

Features

- Low Noise Figure:
 - 0.35 dB @ 1.9 GHz
 - 0.50 dB @ 2.6 GHz
- High Gain:
 - 22 dB @ 2.6 GHz
 - 15 dB @ 6.0 GHz
- High Linearity: 33 dBm OIP3
- Single Voltage Bias: 3 - 5 V
- Integrated Active Bias Circuit
- Current Adjustable 30 - 80 mA
- Lead-Free 2 mm 8-LD PDFN Package
- Halogen-Free “Green” Mold Compound
- RoHS* Compliant and 260°C Reflow Compatible

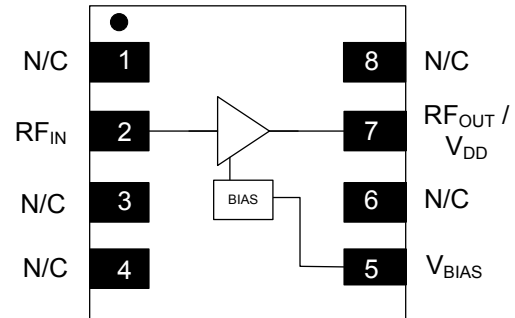
Description

The MAAL-011078 is a high dynamic range, single stage MMIC LNA with ultra low noise figure, high gain and excellent linearity. This amplifier is designed for operation from 700 MHz to 6 GHz and is housed in a lead-free 2 mm 8-lead PDFN plastic package.

This low noise amplifier has an integrated active bias circuit allowing direct connection to 3 V or 5 V bias and minimizing variations over temperature and process. The bias current is set by an external resistor, so the user can customize the power consumption to fit the application. V_{BIAS} can be utilized as an enable pin to power the device up and down during operation.

In the 50 Ω environment and at 3 V, the MAAL-011078 offers 0.5 dB noise figure at 2.6 GHz, with 22 dB of gain and over 33 dBm output third order intercept point (OIP3). It is ideal for 5G & 4G cellular infrastructure and Wi-Fi applications.

Functional Block Diagram



Pin Configuration³

| Pin # | Pin Name | Description |
|---------------|-------------------------------------|---------------------------|
| 1, 3, 4, 6, 8 | N/C | No Connection |
| 2 | RF _{IN} | RF Input |
| 5 | V _{BIAS} | Bias Voltage |
| 7 | RF _{OUT} / V _{DD} | RF Output / Drain Voltage |
| 9 | Pad ⁴ | Ground |

3. MACOM recommends connecting unused package pins to ground.
4. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.

Ordering Information^{1,2}

| Part Number | Package |
|--------------------|-------------------------------|
| MAAL-011078-TR1000 | 1000 piece reel |
| MAAL-011078-TR3000 | 3000 piece reel |
| MAAL-011078-001SMB | Sample Board 2.3 - 2.7 GHz |

1. Reference Application Note M513 for reel size information.
2. All sample boards include 3 loose parts.

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.

Low Noise Amplifier 700 MHz - 6 GHz

Rev. V4

Electrical Specifications: Freq = 1.9 GHz, $V_{DD} = 3\text{ V}$, $+25^{\circ}\text{C}$, $Z_0 = 50\ \Omega$, $V_{BIAS} = 2.3\text{ V}$ ⁵

| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|---------------------------------|--|-------|------|------|------|
| Noise Figure | - | dB | — | 0.35 | 0.7 |
| Gain | - | dB | 21 | 23 | 25 |
| Input Return Loss ⁶ | - | dB | — | 5 | — |
| Output Return Loss ⁶ | - | dB | — | 5 | — |
| Output IP3 | $P_{IN} = -22\text{ dBm}$, tones 11 MHz apart | dBm | — | 33 | — |
| Output P1dB | - | dBm | — | 17.5 | — |
| Total Current | $I_{DQ} = I_{DD} + I_{BIAS}$ | mA | 39 | 50 | 68 |

5. Refer to biasing options on page 3.

6. Return Loss can be improved with external matching components. Refer to application section.

Absolute Maximum Ratings^{7,8,9}

| Parameter | Absolute Maximum |
|------------------------------------|---|
| RF Input Power CW | 19 dBm |
| V_{DD} | 6 V |
| V_{BIAS} | 5 V |
| Storage Temperature | -55°C to $+150^{\circ}\text{C}$ |
| Operating Temperature | -40°C to $+85^{\circ}\text{C}$ |
| Junction Temperature ¹⁰ | $+150^{\circ}\text{C}$ |

7. Exceeding any one or combination of these limits may cause permanent damage to this device.

8. MACOM does not recommend sustained operation near these survivability limits.

9. Operating at nominal conditions with $T_J \leq 150^{\circ}\text{C}$ will ensure $MTTF > 1 \times 10^6$ hours.

10. Junction Temperature (T_J) = $T_C + \Theta_{JC} * ((V * I) - (P_{OUT} - P_{IN}))$

Typical thermal resistance (Θ_{JC}) = 83°C/W

a) For $T_C = +25^{\circ}\text{C}$,

$T_J = 33^{\circ}\text{C}$ @ 3 V, 0.05 A, $P_{OUT} = 17.5\text{ dBm}$, $P_{IN} = -4.5\text{ dBm}$

b) For $T_C = +85^{\circ}\text{C}$,

$T_J = 93^{\circ}\text{C}$ @ 3 V, 0.05 A, $P_{OUT} = 17.5\text{ dBm}$, $P_{IN} = -4.5\text{ dBm}$

Handling Procedures

Please observe the following precautions to avoid damage:

Static Sensitivity

Gallium Arsenide Integrated Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

Biasing Options

The MAAL-011078 bias can be set in 2 different ways: using only V_{DD} or using separate V_{DD} and V_{BIAS} voltages. A separate V_{BIAS} voltage allows pin 5 (V_{BIAS}) to be used as an enable pin to power the device up and down during operation.

For both bias methods select the value of R_{BIAS} to achieve the desired current based on the tables on page 4, and use DC blocks at pin 2 (RF_{IN}) and pin 7 (RF_{OUT} / V_{DD}).

Biasing Option - V_{DD} only

To use only V_{DD} , connect pin 7 (RF_{OUT} / V_{DD}) to V_{DD} through an RF choke inductor and connect pin 5 (V_{BIAS}) to V_{DD} through bias resistor R_{BIAS} as shown in Figure 1.

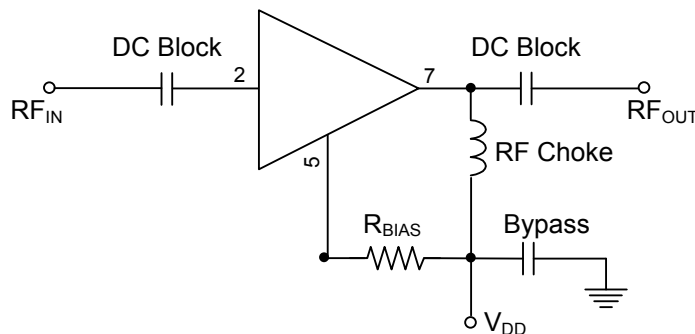


Figure 1

Biasing Option - Separate V_{DD} and V_{BIAS} Voltages ($V_{BIAS} \leq V_{DD}$)

To use separate V_{DD} and V_{BIAS} voltages, connect pin 7 (RF_{OUT} / V_{DD}) to V_{DD} through an RF choke inductor and connect pin 5 (V_{BIAS}) to V_{BIAS} through bias resistor R_{BIAS} as shown in Figure 2. Typical current (I_{BIAS}) draw for pin 5 (V_{BIAS}) is 1.4 mA @ $V_{BIAS} = 3$ V and 1 μ A @ $V_{BIAS} = 0$ V. Typical current (I_{DD}) draw for pin 7 (RF_{OUT} / V_{DD}) is < 1 μ A @ $V_{BIAS} = 0$ V.

