



A 2-WATT, 2 GHz POWER AMPLIFIER

This application note describes the design of a two-watt, single stage power amplifier at 2 GHz using AMCOM's low cost surface mount plastic package AM072MX-QG series of GaAs MESFETs. This design demonstrates the performance capability of the AM072MX-QG device. The design features simplicity, reliability, repeatability, and outstanding performance. The amplifier delivers two watts of output power and minimum gain of 14 db with excellent linearity, harmonics, and efficiency at 2 GHz.

THE AMPLIFIER DESIGN

The first step in designing a power amplifier is to choose a device and evaluate it by measuring the small signal S-parameters using a network analyzer and measuring large signal parameters using an automatic tuner. Then, an output matching circuit is designed to achieve the required power. Finally, the input matching circuit is designed and optimized for best input return loss and maximum gain. **Figure 1** shows the design topology of the single stage PA. The circuit is a single stage power amplifier driven by a 50-Ohm source and terminated in a 50-Ohm load. Distributed microstrip elements are used in the design. This technique is more efficient than the lumped element technique and is also more reliable and repeatable.

The PC Board material used is Roger's 4003 which has a dielectric constant $\epsilon_r = 3.38$ with thickness of 0.020".

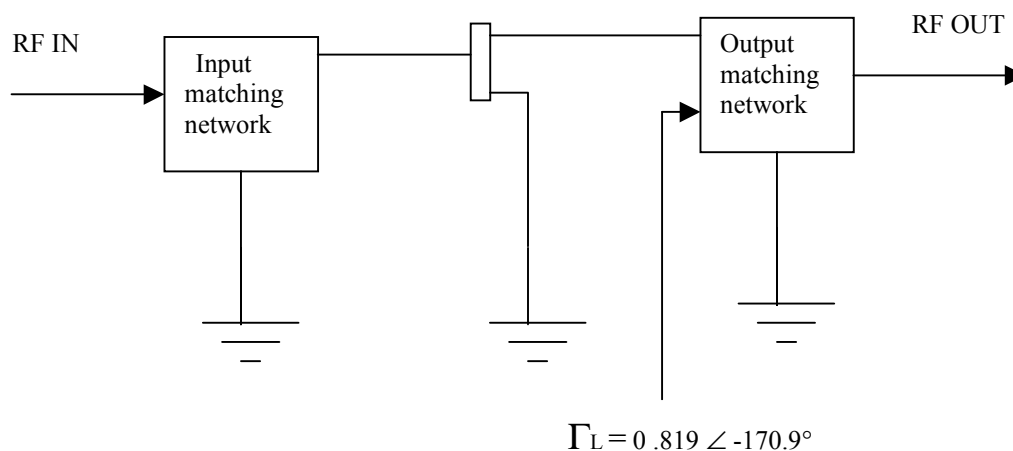


Figure 1.

Output matching network

The main purpose of a power amplifier is to achieve the maximum output power of the device. The output power is determined by the output matching circuit which can be designed to achieve the maximum output power. To do so, it is necessary to determine the optimum load impedance of the FET (Z_L) and design a matching circuit to transform that impedance to 50 Ohms. We used a computer controlled microwave tuner measurement system to measure the optimum load and determined the maximum output power of the device. A typical output power at P1dB of the AM072 MX-QG is 34 dBm. Table 1 shows the optimum load reflection coefficient for a 7.2 mm device at different frequencies. From the table we choose the optimum load at the required frequency. At 2 GHz the optimum load reflection coefficient Γ_L is $0.819 \angle -170.9^\circ$

