VHF POWER AMPLIFIERS

part 3

Final part of the VHF power amp saga by Roger Harrison VK2ZTB. and Phil Wait VK2ZZQ – and this is where the story really ends, that is the way it is, sometimes.

140 W Microstrip 2 Meter Amplifier

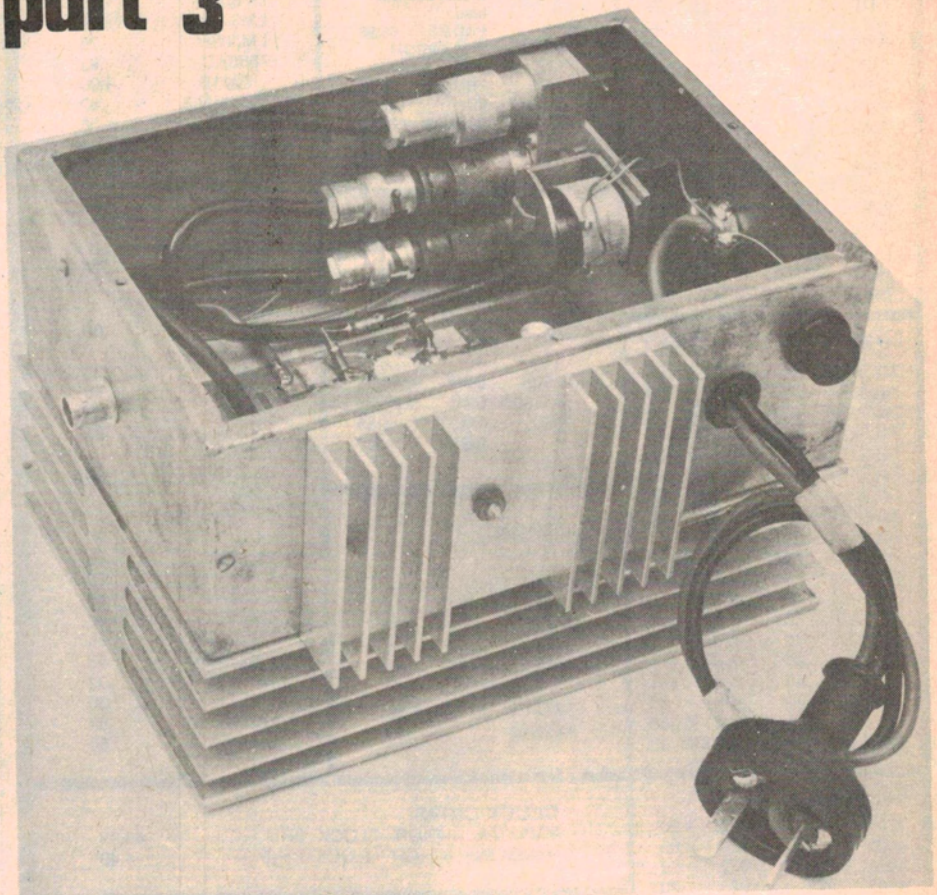
With the introduction of larger VHF transistors it is now possible to construct relatively simple high power amplifiers. The circuit of Fig. 17 shows a 140 W output amplifier using two CTC BM 70-12 transistors. The transistors are used in parallel with separate input and output circuits of 25 Ω impedance, the two circuits combining to make a 12.5 Ω impedance point at C13 and C14.

Stabilization is accomplished by using collector to base feedback networks which have a low impedance to low frequencies applying large negative feedback to prevent oscillations.

Current sharing between the devices is improved by tying the devices together at a high impedance point (relative to the transistor impedance) along the line (12.5 ohms) and tying the bases and collectors together with 15 ohm resistors, R3 and R4.

Underwood metal clad mica capacitors are used throughout because of their low series inductance and high current capacity. They cannot be substituted. Elmenco trimmers are used for C13 and C14. These were not variable in the original design but were found necessary to optimise the matching at two metres.

Bias can be applied for linear operation using one of the bias circuits. described in November and 140 watts pep can be achieved before flat topping.