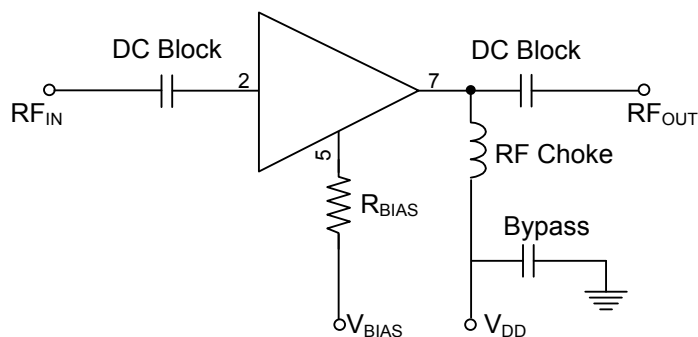
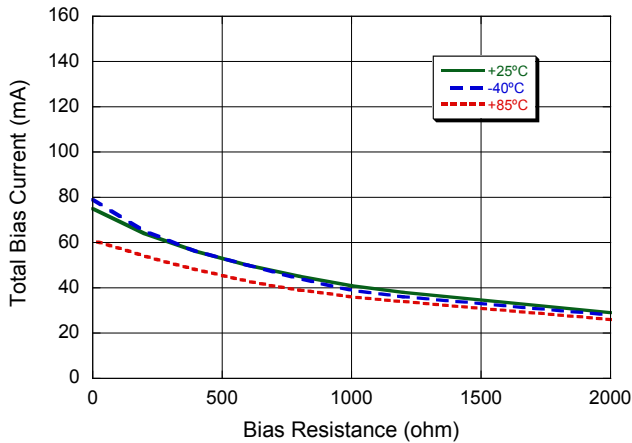


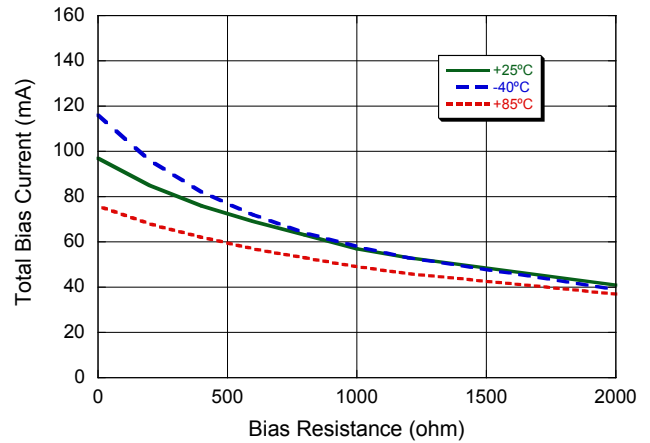
Figure 2

Typical Performance Curves of the Active Bias Circuit

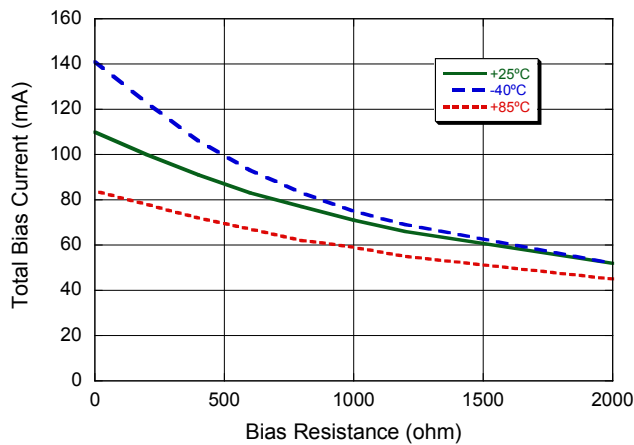
Current, $V_{DD} = 3\text{ V}$



Current, $V_{DD} = 4\text{ V}$



Current, $V_{DD} = 5\text{ V}$



Bias Table

| Bias Resistance (Ω) | Total Current (mA) | | | | | | | | |
|---------------------------------|-----------------------|-------|-------|-----------------------|-------|-------|-----------------------|-------|-------|
| | $V_{DD} = 3\text{ V}$ | | | $V_{DD} = 4\text{ V}$ | | | $V_{DD} = 5\text{ V}$ | | |
| | +25°C | -40°C | +85°C | +25°C | -40°C | +85°C | +25°C | -40°C | +85°C |
| 2000 | 29 | 28 | 26 | 41 | 39 | 37 | 52 | 52 | 45 |
| 1200 | 38 | 36 | 34 | 53 | 53 | 46 | 66 | 69 | 55 |
| 1000 | 41 | 39 | 36 | 57 | 58 | 49 | 71 | 75 | 59 |
| 800 | 45 | 44 | 39 | 63 | 64 | 53 | 77 | 83 | 62 |
| 600 | 50 | 50 | 43 | 69 | 72 | 57 | 83 | 93 | 67 |
| 400 | 56 | 56 | 48 | 76 | 82 | 62 | 91 | 106 | 72 |
| 200 | 64 | 65 | 54 | 85 | 96 | 68 | 100 | 123 | 78 |
| 0 | 75 | 79 | 61 | 97 | 116 | 76 | 110 | 141 | 84 |

4

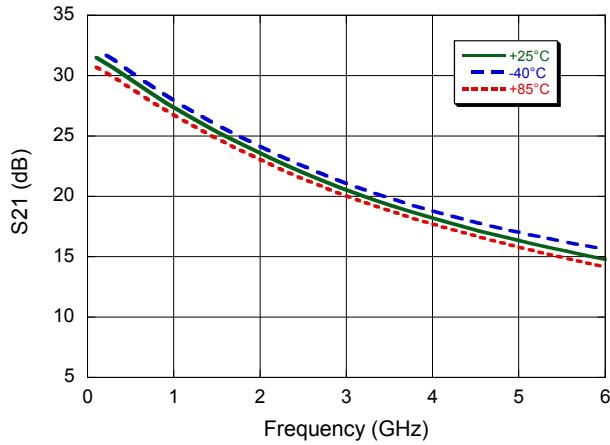
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Low Noise Amplifier 700 MHz - 6 GHz

