Low Noise Amplifier
0.076 - 6 GHz

AEC-Q100

MAAL-011207-QR3000
Rev. V5

Features

- AEC-Q100 Grade 2 Qualified (-40°C to +105°C)
- Low Noise Figure:
- 0.60 dB @ 0.15 GHz
  0.35 dB @ 1.9 GHz
  0.70 dB @ 2.6 GHz
- High Gain:
  23.5 dB @ 0.15 GHz
  23.0 dB @ 2.6 GHz
  18.0 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
- RoHS* Compliant

Applications

This part is ideal for Automotive applications such as Compensators and Smart Antenna Systems, designed for V2X infrastructure technologies (either DSRC or C-V2X) based Telematics Control Units (TCUs).

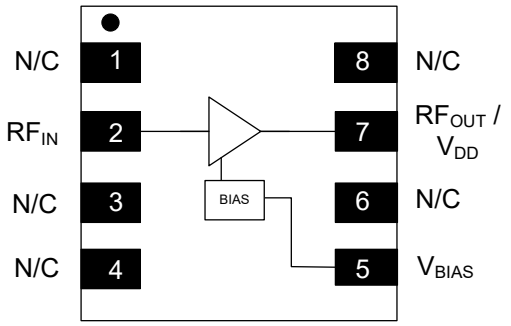
Description

The MAAL-011207 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 0.076 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-011207 offers 0.7 dB noise figure at 2.6 GHz, with 23 dB of gain and over 33 dBm output third order intercept point (OIP3).

Functional Block Diagram



Pin Configuration[1]

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[2]	Ground

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

Ordering Information[3,4]

Part Number	Package
MAAL-011207-QR3000	3000 Piece Reel
MAAL-011207-Q01SMB	5.9 GHz Sample Board
MAAL-011207-Q02SMB	0.76 GHz Sample Board

3. Reference Application Note M513 for reel size information.
4. All sample boards include 5 loose parts.

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

Electrical Specifications: Freq = 1.9 GHz, V_{DD} = 3 V, +25ºC, Z_0 = 50 Ω, V_{BIAS} = 2.3 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 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	-55ºC to +150ºC
Operating Temperature	-40ºC to +105ºC
Junction Temperature[10]	+150ºC

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 $T_J \leq 150°C$ will ensure MTTF > 1 x 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°C,
    T_J = 33°C @ 3V, 0.05 A, P_{OUT} = 17.5 dBm, P_{IN} = -4.5 dBm
    b) For T_C = +85°C,
    T_J = 93°C @ 3V, 0.05 A, P_{OUT} = 17.5 dBm, P_{IN} = -4.5 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 Class C3 CDM, Class 1A HBM devices.

Biasing Options

The MAAL-011207 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.

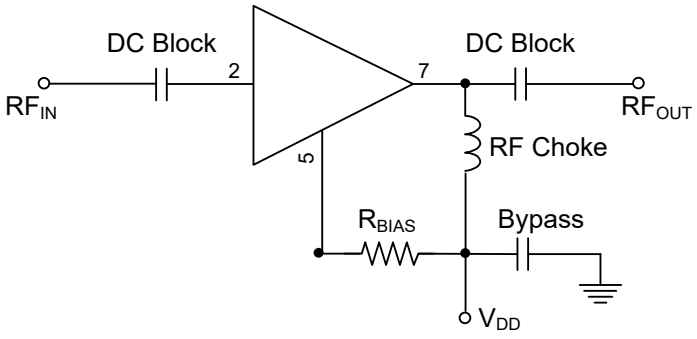


Figure 1

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 µA @ V_{BIAS} = 0 V. Typical current (I_{DD}) draw for pin 7 (RF_{OUT} / V_{DD}) is < 1 µA @ V_{BIAS} = 0 V.

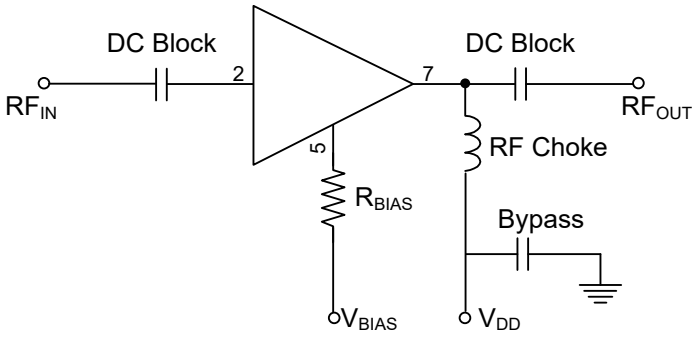
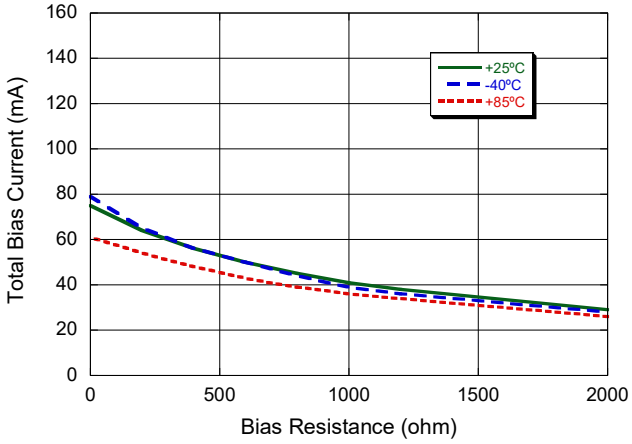


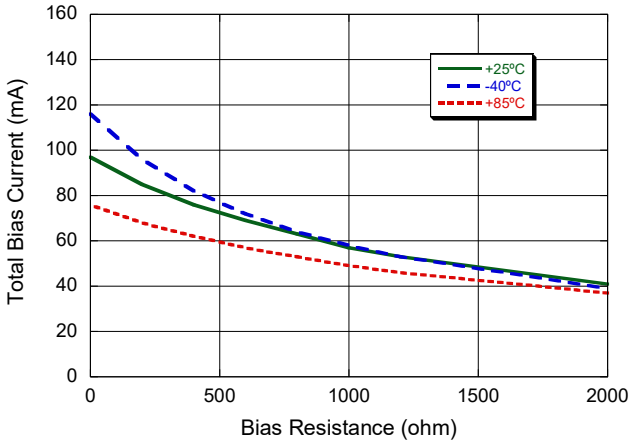
Figure 2

Typical Performance Curves of the Active Bias Circuit

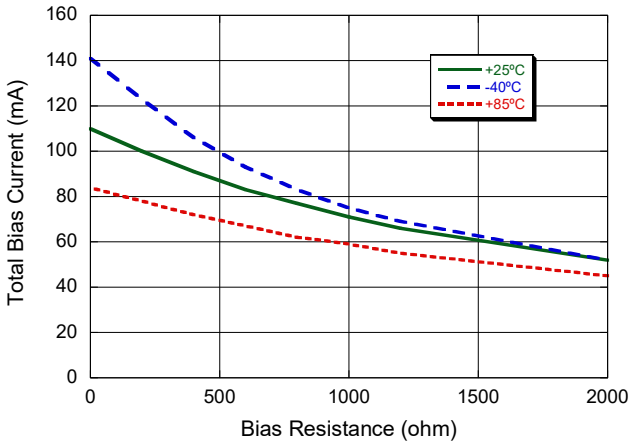
Current, V_{DD} = 3 V



Current, V_{DD} = 4 V



Current, V_{DD} = 5 V

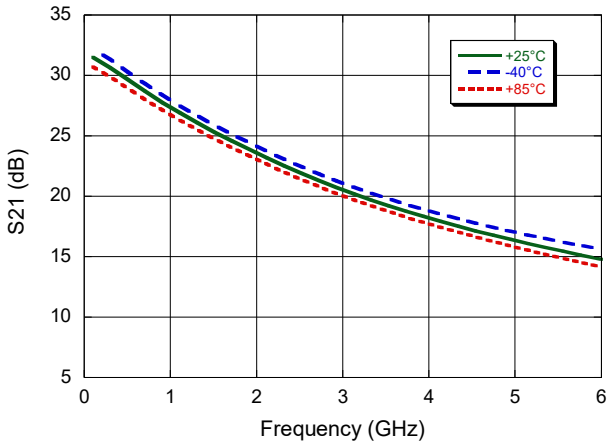


Bias Table

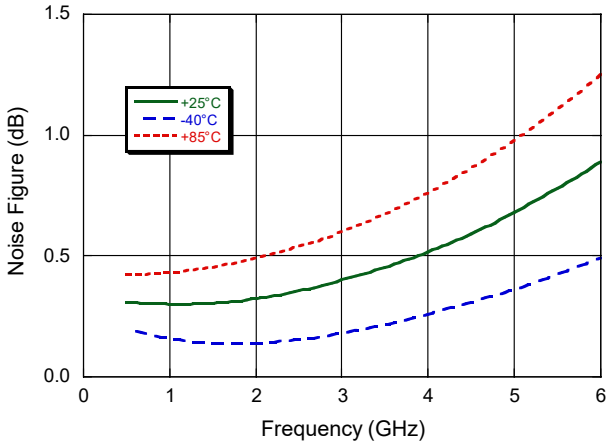
Bias Resistance (Ω)	Total Current (mA)								
	V_{DD} = 3 V			V_{DD} = 4 V			V_{DD} = 5 V		
	+25°C	-40°C	+85°C	+25°C	-40°C	+85°C	+25°C	-40°C	+85°C
2000	29	28	26	41	39	37	52	52	45
1200	38	36	34	53	53	46	66	69	55
1000	41	39	36	57	58	49	71	75	59
800	45	44	39	63	64	53	77	83	62
600	50	50	43	69	72	57	83	93	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