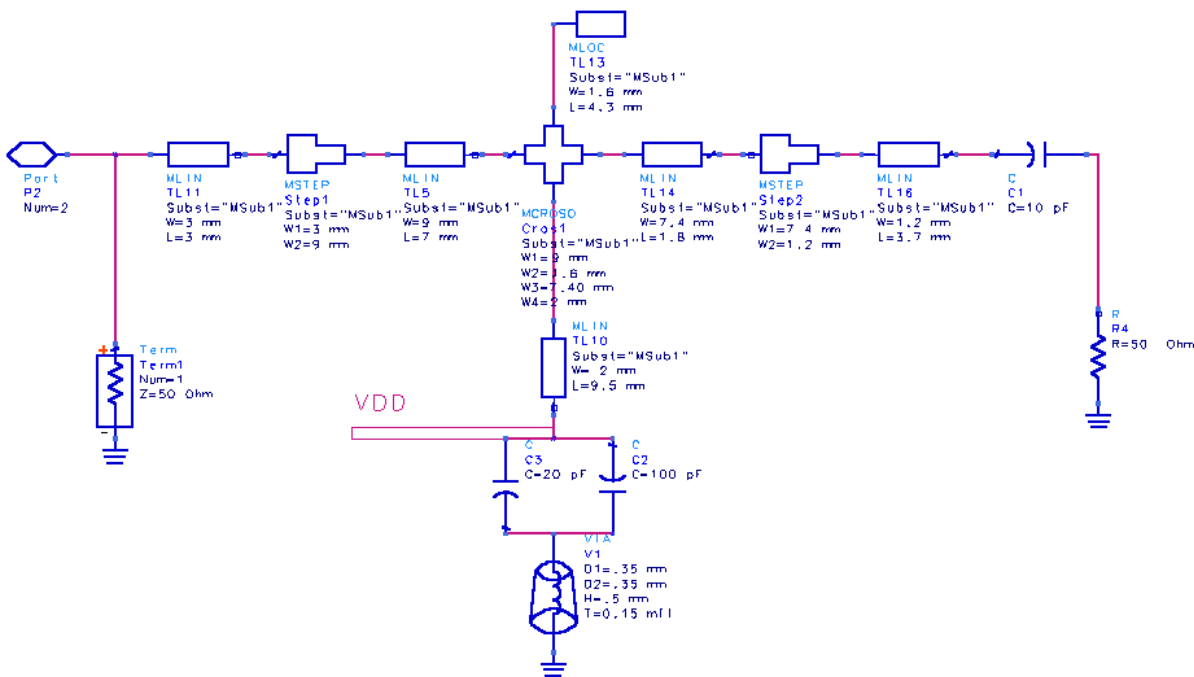


Figure 2.

In order to design the output matching network, we locate Z_L in the Smith chart then use microstrip lines and an open-circuited stub to move from the center of the chart to Z_L . **Figure 2** shows a detailed schematic of the output matching circuit. C1 is a coupling capacitor; C2 and C3 are bypass capacitors; and the short-circuited shunt stub is used for the positive DC bias. **Figure 3** shows the impedance of the output matching network.

Freq GHz	MAG	ANG
1.400	.819	-173.68
1.600	.819	-172.77
1.800	.819	-171.85
2.000	.819	-170.93
2.200	.819	-170.00
2.400	.819	-169.07
2.600	.819	-168.13

Table 1.

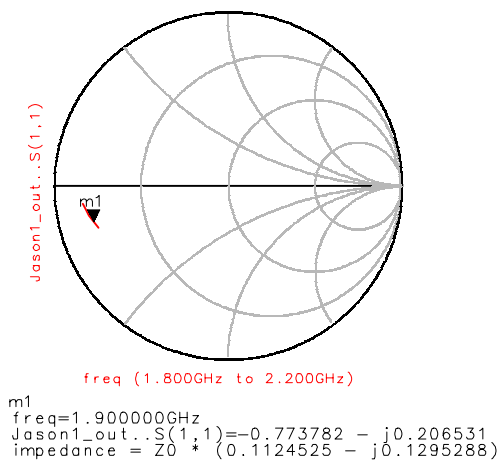


Figure 3.

Input matching network

To design the input matching network, we use the same technique as in the output matching network except the input matching circuit is optimized for the best input return loss and maximum gain. In other words, the measured small-signal S-parameter S11 was matched to 50 Ohms. **Figure 4** shows a detailed schematic of the input matching circuit. Capacitor C1 is a coupling capacitor; C2 and C3 are by pass capacitors; and the short-circuited shunt stub is used to bias the gate.