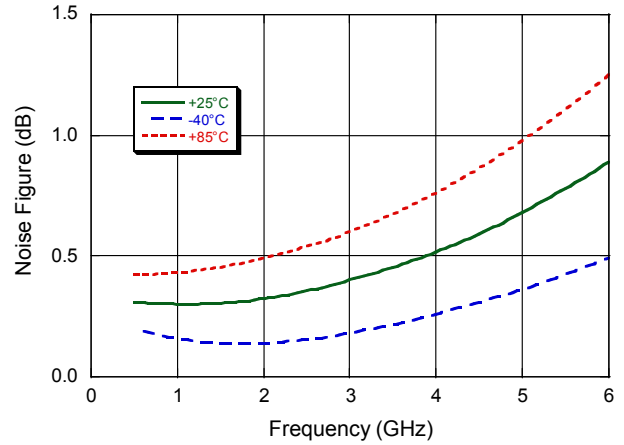
Rev. V4

Typical Performance Curves @ 3 V / 50 mA, $Z_0 = 50 \Omega$

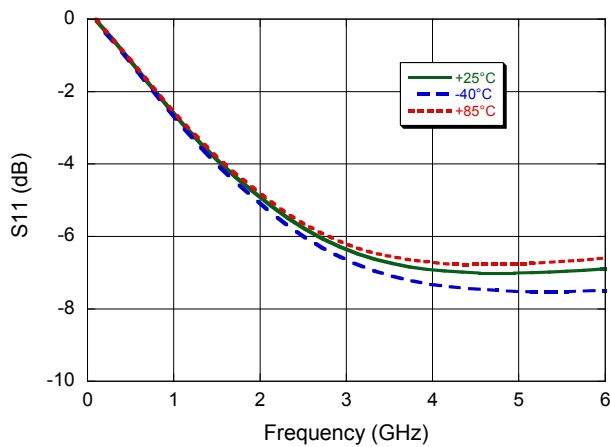
Gain



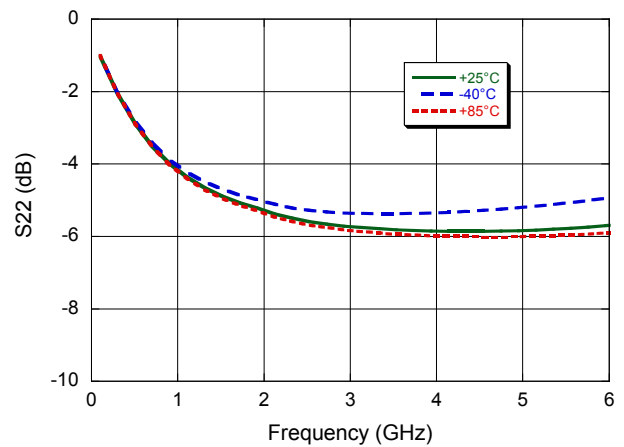
Noise Figure



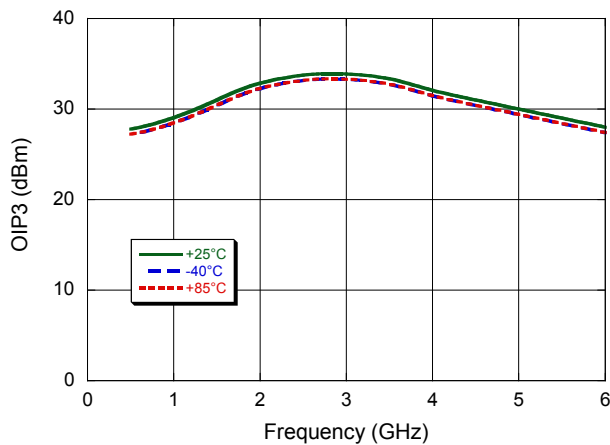
Input Return Loss



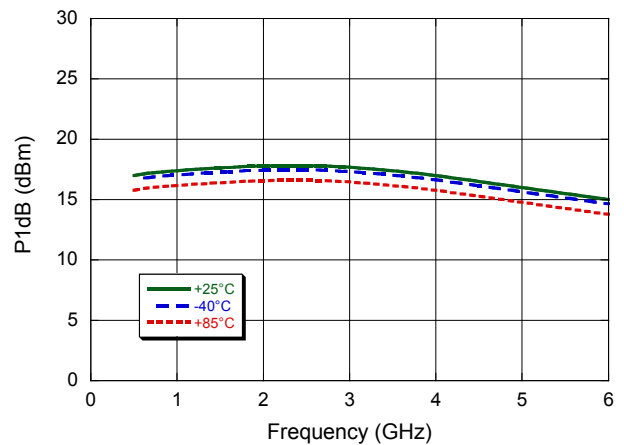
Output Return Loss



OIP3



P1dB

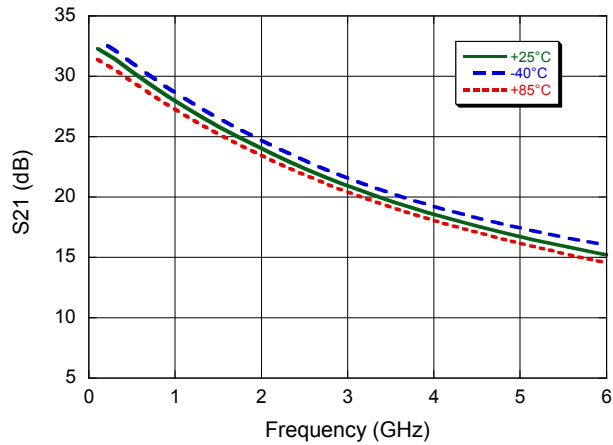


Low Noise Amplifier 700 MHz - 6 GHz

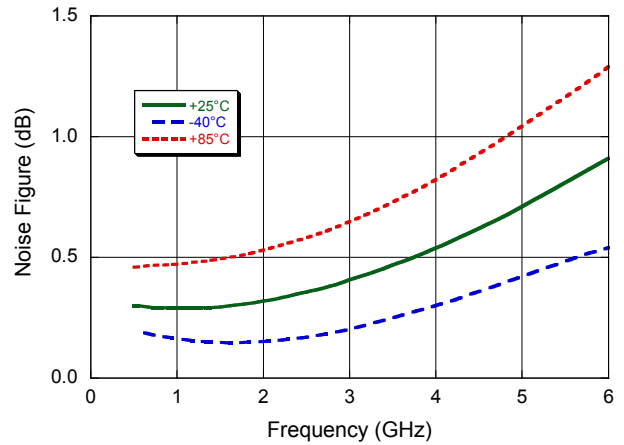
Rev. V4

Typical Performance Curves @ 5 V / 70 mA, $Z_0 = 50 \Omega$

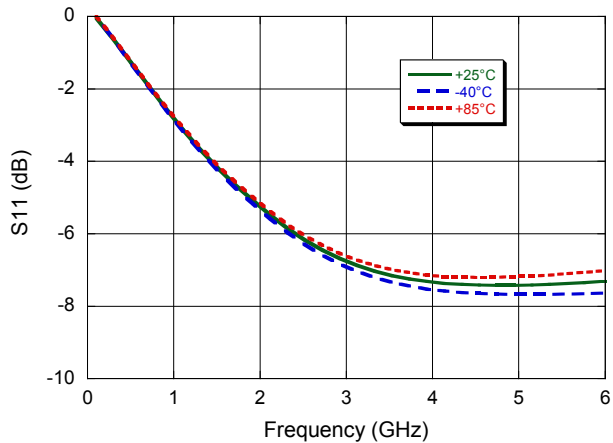
Gain



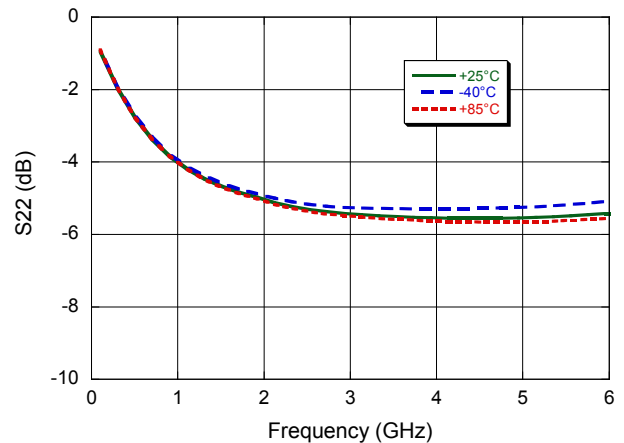
Noise Figure



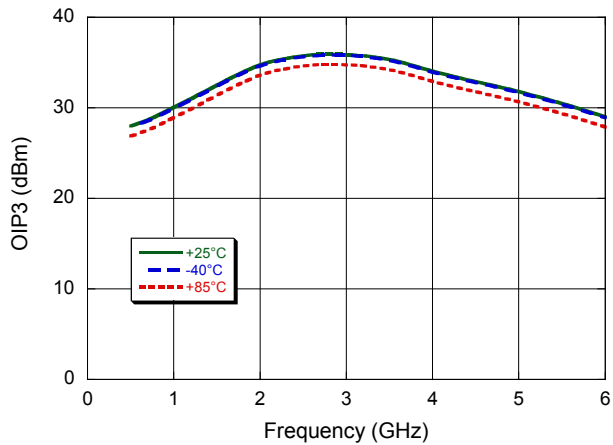
Input Return Loss



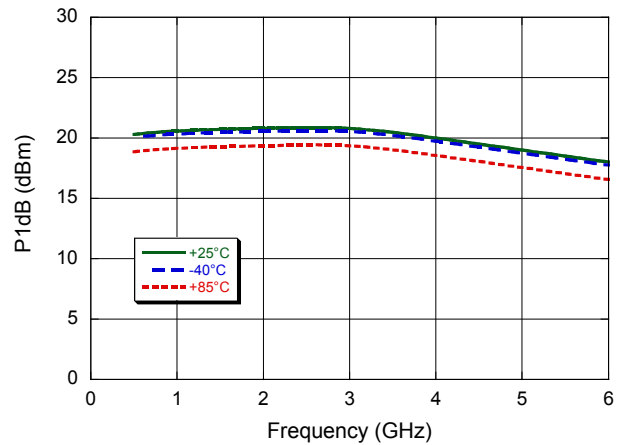
