

## Low Noise Amplifier 5 - 4000 MHz

Rev. V2

### Features

- Single Stage, Single Ended
- 75  $\Omega$  CATV, 5 - 1218 MHz
- 21 dB Flat Gain
- 1 dB Noise Figure
- 50  $\Omega$  System, 5 - 2000 MHz
- 17 dB Gain
- 1.5 dB Noise Figure @ 1.5 GHz
- 17 dB Maximum Available Gain @ 4 GHz
- 75  $\Omega$  CATV Full Duplex, 5 - 700 MHz
- Adjustable Current, 20 - 85 mA
- Excellent Return Loss
- Low Distortion Performance
- 3 V to 5 V Operation
- Lead-Free SOT-89 Plastic Package
- Halogen-Free “Green” Mold Compound
- RoHS\* Compliant

### Description

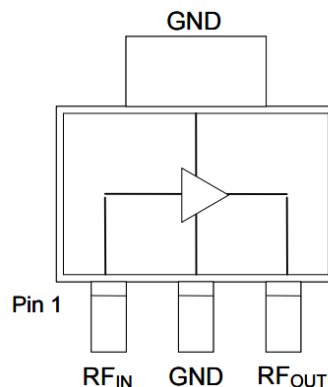
The MAAL-011139 is an RF amplifier assembled in a SOT-89 plastic package. In a 75  $\Omega$  CATV application, the amplifier provides 21.5 dB of flat gain while biased from 3 to 5 volts. The amplifier provides superior noise figure while maintaining excellent return losses. Gain and current may be optimized with adjustment of external component values.

The MAAL-011139 provides high gain, low noise and low distortion making it ideally suited as input stage for fiber-to-the-home (FTTh) applications and other 75  $\Omega$  infrastructure applications. It can support both upstream (5 - 204 MHz) and downstream (45 - 1218 MHz) CATV operation.

It can also be used for 75  $\Omega$  CATV Full Duplex applications (5 - 700 MHz) with appropriate external components.

The MAAL-011139 can also be matched into a 50-ohm system. In a broadband 50 - 2000 MHz application, the amplifier provides 17 dB of flat gain. The MAAL-011139 offers 17 dB of available gain beyond 4 GHz.

### Functional Schematic



### Pin Configuration

| Pin # | Pin Name          | Function                    |
|-------|-------------------|-----------------------------|
| 1     | RF <sub>IN</sub>  | RF Input                    |
| 2     | GND               | Ground                      |
| 3     | RF <sub>OUT</sub> | RF Output / V <sub>DD</sub> |

### Ordering Information<sup>1,2</sup>

| Part Number        | Package                       |
|--------------------|-------------------------------|
| MAAL-011139-TR1000 | 1000 Part Reel                |
| MAAL-011139-TR3000 | 3000 Part Reel                |
| MAAL-011139-DSBSMB | Sample Board<br>45 - 1218 MHz |
| MAAL-011139-USBSMB | Sample Board<br>5 - 300 MHz   |
| MAAL-011139-050SMB | Sample Board,<br>5 - 2000 MHz |

1. Reference Application Note M513 for reel size information.
2. All production sample boards include 5 loose parts.

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

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### Electrical Specifications: $T_A = 25^\circ\text{C}$ , $V_{DD} = 5\text{ V}$ , $Z_0 = 75\ \Omega$ , 45 - 1218 MHz Application

| Parameter                    | Test Conditions  | Units | Min. | Typ.       | Max. |
|------------------------------|--|-------|------|------------|------|
| Gain                         | —  | dB    | 20.5 | 21.5       | 22.5 |
| Gain Flatness                | —  | dB    | —    | +/- 0.2    | —    |
| Reverse Isolation            | —  | dB    | —    | 25         | —    |
| Input Return Loss            | —  | dB    | —    | 23         | —    |
| Output Return Loss           | —  | dB    | —    | 23         | —    |
| Noise Figure                 | 45 MHz<br>1218 MHz   | dB    | —    | 1.2<br>1.4 | 1.8  |
| Output IP2                   | 45 - 1200 MHz, tone spacing 6 MHz,<br>$P_{OUT}$ per tone = 0 dBm       | dBm   | —    | 42         | —    |
| Output IP3                   | 45 - 1200 MHz, tone spacing 6 MHz,<br>$P_{OUT}$ per tone = 0 dBm       | dBm   | —    | 34         | —    |
| P1dB                         | —  | dBm   | —    | 19         | —    |
| Composite Triple Beat (CTB)  | 79 channels, 0 dB Tilt, 32 dBmV per<br>channel output, QAM to 1000 MHz | dBc   | —    | -68        | —    |
| Composite Second Order (CSO) | 79 channels, 0 dB Tilt, 32 dBmV per<br>channel output, QAM to 1000 MHz | dBc   | —    | -61        | —    |
| $I_{DD}$                     | —  | mA    | —    | 85         | 100  |

### Absolute Maximum Ratings<sup>3,4,5</sup>

| Parameter                         | Absolute Maximum |
|-----------------------------------|------------------|
| Input Power                       | 17 dBm           |
| Voltage                           | 7 V              |
| Operating Temperature             | -40°C to +85°C   |
| Storage Temperature               | -65°C to +150°C  |
| Junction Temperature <sup>6</sup> | 150°C            |

- Exceeding any one or combination of these limits may cause permanent damage to this device.
- MACOM does not recommend sustained operation near these survivability limits.
- Operating at nominal conditions with  $T_J \leq 150^\circ\text{C}$  will ensure  $MTTF > 1 \times 10^6$  hours.
- Junction Temperature ( $T_J$ ) =  $T_C + \Theta_{JC} \cdot (V \cdot I)$   
Typical thermal resistance ( $\Theta_{JC}$ ) = 63°C/W.
  - For  $T_C = 25^\circ\text{C}$ ,  
 $T_J = 52^\circ\text{C}$  @ 5 V, 85 mA
  - For  $T_C = 85^\circ\text{C}$ ,  
 $T_J = 108^\circ\text{C}$  @ 5 V, 72 mA

### Handling Procedures

Please observe the following precautions to avoid damage:

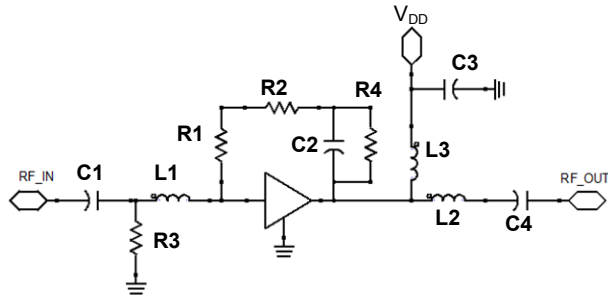
### Static Sensitivity

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 Class 1C devices.

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### Schematic Including Off-Chip Components 45 - 1218 MHz Application

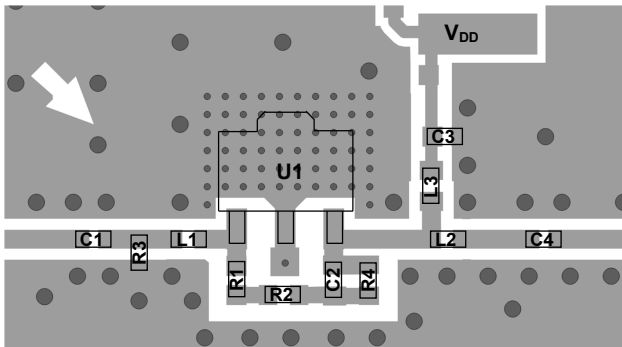


### Parts List, $V_{DD} = 5\text{ V}$ , 85 mA

| Component | Value                     | Package |
|-----------|---------------------------|---------|
| C1 - C3   | 10 nF                     | 0402    |
| C4        | 270 pF                    | 0402    |
| L1        | 6.2 nH                    | 0402    |
| L2        | 3.3 nH                    | 0402    |
| L3        | Ferrite Bead <sup>7</sup> | 0402    |
| R1 - R2   | 510 $\Omega$              | 0402    |
| R3        | 10 k $\Omega$             | 0402    |
| R4        | 30.1 k $\Omega$           | 0402    |

7. Murata, part number BLM15HD182SN.

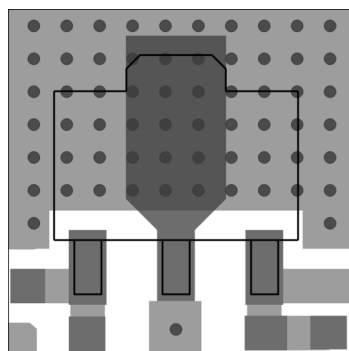
### Recommended PCB Layout



The bias current can be adjusted to support lower noise figure and lower power consumption by removing external bias resistor R4 and replacing R3 as detailed below.

