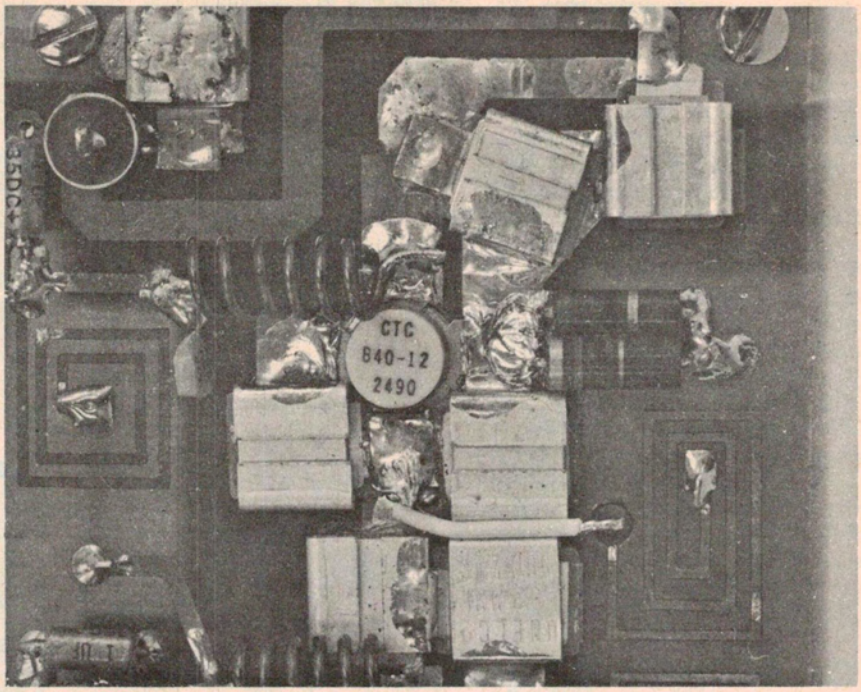
3 Stage 40 W Stripline Broadband Amp

Fig. 16 is a three stage broadband power amp for use in the 144 - 174 MHz band, without retuning.

The B3-12, B12-12 and B40-12 transistors are used in a microstripline circuit in conjunction with high quality metal clad mica capacitors. Low-frequency stability is achieved by using parasitic suppressors in the base circuits.

Impedance transformations are made by discrete, low-Q, L sections. These are composed of a series of 50 Ω transmission lines and a high quality shunt capacitor. The maximum Q for each section is limited by desired bandwidth. Capacitors C5 and C8 are used in conjunction with the series base lead inductance to raise the impedance of the device to a real value, simplifying circuit design. The interstage networks include DC blocking (C3, C6). This reactance has been compensated for in the design of the series line. Low frequency parasitic oscillation is controlled by using a parallel RL circuit in the bases. This presents a low impedance at low frequencies where oscillation is likely to occur.