Output Return Loss



OIP3



P1dB

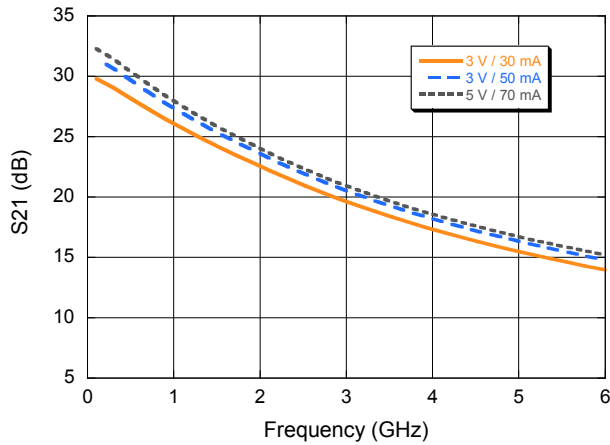


Low Noise Amplifier 700 MHz - 6 GHz

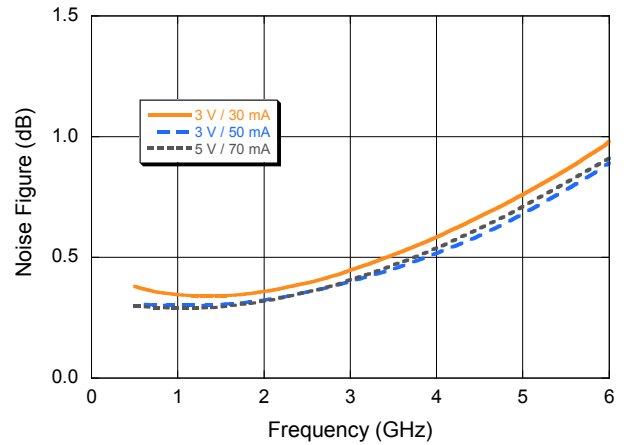
Rev. V4

Typical Performance Curves @ 3 V / 30 mA, 3 V / 50 mA, 5V / 70 mA, $Z_0 = 50 \Omega$

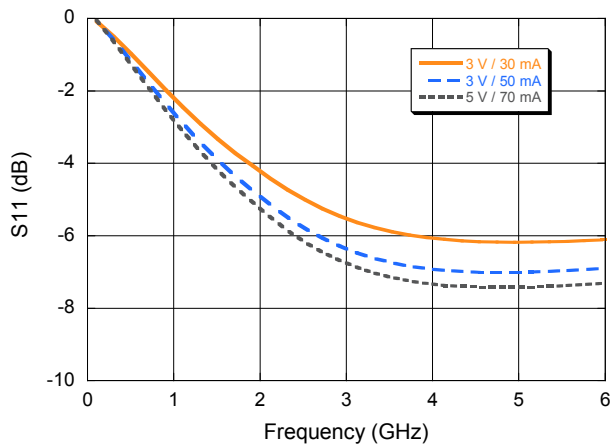
Gain



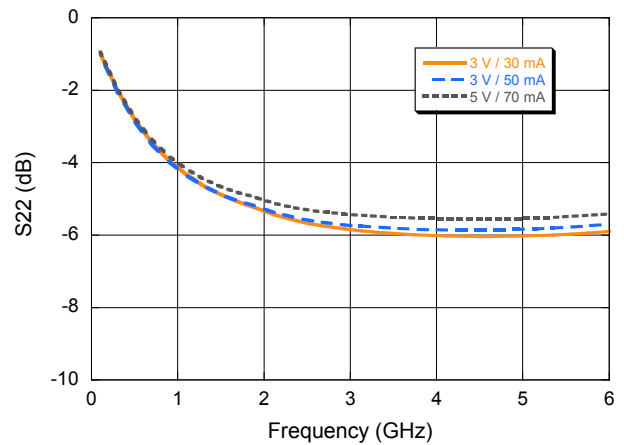
Noise Figure



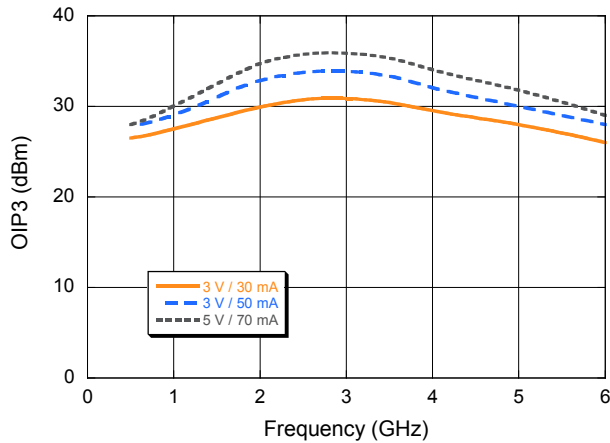
Input Return Loss



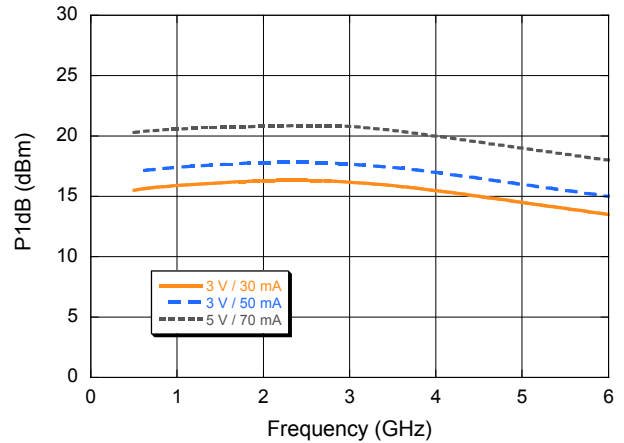
Output Return Loss



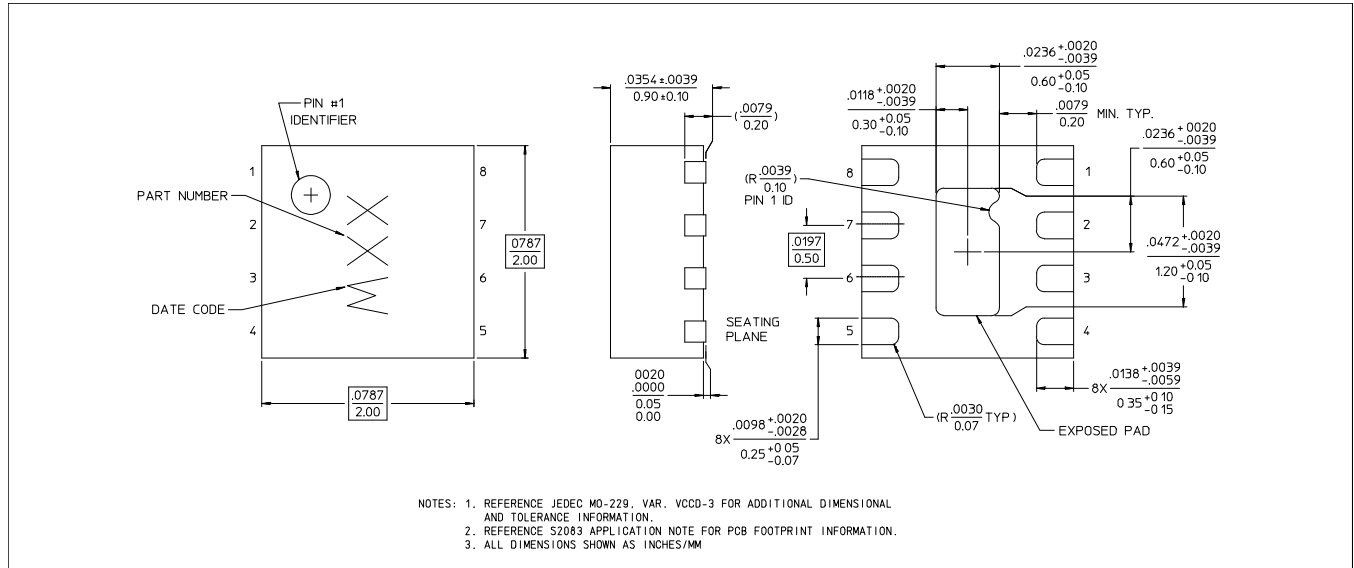
OIP3



P1dB



Lead-Free 2 mm 8-Lead PDFN[†]



[†] Reference Application Note S2083 for lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level 1 requirements.
Plating is 100% matte tin over copper.