Typical Performance Curves @ 3 V / 50 mA, Z_0 = 50 Ω

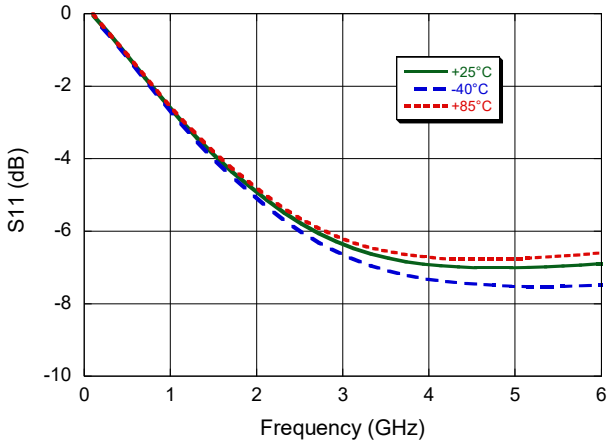
Gain



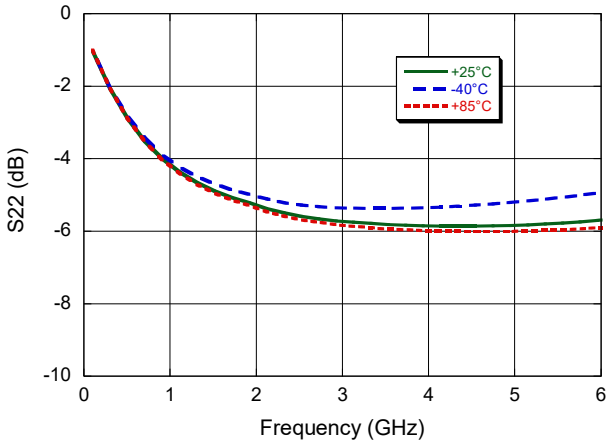
Noise Figure



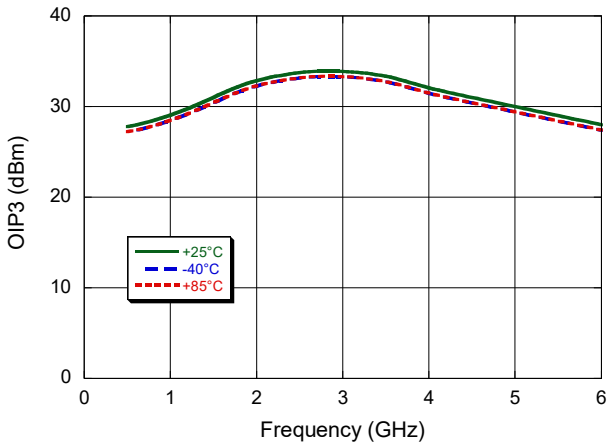
Input Return Loss



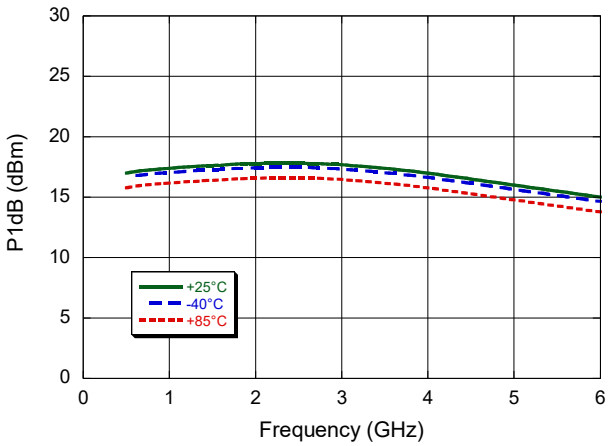
Output Return Loss



OIP3

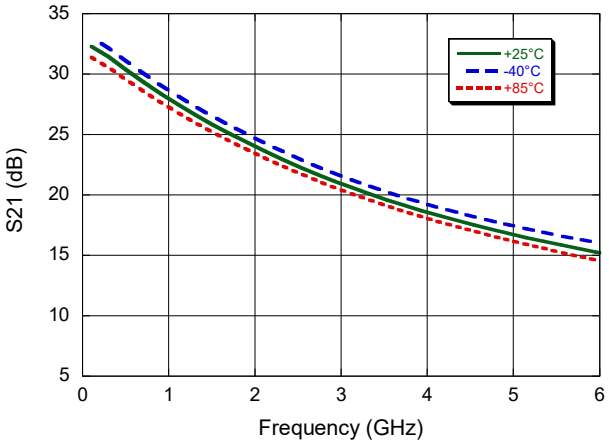


P1dB

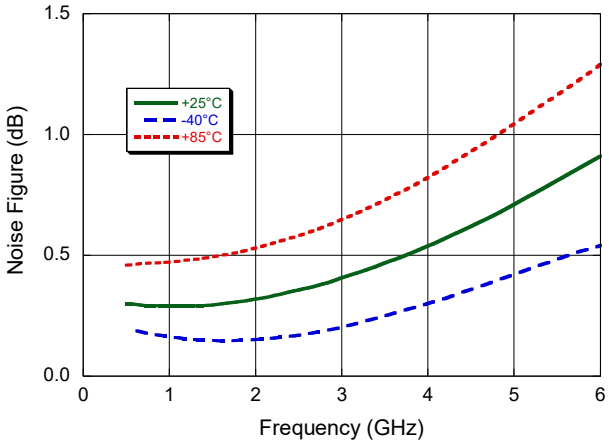


Typical Performance Curves @ 5 V / 70 mA, Z_0 = 50 Ω

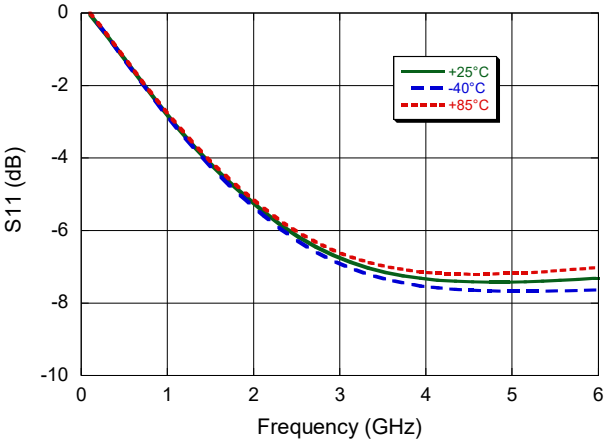
Gain



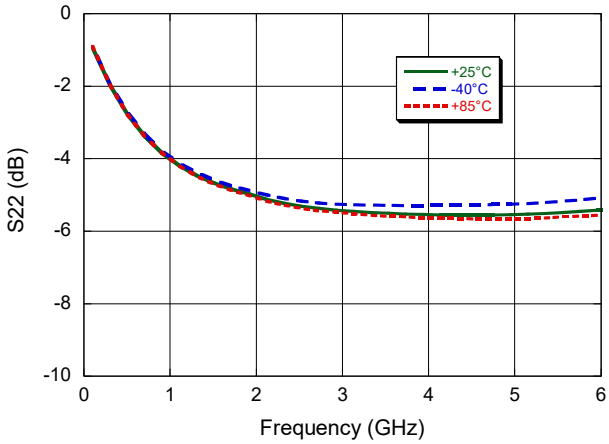
Noise Figure



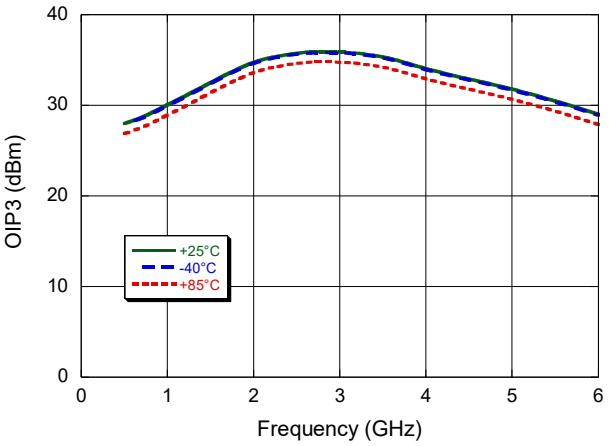
Input Return Loss



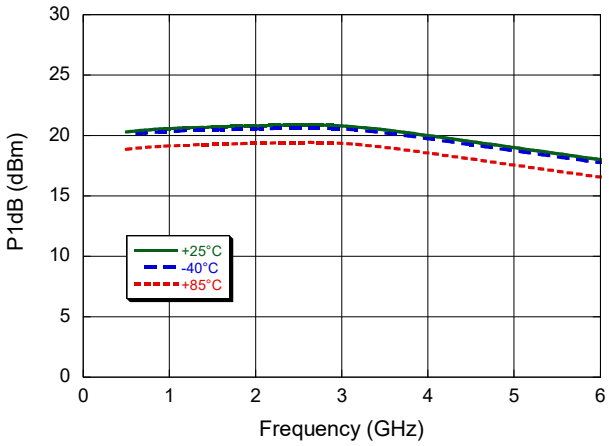
Output Return Loss



OIP3

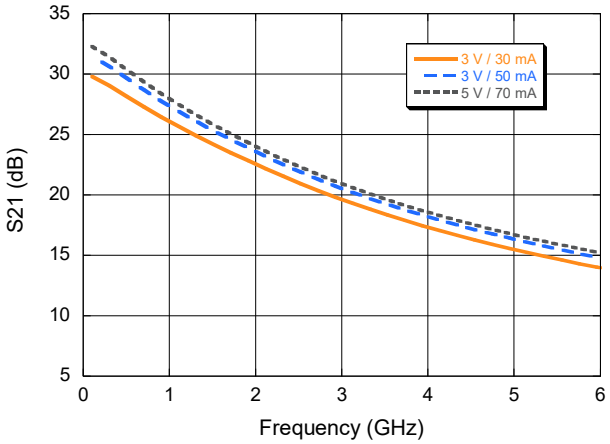


P1dB