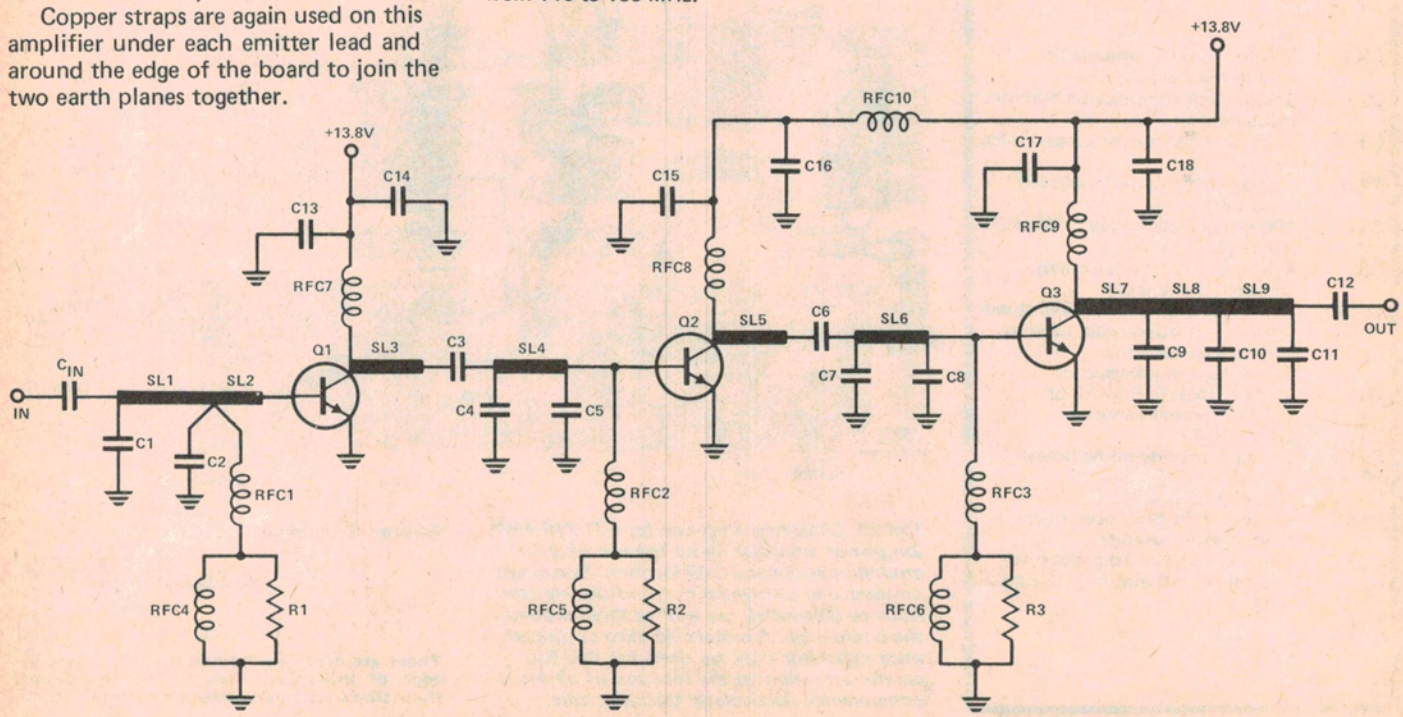
Copper straps are again used on this amplifier under each emitter lead and around the edge of the board to join the two earth planes together.

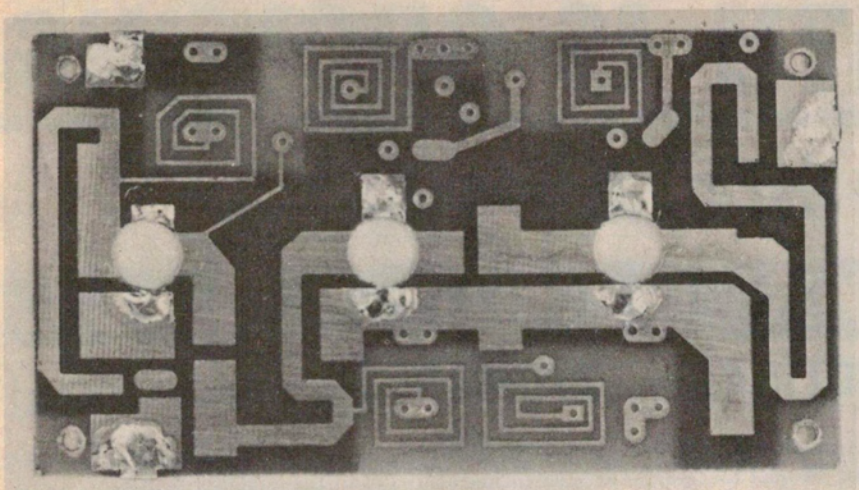


Close view of the output stage showing the placement of the metal-clad mica capacitors and RF chokes. Note the jumper from Q3 base to printed RF choke, RFC3.

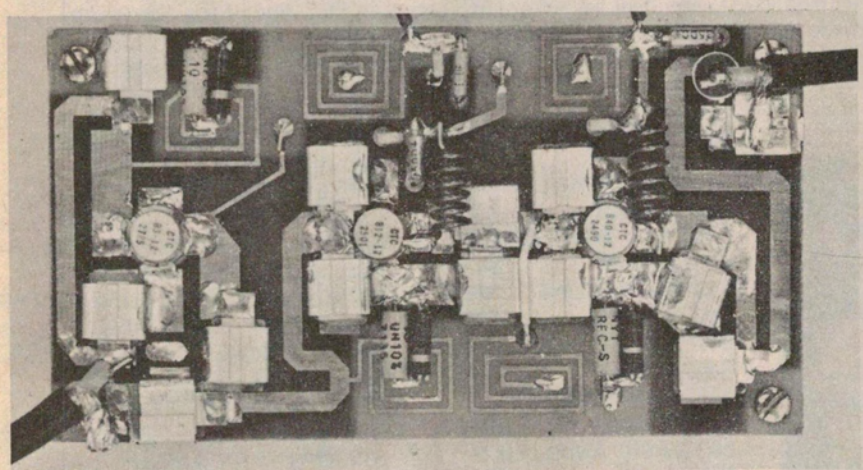
PCB's for this project (716) are on pages 74, 75.

