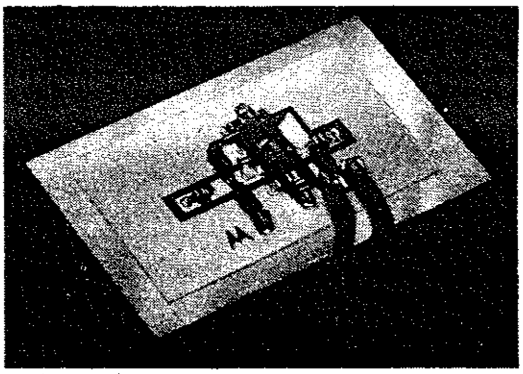
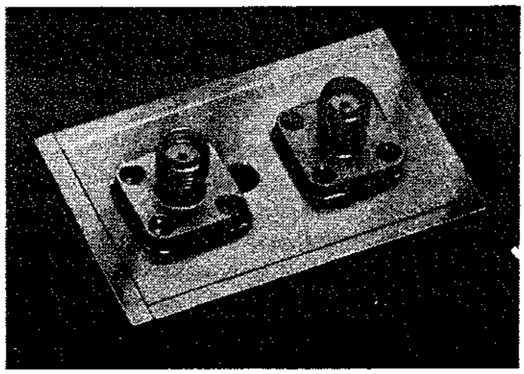
Amplifier Gains 10 dB Over Nine Octaves





By: Mike Hadley

The introduction of Motorola encapsulated transistors fabricated with ion-implanted arsenic emitters has made a reality of economical small-signal amplifiers with bandwidths exceeding 1 GHz. The recently developed MRF901, an example of this technology, has an f_T exceeding 4.5 GHz, and a maximum noise figure at 1 GHz of 2.5 dB. The device package (case 302) employs the Motorola dual emitter bonding concept to minimize parasitic inductance and enhance high-frequency performance.

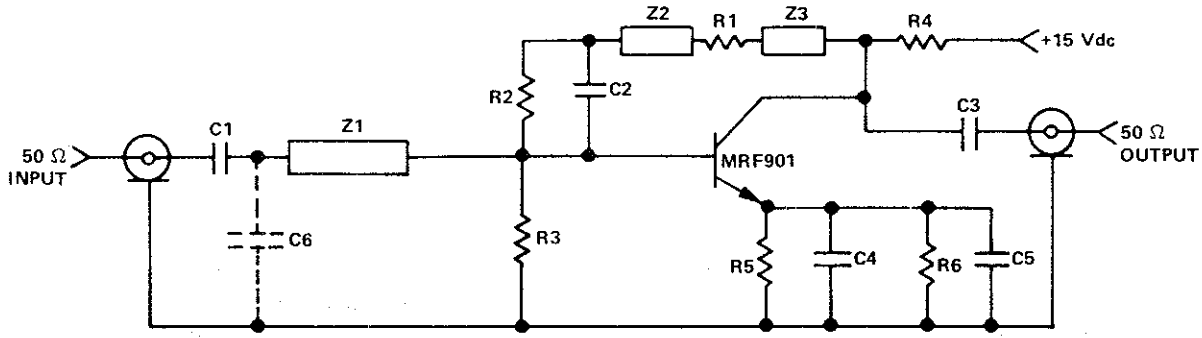
Using the MRF901, an amplifier has been developed which exhibits a nominal gain of 10 dB over nine octaves of bandwidth. The circuit design is a class A amplifier employing both ac and dc feedback. Bias is stabilized at 15 mA of collector current using dc feedback from the collector. The ac feedback from collector to base, and in each of the partially bypassed emitter circuits, compensates for the increase in device gain with decreasing frequency, yielding a flat response over a maximum bandwidth. Transistor S parameters, as provided by the MRF901 data sheet, and computer-aided circuit optimization techniques were used to choose component values for gain flatness, input VSWR and output VSWR. The described performance was achieved using common high-frequency amplifier construction techniques and a standard printed circuit board substrate. Even better results could be expected from the use of today's hybrid circuit technology.