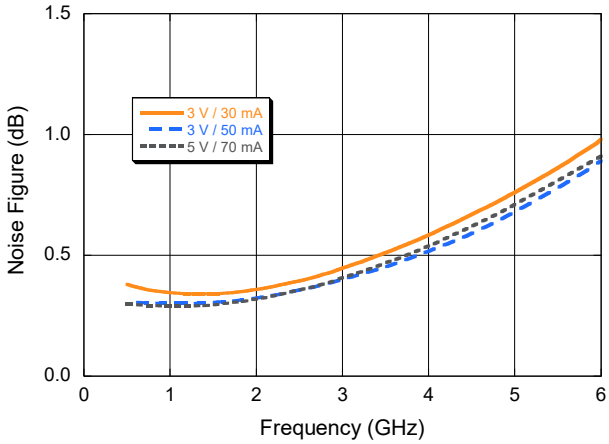


Typical Performance Curves @ 3 V / 30 mA, 3 V / 50 mA, 5V / 70 mA, Z_0 = 50 Ω

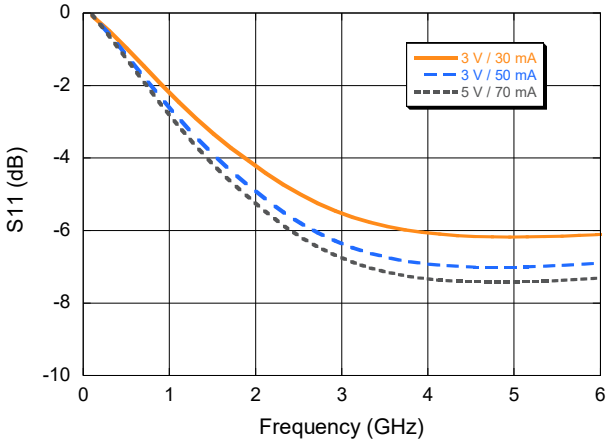
Gain



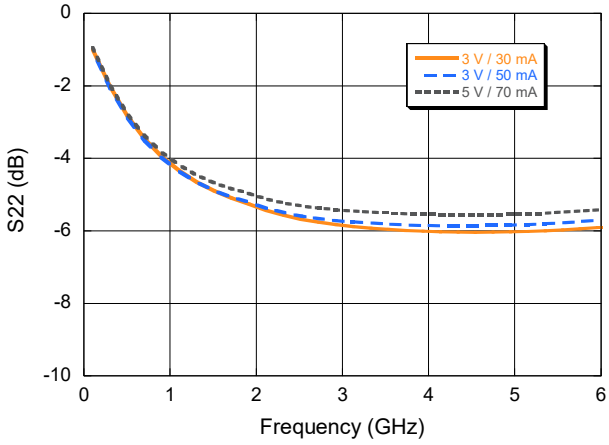
Noise Figure



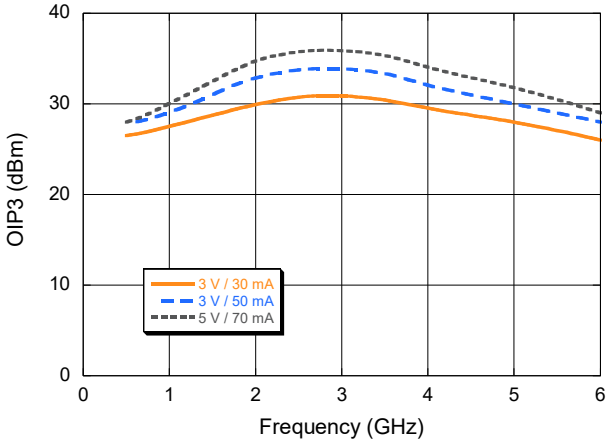
Input Return Loss



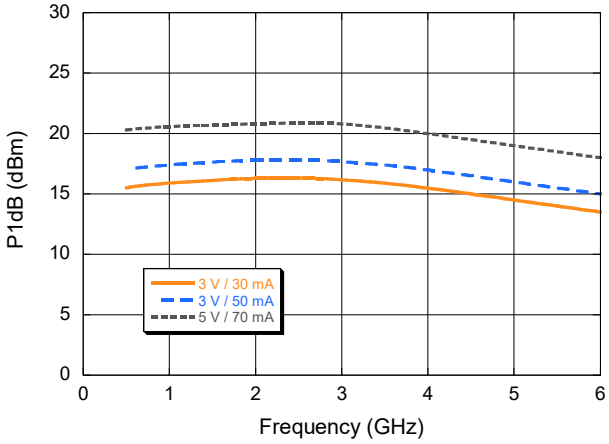
Output Return Loss



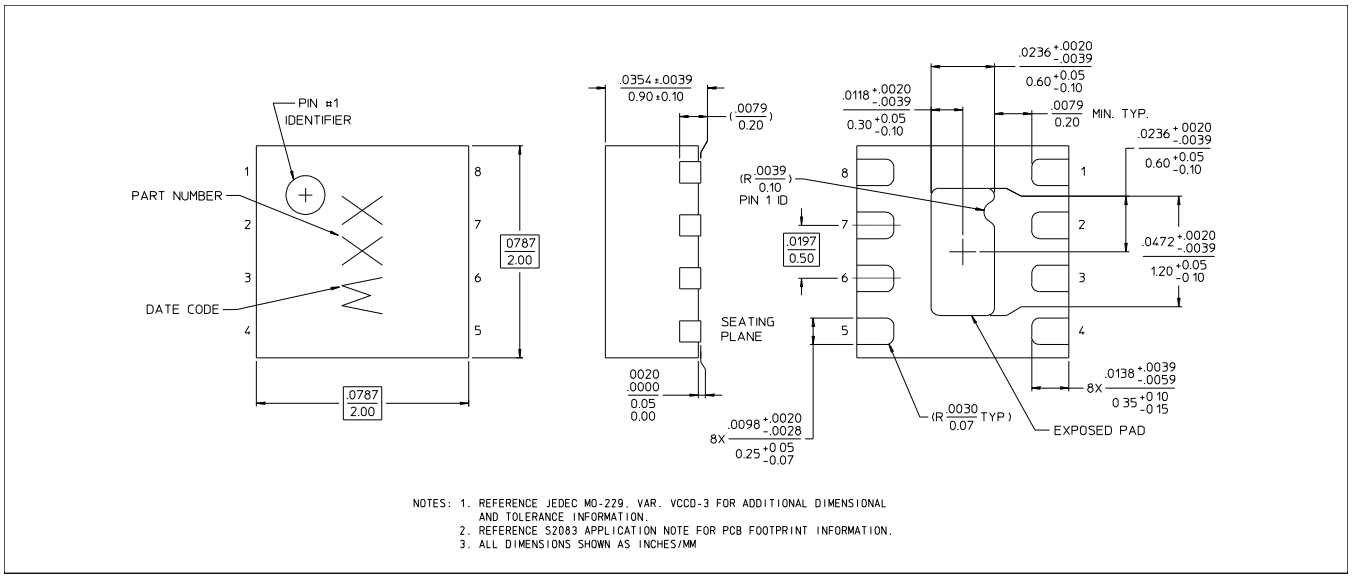
OIP3



P1dB



Lead-Free 2 mm 8-Lead PDFN†

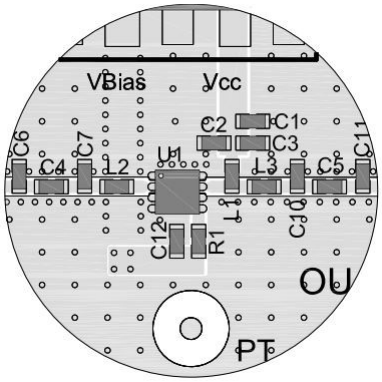


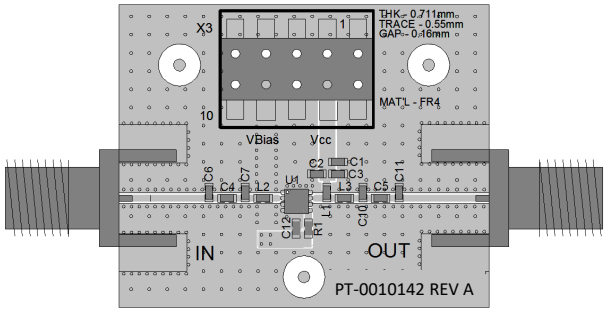
NOTES: 1. REFERENCE JEDEC MO-229, VAR. VCCD-3 FOR ADDITIONAL DIMENSIONAL AND TOLERANCE INFORMATION.
2. REFERENCE S2083 APPLICATION NOTE FOR PCB FOOTPRINT INFORMATION.
3. ALL DIMENSIONS SHOWN AS INCHES/MM

