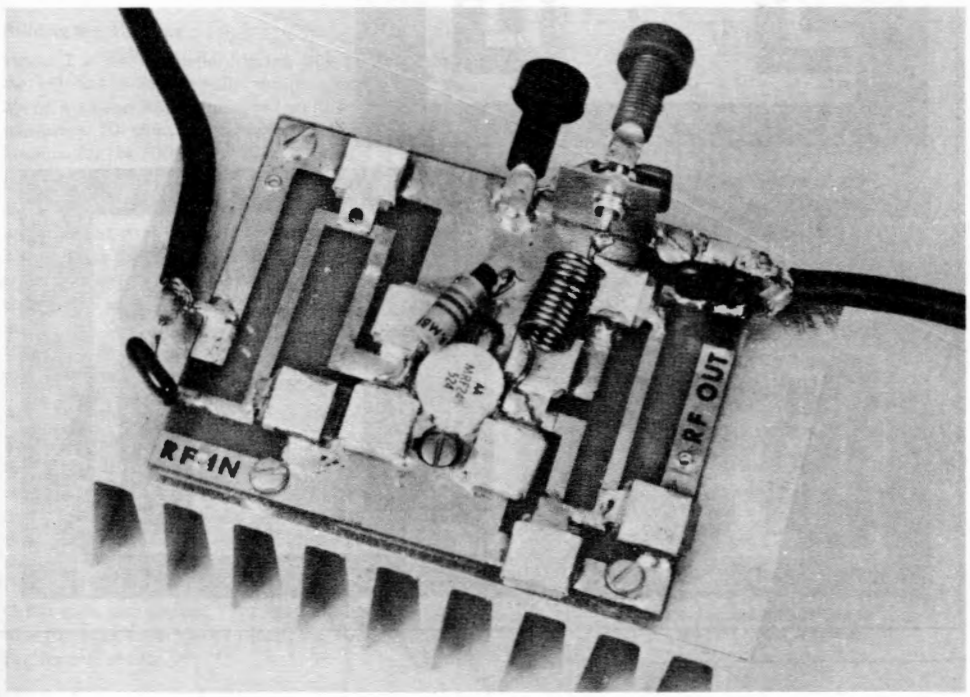
A SINGLE-DEVICE, 80-WATT, 50-OHM VHF AMPLIFIER

Prepared by
Tom Bishop
RF Circuits Engineering

The introduction of MRF245, an internally matched CQ* transistor for 12.5-volt operation, now makes possible single-device, 80-watt amplifiers operating at VHF bands at or below 175 MHz. This engineering bulletin describes the design and construction of an amplifier using a single MRF245 and providing 80 W with 9.4-dB gain across the 143- to 156-MHz band. Modifications of the basic amplifier for operation across broader bands are also discussed.

The RF Transistor—MRF245

The MRF245 is rated at 80 watts power output, 175 MHz, at 12.5 Vdc with a minimum of 6.4-dB gain. It features a T-type input matching in a CQ package for optimum broadband characteristics. This rugged device will withstand a 20:1 VSWR at all phase angles at rated operating conditions.



The Building Block Amplifier

The amplifier operates across the 143- to 156-MHz band with approximately 9.4 dB of gain. Eight watts of drive at 13.5 Vdc produces 80 watts of output power. With minor matching changes, the amplifier will operate across the 155- to 175-MHz band with typically 9.0-dB gain. Efficiency averages 60% across the bands, varying slightly with each variation used. The second harmonic at 150 MHz is -40 dB (40 dB below 80 W) without an output filter. Each version has been built and tested at a 20:1 VSWR mismatch at all phase angles with no degradation.

Building the Board

The basic amplifier is built on 57-gram, copper-clad, double-sided, printed circuit board measuring 6 x 7.7 cm. The material is G10, $\epsilon_r \approx 5$, t = 0.16 cm. Figure 1 is a 1:1 photomask for the top and bottom of the amplifier. Dots on the mask signify positions where eyelets are used to effectively interconnect the grounds on the top and bottom of the board. These are USM Electronic Eyelets "S-6084" or equivalent.

The series tuning inductors are printed strip lines with the ground plane removed beneath them. This technique reduces the I^2R losses and improves the consistency of these critical elements. The elements are referred to as airlines or airstrip inductors later in the text. The letter "Q" signifies the placements of 4-40 screws used to fasten the board to the heatsink.