| $I_{DD}$ | R3 Value       | Package |
|----------|----------------|---------|
| 55 mA    | Do Not Install | 0402    |
| 40 mA    | 75 k $\Omega$  | 0402    |
| 30 mA    | 39 k $\Omega$  | 0402    |
| 20 mA    | 27 k $\Omega$  | 0402    |

### Recommended PCB Land Pattern



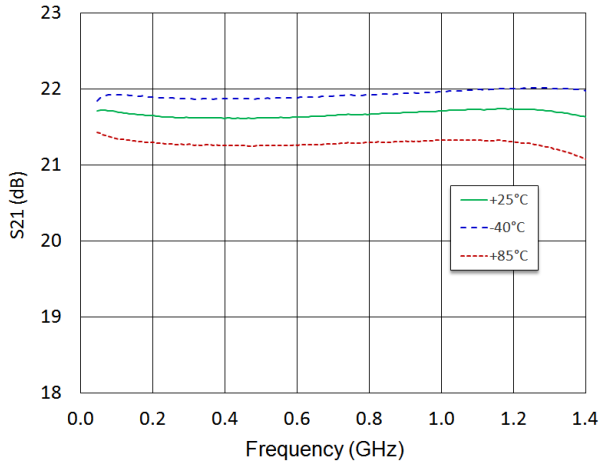
62 vias beneath package  
0.012 in. via diameter

## Low Noise Amplifier 5 - 4000 MHz

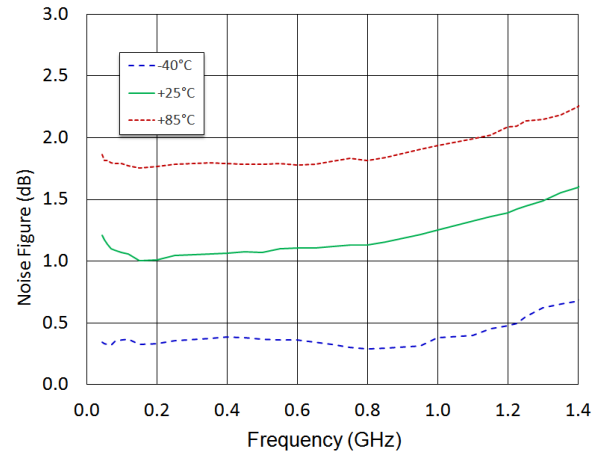
Rev. V2

Typical Performance Curves:  $V_{DD} = 5\text{ V}$ ,  $85\text{ mA}$ ,  $+25^\circ\text{C}$ ,  $Z_0 = 75\ \Omega$ , 45 - 1218 MHz

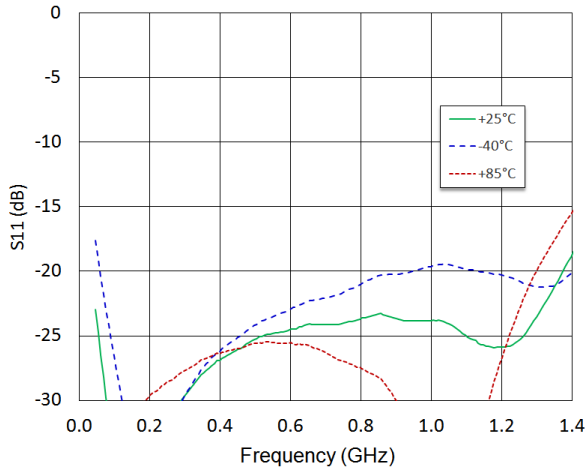
**Gain**



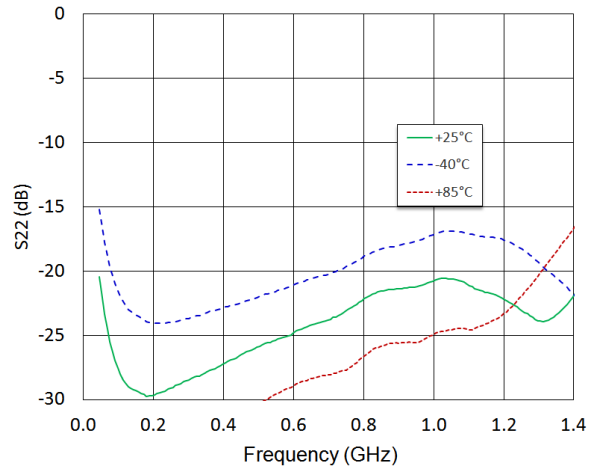
**Noise Figure**



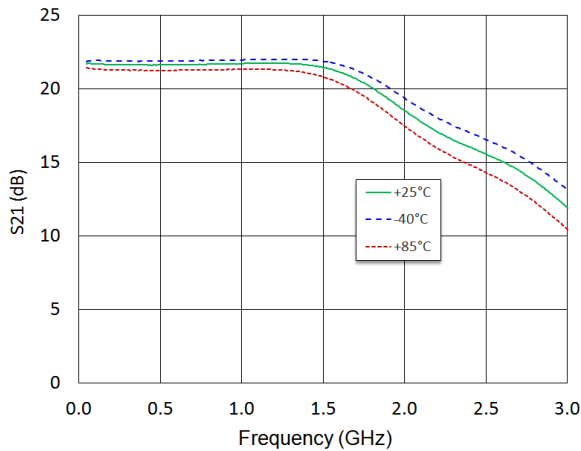
**Input Return Loss**



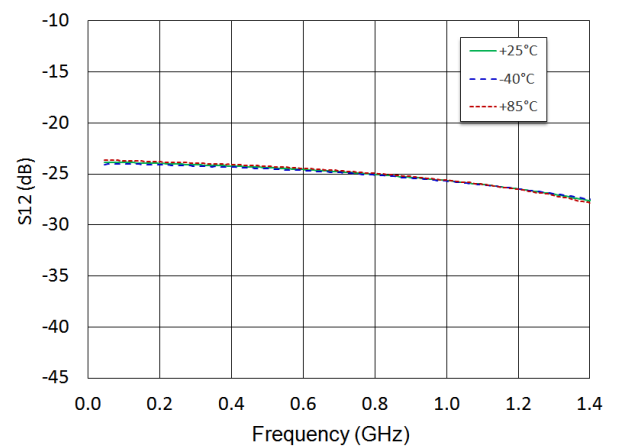
**Output Return Loss**



**Gain to 3 GHz**



**Reverse Isolation**

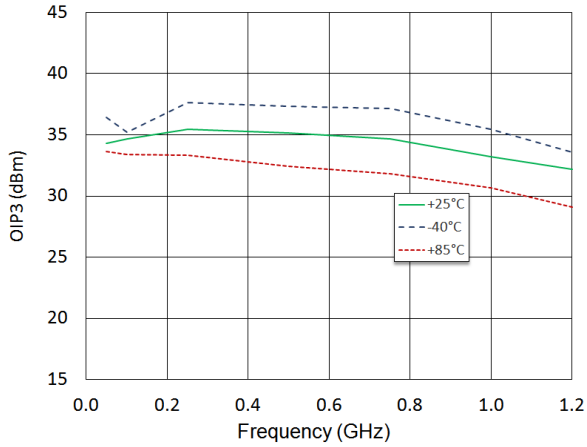


## Low Noise Amplifier 5 - 4000 MHz

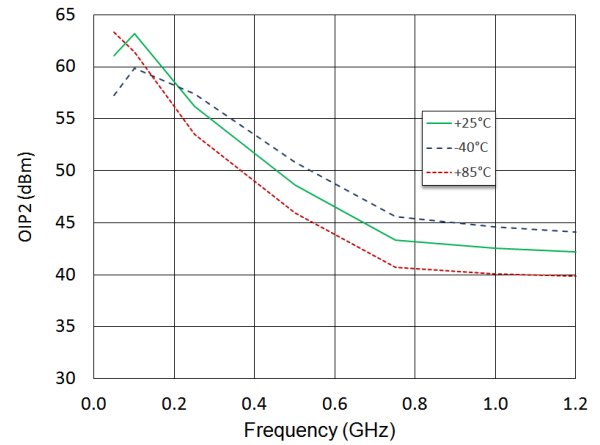
Rev. V2

Typical Performance Curves:  $V_{DD} = 5\text{ V}$ ,  $85\text{ mA}$ ,  $+25^\circ\text{C}$ ,  $Z_0 = 75\ \Omega$ , 45 - 1218 MHz

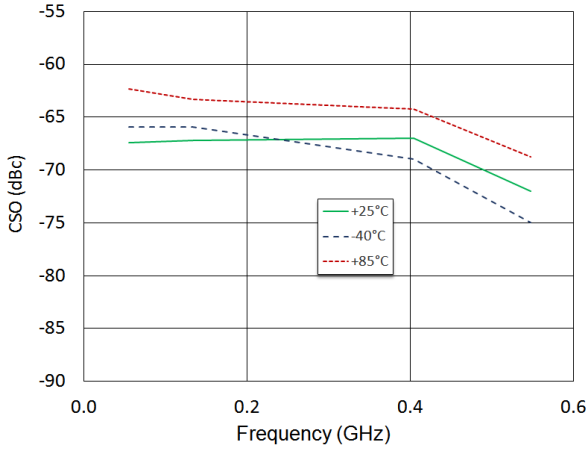
**OIP3,  $P_{OUT} = 0\text{ dBm/tone}$**