Evaluation of the amplifier shows a nominal 10 dB power gain from 3 MHz to 1.4 GHz. With only a minimum matching network used at the amplifier input, the input VSWR remains less than 2.5:1 to approximately 1 GHz while the output VSWR stays under 2:1 to approximately 1.4 GHz (figure 2). If input impedance matching were of prime consideration, connecting a 2.1 pF capacitor from the junction of C1 and Z1 to ground (C6 in figure 1) would hold input VSWR below 2.2:1 over the complete frequency range (figure 3). Note that a slight degradation in gain flatness and output VSWR occurs with the addition of C6. A more elaborate network design would probably optimize impedance matching while maintaining gain flatness.

The amplifier was built on a glass Teflon® printed circuit board 1.8" x 1.2". A 2:1 reproduction of the circuit pattern is provided in figure 4. The type OSM215 50-ohm input and output connectors were mounted opposite the component side to facilitate laboratory measurements. Board size could be reduced to approximately half by reducing the ground plane around the circuit perimeter. A combination of chip capacitors, chip resistors and standard carbon resistors were used to obtain maximum performance at minimum cost.

Extra care was taken to keep all component lead lengths to an absolute minimum and to provide a good ground plane. In the interest of maintaining a good ground, copper foil was soldered at the board edges to connect the top and bottom circuit grounds, and an eyelet was inserted near each emitter lead.

Figure 1 Schematic Diagram



C1–C3 – 2200 pF chip capacitor
C4 C5 – 6.5 pF chip capacitor
C6 – Optional 2.1 pF chip capacitor
Z1 – 0.3" x 0.125" microstrip line
Z2 – 0.15" x 0.125" microstrip line

Z3 – 0.3" x 0.125" microstrip line
R1 – 200 Ω 1/8 W ±5% carbon resistor
R2 – 4.3 kΩ carbon resistor
R3 – 680 Ω carbon resistor

R4 – 560 Ω carbon resistor
R5 R6 – 15 Ω ±5% chip resistor
Substrate – 1 oz copper, double sided glass Teflon® board 0.0625" thick $\epsilon_r \approx 2.5$
® Registered trademark of DuPont

Figure 2
Gain and VSWR vs Frequency

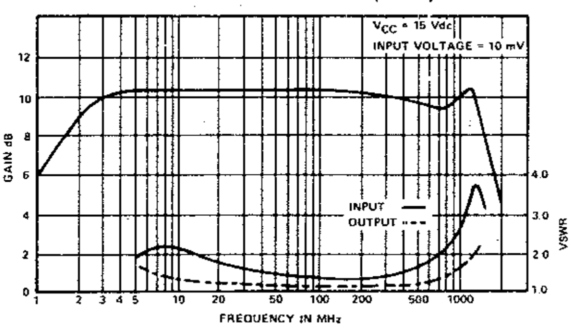


Figure 3
Gain and VSWR vs Frequency with Matching Capacitor C6

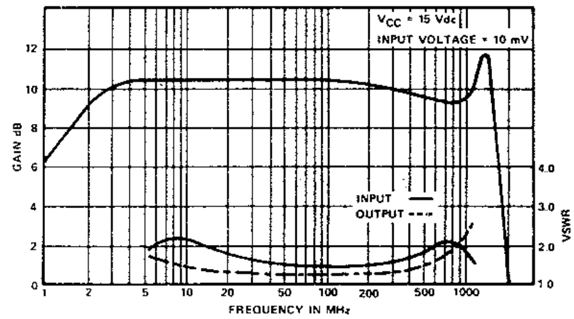


Figure 4. Amplifier PCB Artwork Scale 2:1

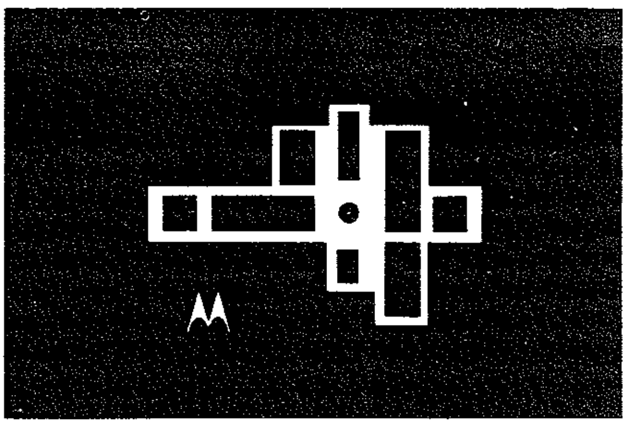


Figure 5. Parts Layout