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

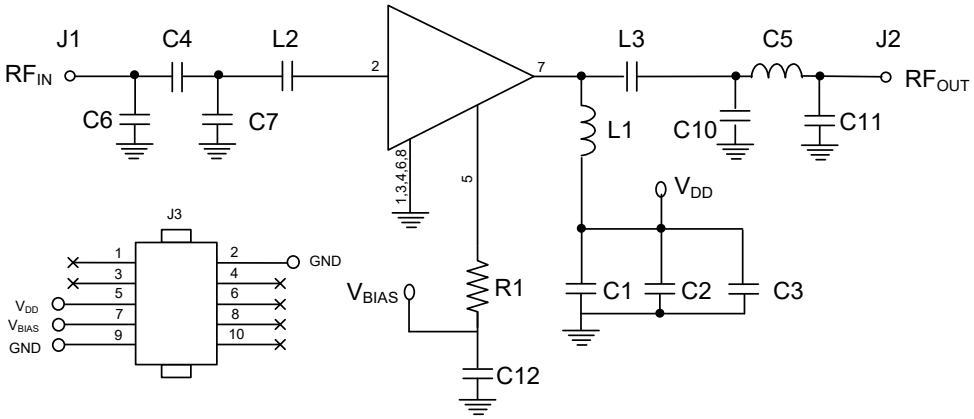
Application Section: 5.9 GHz

Recommended PCB Layout





Schematic Including Off-Chip Components



Application Section: 5.9 GHz

Parts List

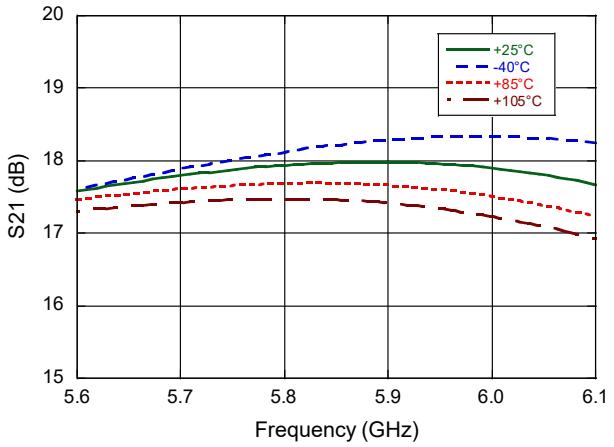
Component	Value	Size	Manufacturer
C1, C12	0.1 µF	0402	Murata GRM155R71C104K
C2, C3	47 pF	0402	Murata GRM1555C1H470JA01D
C4, C5	2.2 pF	0402	Murata GJM1555C1H2R2WB01D
C6, C11	DNF	0402	Do Not Fit
C7, C10	0.5 pF	0402	Murata GJM1555C1HR50WB01D
L1	2.7 nH	0402	TDK MLG1005S2N7BT000
L2	2.2 pF	0402	Murata GJM1555C1H2R2WB01D
L3	10 pF	0402	Murata GJM1555C1H100FB01D
R1	1 kΩ	0402	Rohm MCR01MZPF1001

Electrical Specifications: Freq = 5.9 GHz, V_{DD} & V_{BIAS} = 3.3 V, +25ºC, Z_0 = 50 Ω, R_{BIAS} = 1 kΩ

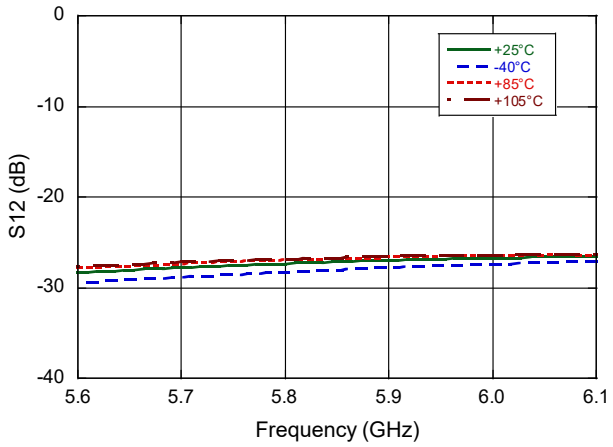
Parameter	Test Conditions	Units	Min.	Typ.	Max.
Noise Figure	—	dB	—	1	—
Gain	—	dB	—	18	—
Input Return Loss	—	dB	—	25	—
Output Return Loss	—	dB	—	14	—
Output P1dB	—	dBm	—	15	—
Current	I_{DD} + I_{BIAS}	mA	—	45	—

Typical Performance Curves for 5.9 GHz Application Section

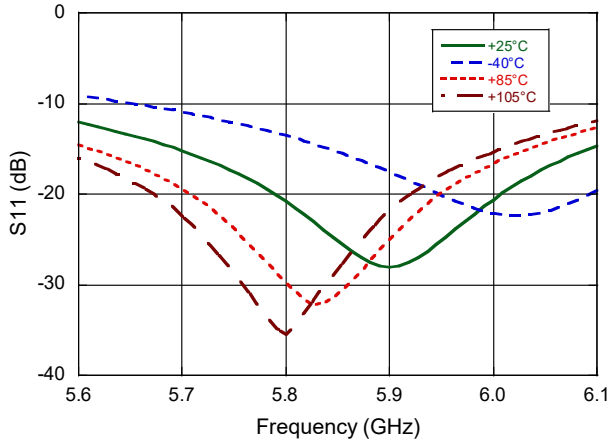
Gain



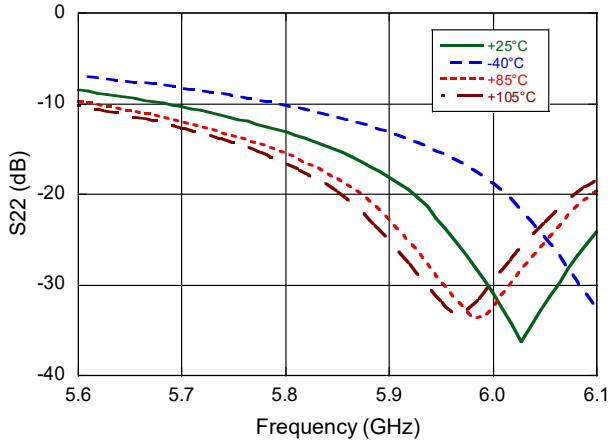
Reverse Isolation



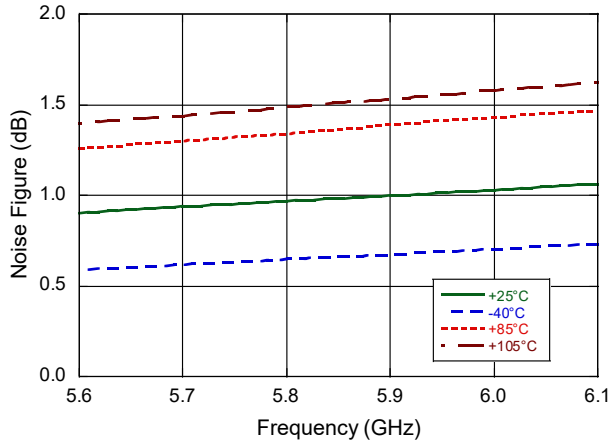
Input Return Loss



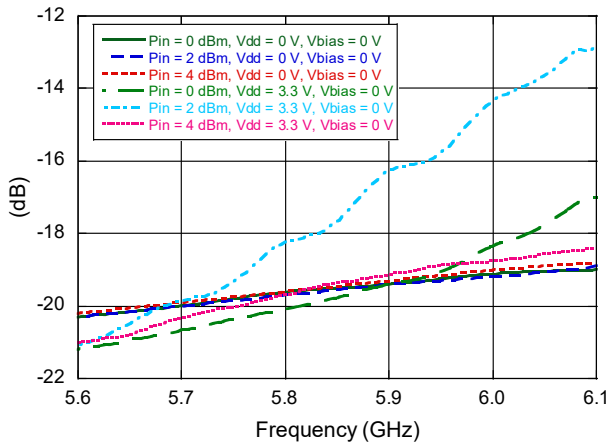
Output Return Loss



Noise Figure



Sleep Mode Isolation



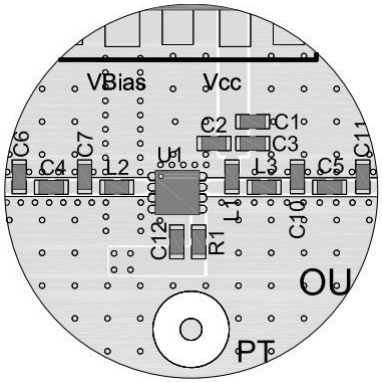
Applications Section: 0.76 GHz

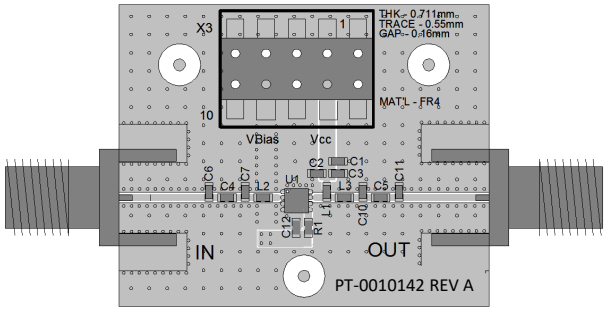
The MAAL-011207 is designed to work as a low noise gain block over a wide range of frequencies in a 50 Ω environment.