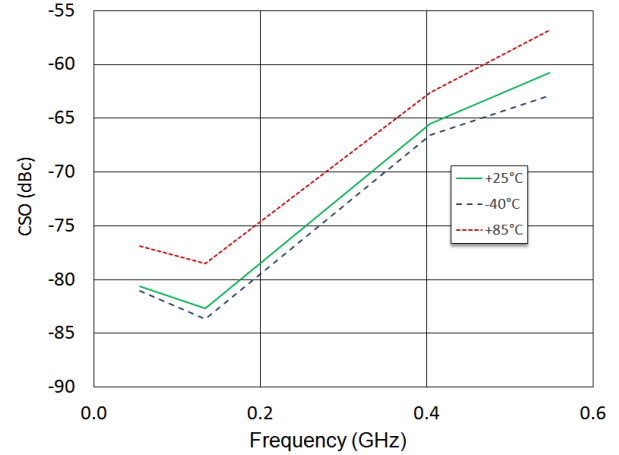
**OIP2,  $P_{OUT} = 0\text{ dBm/tone}$**



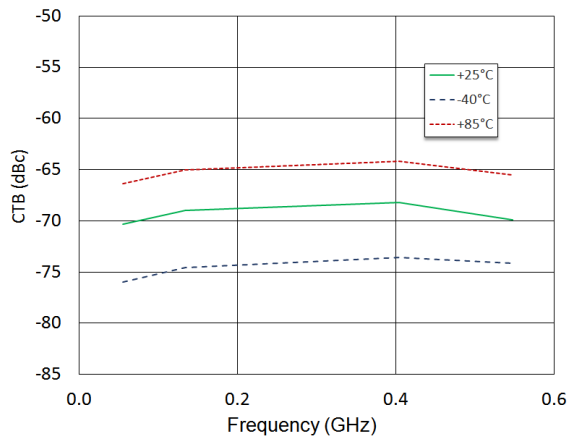
**CSO Lower, 79 channels + QAM to 1 GHz, 0 dB tilt, 32 dBmV per channel**



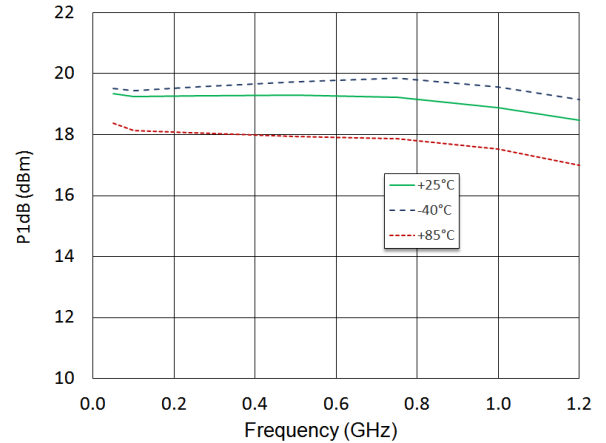
**CSO Lower, 79 channels + QAM to 1 GHz, 0 dB tilt, 32 dBmV per channel**



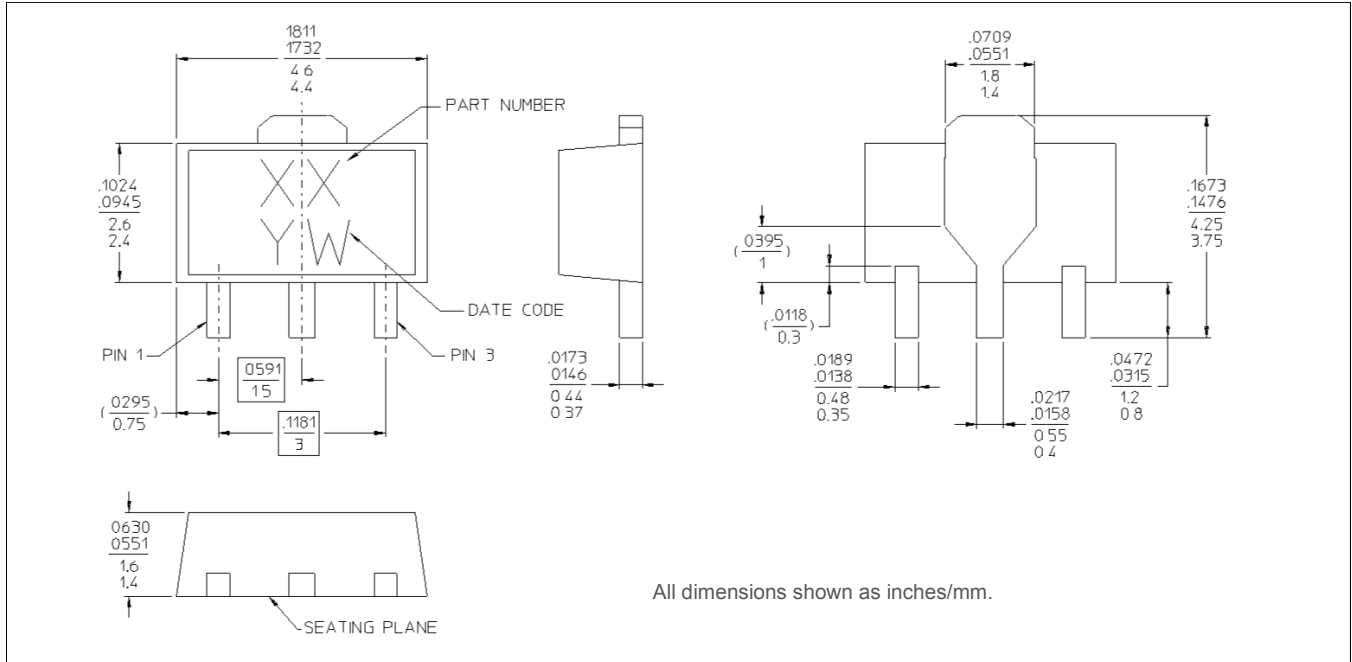
**CTB Lower, 79 channels + QAM to 1 GHz, 0 dB tilt, 32 dBmV per channel**



**P1dB**



**Lead Free SOT-89<sup>†</sup>**



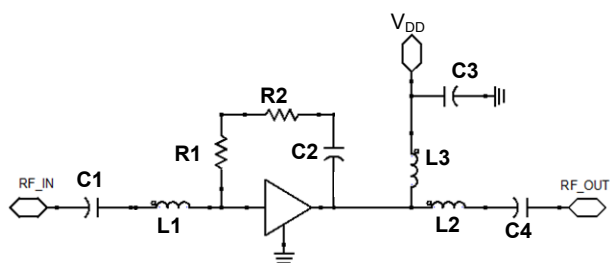
<sup>†</sup> Reference Application Note S2083 for lead-free solder reflow recommendations.  
Meets JEDEC moisture sensitivity level 1 requirements.  
Plating is 100% matte tin over copper.

## Low Current and Low Noise Application Section

The MAAL-011139 can also be operated with lower current to support lower noise figure by removing 2 bias resistors, R3 and R4, as detailed below.

### Schematic Including Off-Chip Components 45 - 1218 MHz Application

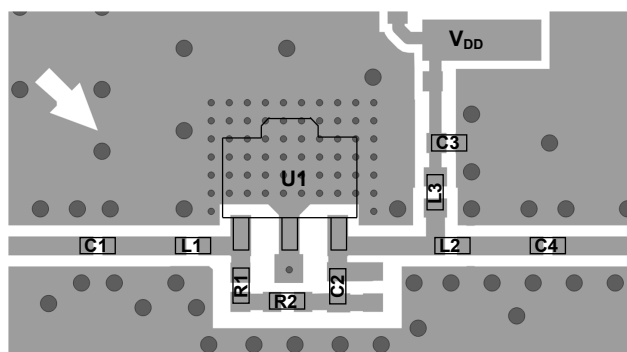
### Parts List, $V_{DD} = 5\text{ V}$ , 55 mA



| Component | Value                     | Package |
|-----------|---------------------------|---------|
| C1 - C3   | 10 nF                     | 0402    |
| C4        | 270 pF                    | 0402    |
| L1        | 6.2 nH                    | 0402    |
| L2        | 3.3 nH                    | 0402    |
| L3        | Ferrite Bead <sup>8</sup> | 0402    |
| R1 - R2   | 510 $\Omega$              | 0402    |