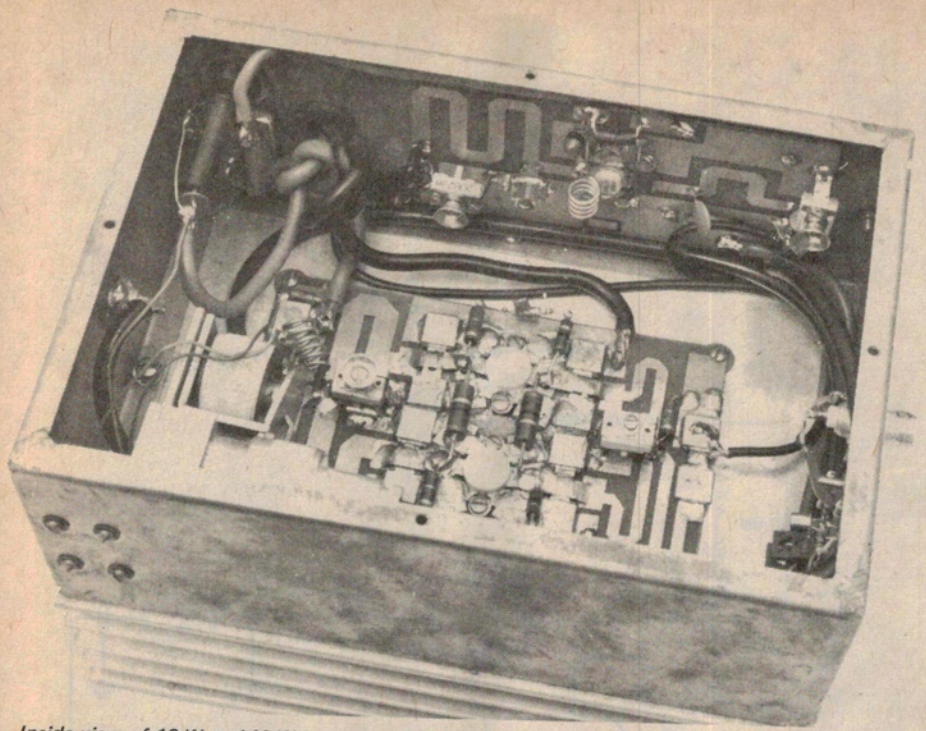
Overall view of the 10 W to 140 W amplifier used for 2 m mobile operation. Note size of the main heatsink – designed for continuous operation! Heatsink for the ETI 716 driver in the foreground. Mounted on the inside back panel is the changeover relay. The fuse holder proved inadequate for the job as around 25 amps is pulled from the car battery when you hit the button!

Construction

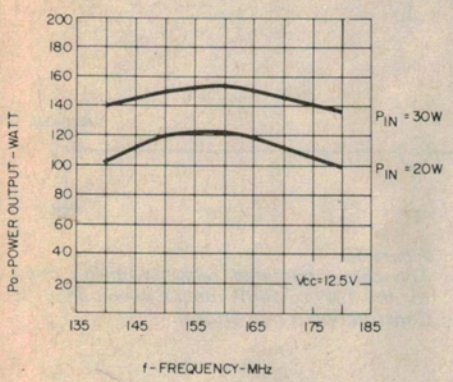
The pc board layout is shown on page 75. This layout will work for G-10 glass filled epoxy board with a thickness of .062" = 1.6mm. Other types of pc board can be used, however, microstrip line length and widths will have to be corrected! The pc board has copper foil on both sides. One side is etched to form the pattern and the other side is used as a ground plane.

The recommended assembly procedure follows:

1. Trim the board to size.
2. Punch or drill 10 tap holes for 6BA screws (no. 43 drill). Hole centres shown as small dots on the pc layout.
3. Use the pc board for a template and lay it on the heat sink. Drill 8 pilot holes into the heatsink using the previously drilled holes in pc board as guides. Drill one in each corner and one in each side of the device mounting hole. Drill out centre holes where the transistors mount.
4. Tap the 8 heatsink holes for 6BA screws.
5. Use a file to clear the mounting hole for the BM70-12 flange. Check transistor for flange dimension.
6. Use 10 mil copper shim stock to connect top side ground points to the ground plane (bottom side). Make one ground plane connection under each emitter lead. Two additional ground plane connections are made by folding the shim stock over the edge of the board to ground the case of C15 and C18.
7. Study photograph very carefully. first, mount the BM70-12 into position. Locate the shunt capacitors as shown in the photograph and spot solder the case to ground. Remove the BM70-12 and mount copper straps L1 and L2. Notice that these straps mount on top of the capacitor



Inside view of 10 W to 140 W broadband power amplifier used on 2 m band. Input on the right, output on the left. The ETI 716 drives the 140 W output broadband amplifier utilising two BM70-12's. By a fortunate accident, the ETI 716 pc board was made laterally reversed! Simplified cabling arrangements. The carrier-operated switching and bias circuits are located on a small board on the lower right.



leads and the base and emitter leads will mount on top of the straps. Solder all capacitors and straps carefully to avoid shorts. Mount the BM70-12 and solder its leads near the cap. Repeat Step 7 for Q2.

