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A 30 WATT, 800 MHz AMPLIFIER DESIGN

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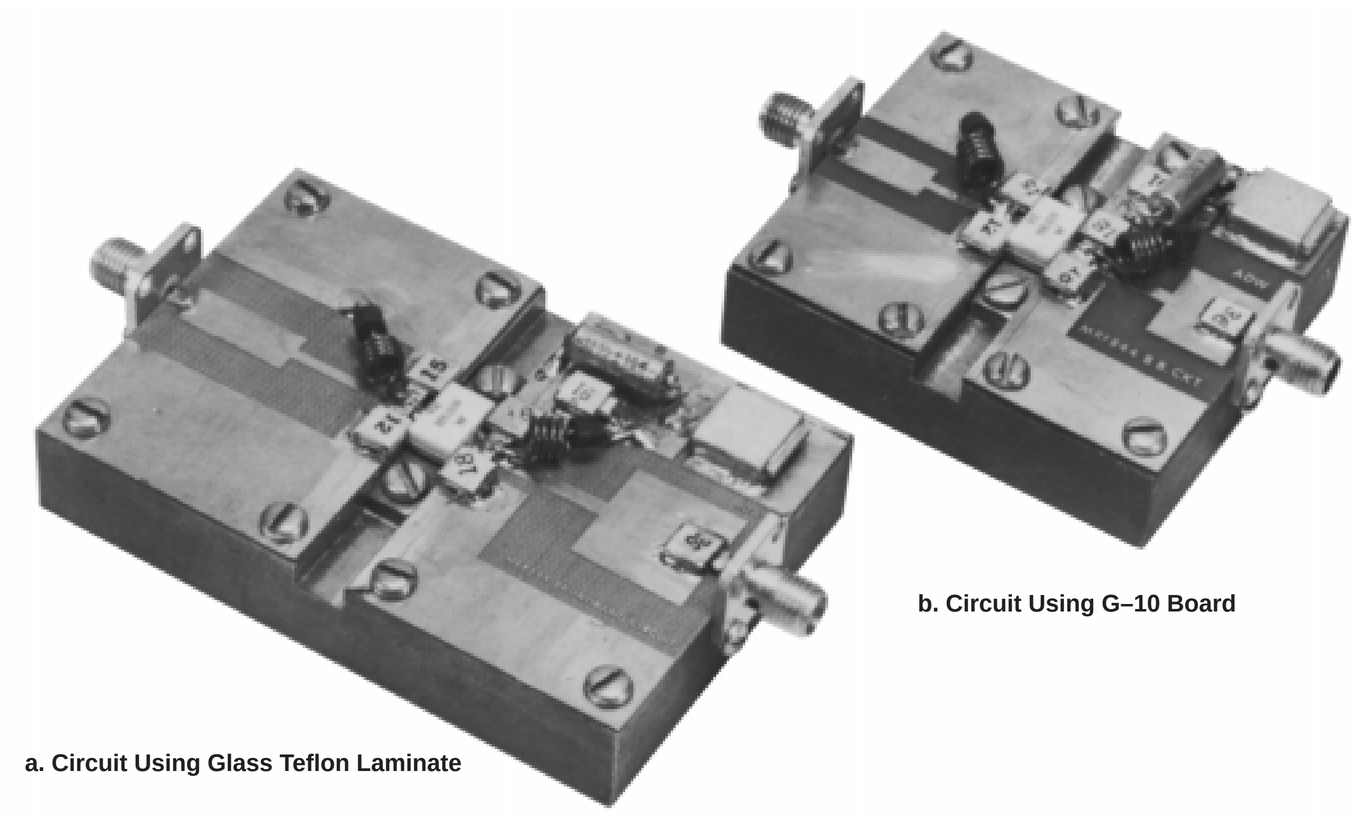
INTRODUCTION

Simplicity and compactness mark the design of this 30 Watt amplifier designed for the 800 MHz mobile communications band. The amplifier uses the internally matched MRF844 transistor in a common base Class C configuration providing a minimum of 5.0 dB gain over a fixed tuned bandwidth of 800 to 870 MHz at 12.5 volts. Lower manufacturing costs are of prime concern to land mobile equipment suppliers and single-board, fixed tuned transmitter amplifier designs are becoming increasingly common. Two versions are therefore presented, one using glass teflon laminate and the second using less expensive G-10 board. (Figure 1).