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

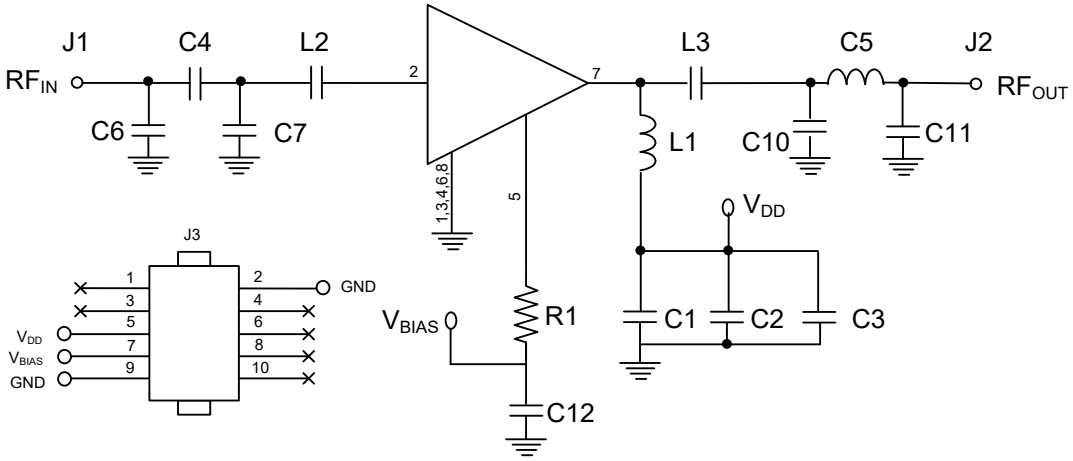
An alternative FR4 evaluation board using all 0402 components is shown opposite. In this application the board has been tuned for optimal performance @ 0.76 GHz. The parts list on the following page details the components needed to tune the MAAL-011207 for operation for this application.

Recommended PCB Layout for 0.76 GHz





Schematic Including Off-Chip Components for 0.76 GHz



Applications Section: 0.76 GHz

Parts List: 0.76 GHz

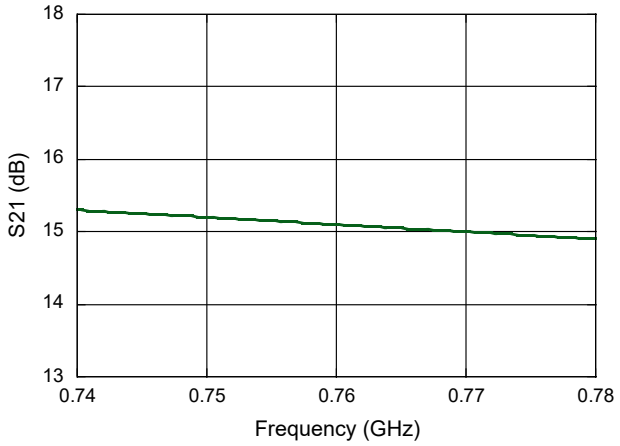
Component	Value	Size	Manufacturer / Part#
C1, C12	0.1 µF	0402	Murata / GRM155R71C104K
C2, C3	47 pF	0402	Murata / GRM1555C1H470JA01D
C4	12 nH	0402	TDK / MLG1005S12NJT000
C5	150 R	0402	Rohm / MCR01MRTF1500
C6	6.8 nH	0402	TDK / MLG1005S6N8JT000
C7	DNF	0402	Do Not Fit
C10, C11	68 R	0402	Rohm \ MCR01MRTF68R0
L1	56 nH	0402	TDK / MLG1005S56NJT000
L2, L3	120 pF	0402	Murata / GRM1555C1E121JA01D
R1	3.9 kΩ	0402	Rohm / MCR01MRTJ392

Electrical Specifications: Freq. = 0.76 GHz, V_{DD} & V_{BIAS} = 3.3 V, T_A = +25°C, R_{BIAS} = 3.9 kΩ

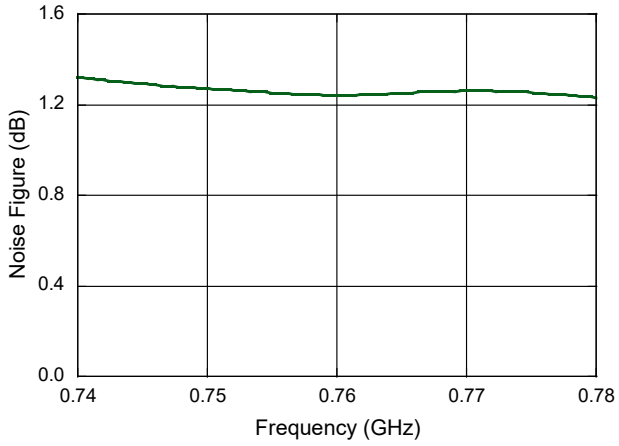
Parameter	Test Conditions	Units	Min.	Typ.	Max.
Gain	—	dB	—	15.5	—
Input Return Loss	—	dB	—	30	—
Output Return Loss	—	dB	—	30	—
Noise Figure	—	dB	—	1.2	—
Input P1dB	—	dBm	—	-13	—
Current	I_{DD} + I_{BIAS}	mA	—	20	—
Voltage	V_{DD}, V_{BIAS}	V	—	3.3	—

Typical Performance Curves: 0.76 GHz Application Section

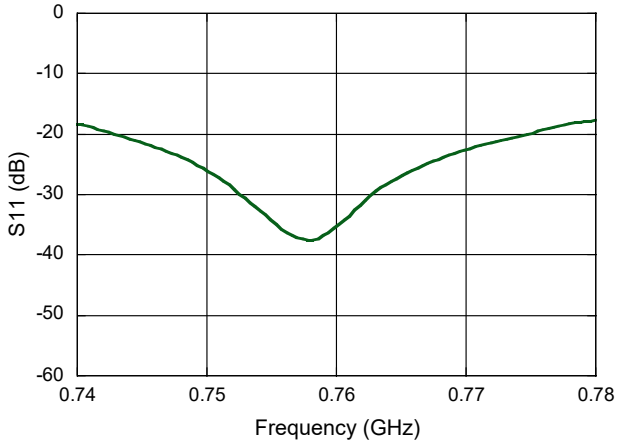
Gain



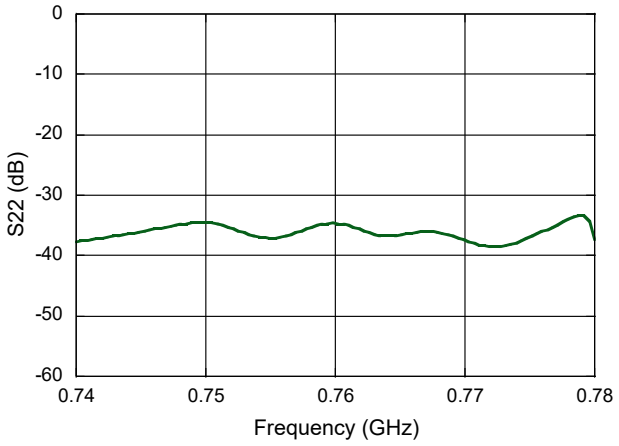
Noise Figure



Input Return Loss



Output Return Loss



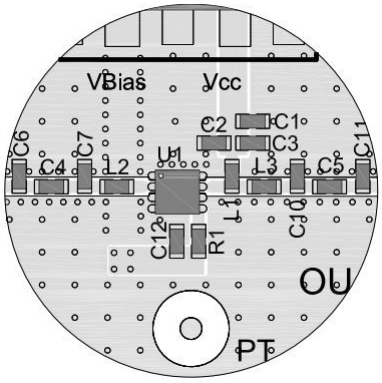
Application Section: 2.3 - 2.7 GHz

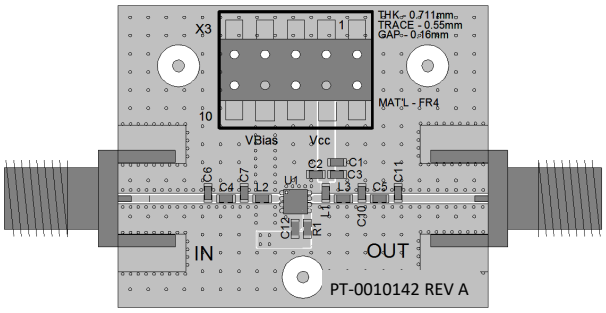
The MAAL-011207 is designed to work as a low noise gain block over a wide range of frequencies in a 50 Ω environment.

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

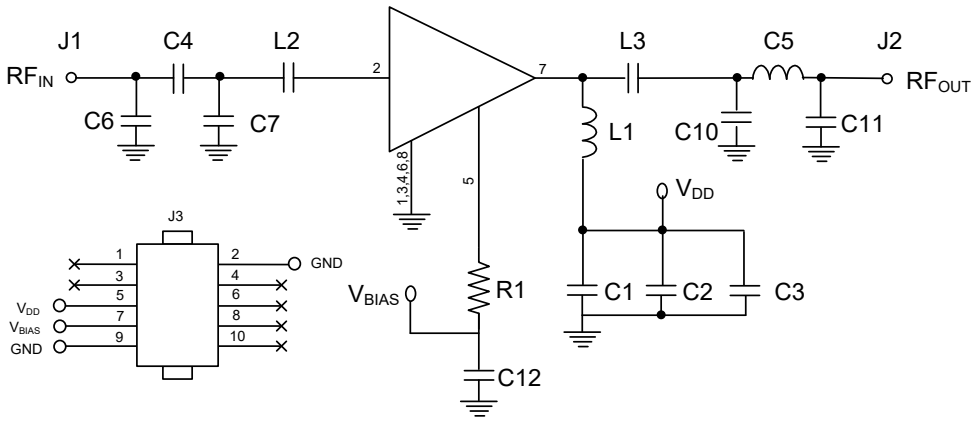
The evaluation board shown has been designed for tuning flexibility. The parts list on page 10 details the components needed to tune the MAAL-011207 for operation from 2.3 - 2.7 GHz. R1 or R2 may be used as R_{BIAS} according to the biasing option chosen.