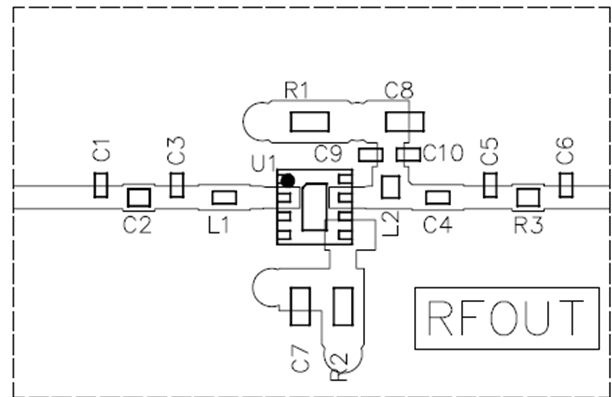
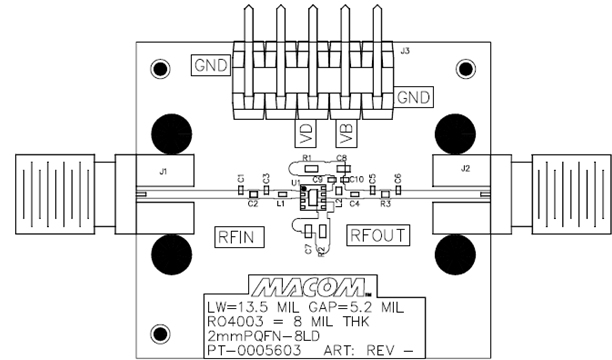
2.3 - 2.7 GHz Application Section

The MAAL-011078 is designed to work as a low noise gain block over a wide range of frequencies in a 50 Ω environment.

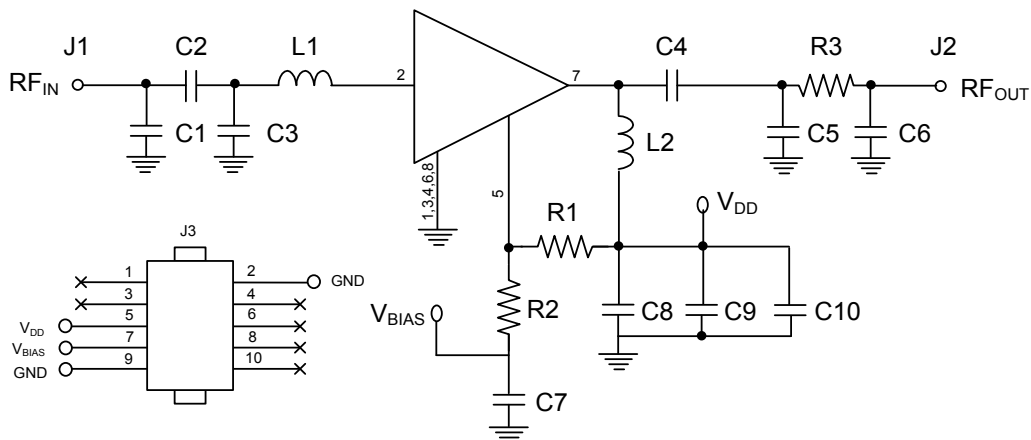
Input and output can be tuned to improve return loss over a specific frequency band.

The evaluation board shown has been designed for tuning flexibility. The parts list on page 10 details the components needed to tune the MAAL-011078 for operation from 2.3 – 2.7 GHz. R1 or R2 may be used as R_{BIAS} according to the biasing option chosen.

Evaluation Board, 2.3 - 2.7 GHz



Schematic, 2.3 - 2.7 GHz



2.3 - 2.7 GHz Application Section

Parts List, 2.3 - 2.7 GHz

| Component | Value | Size | Manufacturer | Manufacturer Part # |
|-----------|--------------|------|--------------|---------------------|
| C1 | — | 0201 | — | — |
| C2 | 10 pF | 0201 | Murata | GJM0336C1E100JB01 |
| C3 | 0.7 pF | 0201 | Murata | GJM0335C1ER70WB0 |
| C4 | 1.8 pF | 0201 | Murata | GJM0335C1E1R8BB01 |
| C5 | 0.4 pF | 0201 | Murata | GJM0335C1ER40WB01 |
| C6 | — | 0201 | — | — |
| C7 | — | 0402 | — | — |
| C8 | 0.1 μ F | 0402 | — | — |
| C9, C10 | 49 pF | 0201 | — | — |
| L1 | 2.5 nH | 0201 | Coilcraft | 0201DS-2N5XJL |
| L2 | 2.7 nH | 0201 | Murata | LQP03TN2N7C02 |
| R1 | 470 Ω | 0402 | — | — |
| R2 | — | 0402 | — | — |
| R3 | 0 Ω | 0201 | — | — |

Low Noise Amplifier 700 MHz - 6 GHz

Rev. V4

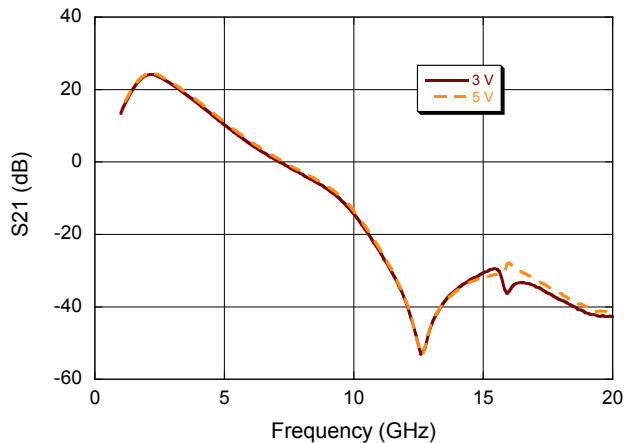
Electrical Specifications: Freq = 2.6 GHz^{11,12}, V_{DD} = 3 V, +25°C, Z₀ = 50 Ω

| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|--------------------|---|-------|------|------|------|
| Noise Figure | - | dB | — | 0.7 | — |
| Gain | - | dB | — | 23 | — |
| Input Return Loss | - | dB | — | 16 | — |
| Output Return Loss | - | dB | — | 10 | — |
| Output IP3 | P _{IN} = -22 dBm, tones 11 MHz apart | dBm | — | 33.4 | — |
| Total Current | I _{DQ} = I _{DD} + I _{BIAS} | mA | — | 50 | — |

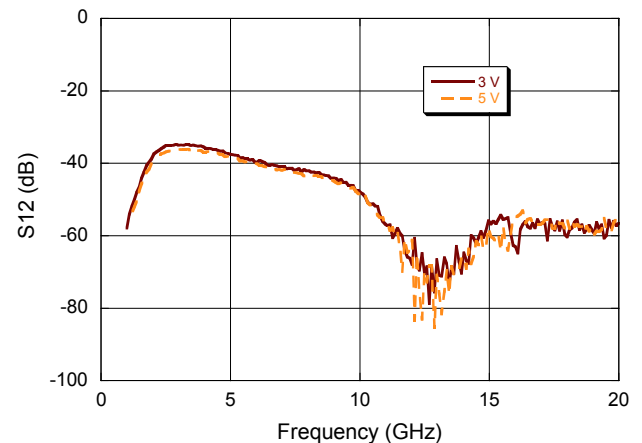
11. Typical performance of the evaluation module with exact components shown on the 2.3 - 2.7 GHz parts list.
12. Typical measured data includes evaluation board and connector losses.