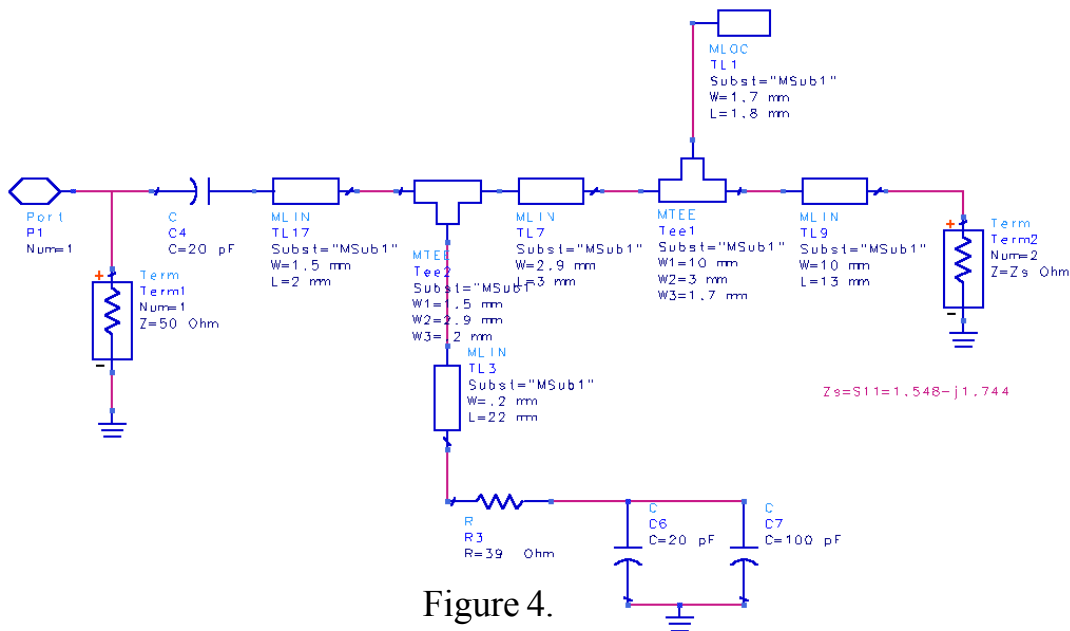


Figure 4.

Another way to design the input matching circuit is to determine the optimum source impedance using the source pull technique and locate Zs on the Z Smith chart; then, design a matching circuit to transform that impedance to 50 Ohms. In this case, slightly more power can be achieved at the output; however, this is at the expense of the amplifier's gain and input return loss.

