AM048MX-QG-R

1.5-WATT, 2 GHz POWER AMPLIFIER

INTRODUCTION

This application note describes the design of a 1.5 watt, single stage power amplifier at 2GHz using AMCOM's low cost surface mount plastic package AM048MX-QG-R series of GaAs MESFETs. This design demonstrates the performance capability of the AM048MX-QG-R device. The design features simplicity, reliability, repeatability, and outstanding performance. The amplifier delivers 1.5 watts of output power and minimum gain of 12db with excellent linearity, harmonics, and efficiency at 2GHz.

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 of εr = 3.38 with thickness of 0.020."

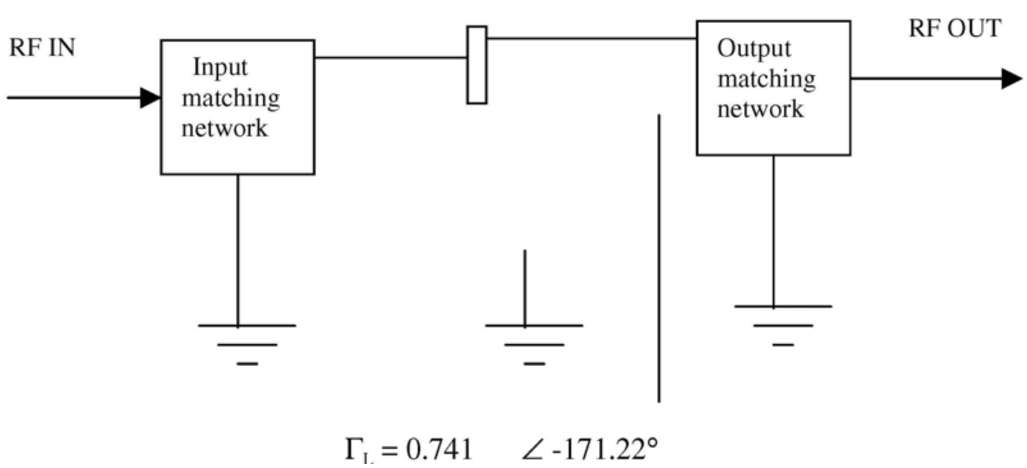

Figure 1

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OUPUT 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) 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 AM048MX-QG-R is 32dBm. Table 1 shows the optimum load reflection coefficient for a 4.8mm device at different frequencies. From the table we choose the optimum load at the required frequency. At 2GHz the optimum load reflection coefficient Γ is 0.741 < -171.22°