Typical Performance Curves: Broadband performance (2.3 - 2.7 GHz evaluation board)

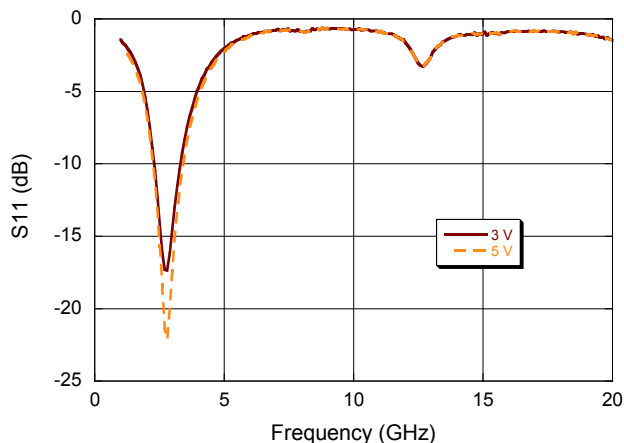
Gain



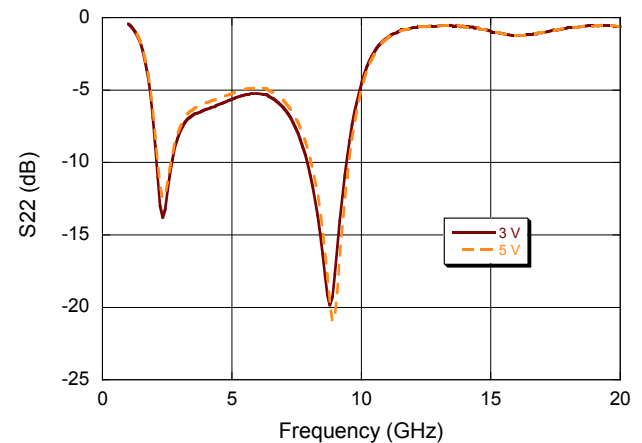
Reverse Isolation



Input Return Loss



Output Return Loss

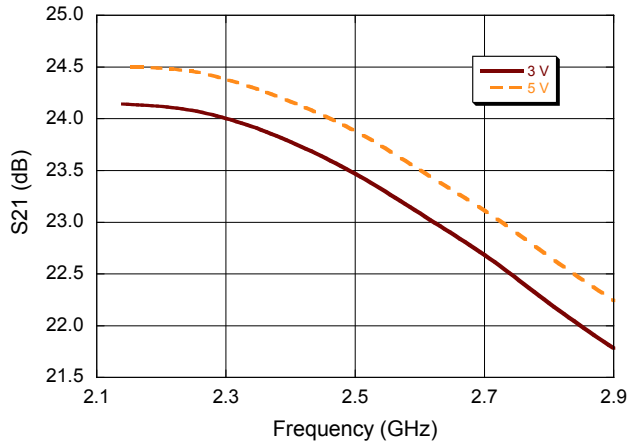


Low Noise Amplifier 700 MHz - 6 GHz

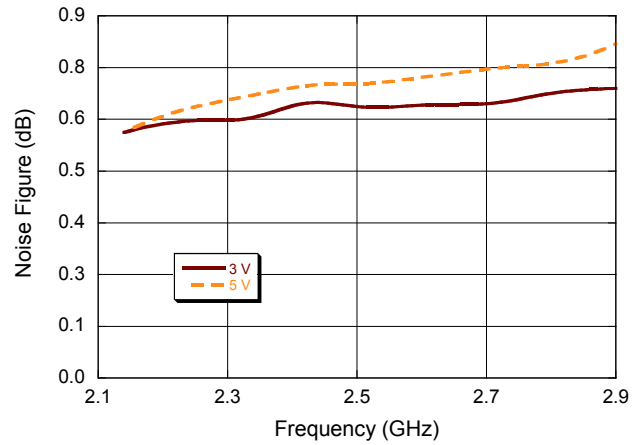
Rev. V4

Typical Performance Curves: Freq = 2.3 - 2.7 GHz, $Z_0 = 50 \Omega$

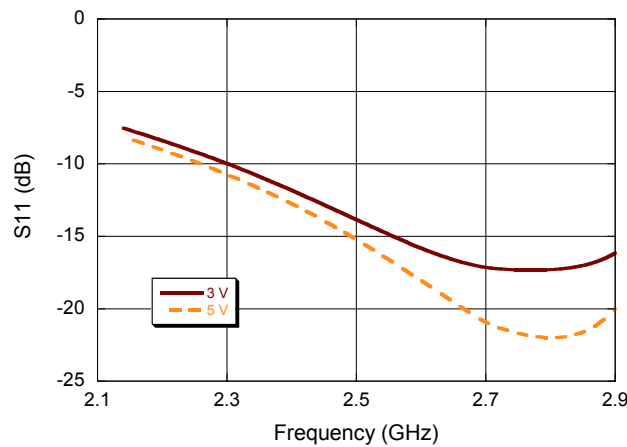
Gain



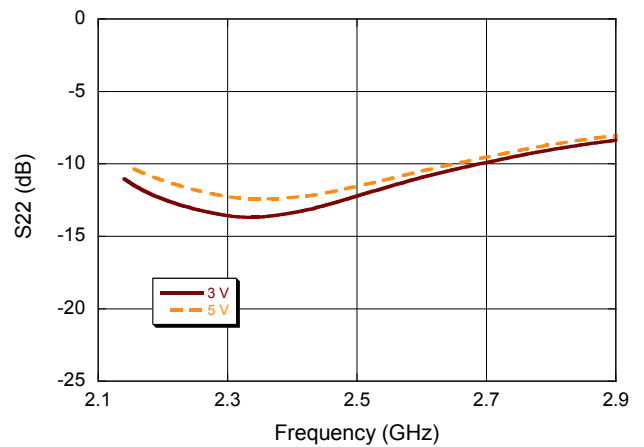
Noise Figure



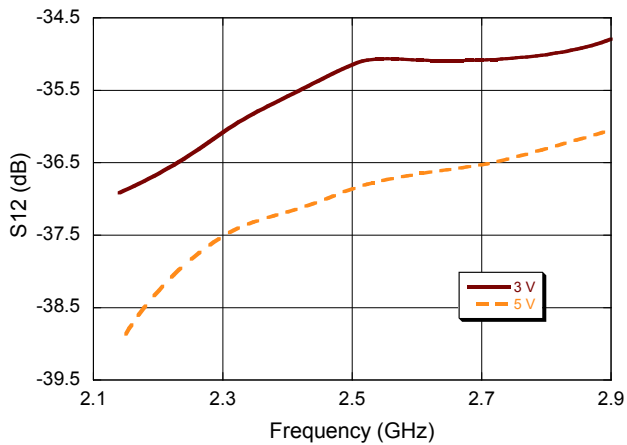
Input Return Loss



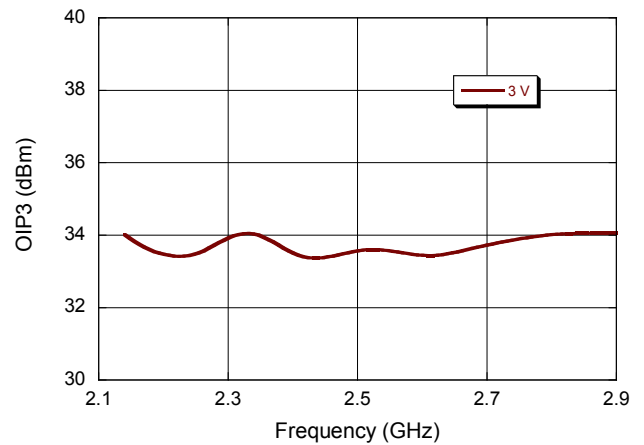
Output Return Loss



Reverse Isolation



OIP3



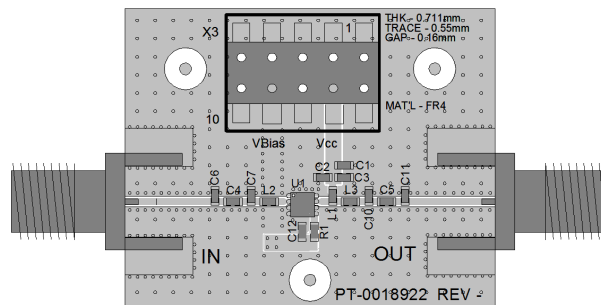
3.6 - 4.2 GHz Application Section

The MAAL-011078 is designed to work as a low noise gain block over a wide range of frequencies in a 50 Ω environment.

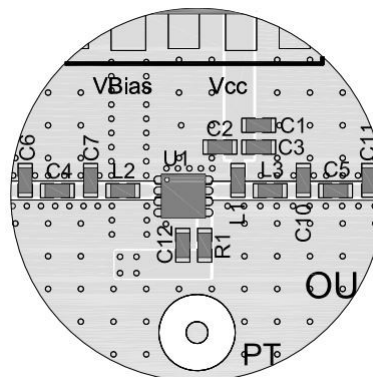
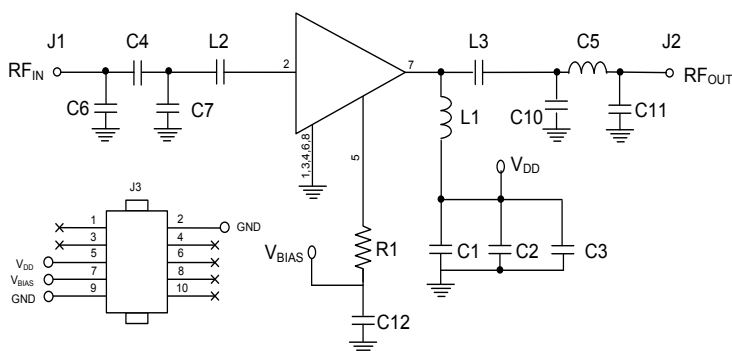
Input and output can be tuned to improve return loss over a specific frequency band.

The evaluation board shown has been designed for tuning flexibility. The parts list on page 14 details the components needed to tune the MAAL-011078 for operation from 3.6 – 4.2 GHz. R1 or R2 may be used as R_{BIAS} according to the biasing option chosen.

Evaluation Board, 3.6 - 4.2 GHz



Schematic, 3.6 - 4.2 GHz



Parts List