8. Murata, part number BLM15HD182SN.

### Recommended PCB Layout



## Low Current and Low Noise Application Section

**Typical Performance:  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 5\text{ V}$ ,  $55\text{ mA}$ ,  $Z_0 = 75\ \Omega$ , 45 - 1218 MHz Application**

| Parameter                   | Test Conditions  | Units | Min. | Typ.       | Max. |
|-----------------------------|--|-------|------|------------|------|
| Gain                        | —  | dB    | —    | 21.5       | —    |
| Gain Flatness               | —  | dB    | —    | +/- 0.2    | —    |
| Reverse Isolation           | —  | dB    | —    | 25         | —    |
| Input Return Loss           | —  | dB    | —    | 23         | —    |
| Output Return Loss          | —  | dB    | —    | 23         | —    |
| Noise Figure                | 45 MHz<br>1218 MHz   | dB    | —    | 1.0<br>1.2 | —    |
| Output IP2                  | 45 - 1200 MHz, tone spacing 6 MHz,<br>$P_{OUT}$ per tone = 0 dBm       | dBm   | —    | 44         | —    |
| Output IP3                  | 45 - 1200 MHz, tone spacing 6 MHz,<br>$P_{OUT}$ per tone = 0 dBm       | dBm   | —    | 35         | —    |
| P1dB                        | —  | dBm   | —    | 18         | —    |
| Composite Triple Beat, CTB  | 79 channels, 0 dB Tilt, 18 dBmV per<br>channel output, QAM to 1000 MHz | dBc   | —    | -80        | —    |
| Composite Second Order, CSO | 79 channels, 0 dB Tilt, 18 dBmV per<br>channel output, QAM to 1000 MHz | dBc   | —    | -63        | —    |
| $I_{DD}$                    | —  | mA    | —    | 55         | —    |

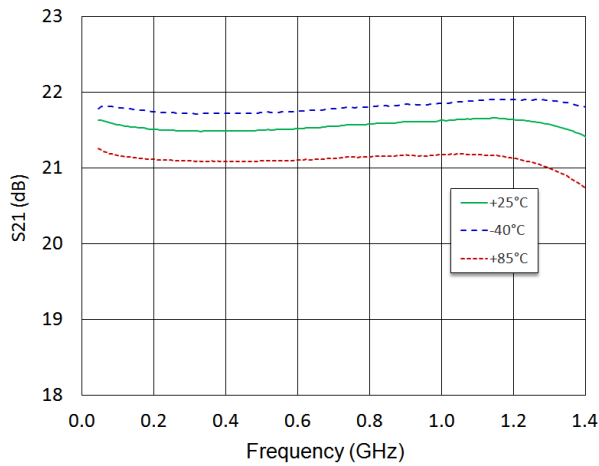


## Low Noise Amplifier 5 - 4000 MHz

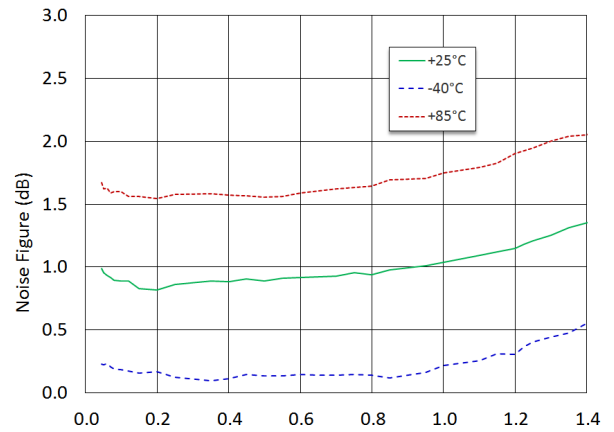
Rev. V2

Typical Performance Curves:  $V_{DD} = 5\text{ V}$ ,  $55\text{ mA}$ ,  $+25^\circ\text{C}$ ,  $Z_0 = 75\ \Omega$ , 45 - 1218 MHz

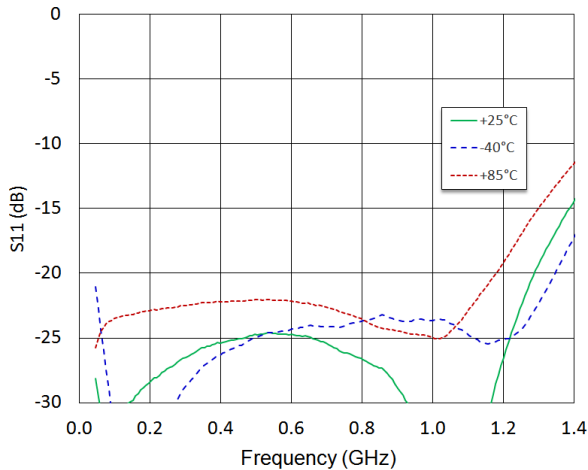
**Gain**



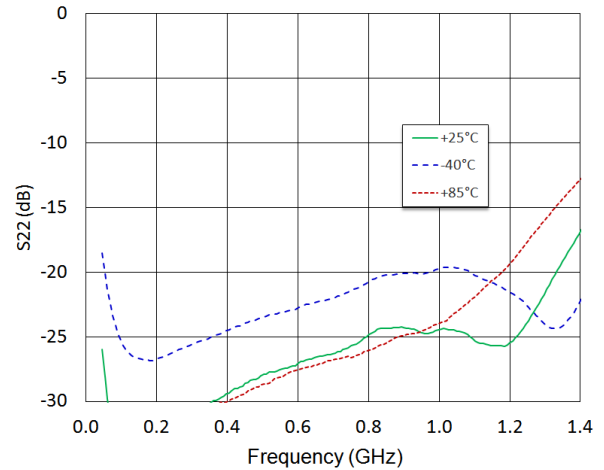
**Noise Figure**



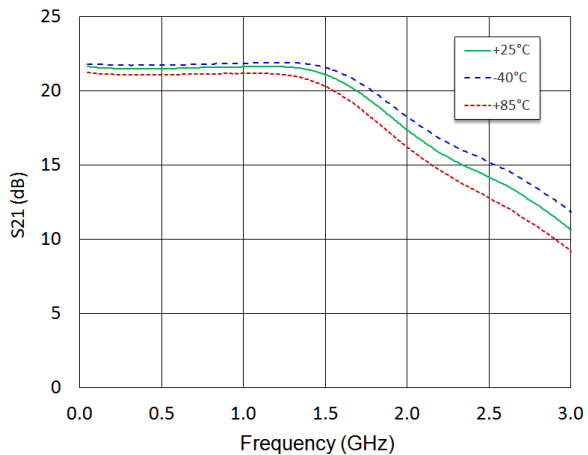
**Input Return Loss**



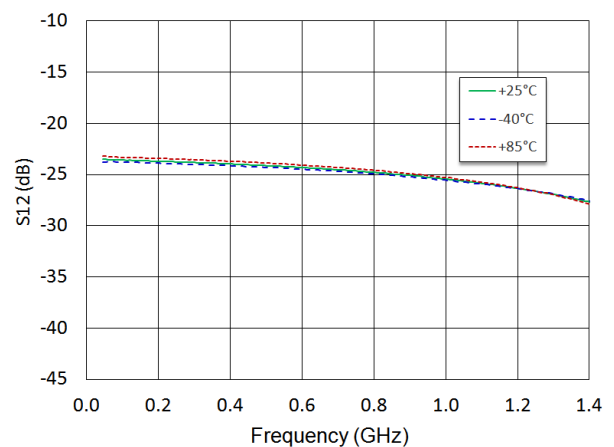
**Output Return Loss**



**Gain to 3 GHz**



**Reverse Isolation**

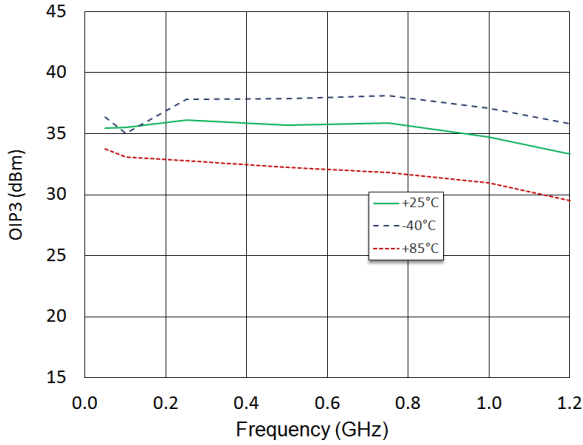


## Low Noise Amplifier 5 - 4000 MHz

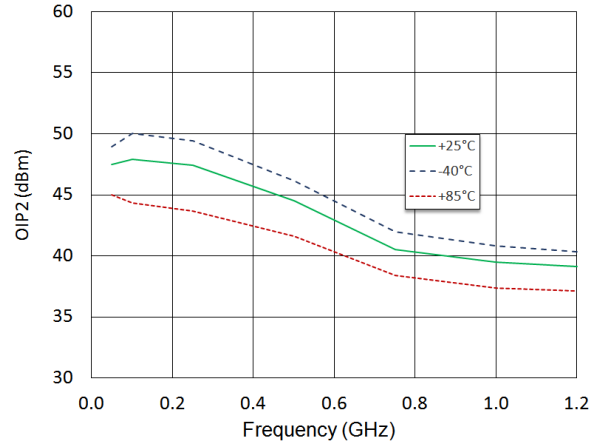
Rev. V2

Typical Performance Curves:  $V_{DD} = 5\text{ V}$ ,  $55\text{ mA}$ ,  $+25^\circ\text{C}$ ,  $Z_0 = 75\ \Omega$ , 45 - 1218 MHz