8. Mount remaining shunt capacitor and miscellaneous components as shown in photograph.

Performance

The power bandwidth is shown on the graph. The performance at 146 MHz was improved by making C13 and C14 variable.

Power output – 140 watts
Power input – 30 watts
Efficiency – 50%
Supply voltage – 12.5V
Supply current – 23 amps
Max supply voltage – 16.0V
Spurii – better than 60dB down

This amplifier is fully protected against infinite VSWR. In fact a 10 mm spark can be drawn from the output terminal to a key ring with the antenna removed. We did it and the amp still worked!

Using the ETI 716 and the 140 W Amp

How about 140 watts output mobile? The ETI 716 was mounted in the same case as the 140 W amp and used to drive it. See Fig. 18.

A coax relay was used on the output with diode switching on the input. The ¼λ coax line was used with the delay which shorted the unused contacts to earth on transmit, therefore shorting the end of a ¼λ line which reflects an open circuit at the amplifier input. The exact length of this line will have to be measured with an impedance meter or by cut and try method due to the effects of the coax fittings into the relay and the length of line inside the relay itself to the shorting contacts.

If a shorting type relay is not available, normally open contacts can be used with a ½λ line which again reflects an open circuit at the amplifier input. This line must also be measured in situ due to the effects of the relay.

Switching

A carrier operated relay circuit is included in Fig. 18. A small portion of the drive signal is tapped off via the 1pF capacitor, rectified and used to drive the BC109-179 pair which switches the coax relay. A delay is introduced if the 10μF capacitor is switched in giving fast-attack slow-delay switching for SSB use. This simple circuit is very effective and will operate on less than a watt input.

Heatsinks

Heatsink requirements for these amplifiers depend on the type of service. However maximum heatsink temperature should not be allowed to rise above 100°C from a 30°C ambient.

For the ETI 716 amplifier the recommended heatsink would be better than 2.3°C/watt rating – for the 140 watt amplifier better than 0.5°C/watt.

$$\text{H.S.} = \frac{\Delta T^0 C}{\text{power dissipated (watts)}}$$

Always use heat conducting compound between the transistor and the heatsink and be sure that the heatsink is *perfectly smooth and flat.*

Parts List

C1, C3	two each 68p or 69p metal-clad mica caps.
C2, C4	two each 200p metal-clad mica caps.
C5, C7	two each 100p metal-clad mica caps.
C6, C8	two each 68p metal-clad mica caps.
C9, C11	1500p redcap or hi-k ceramic
C10, C12	1μ 35V DC tantalum (metal-case type)
C13, C14	40p Elmenco mica compression trimmer in parallel with 25 to 47p metal clad mica cap. – or 115p Elmenco trimmer.
C15, C18	33p metal-clad mica caps.
C16, C17	300p metal-clad mica caps
R1, R2	15 ohm ½W resistors
R3, R4	15 ohm 1W resistors
RFC1	0.33μH moulded RFC.
RFC2, RFC3	0.15μH moulded RF chokes
RFC4	6 turns, 18g tinned or enamel wire, 6mm i.d., 15mm long.
L1, 2, 3, 4	copper strap, 5mm wide x 20mm long x 0.4mm thick (0.2 x 0.75 x 0.015 mil)
Q1, Q2	CTC BM70-12.

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What Next?

The last 10 years or so have seen the introduction of commonly available RF power transistors to 150 W power output and others that operate to 3000 – 4000 MHz.

The next generation of devices are likely to be VMOS power FETS. Already available is a device which gives 20 watts output at 160 MHz, has a gain of 15dB, a drain impedance of around 60 ohms, is completely indestructable, can be used in a broadband circuit flat from 30 – 250 MHz and if that's not enough can be used for the front end transistor as well with a noise figure of 2.4dB!

Acknowledgements

The authors wish to thank Sydney University Department of Electrical Engineering for their help in providing much of the test equipment used. We would also like to thank Ian Little of Ampec Engineering for generously supplying us with the VHF power amp evaluation kits and copious amounts of data on the CTC range of transistors used in these projects.