Recommended PCB Layout





Schematic Including Off-Chip Components



Application Section: 2.3 - 2.7 GHz

Parts List, 2.3 - 2.7 GHz

Component	Value	Size	Manufacturer	Manufacturer Part #
C1, C12	0.1 µF	0402	Murata	GRM155R71C104K
C2, C3	47 pF	0201	Murata	GRM1555C1H470JA01D
C4	10 pF	0201	Murata	GJM0336C1E100JB01
C5	0 Ω	0201	—	—
C6	—	0201	—	—
C7	0.7 pF	0201	Murata	GJM0335C1ER70WB0
C10	0.4 pF	0201	Murata	GJM0335C1ER40WB01
C11	—	0201	—	—
L1	2.7 nH	0201	Murata	LQP03TN2N7C02
L2	2.5 nH	0201	Coilcraft	0201DS-2N5XJL
L3	1.8 pF	0201	Murata	GJM0335C1E1R8BB01
R1	3.9 kΩ	0402	Rohm	MCR01MRTJ392

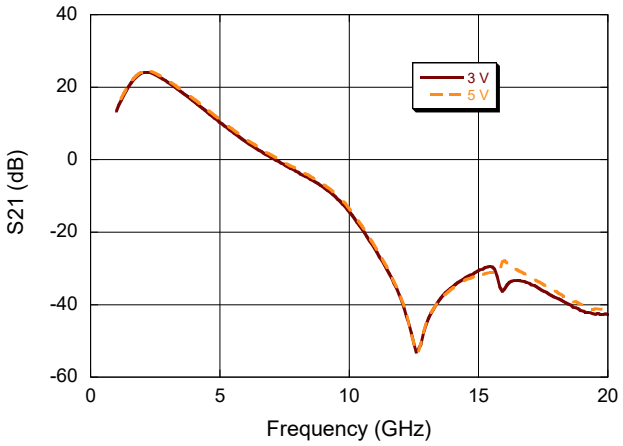
Electrical Specifications: Freq = 2.6 GHz[11,12], V_{DD} = 3 V, +25ºC, Z_0 = 50 Ω

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	—

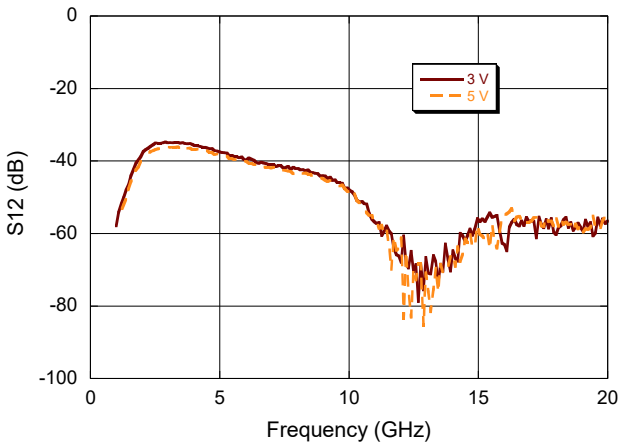
11. Typical performance of the evaluation module with exact components shown on the 2.3 - 2.7 GHz parts list.
12. Typical measured data includes evaluation board and connector losses.