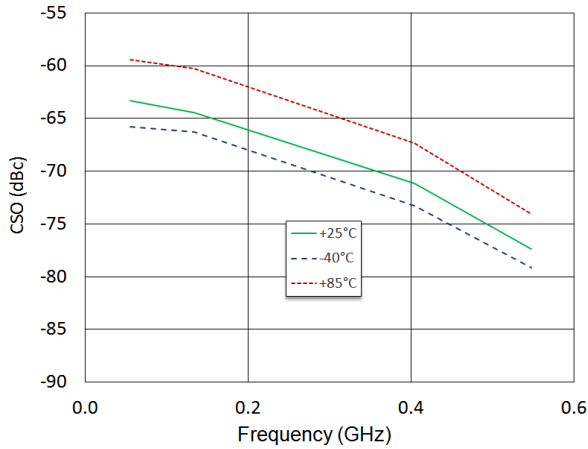
**OIP3,  $P_{OUT} = 0\text{ dBm/tone}$**



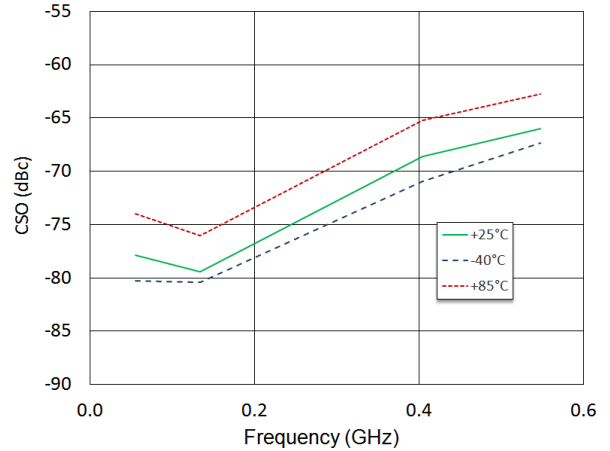
**OIP2,  $P_{OUT} = 0\text{ dBm/tone}$**



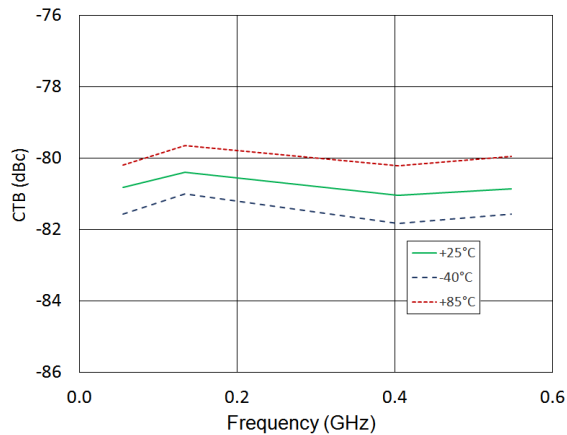
**CSO Lower, 79 channels + QAM to 1 GHz, 0 dB tilt, 18 dBmV per channel**



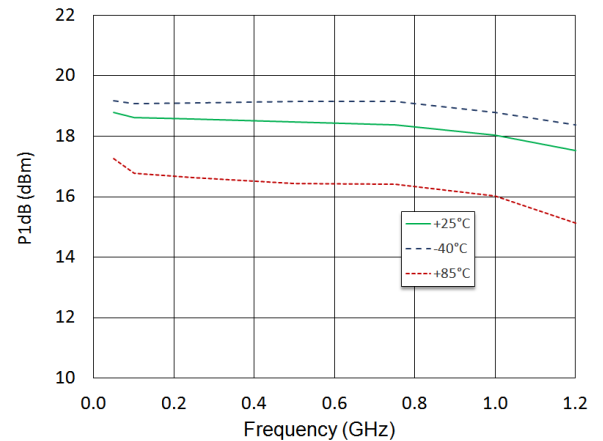
**CSO Lower, 79 channels + QAM to 1 GHz, 0 dB tilt, 18 dBmV per channel**



**CTB Lower, 79 channels + QAM to 1 GHz, 0 dB tilt, 18 dBmV per channel**



**P1dB**



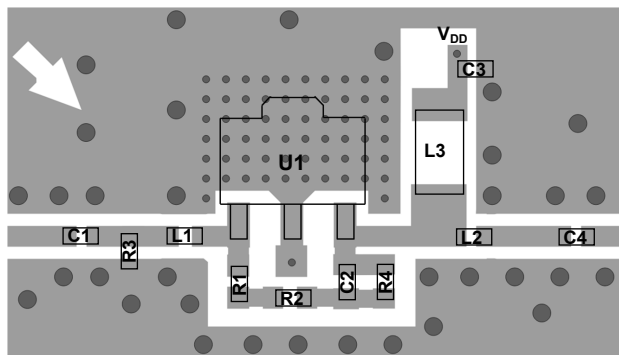
## 5 - 300 MHz Application Section

The MAAL-011139 can be tuned for operation in the 5 - 300 MHz band for CATV reverse path (upstream) applications using alternate external tuning components.

### Typical Performance: $T_A = 25^\circ\text{C}$ , $V_{DD} = 5\text{ V}$ , $85\text{ mA}$ , $Z_0 = 75\ \Omega$ , 5 - 300 MHz Application

| Parameter          | Test Conditions  | Units | Min. | Typ.       | Max. |
|--------------------|--|-------|------|------------|------|
| Gain               | —  | dB    | —    | 21.6       | —    |
| Gain Flatness      | —  | dB    | —    | +/- 0.2    | —    |
| Reverse Isolation  | —  | dB    | —    | 25         | —    |
| Input Return Loss  | —  | dB    | —    | 25         | —    |
| Output Return Loss | —  | dB    | —    | 22         | —    |
| Noise Figure       | 10 - 50 MHz<br>50 - 300 MHz  | dB    | —    | 3.1<br>1.2 | —    |
| Output IP2         | 5 - 300 MHz, tone spacing 6 MHz,<br>$P_{OUT}$ per tone = 0 dBm             | dBm   | —    | 55         | —    |
| Output IP3         | 5 - 300 MHz, tone spacing 6 MHz,<br>$P_{OUT}$ per tone = 0 dBm             | dBm   | —    | 34         | —    |
| P1dB               | —  | dBm   | —    | 19         | —    |
| Noise Power Ratio  | 5 - 85 MHz, 41 MHz Notch, Peak NPR<br>5 - 204 MHz, 100 MHz Notch, Peak NPR | dB    | —    | 65<br>61   | —    |
| $I_{DD}$           | —  | mA    | —    | 85         | —    |

### Recommended PCB Layout 5 - 300 MHz Application



### Parts List, $V_{DD} = 5\text{ V}$ , $85\text{ mA}$

| Component | Value              | Package |
|-----------|--------------------|---------|
| C1 - C3   | 10 nF              | 0402    |
| C4        | 2200 pF            | 0402    |
| L1        | 0 $\Omega$         | 0402    |
| L2        | 6.8 nH             | 0402    |
| L3        | 22 $\mu\text{H}^9$ | 0806    |
| R1 - R2   | 510 $\Omega$       | 0402    |
| R3        | 10 k $\Omega$      | 0402    |
| R4        | 30.1 k $\Omega$    | 0402    |

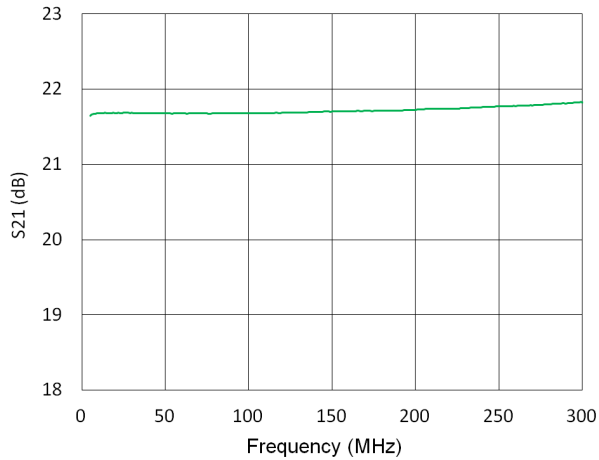
9. Inductor from Murata, part number LQH2MCN220K02.