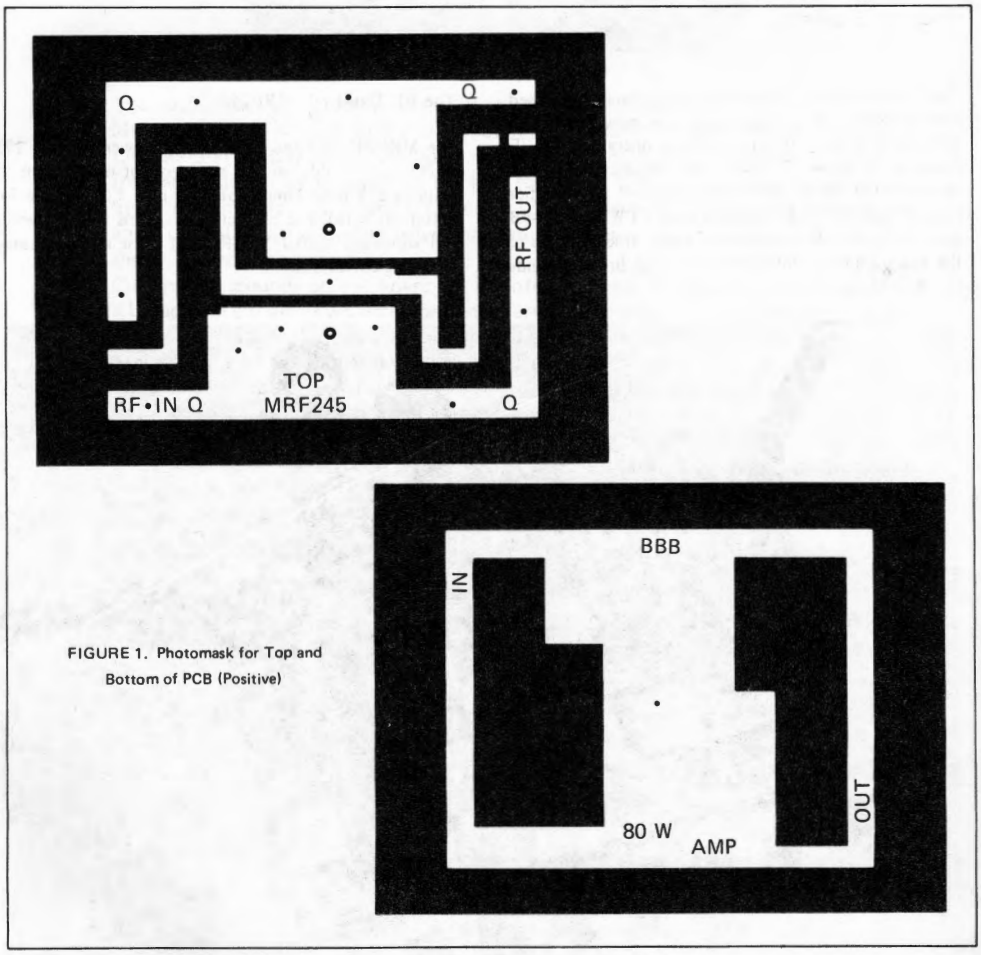
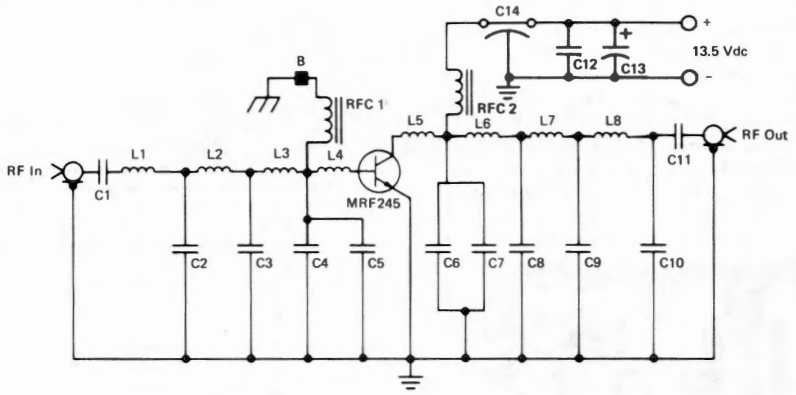


FIGURE 1. Photomask for Top and Bottom of PCB (Positive)



C1, 11 – 500 pF Dipped mica
C2, 9 – 10 pF UNELCO
C3 – 60 pF UNELCO
C4, 5 – 250 pF UNELCO
C6, 7 – 250 pF UNELCO
C8 – 80 pF UNELCO
C10 – 40 pF UNELCO
C12 – 0.1 μF Erie Redcap
C13 – 1 μF Tantalum
C14 – 680 pF Allen Bradley Feed-Thru

RFC 1 – 0.15 μH Molded choke
RFC 2 – 10 T NO. 18 AWG Enameled Wire, 1/4" I.D.
B – Ferroxcube Bead 56-590-65, 3 Beads

L1 – 1.2 X 0.3 cm Airline Inductor
L2 – 3.5 X 0.3 cm Airline Inductor
L3 – 4.0 X 0.3 cm Airline Inductor
L4, L5 – 0.3 X 0.3 cm Airline Inductor
L6 – 2.7 X 0.3 cm Airline Inductor
L7 – 0.8 X 0.3 cm Airline Inductor
L8 – 3.0 X 0.3 cm Airline Inductor

Board: G10, $\epsilon_r \approx 5$, t = 0.16 cm, 57 gm, Copper-Clad
connectors = BNC

FIGURE 2. Circuit Schematic of 80-Watt, 143–156-MHz Power Amplifier

4.2

Building the Amplifier

Figure 2 is the schematic diagram, with parts list, for the 143- to 156-MHz amplifier version. The base matching network consists of a three-section "L" network that transforms 50 ohms to the optimum broadband and load-line for the MRF245 at 80 watts.