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

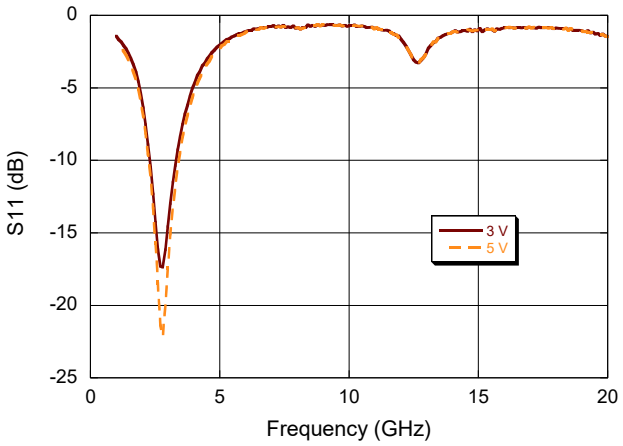
Gain



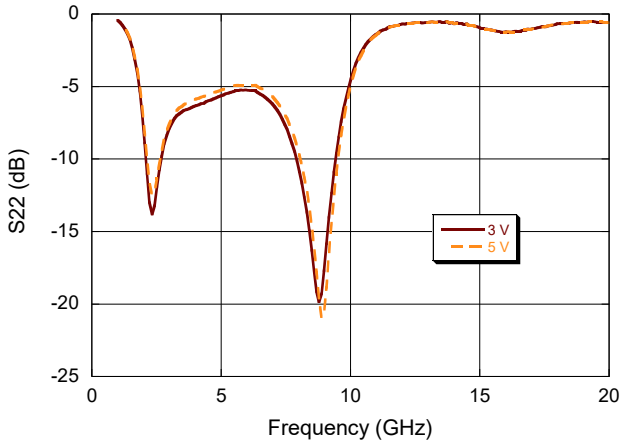
Reverse Isolation



Input Return Loss

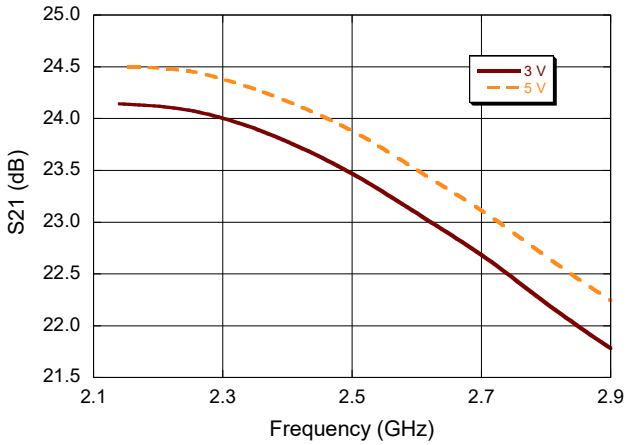


Output Return Loss

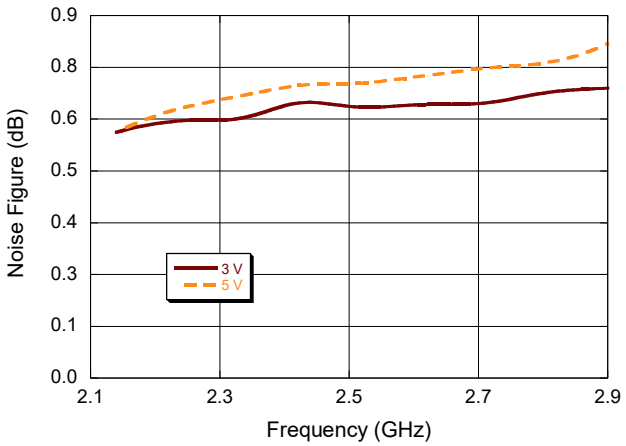


Typical Performance Curves: Freq = 2.3 - 2.7 GHz, Z_0 = 50 Ω

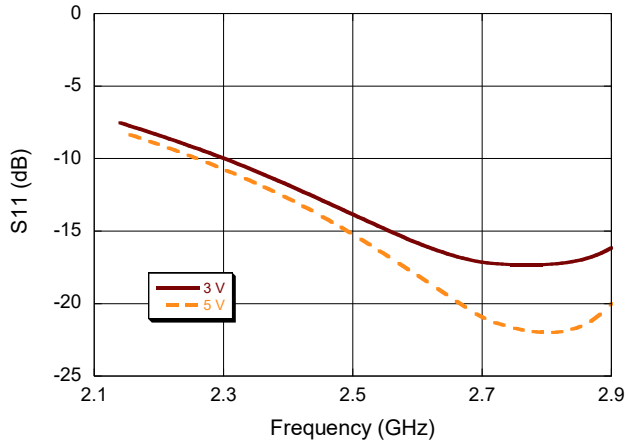
Gain



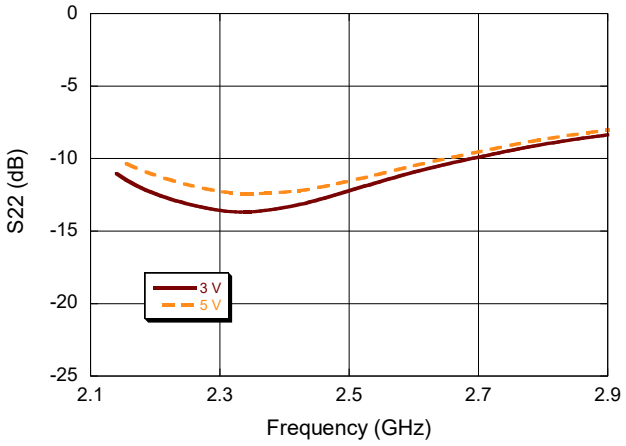
Noise Figure



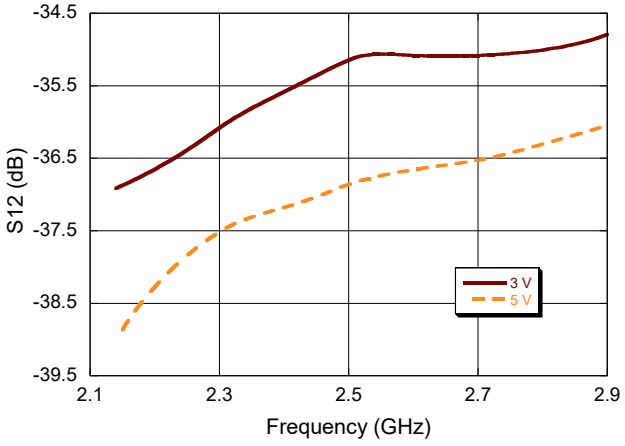
Input Return Loss



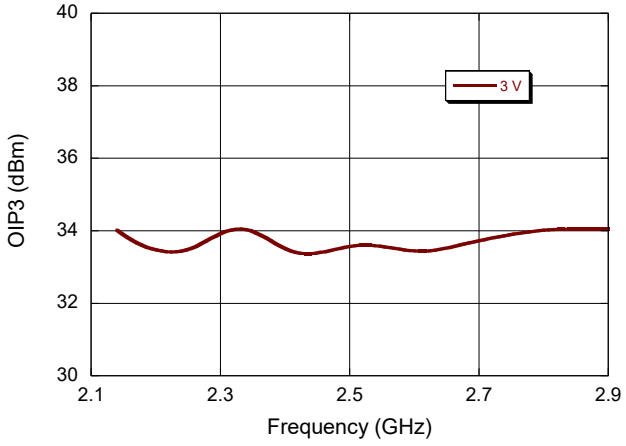
Output Return Loss



Reverse Isolation



OIP3



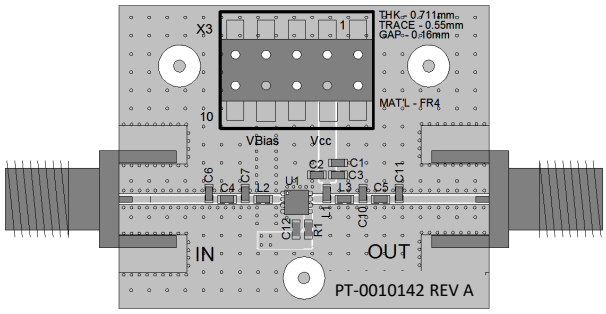
Application Section: 3.6 - 4.2 GHz

The MAAL-011207 is designed to work as a low noise gain block over a wide range of frequencies in a 50 Ω environment.

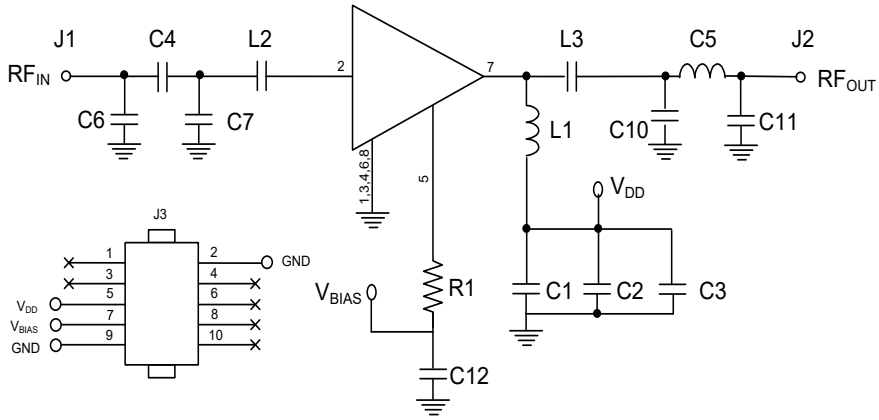
Input and output can be tuned to improve return loss over a specific frequency band.

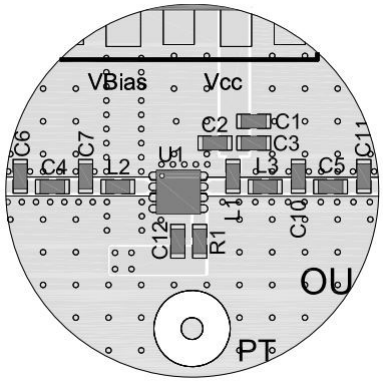
The evaluation board shown has been designed for tuning flexibility. The parts list on page 14 details the components needed to tune the MAAL-011207 for operation from 3.6 – 4.2 GHz. R1 or R2 may be used as R_{BIAS} according to the biasing option chosen.

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

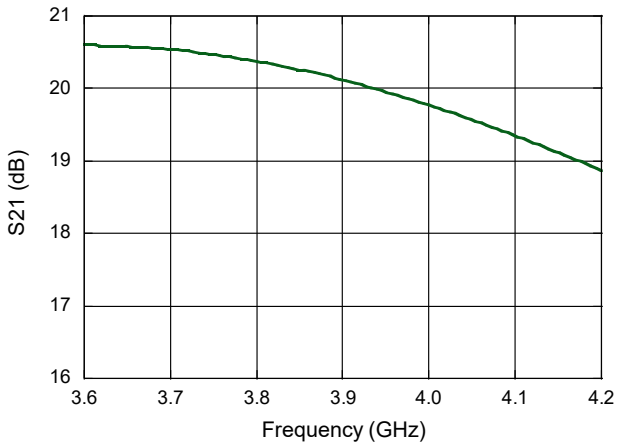
Electrical Specifications: Freq = 3.6 - 4.2 GHz[13], V_{DD} = 3 V, +25ºC, Z_0 = 50 Ω

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	—

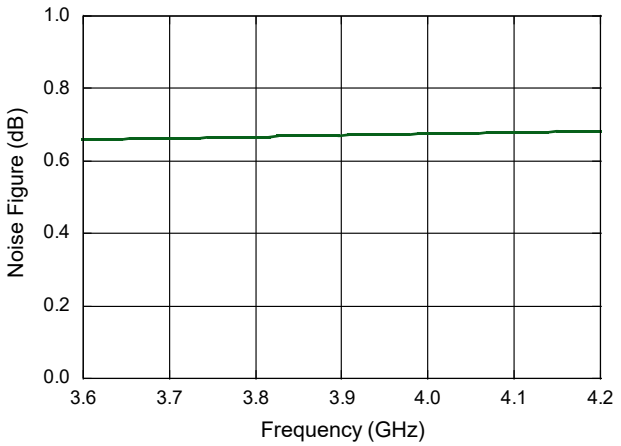
13. Typical performance of the evaluation module with exact components shown on the 3.6 - 4.2 GHz parts list.

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

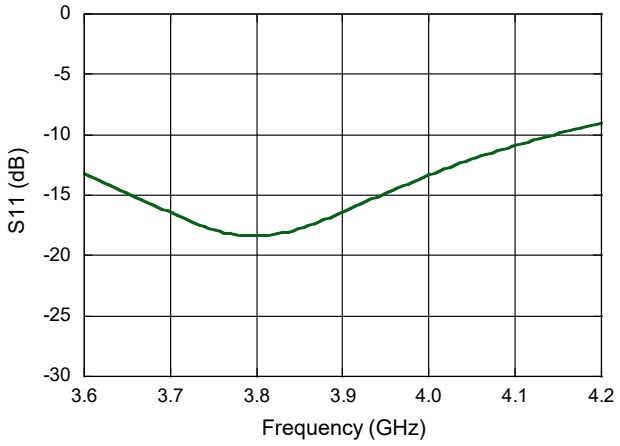
Gain



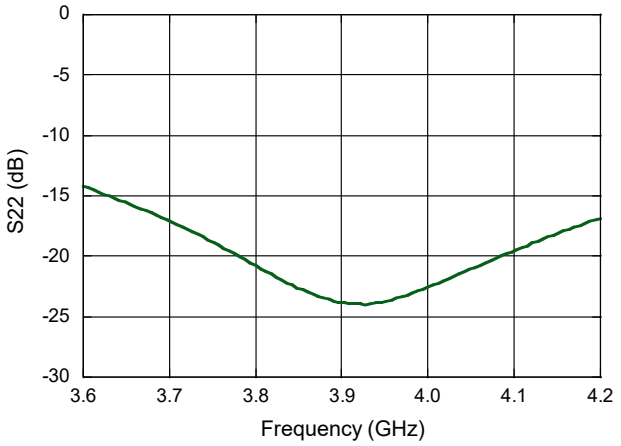
Noise Figure



Input Return Loss



Output Return Loss



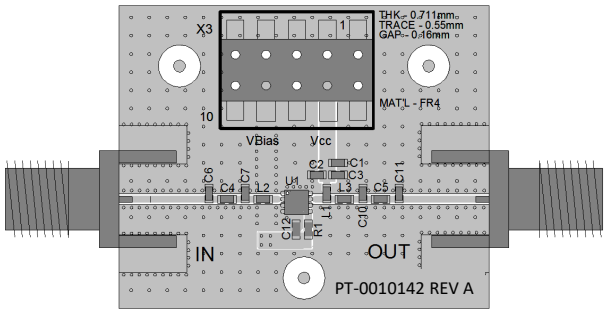
Application Section: 4.4 - 4.9 GHz

The MAAL-011207 is designed to work as a low noise gain block over a wide range of frequencies in a 50 Ω environment.

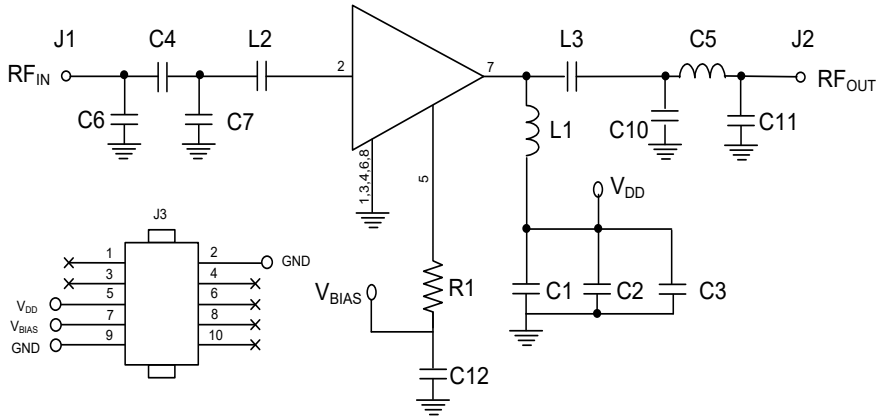
Input and output can be tuned to improve return loss over a specific frequency band.