## Low Noise Amplifier 5 - 4000 MHz

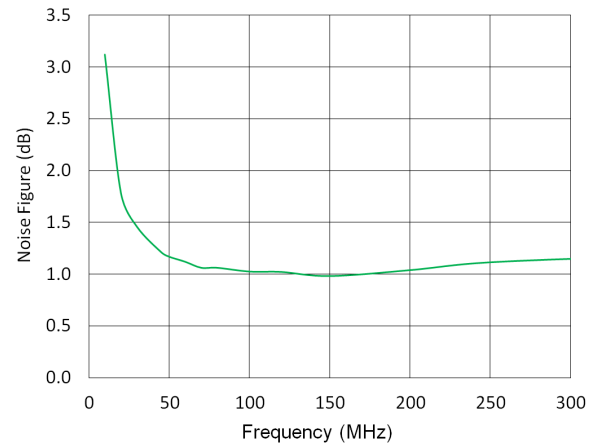
Rev. V2

Typical Performance Curves:  $V_{DD} = 5\text{ V}$ ,  $85\text{ mA}$ ,  $+25^\circ\text{C}$ ,  $Z_0 = 75\ \Omega$ , 5 - 300 MHz

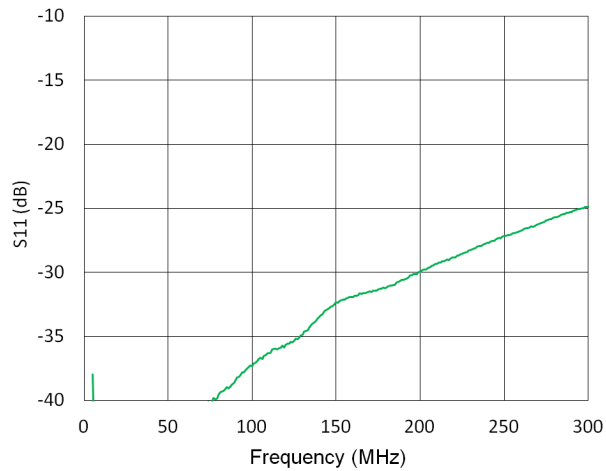
**Gain**



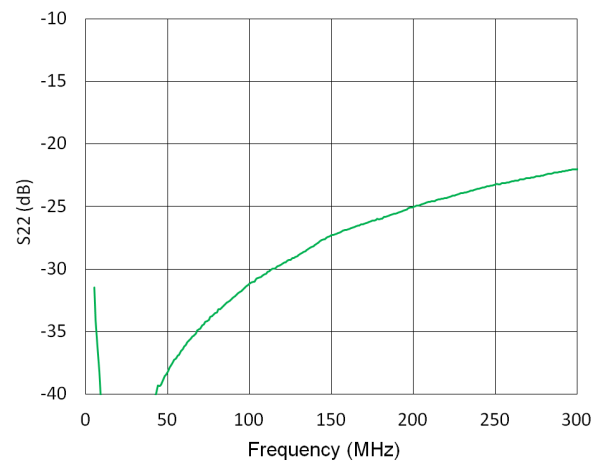
**Noise Figure, 10 - 300 MHz**



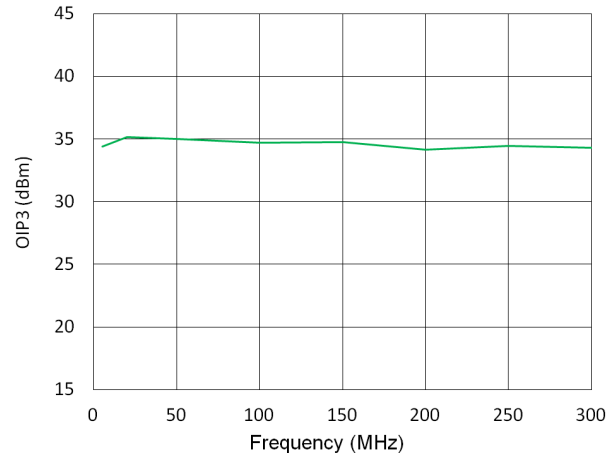
**Input Return Loss**



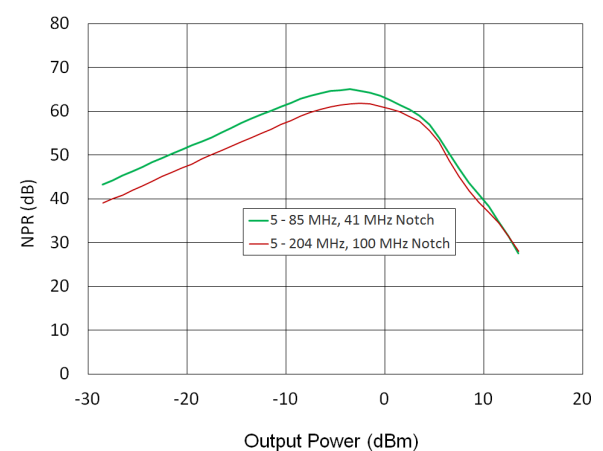
**Output Return Loss**



**OIP3,  $P_{OUT} = 0\text{ dBm/tone}$**



**NPR**



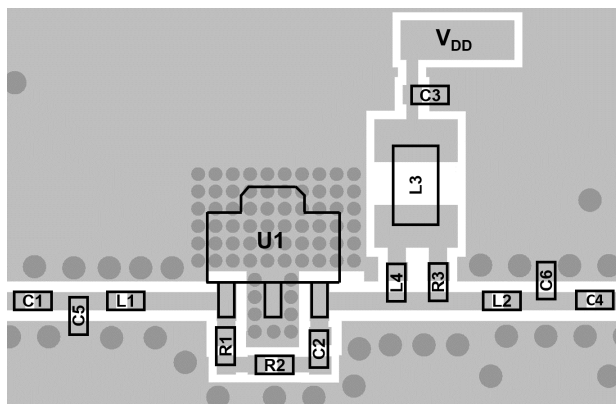
## 5 - 700 MHz Full Duplex Application Section

The MAAL-011139 can be tuned for operation in the 5-700 MHz band for CATV Full Duplex applications using alternate external tuning components.

### Typical Performance: $T_A = 25^\circ\text{C}$ , $V_{DD} = 5\text{ V}$ , $55\text{ mA}$ , $Z_0 = 75\ \Omega$ , 5 - 700 MHz Application

| Parameter          | Test Conditions  | Units | Min. | Typ.       | Max. |
|--------------------|--|-------|------|------------|------|
| Gain               | —  | dB    | —    | 21.3       | —    |
| Gain Flatness      | —  | dB    | —    | +/- 0.3    | —    |
| Reverse Isolation  | —  | dB    | —    | 23         | —    |
| Input Return Loss  | —  | dB    | —    | 22         | —    |
| Output Return Loss | —  | dB    | —    | 20         | —    |
| Noise Figure       | 10 - 50 MHz<br>50 - 700 MHz                                      | dB    | —    | 2.5<br>1.0 | —    |
| Output IP2         | 5 - 700 MHz, tone spacing 6 MHz,<br>$P_{OUT}$ per tone = -10 dBm | dBm   | —    | 44         | —    |
| Output IP3         | 5 - 700 MHz, tone spacing 6 MHz,<br>$P_{OUT}$ per tone = -10 dBm | dBm   | —    | 35         | —    |
| P1dB               | —  | dBm   | —    | 18         | —    |
| Noise Power Ratio  | 5 - 204 MHz, 100 MHz Notch, Peak NPR                             | dB    | —    | 54         | —    |
| $I_{DD}$           | —  | mA    | —    | 55         | —    |

### Recommended PCB Layout 5 - 700 MHz Application



### Parts List, $V_{DD} = 5\text{ V}$ , $55\text{ mA}$

| Component | Value                      | Package |
|-----------|----------------------------|---------|
| C1 - C3   | 10 nF                      | 0402    |
| C4        | 2200 pF                    | 0402    |
| L1        | 0 $\Omega$                 | 0402    |
| L2        | 6.8 nH                     | 0402    |
| L3        | 22 $\mu\text{H}^{10}$      | 0806    |
| L4        | Ferrite Bead <sup>11</sup> | 0402    |
| R1 - R2   | 510 $\Omega$               | 0402    |
| R3        | 1.2 k $\Omega$             | 0402    |

10. Murata Inductor, part number LQH2MCN220K02.

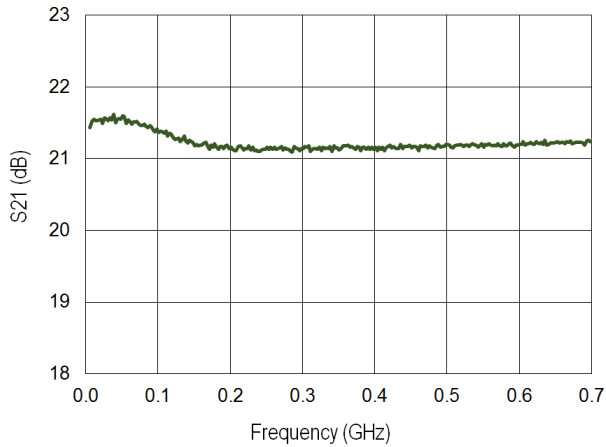
11. Murata Ferrite Bead, part number BLM15HD182SN.