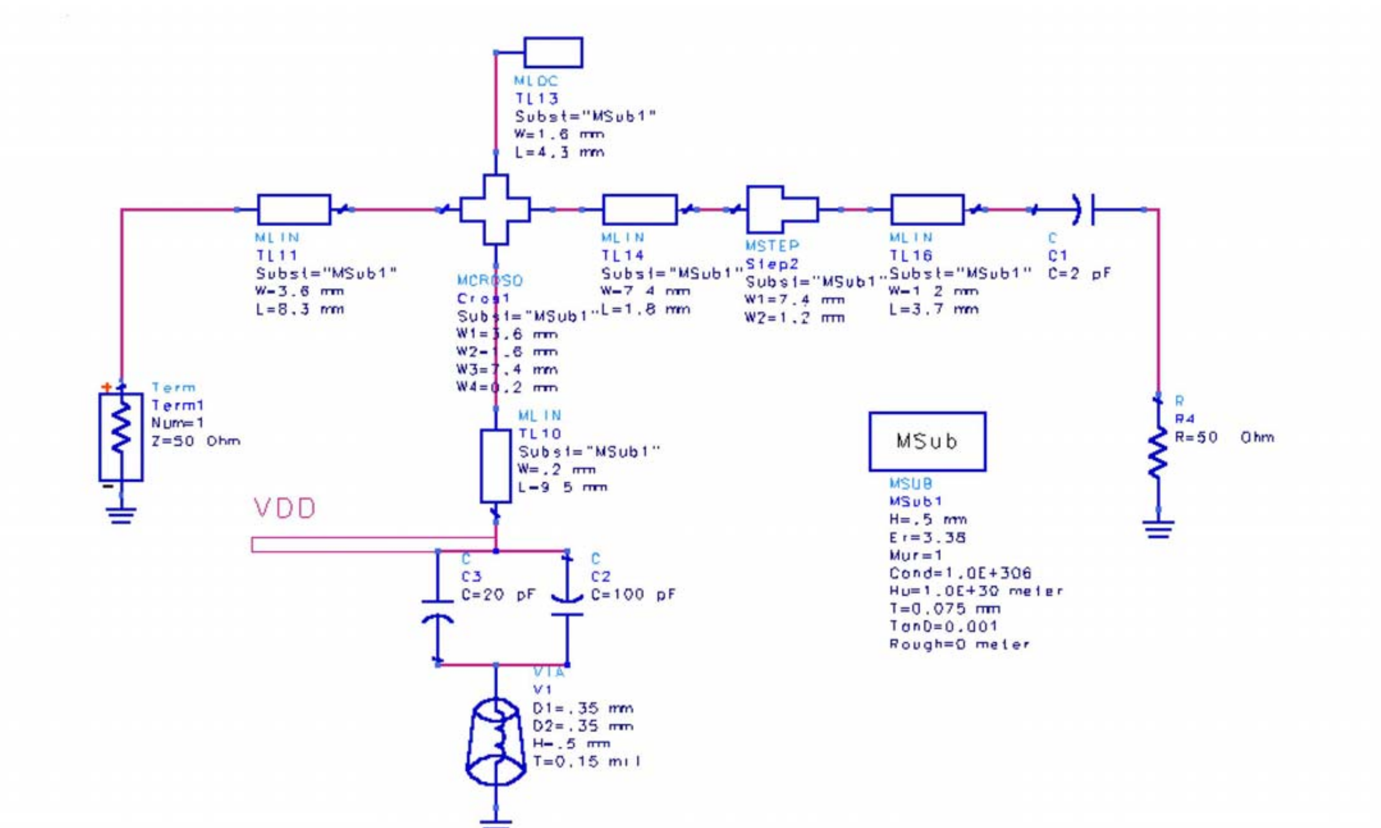


Figure 2

In order to design the output matching network, we locate Z in the Smith chart then use microstip lines and an open-circuited stub to move from the center of the chart to Z. **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	.74	173.9
1.600	.741	173
1.800	.741	172.1
2.000	.741	171.2
2.200	.742	170
2.400	.742	169
2.600	.743	168.5

Table 1

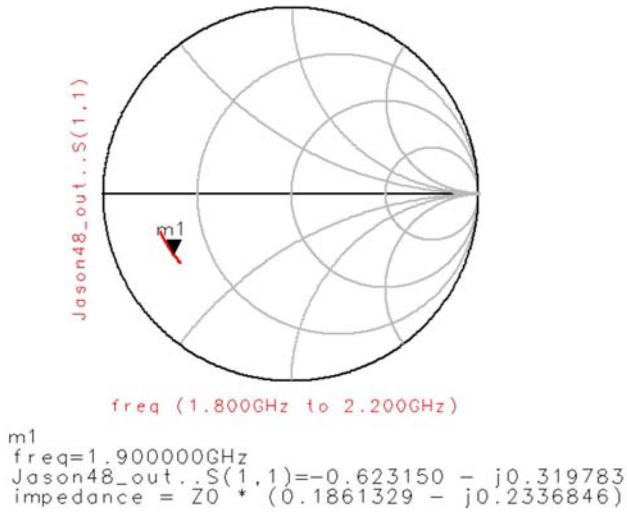


Figure 3

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 C4 is a coupling capacitor; C6 and C7 are bypass capacitors; and the short-circuited shunt stub is used to bias the gate.