Fig. 16. Circuit of the three stage, 40W VHF stripline broadband power amplifier. Overall size of the assembly is 65 x 120 mm making it an excellent proposition for a homebuilt 2m FM transceiver output section. Around 300 - 500mW drive will deliver 40W output. Low-frequency stability is critically dependent on base and collector decoupling circuitry. Bandwidth extends from 140 to 180 MHz.

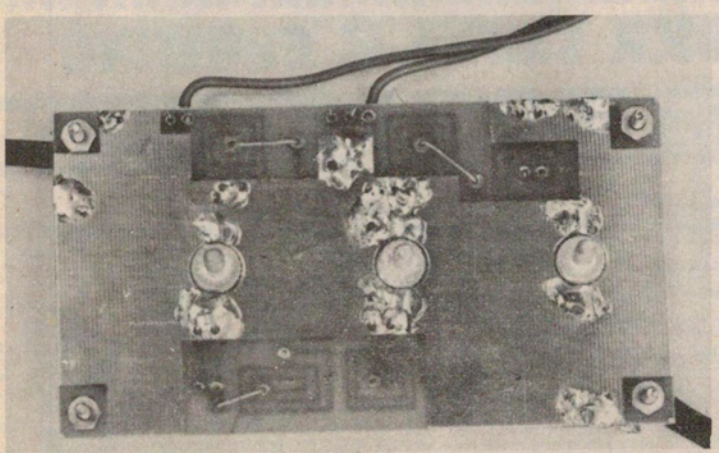




Top view of pc board following drilling and installation of emitter and topside ground area grounding straps.



View of completed assembly showing placement of all metal-clad mica capacitors, RF chokes and base decoupling components. Input is on the left, output on the right.



Under view of completed pc board showing interconnecting straps between the base RF chokes (printed inductors) and low frequency decoupling components.

Performance

The amplifier was tested on 146 MHz from a 0.5 W driving source.

Power output	40 watts
Power input	0.5 watts
Efficiency	52%
Spurii	Better than -60dB

This amplifier will withstand an infinite VSWR on the output when operated at the rated output up to the maximum supply voltage.

To optimise performance at two metres, C9 was moved along the line to obtain highest overall gain at 40 W output.

Note on mica caps.

These are expensive, but indispensable and certainly worth it for the performance obtainable from the stripline amps.

Dipped-mica capacitors, carrying the Sangamo brand name, were obtained from Amtron-Tyree of 176 Botany St, Waterloo, 2017. They are component importer/distributors and a minimum quantity/price applies.

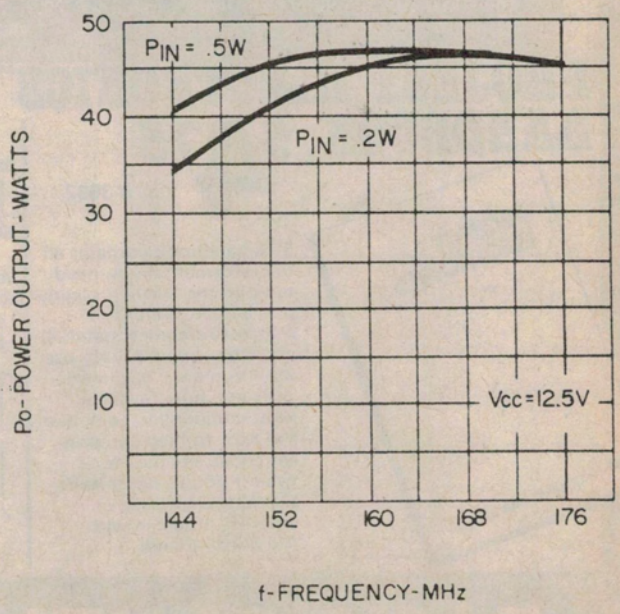
Metal-clad mica capacitors, made by Underwood in the USA, were obtained through the same company.