## Low Noise Amplifier 5 - 4000 MHz

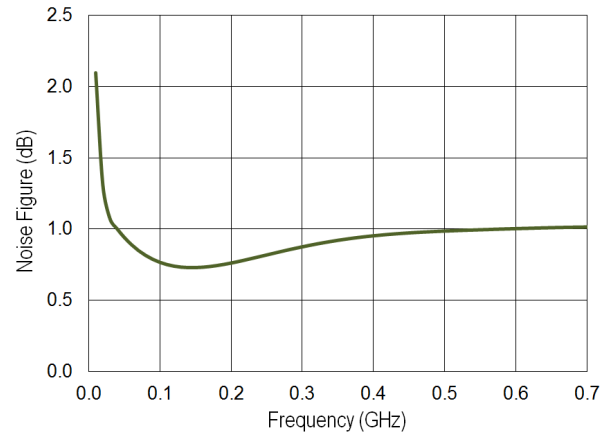
Rev. V2

Typical Performance Curves:  $V_{DD} = 5\text{ V}$ ,  $55\text{ mA}$ ,  $+25^\circ\text{C}$ ,  $Z_0 = 75\ \Omega$ , 5 - 700 MHz

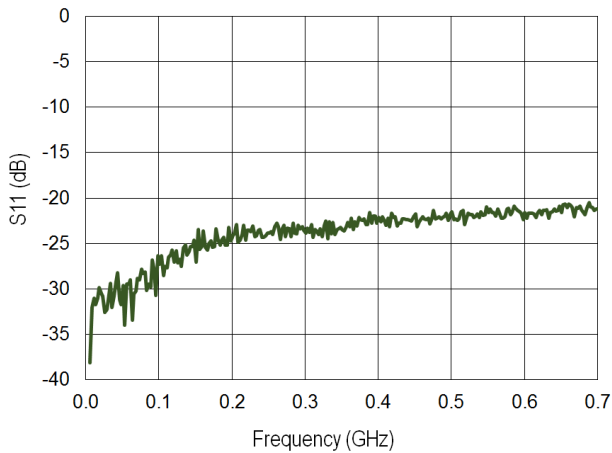
**Gain**



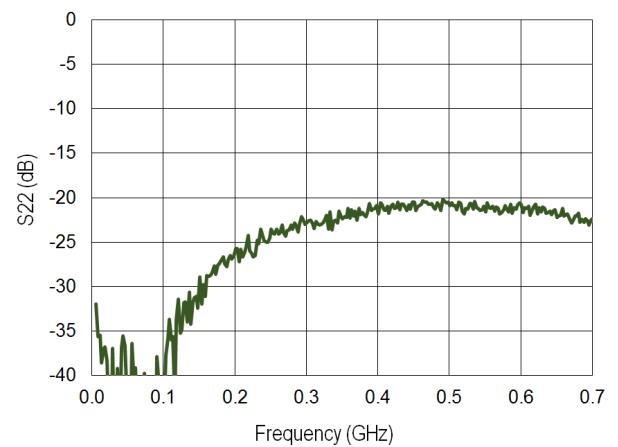
**Noise Figure, 10 - 700 MHz**



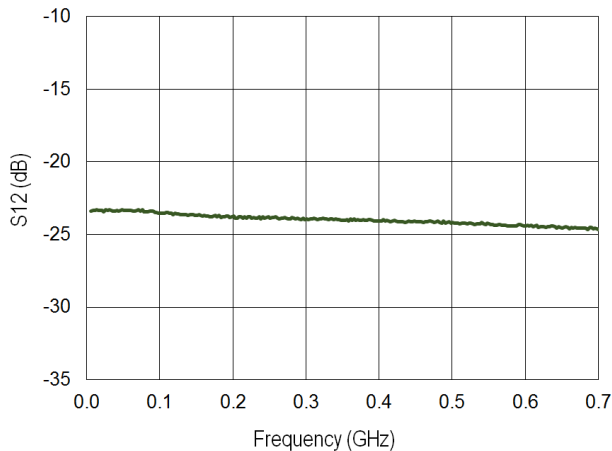
**Input Return Loss**



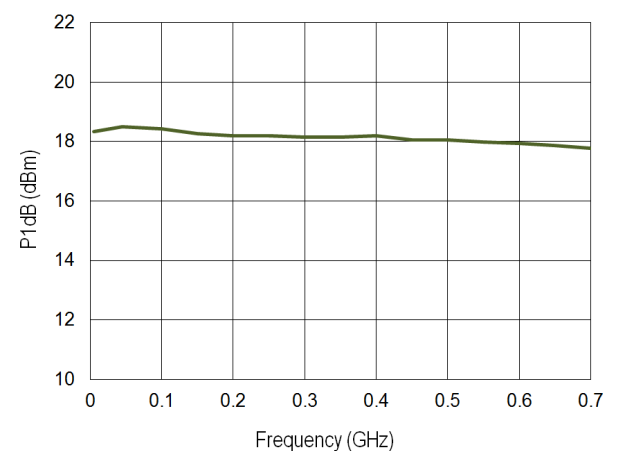
**Output Return Loss**



**Reverse Isolation**



**P1dB**

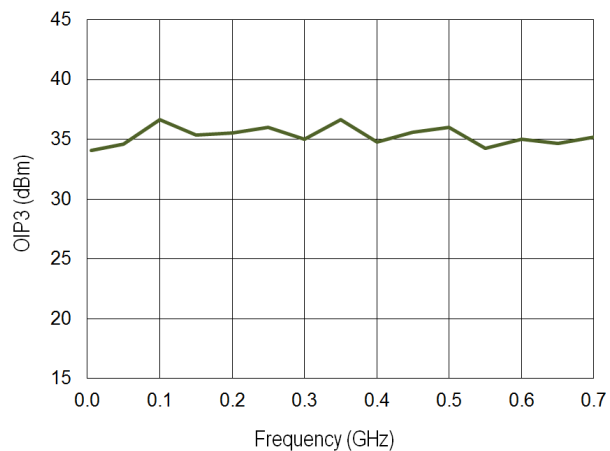


## Low Noise Amplifier 5 - 4000 MHz

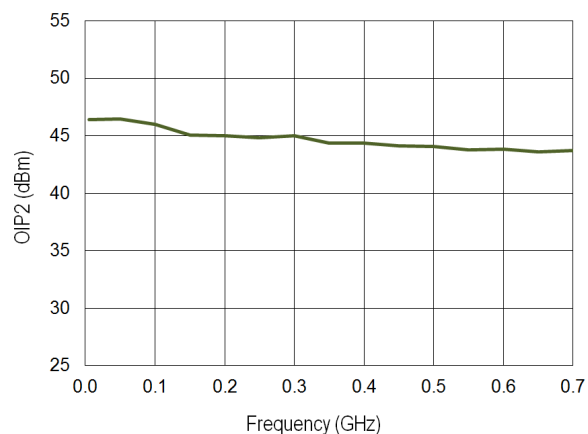
Rev. V2

Typical Performance Curves:  $V_{DD} = 5\text{ V}$ ,  $55\text{ mA}$ ,  $+25^\circ\text{C}$ ,  $Z_0 = 75\ \Omega$ , 5 - 700 MHz

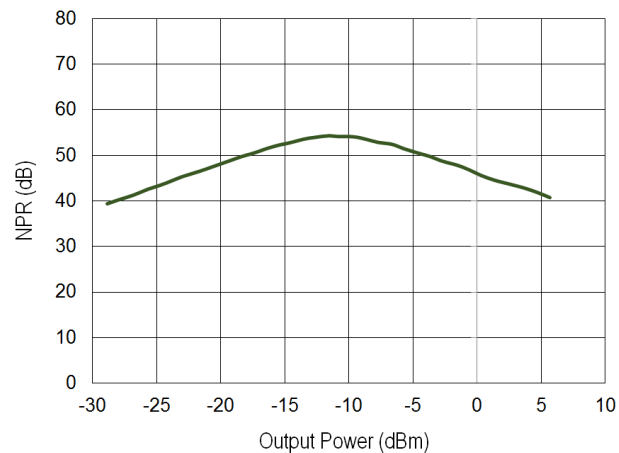
**OIP3**,  $P_{OUT} = -10\text{ dBm/tone}$



**OIP2**,  $P_{OUT} = -10\text{ dBm/tone}$



**NPR**



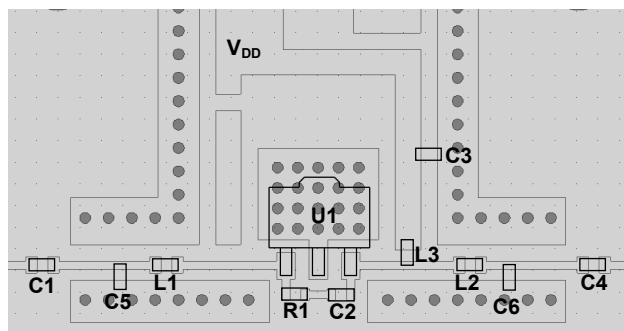
## 50 Ω System Application Section

The MAAL-011139 can be used for 50 Ω system by using a 50 Ω evaluation board and alternate external tuning components.