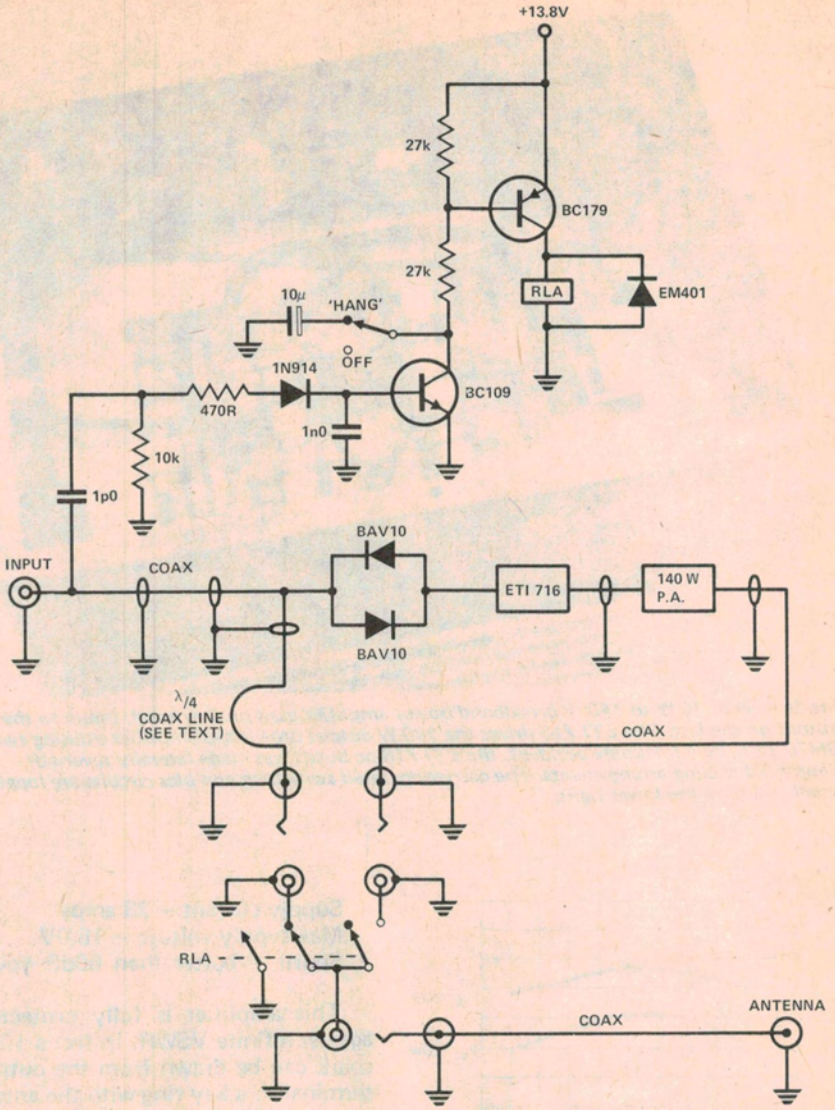
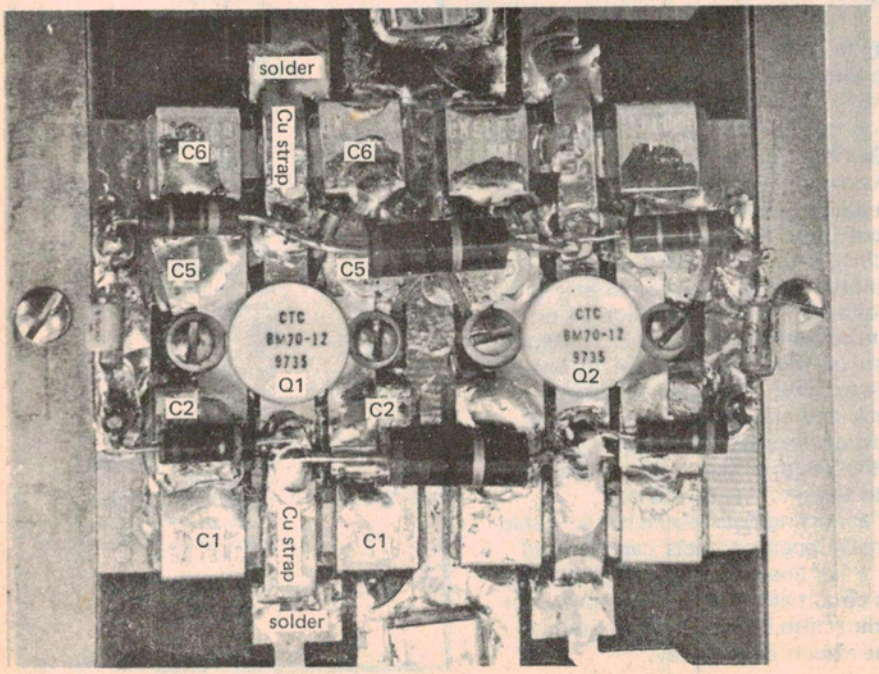


Figure 18.
The carrier-operated relay switching circuit for the 10W to 140W mobile power amplifier. Construction is non-critical.