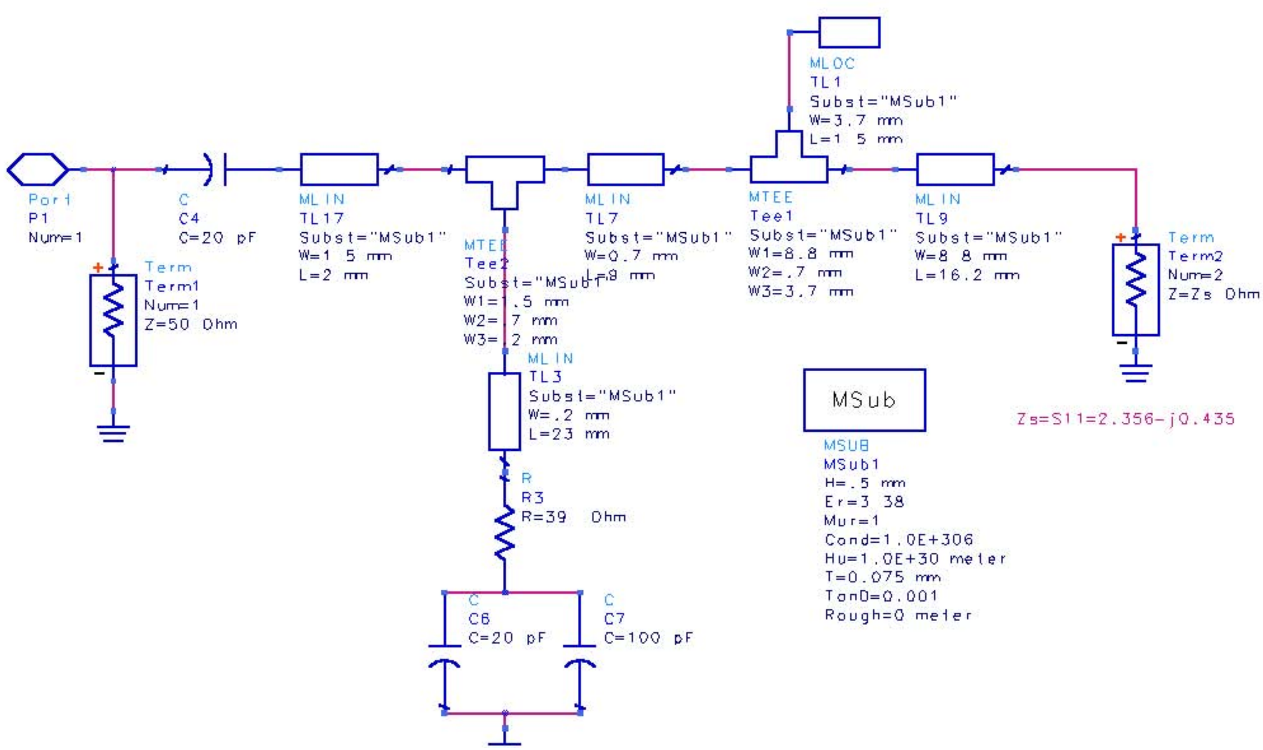
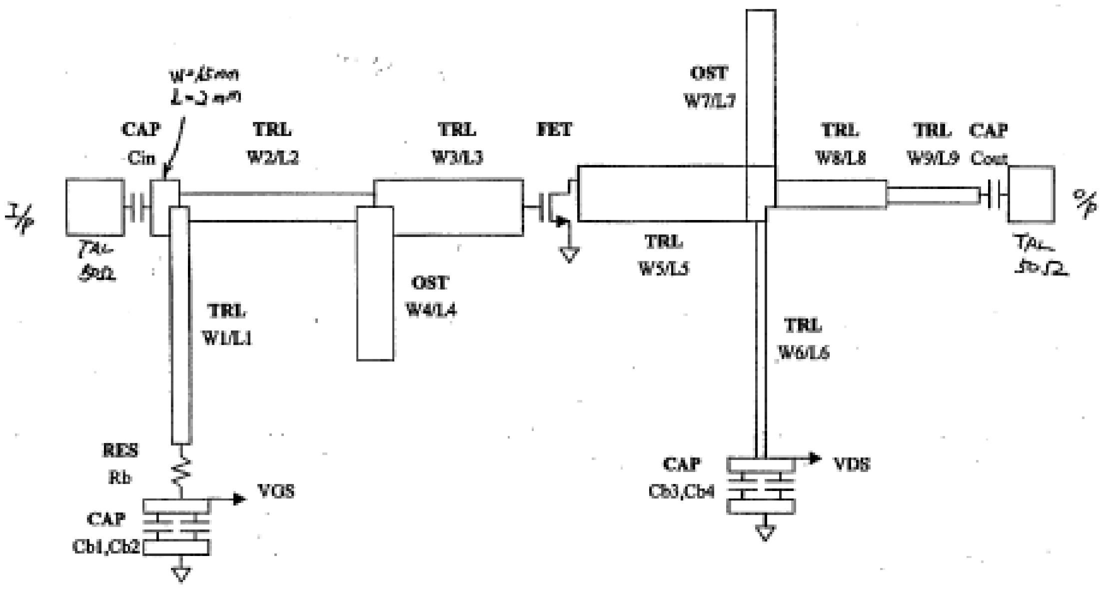