| Component | Value | Size | Component | Value | Size |
|-----------|---------|------|--------------|--------|------|
| C1, C12 | 0.1 μF | 0402 | C7, C10, C11 | DNF | 0402 |
| C2, C3 | 47 pF | 0402 | L1 | 2.4 nH | 0402 |
| C4 | 0.75 pF | 0402 | L2 | 1.5 nH | 0402 |
| C5 | 10 pF | 0402 | L3 | 1.0 nH | 0402 |
| C6 | 0.3 pF | 0402 | R1 | 470 Ω | 0402 |

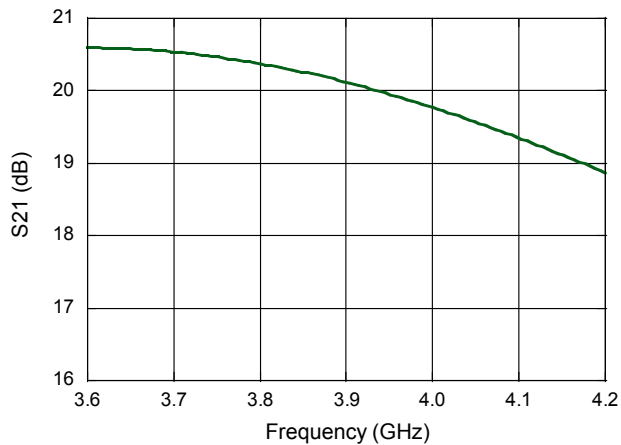
Electrical Specifications: Freq = 3.6 - 4.2 GHz¹³, V_{DD} = 3 V, +25°C, Z₀ = 50 Ω

| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|--------------------|---|-------|------|------|------|
| Noise Figure | - | dB | — | 0.7 | — |
| Gain | - | dB | — | 19.5 | — |
| Input Return Loss | - | dB | — | 17 | — |
| Output Return Loss | - | dB | — | 15 | — |
| Total Current | I _{DQ} = I _{DD} + I _{BIAS} | mA | — | 56 | — |

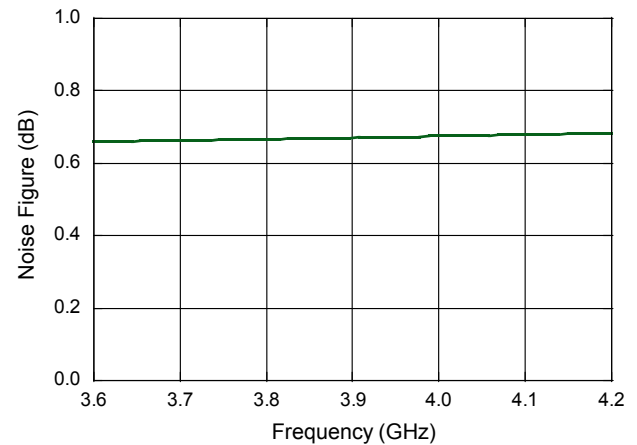
13. Typical performance of the evaluation module with exact components shown on the 3.6 - 4.2 GHz parts list.

Typical Performance Curves: Broadband performance (3.6 - 4.2 GHz evaluation board)

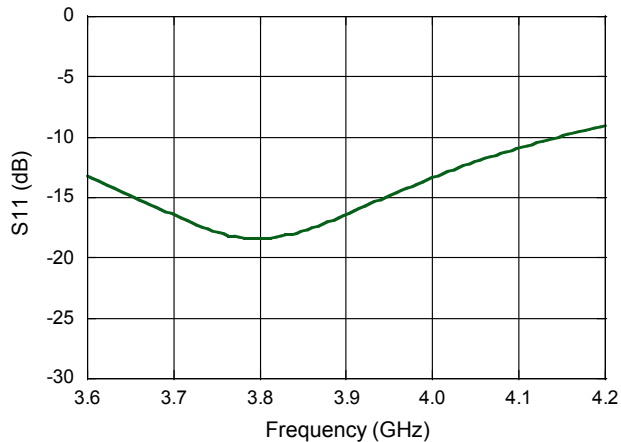
Gain



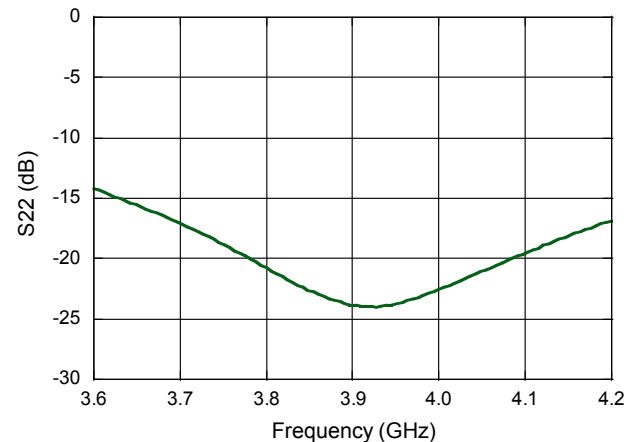
Noise Figure



Input Return Loss



Output Return Loss



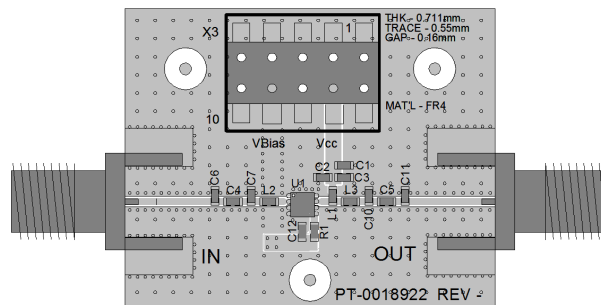
4.4 - 4.9 GHz Application Section

The MAAL-011078 is designed to work as a low noise gain block over a wide range of frequencies in a 50 Ω environment.