Pix 6
Close view of portion of the 140W amplifier showing mounting of the transistors, metal-clad mica capacitors and small components.

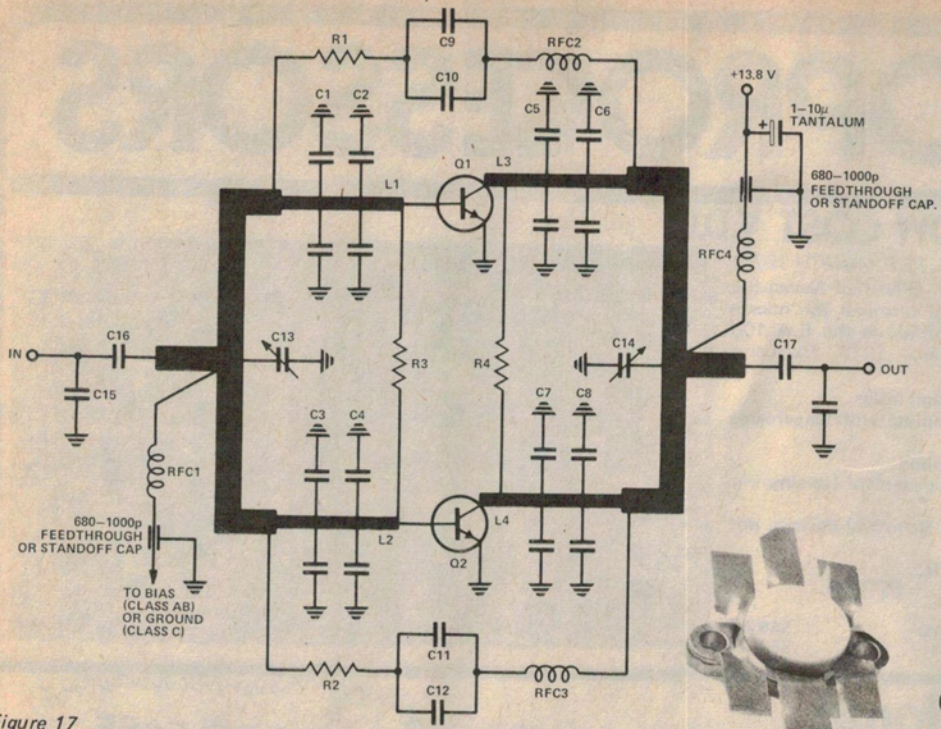


Figure 17
Circuit of the 140W stripline broadband VHF power amplifier. Two BM70-12's produce around 140W output from about 25W drive. Bandwidth extends from 140 to 180 MHz. Construction is illustrated in the photographs. The DC input power may be reduced by simply reducing drive power or the DC supply voltage.

THE BM70-12 PACKAGE

References

Not a definitive list, but certainly 'required reading'.

1. "Matching Network Designs with Computer Solutions", by Frank Davis; Motorola Applications Note AN-267.
2. "Practical VHF and UHF Coil-Winding Data", by Donald Kochen, K35VC; 'Ham Radio', April 1971, pp. 6–14.
3. "Solid State Two-Metre FM RF Power Amplifiers", by Arthur R. Hall, W4CGC; 'Ham Radio', April 1973.
4. "Mounting Stripline-Opposed-Emitter (SOE) Transistors", by Lou Danley; Motorola Applications Note AN-555.
5. "Transmitter Power Amplifier Design", by W.P. O'Reilly; Wireless World, September-October-November 1975 – January 1976.
6. "40 Watt, 12 Volt VHF Broadband Power Amplifier", by Robert Artigo, CTC Applications Note 2.1.8.4D.
7. "140 Watt, 12 Volt VHF Broadband Power Amplifier", by Robert Artigo, CTC Applications Note 2.1.8.4E.
8. "Microstrip Transmission Line", by James R. Fisk, WIHR; 'Ham Radio', January 1978, pp. 28-37.