CIRCUIT DESCRIPTION

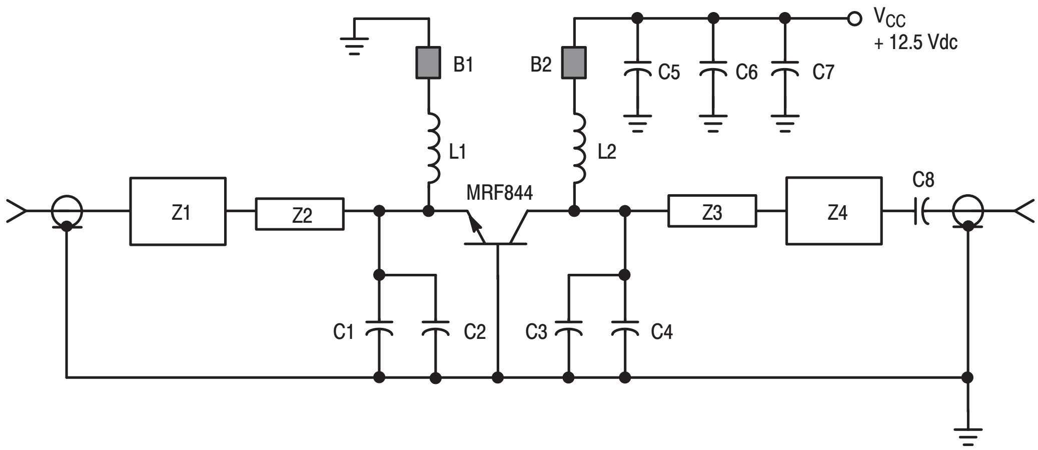
The circuit is designed to be driven from a 50 ohm source and be terminated in a nominal 50 ohm load. Both input and output matching networks are similar in design and consist of two element short-step Chebyshev transmission line transformations fabricated as microstrip lines (Reference 1). Mini-Underwood mica capacitors are used at the input and output of the transistor transforming the complex inductive impedance to an essentially non-reactive real impedance over most of the band. A minimum of additional components provide the dc biasing and RF decoupling. Refer to Figure 2 for a schematic diagram of the amplifier.



b. Circuit Using G–10 Board

a. Circuit Using Glass Teflon Laminate

Figure 1. Two Versions of MRF844 Broadband Circuit



B1, B2 — Ferroxcube Bead 56-590-65/3B
C1 — 15 pF Mini-Underwood Mica
C2 — 12 pF Mini-Underwood Mica
C3, C4 — 18pF Mini-Underwood Mica
C5 — 91 pF Mini-Underwood Mica
C6 — 1000 pF Unelco Mica
C7 — 1.0 µF Electrolytic
C8 — 36 pF Mini-Underwood Mica
L1, L2 — 4 Turns, #20 AWG Enameled Wire 0.15″ ID
Z1 – Z4 — Microstrip; See Photomasters
Board Material — See Text

Figure 2. Circuit Schematic of 30 Watt 806 – 870 MHz Amplifier

Design of microstrip circuits using a G-10 board material is complicated by several factors. This is discussed in detail in Reference 2. The main points to be considered are, the lack of control over the dilectric constant in the manufacturing process; a greater tolerance in the dilectric thickness than in the case of higher quality substrates intended for microstrip applications, and changes in relative dilectric constant with frequency. Despite these apparent disadvantages, G-10 board can be used successfully if the ultimate in bandwidth is not sought.

Frequency dependence of the relative dilectric constant was determined by characterizing a nominal 25 ohm microstrip line over a wide range of frequencies using an automatic network analyser. Compensation for the coaxial to microstrip transitions was established using a computer optimized model (Reference 3). Figure 3 is a graph of the relative dilectric constant versus frequency determined for the laminate used by this method. It should be noted that differences in epoxy composition could affect both the low frequency dilectric constant and its frequency dependence.

CONSTRUCTION PROCEDURES

Both amplifiers were mounted on 0.5″ thick copper blocks, 2.25″ by 2″ in the case of the G-10 board design and 3″ by 2″ for the glass teflon board. The blocks were slotted to a depth of 0.130″ to enable mounting the transistor leads level with the top of the circuit board. Thermal compound was used between the transistor flange and the mounting block to ensure low thermal resistance. With the block held in contact with a larger heatsink this configuration proved adequate for test purposes. In a production design, the transistor would normally be thermally connected to the case of the transmitter. However, care should be taken to operate the device under all conditions within the Power Dissipation limits shown on the data sheet.

As with any circuit designed to work at UHF frequencies, good grounding is essential for best performance and stability. Copper foil was wrapped around the board adjacent to the transistor mounting to connect the underside ground plane to the transistor common leads. Additional copper foil was wrapped around the board to connect the 1000 pF Unelco capacitor pad to the lower ground plane.