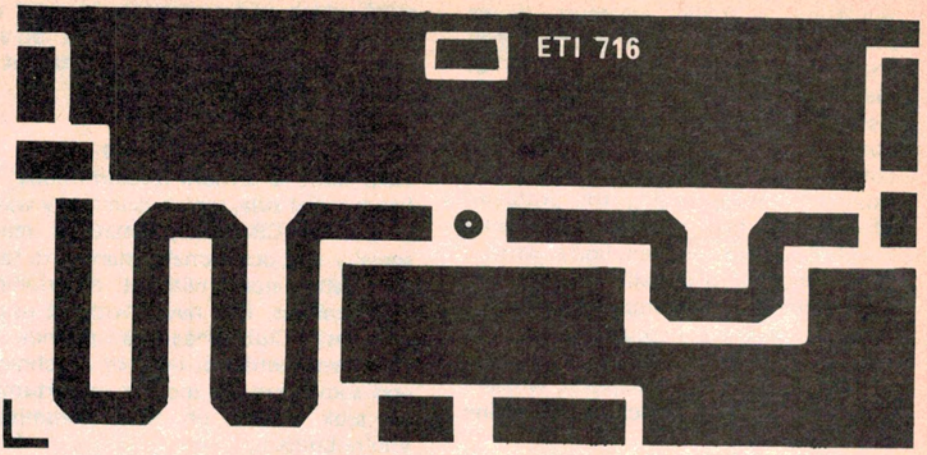
Metal-clad mica capacitors made by Elmenco of the USA, may possibly be obtained through RIFA at P.O. Box 95, Preston, Vic.

The address of Underwood in the United States is:– Underwood Electric (division of Standex Electronics), 148 South Eight Avenue, Maywood, Illinois, 60153, USA.

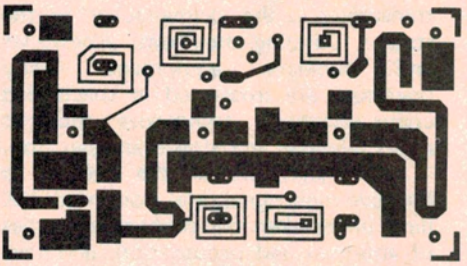
The USA address of Elmenco is:- Elmenco Capacitors, 316 South Service Road, Melville, N.Y. 11746.

Next month we shall conclude with a description of a 140 W stripline amp.



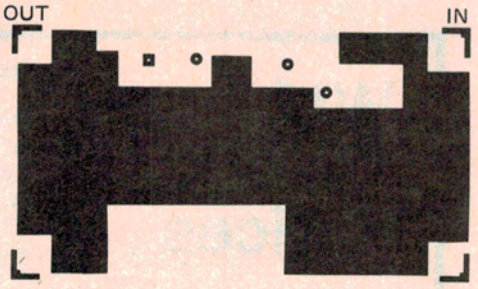


ETI 716 45 W stripline 2 m power amplifier pc board, component side. This is a double-sided board, other side is complete groundplane.

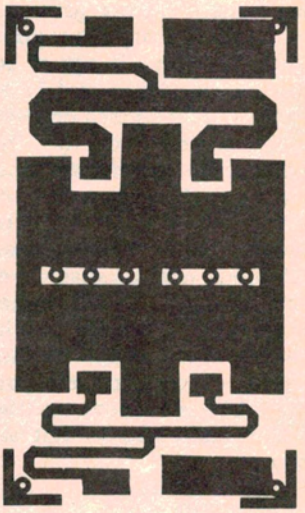


Component side.

40 W, three stage broadband stripline VHF power amplifier pc board. 50% actual size.



Groundplane side.



140 W stripline broadband VHF power amplifier pc board. This is double-sided board, component side. Other side is complete groundplane. 50% actual size.

The reverse of these pages is printed in blue so that the page can be used to directly make Scotchcal negatives and hence (using photo-sensitive resist) finished printed circuit boards. The method of doing this was described in the December 1977 issue of ETI. Back issues are available – see the information on the Reader Services page.