

# Low Noise Amplifier for 2.3 GHz using the ATF-36077 Low Noise PHEMT

## Application Note 1129

### Introduction

The Agilent Technologies ATF-36077 PHEMT device is described in a low noise amplifier for 2.3 GHz. The ATF-36077 is characterized for use as a low noise amplifier in 12 GHz DBS applications providing 0.5 dB noise figures. The device is also capable of noise figures below 0.4 dB at 2.3 GHz and below. The chief limitation in lowering amplifier noise figure is matching circuit losses. The amplifier described provides less than a 0.5 dB noise figure and greater than 15 dB of associated gain.

### Design

Typical low noise amplifier designs for 2.3 GHz utilize microstripline matching providing a noise match at the input and a conjugate impedance match at the output for maximum associated gain. A similarly designed 2.3 GHz amplifier for the ATF-10136 has been described in an Agilent Technologies application note<sup>[1]</sup>. The original 2.3 GHz amplifier using the ATF-10136 500 micron MESFET produced noise figures as low as 0.6 dB. Some of the limitation in noise figure is due to the microstripline losses. The losses associated with typical

microstripline matching networks and the method of calculating the losses have been discussed in an Agilent application note<sup>[2]</sup>. The application note suggests a measured 0.14 dB loss for the microstripline matching network for the ATF-10136 at 2.3 GHz. The amplifier in this note uses a lower noise PHEMT device and makes use of a wire inductor for the input match in an attempt to minimize circuit losses and lower amplifier noise figure.

The 2.3 GHz LNA including component placement is shown in Figure 1. The LNA uses a wire

inductor for the low noise input match. A microstripline network is used for output matching with a small resistor in series with the drain to lower gain and improve stability. Quarterwave bias decoupling lines are used to provide gate and drain bias to the ATF-36077. 50  $\Omega$  chip resistors are used along with the bias decoupling lines to provide low frequency terminations for the device.

Good grounding of the device source leads is required for stable operation. This is accomplished by the use of two plated through

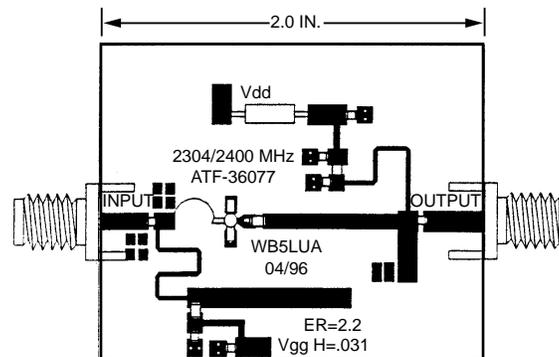


Figure 1. 2.3 GHz LNA Showing Component Placement

holes on each source lead mounting pad. The pads are placed directly beneath each device source lead. The plated through hole nearest each device should be placed as close as possible to the point where the source lead exits the package. The direct grounding of the source leads necessitates the use of a negative power supply voltage on the gate. The use of self biasing and the associated source resistor bypass capacitor are not recommended. The 0.25 to 0.5 nH inductance associated with a typical chip bypass capacitor is large enough to cause stability concerns above 18 GHz.

The LNA is designed for  $\epsilon_r = 2.2$  dielectric material with 0.031 inches thickness. Taconics TLY-5 and Rogers D5880 material provide very good performance. Microstripline widths can be scaled for use with other dielectric materials.

Nominal bias point for the ATF-36077 is a  $V_{ds}$  of 2 volts and an  $I_{ds}$  of 15 mA. The nominal gate bias is -0.2 volts. A swept gain plot in Figure 2 shows the gain to be a minimum of 16 dB from 2 GHz to 2.5 GHz. Noise Figure versus frequency is shown in Figure 3. The amplifier provides a minimum noise figure slightly under 0.4 dB at midband. The broadband input noise match provides an amplifier with a 0.6 dB maximum noise figure from 2.1 GHz to 2.8 GHz.

Input and output return loss versus frequency is shown in Figures 4 and 5. Output return loss is a maximum of 17 dB at about 2.2 GHz. Better than 10 dB output return loss was obtained from 2 GHz to 2.5 GHz. The frequency at which best output

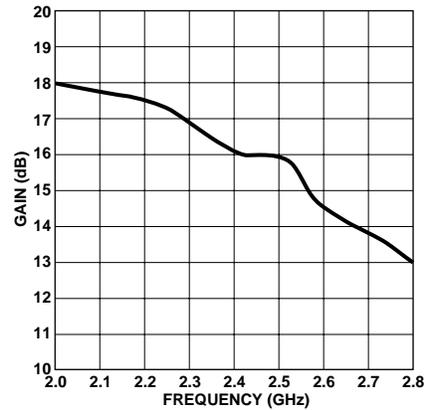


Figure 2. Gain vs. Frequency

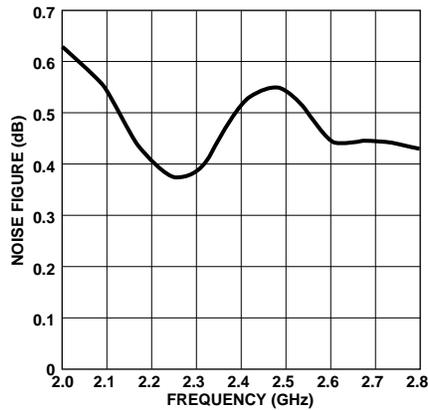


Figure 3. Noise Figure vs. Frequency

match occurs can be easily tuned with the open circuited stub nearest C2.