Figure 4

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.



W1	.2	mm
L1	23	mm
W2	0.7	mm
L2	9.0	mm
W3	8.8	mm
L3	16.2	mm
W4	3.7	mm
L4	1.5	mm
W5	3.6	mm
L5	8.3	mm
W6	0.2	mm
L6	9.5	mm
W7	1.6	mm
L7	4.3	mm
W8	7.4	mm
L8	1.8	mm
W9	1.2	mm
L9	3.7	mm

Figure 5

AMPLIFIER ASSEMBLY

Figure 6 shows the layout of the amplifier. Rogers material RO4003 with a dielectric constant εr = 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.

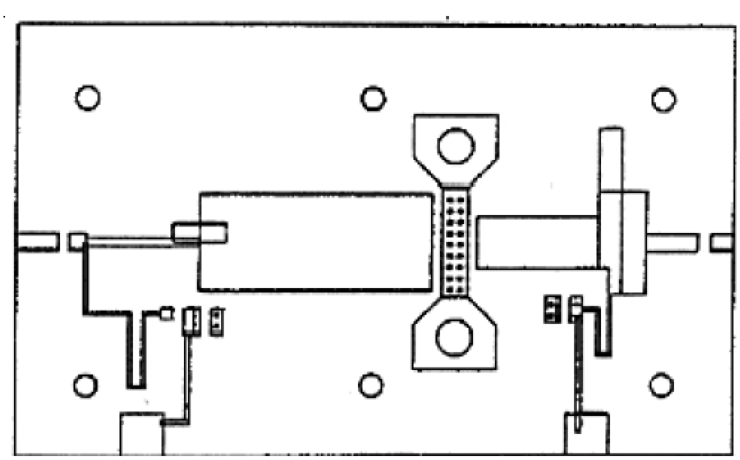


Figure 6

MEASURED PERFORMANCE

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

Power @ P1dB	31.26	dBm
Third Order Intercept	46	dBm
Power Gain	12	dB
Output RL	-6	dB
Input RL	-15	dB
Harmonics @ P1dB	-30	dBm
DC Voltage	5	Volts
DC Current	0.45	Amp

Table 2

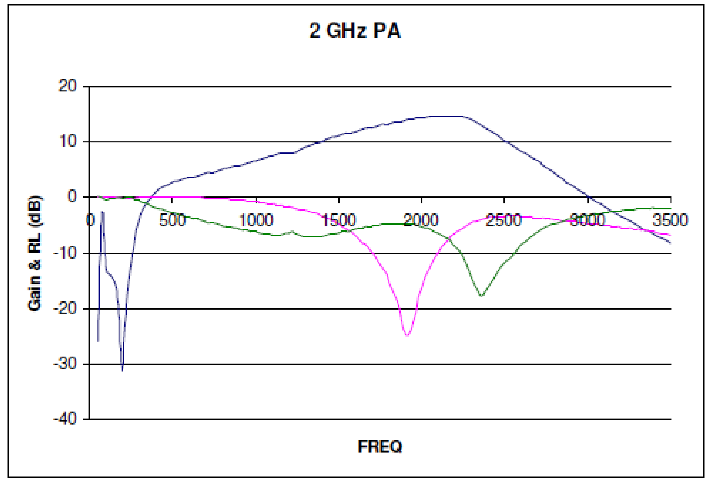


Figure 7

The AM048MX-QG-R device is capable of providing typical power of 32dBm at P1dB. The measured power of the amplifier is about 0.9dB less than the typical output power. The following factors can contribute to this fact:

1) Inductance of the source via (about 0.4dB)

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