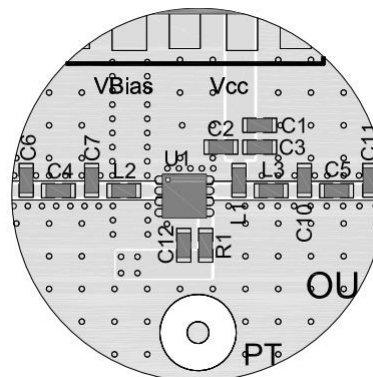
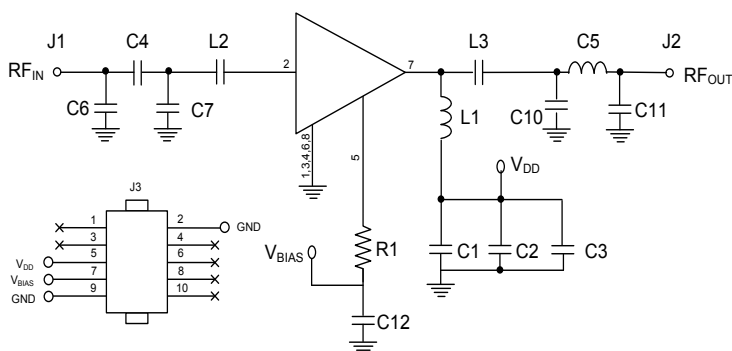
Input and output can be tuned to improve return loss over a specific frequency band.

The evaluation board shown has been designed for tuning flexibility. The parts list on page 14 details the components needed to tune the MAAL-011078 for operation from 4.4 – 4.9 GHz. R1 or R2 may be used as R_{BIAS} according to the biasing option chosen.

Evaluation Board, 4.4 - 4.9 GHz



Schematic, 4.4 - 4.9 GHz



Parts List

| Component | Value | Size | Component | Value | Size |
|-----------|-------------|------|-----------|--------------|------|
| C1,C12 | 0.1 μ F | 0402 | C10 | 1.5 nH | 0402 |
| C2, C3 | 47 pF | 0402 | L1 | 1.0 nH | 0402 |
| C4 | 1.2 pF | 0402 | L2 | 0.6 nH | 0402 |
| C5 | 1.5 pF | 0402 | L3 | 1.0 pF | 0402 |
| C6, C11 | DNF | — | R1 | 470 Ω | 0402 |
| C7 | 0.3 pF | 0402 | | | |

Low Noise Amplifier 700 MHz - 6 GHz

Rev. V4

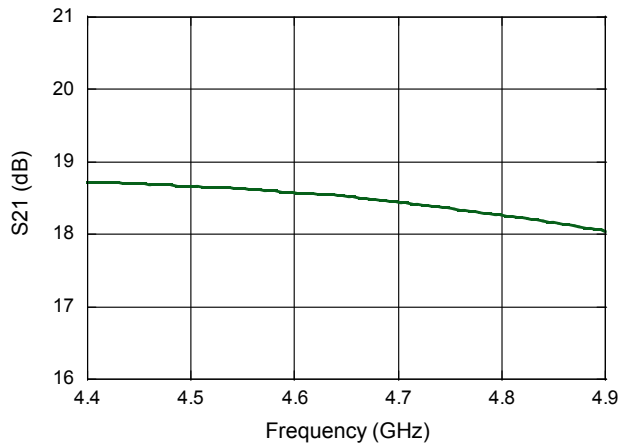
Electrical Specifications: Freq = 4.4 - 4.9 GHz¹⁴, V_{DD} = 3 V, +25°C, Z₀ = 50 Ω

| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|--------------------|---|-------|------|------|------|
| Noise Figure | - | dB | — | 0.65 | — |
| Gain | - | dB | — | 18.5 | — |
| Input Return Loss | - | dB | — | 18 | — |
| Output Return Loss | - | dB | — | 15 | — |
| Total Current | I _{DQ} = I _{DD} + I _{BIAS} | mA | — | 56 | — |

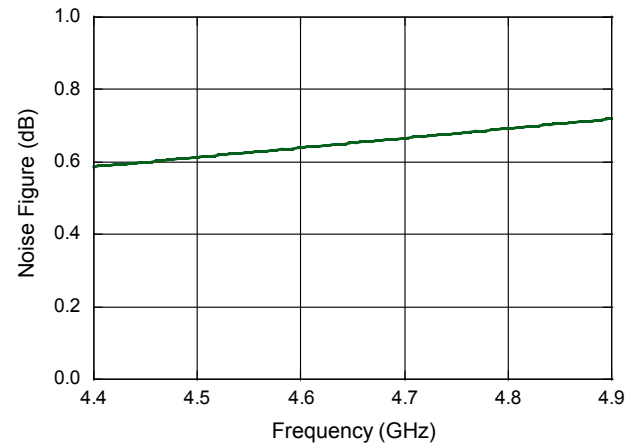
14. Typical performance of the evaluation module with exact components shown on the 4.4 - 4.9 GHz parts list.

Typical Performance Curves: Broadband performance (4.4 - 4.9 GHz evaluation board)

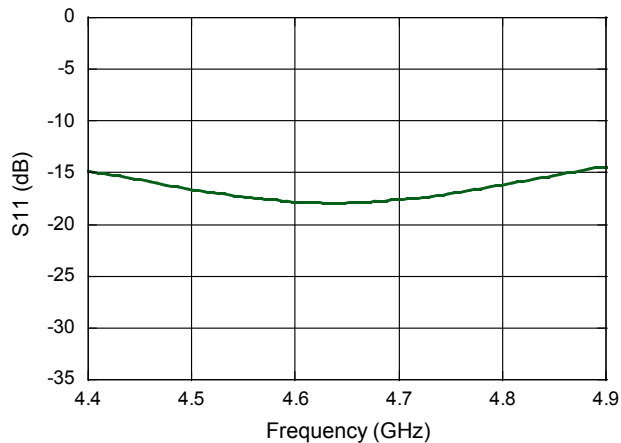
Gain



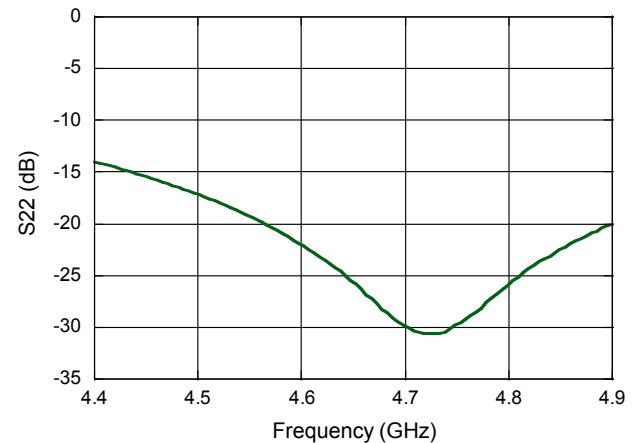
Noise Figure



Input Return Loss



Output Return Loss



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