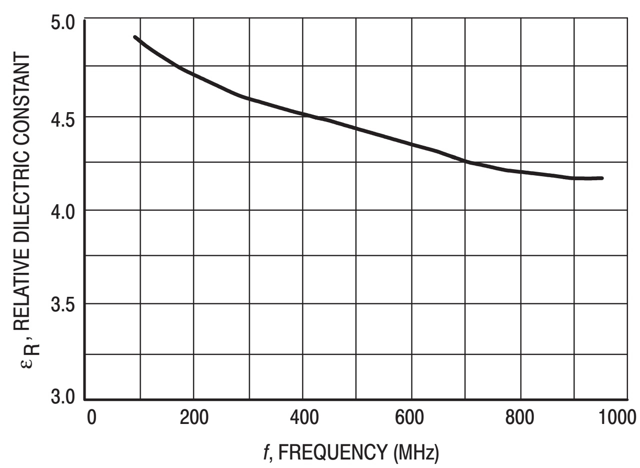


Figure 3. Relative Dilectric Constant (G-10) versus Frequency

Positioning of the emitter and collector shunt capacitors is critical to the resulting amplifier performance. The capacitors should be mounted as close to the transistor case as possible. Minor tuning of the circuit can be achieved by lateral movement of these components. Larger tuning adjustments can be incorporated by replacing part of the fixed shunt capacitance by a variable trimmer.

Both circuits use 28 mil dilectric 2 ounce copper clad laminate. Refer to Figure 6 for a 1:1 Photomaster of the circuit boards.

PERFORMANCE DATA

Similar performance was measured for the same part soldered in either circuit. Typical performance curves for this broadband design are shown in Figures 4a, 4b, and 4c for the glass Teflon design and Figures 5a, 5b, and 5c for the G-10 based circuit. Circuit losses in the G-10 board were less than expected and were certainly minimized by the short fractional wavelength transmission lines employed.