### Typical Performance: $T_A = 25^\circ\text{C}$ , $V_{DD} = 5\text{ V}$ , $55\text{ mA}$ , $Z_0 = 50\ \Omega$ , 45 - 2000 MHz Application

| Parameter          | Test Conditions  | Units | Min. | Typ.       | Max. |
|--------------------|--|-------|------|------------|------|
| Gain               | —  | dB    | —    | 17         | —    |
| Gain Flatness      | —  | dB    | —    | +/- 0.2    | —    |
| Reverse Isolation  | —  | dB    | —    | 19         | —    |
| Input Return Loss  | —  | dB    | —    | 15         | —    |
| Output Return Loss | —  | dB    | —    | 17         | —    |
| Noise Figure       | 45 MHz<br>2000 MHz   | dB    | —    | 1.5<br>1.8 | —    |
| Output IP2         | 45 - 2000 MHz, tone spacing 6 MHz,<br>$P_{OUT}$ per tone = 0 dBm | dBm   | —    | 40         | —    |
| Output IP3         | 45 - 2000 MHz, tone spacing 6 MHz,<br>$P_{OUT}$ per tone = 0 dBm | dBm   | —    | 32         | —    |
| P1dB               | —  | dBm   | —    | 16.5       | —    |
| $I_{DD}$           | —  | mA    | —    | 55         | —    |

### Recommended PCB Layout 50 Ω, 45 - 2000 MHz Application



### Parts List, $V_{DD} = 5\text{ V}$ , $55\text{ mA}$

| Component | Value                      | Package |
|-----------|----------------------------|---------|
| C1 - C3   | 10 nF                      | 0402    |
| C4        | 220 pF                     | 0402    |
| C5        | 0.7 pF                     | 0402    |
| C6        | 0.5 pF                     | 0402    |
| L1 - L2   | 3.3 nH                     | 0402    |
| L3        | Ferrite Bead <sup>12</sup> | 0402    |
| R1        | 430 Ω                      | 0402    |

12. Murata, part number BLM15HD182SN.

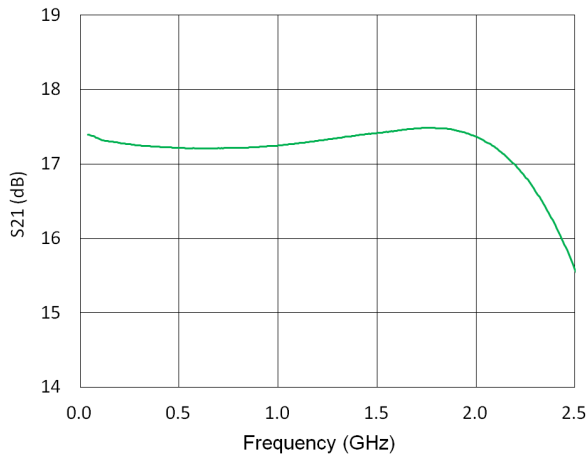


## Low Noise Amplifier 5 - 4000 MHz

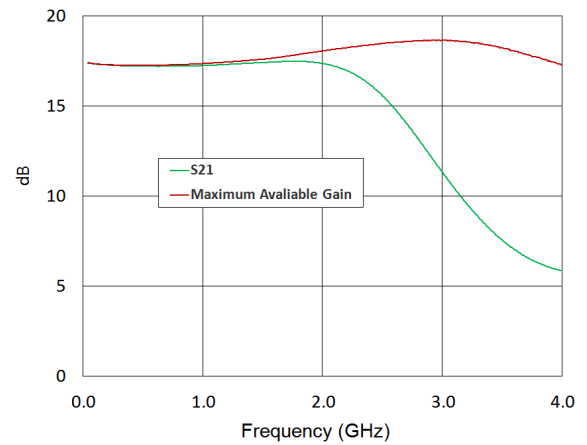
Rev. V2

Typical Performance Curves:  $V_{DD} = 5\text{ V}$ ,  $55\text{ mA}$ ,  $+25^\circ\text{C}$ ,  $Z_0 = 50\ \Omega$ , 45 - 2000 MHz

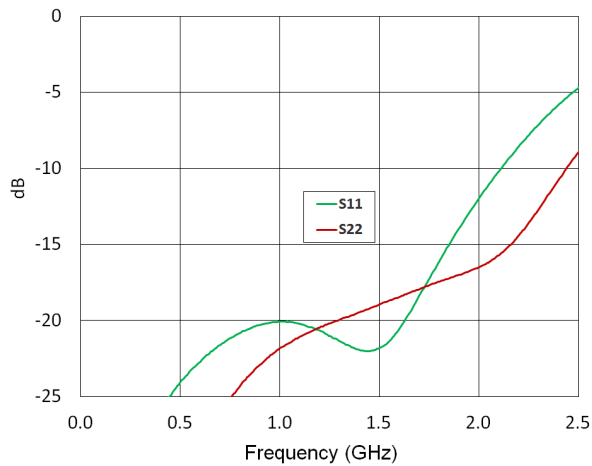
### Gain



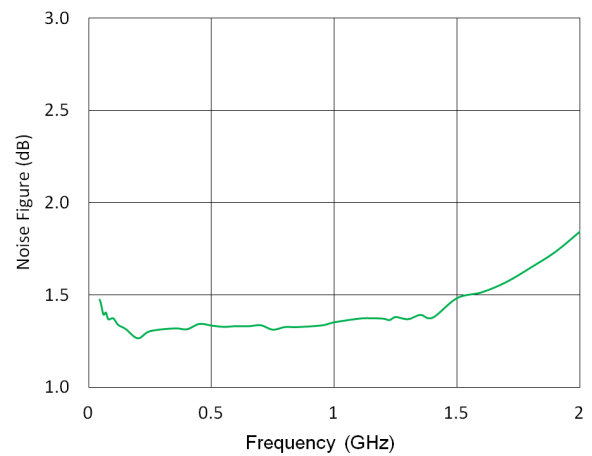
### Gain to 4 GHz



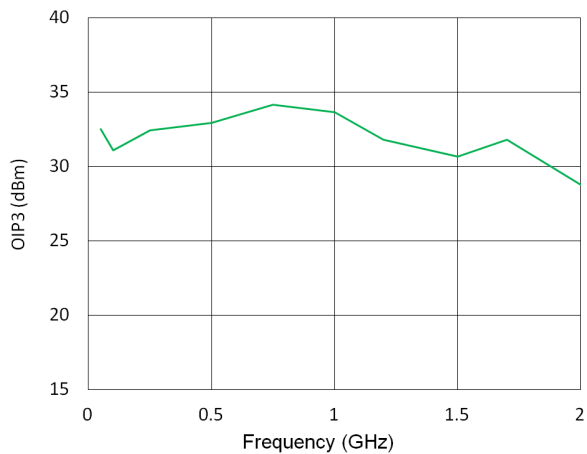
### Input & Output Return Losses



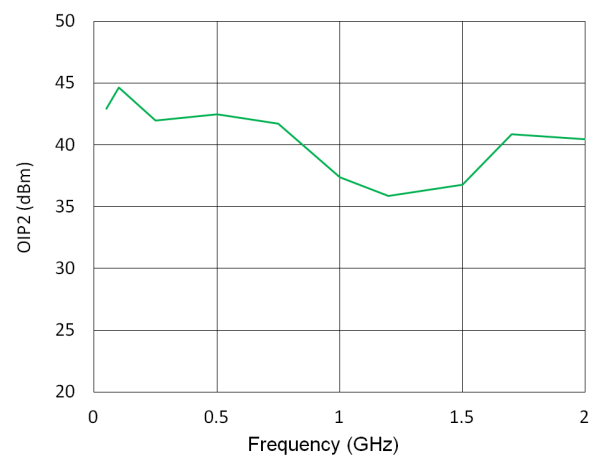
### Noise Figure



### OIP3, $P_{OUT} = 0\text{ dBm/tone}$



### OIP2, $P_{OUT} = 0\text{ dBm/tone}$



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