Figure 5 shows the complete design of the amplifier

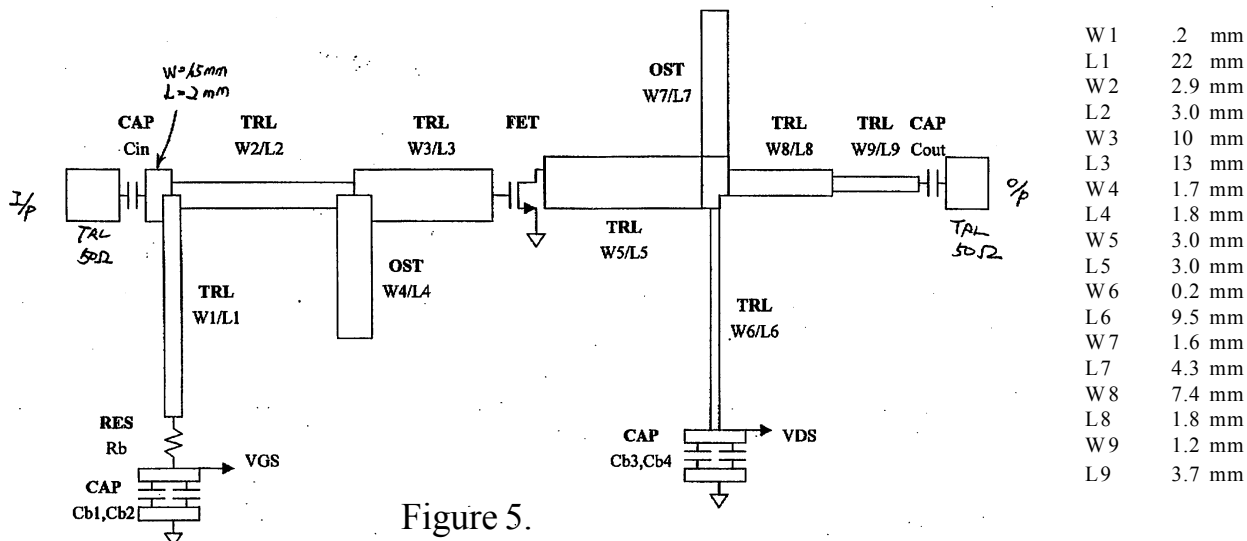


Figure 5.



Amplifier Assembly

Figure 6 shows the layout of the amplifier. Rogers material RO4003 with a dielectric constant $\epsilon_r = 3.38$ and thickness of 0.020" is used as the PC board. The circuit board was mounted on a 2 x 2 x 0.75 inch aluminum block with 6 screws, and SMA connectors were used for input and output ports. Two screws were added to provide a good heat sink.

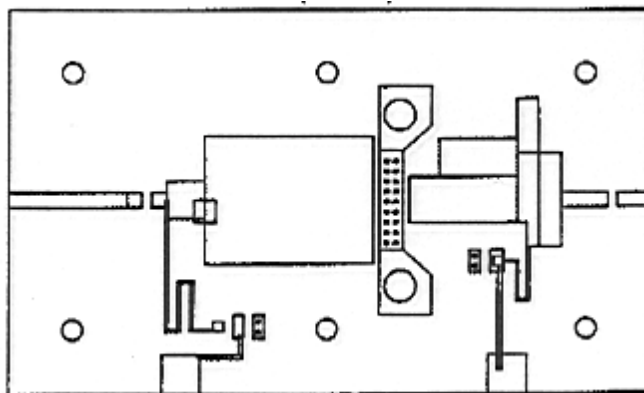


Figure 6.

Measured Performance

Table 2 shows a summary of the amplifier's measured performance at 2 GHz. Figure 7 shows the small signal performance across the frequency range.

Power @ P1dB	33.14	dBm
Third Order Intercept	47	dBm
Gain	15	dB
Output RL	-6	dB
Input RL	-15	dB
Harmonics @ P1dB	-28.8	dBm
DC Voltage	5	Volts
DC Current	0.8	Amp

Table 2.

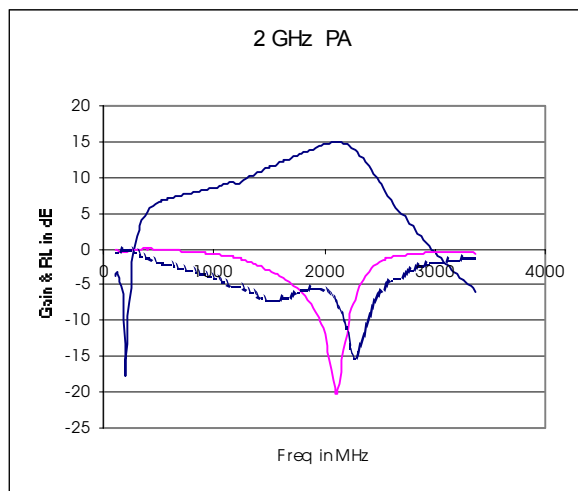


Figure 7.

The AM072 MX – QG device is capable of providing typical power of 34 dBm at P 1dB. The measured power of the amplifier is about 0.9 dB less than the typical output power. The following factors can contribute to this fact:

- 1) Inductance of the source via (about 0.4 dB)
- 2) Input matching circuit is matched for best gain and input return loss but not for best power (about 0.3 dB)
- 3) Circuit losses