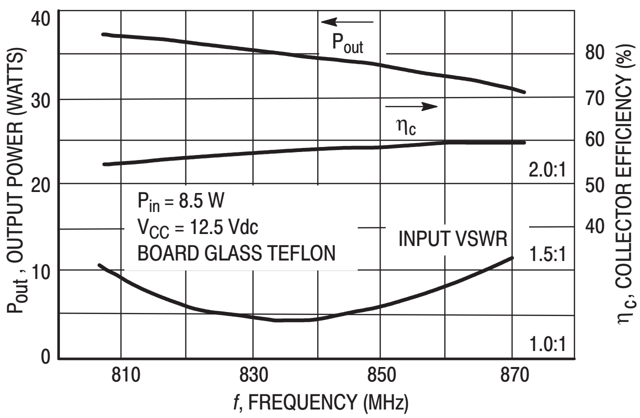


Figure 4a. Typical Performance in Broadband Circuit

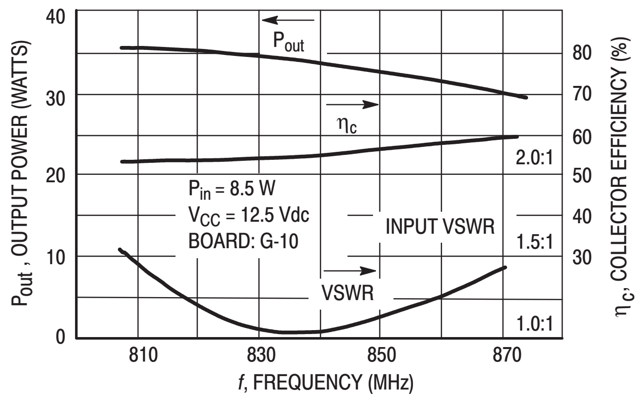


Figure 5a. Typical Performance in Broadband Circuit

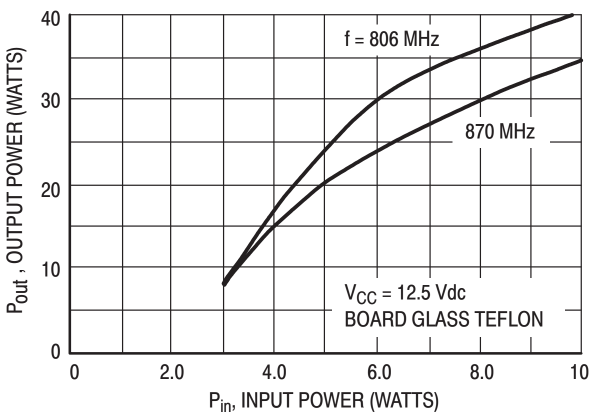


Figure 4b. Output Power versus Input Power

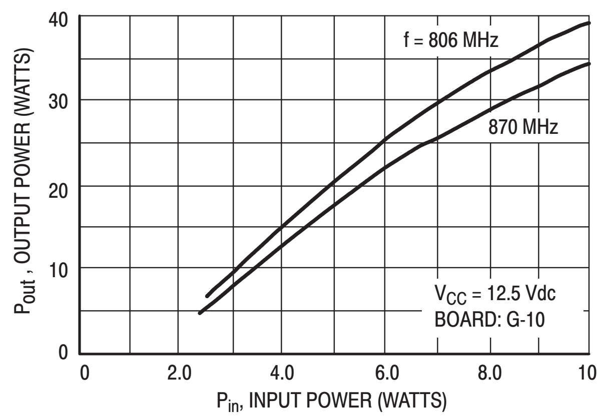


Figure 5b. Output Power versus Input Power

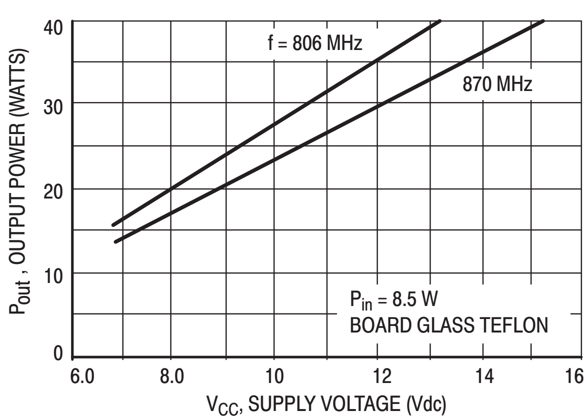


Figure 4c. Output Power versus Supply Voltage

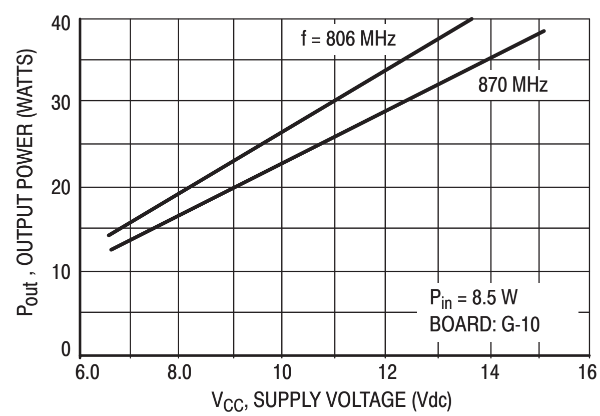
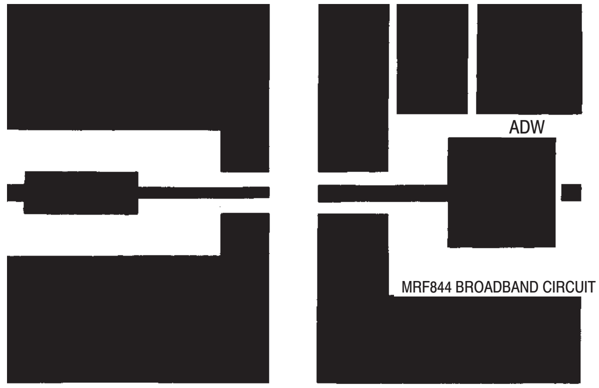
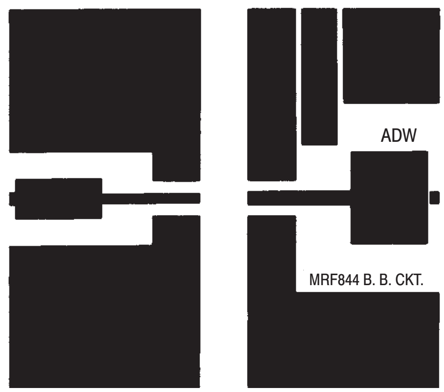


Figure 5c. Output Power versus Supply Voltage

NOTE: Not to Scale



a. Photomaster Using Glass Teflon Laminate



b. Photomaster Using G-10 Board

Figure 4. Two Photomaster Versions of MRF844 Broadband Circuit

REFERENCES

1. G. L. Mattheai. *Short-Step Impedance Transformers. IEEE Transactions on Microwave Theory and Techniques.* Vol. MTT-14 No. 8 August 1966.

2. Glenn Young. *UHF Microstrip Amplifiers Utilizing G-10 Epoxy Glass Laminate.* Motorola Application Note AN-578.

3. M. L. Majewski. *Modeling and Characterization of Microstrip to Co-axial Transistions. IEEE Transactions on Microwave Theory and Techniques.* Vol. MTT-29 No. 8 August 1981.

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