Good input return loss is more difficult to achieve because the best noise match does not coincide with best gain match. Input return loss is typically improved by compromising noise match or by the use of increased source inductance. In the case of the ATF-36077, increased source inductance is not recommended, as it tends to make the device less stable at higher frequencies. Another option is to design a two stage LNA and make use of the interstage matching network to

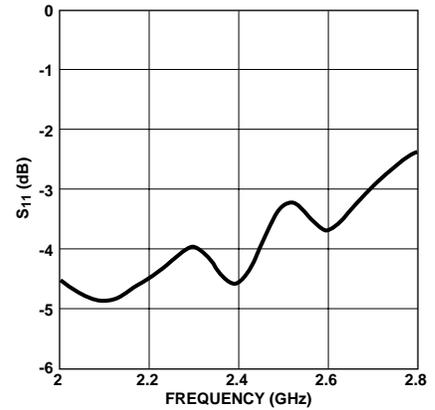


Figure 4. S11 vs. Frequency

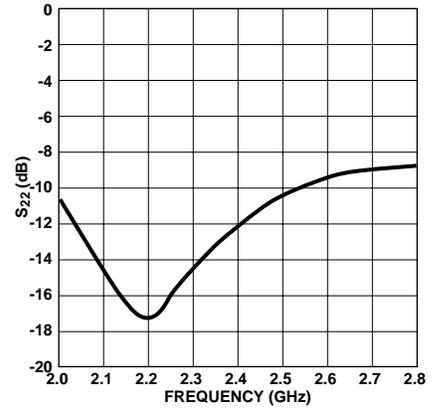
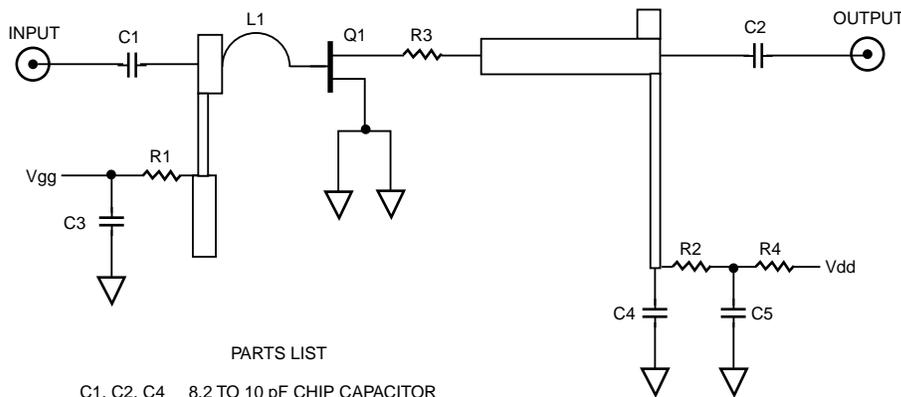


Figure 5. S22 vs. Frequency

force a mismatch at the output of the first stage. The mismatch at the output of the first stage can then be optimized to improve input return loss without adversely affecting noise figure.

The schematic diagram and parts list for the 2.3 GHz LNA are shown in Figure 6.



## PARTS LIST

C1, C2, C4	8.2 TO 10 pF CHIP CAPACITOR
C3, C5	1000 pF // 0.01 $\mu$ F CHIP CAPACITOR
L1	0.007 INCH DIAMETER WIRE 0.5 IN. IN LENGTH WITH 0.075 IN. SOLDERED TO INPUT ETCH AND 0.025 IN. SOLDERED TO GATE LEAD. ADJUST FOR BEST NF.
Q1	AGILENT TECHNOLOGIES ATF-36077 PHEMT
R1, R2	50 $\Omega$ CHIP RESISTOR
R3	10 TO 27 $\Omega$ CHIP RESISTOR (EFFECTS GAIN AND STABILITY)
R4	FOR OPERATION FROM A POWER SUPPLY VOLTAGE OF 5 VOLTS, $R4 = 200 \Omega - R3 - R2$

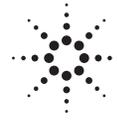
**Figure 6. Schematic Diagram of 2.3 GHz LNA**

## Conclusion

The ATF-36077 has been described in a low noise amplifier providing sub 0.5 dB noise figures in the 2 to 2.5 GHz frequency range. A wire input network provides the match necessary for low noise performance.

## References

- [1] AN-G004, *S-Band Low Noise Amplifiers ATF-10136, ATF-13284*, Agilent Technologies Application Note, publication number 5091-9311E (10/93)
- [2] *900 and 2400 MHz Amplifiers Using the AT-3 series Low Noise Silicon Bipolar Transistors*, Agilent Technologies Application Note 1085, publication number 5964-3854E (9/95)



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