Placement of the fixed capacitors is not extremely critical, but it is suggested that the top view photograph be used with the given "airline" measurements from Figure 2 to optimize performance. UNELCO capacitors or their equivalent are important due to the very high currents encountered in these components at 80 watts. In experiments, the "dipped mica" variety of capacitors were found to change values and sometimes overheat after prolonged use.

Assembling the Amplifier on a Heatsink

Since airstrip inductors are used, it is important to keep the PC board clear of the heatsink to minimize RF losses and maintain inductor value. Insert a nut or spacer, 0.2-cm thick, between the board and the heatsink and put the 4-40 screws through the nuts. Figure 3 illustrates this idea. Be sure to put a thin film of thermal compound, Dow-Corning 340, on the heatsink of the transistor to obtain good heat transfer. The heatsink should be flat, with curvature under the part limited to +0.025, -0.000 cm, for best results.

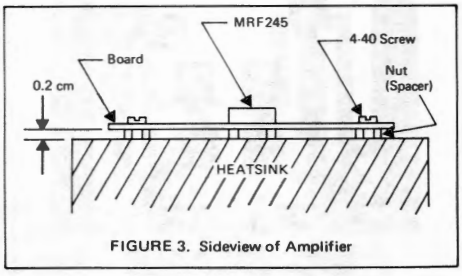


FIGURE 3. Sideview of Amplifier

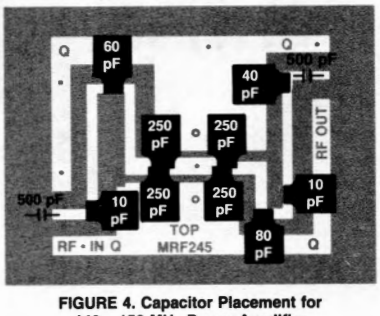


FIGURE 4. Capacitor Placement for 143 – 156-MHz Power Amplifier

Frequency Band Options

Simple modifications can be made to the board layout to change the bandwidth performance of this amplifier. Recommended component value changes and placements are provided in Figures 5 and 6. Figure 5 shows the placement and values for the 155- and 175-MHz amplifier, Figure 6 the changes for the 143- to 170-MHz amplifier. Both amplifiers are capable of 80 watts output at 12.5 Vdc and are able to withstand a 20:1 VSWR.

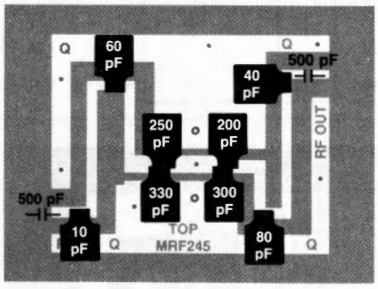


FIGURE 5 — Parts Placement for 155 – 175-MHz Power Amplifier

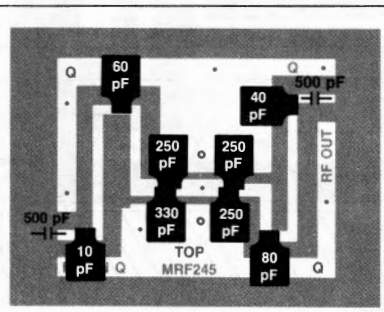


FIGURE 6 — Parts Placement for 143 – 170-MHz Power Amplifier

The measured performance of the 143- to 156-MHz amplifier version is shown in Figure 7.

FIGURE 7 – Performance Data for 143–156-MHz Amplifier at 13.5 Vdc

Frequency MHz	P_{In} W	P_{Out} W	I_C A	Input VSWR
143	10.0	80	12.0	2.1:1
146	9.0	80	11.5	1.8:1
148	8.5	80	11.0	1.6:1
150	8.3	80	11.0	1.5:1
152	8.3	80	10.5	1.6:1
154	8.5	80	10.0	1.8:1
156	9.0	80	10.0	1.8:1

Operating Conditions

The three building block amplifiers, using the MRF245, show gains as high as 3 dB above the data sheet minimums and generally do not saturate until above 100 watts of output power. We recommend, therefore, that the builder monitor his drive power and limit output to 80 watts or less. Beyond this power, the ability of conventional circuit components to withstand very high VSWR mismatches is significantly reduced.

For more information on Transistor Mounting, see AN-555.