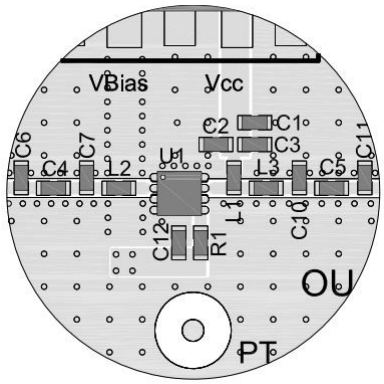
The evaluation board shown has been designed for tuning flexibility. The parts list on page 14 details the components needed to tune the MAAL-011207 for operation from 4.4 – 4.9 GHz. R1 or R2 may be used as R_{BIAS} according to the biasing option chosen.

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 µF	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			

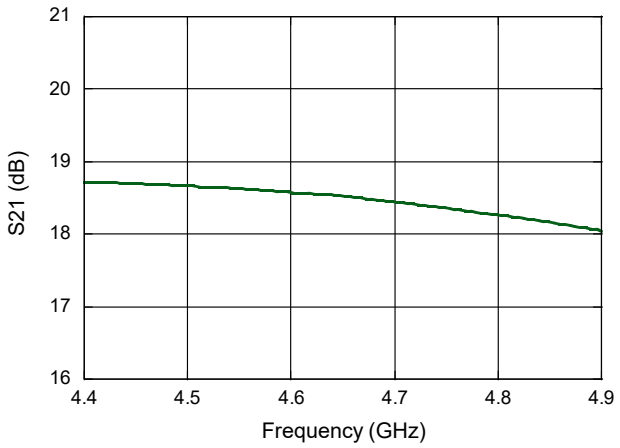
Electrical Specifications: Freq = 4.4 - 4.9 GHz[14], V_{DD} = 3 V, +25ºC, Z_0 = 50 Ω

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	—

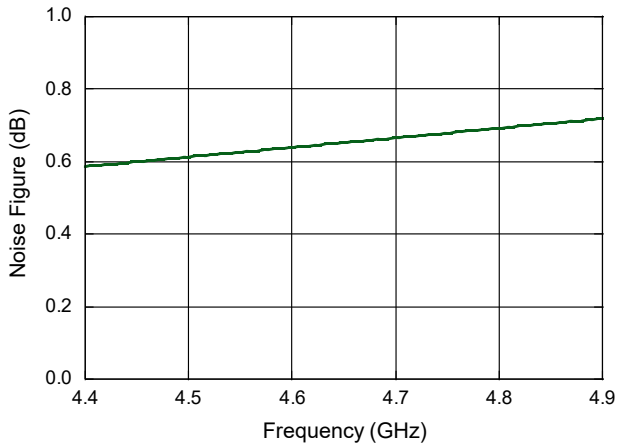
14. Typical performance of the evaluation module with exact components shown on the 4.4 - 4.9 GHz parts list.

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

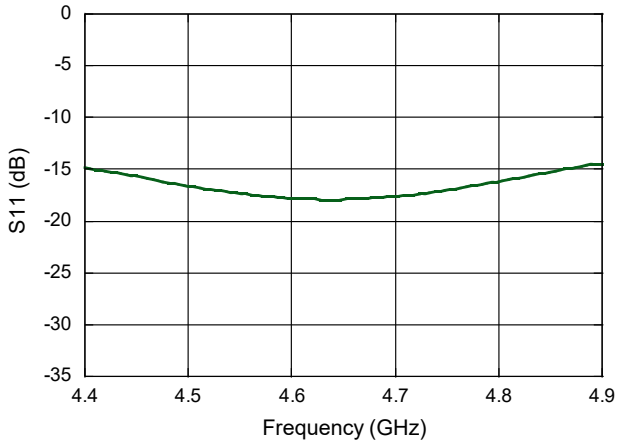
Gain



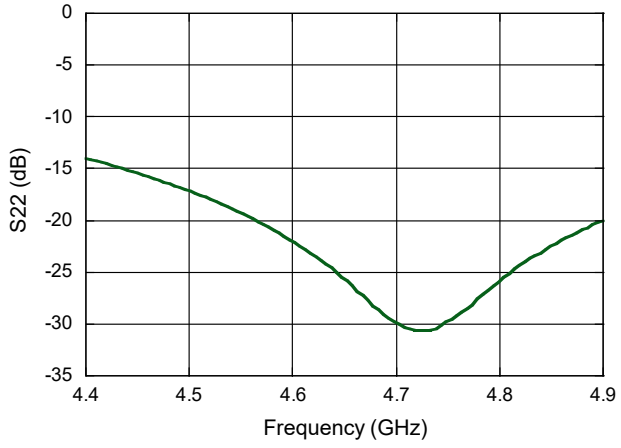
Noise Figure



Input Return Loss



Output Return Loss



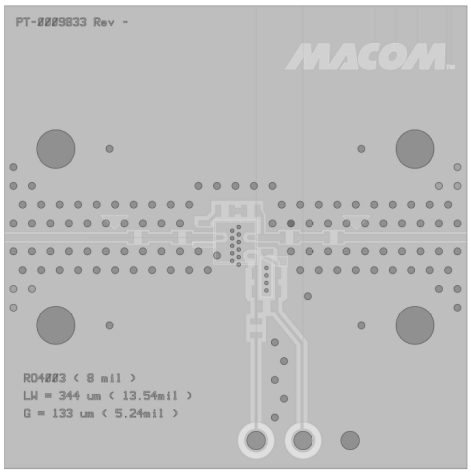
Application Section: 0.15 - 2.2 GHz

The MAAL-011207 is designed to work as a low noise gain block over a wide range of frequencies in a 50 Ω environment.

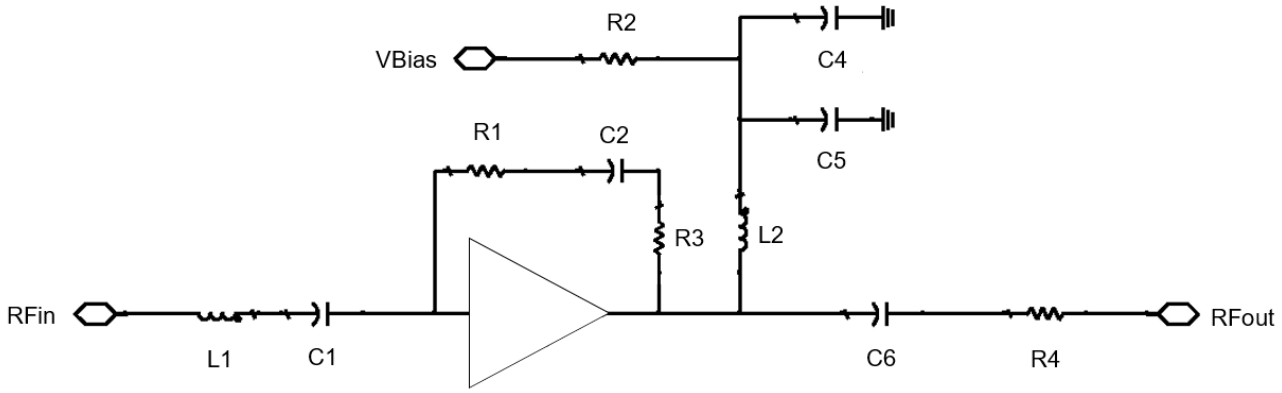
Input and output can be tuned to improve return loss over a specific frequency band.

The evaluation board shown has been designed for tuning flexibility. The parts list on page 23 details the components needed to tune the MAAL-011207 for operation from 0.15 - 2.2 GHz. R2 may be used as R_{BIAS} according to the biasing option chosen.

Evaluation Board, 0.15 - 2.2 GHz
PT-0009833



Schematic, 0.15 - 2.2 GHz



Parts List

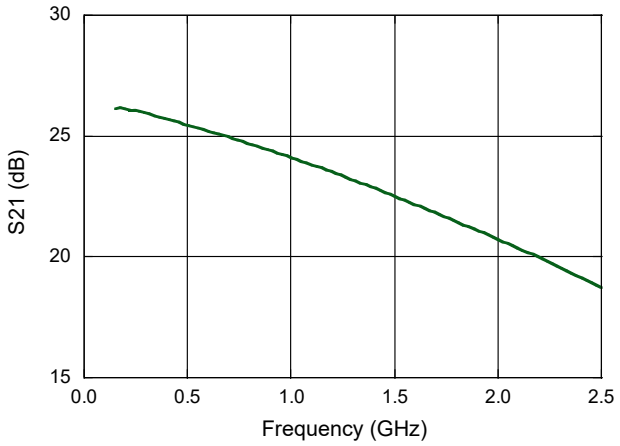
Component	Value	Size	Component	Value	Size
L1	2.7 nH	0402	C4	0.1 µF	0402
C1	43 pF	0402	C5	100 pF	0402
R1	1.5 kΩ	0402	L2	120 nH	0402
C2	39 pF	0402	C6	50 pF	0402
R2	1.5 kΩ	0402	R4	0 Ω	0402
R3	0 Ω	0402	-	-	-

Electrical Specifications: Freq = 0.15 - 2.2 GHz, V_{Bias} = 4 V, +25ºC, Z_0 = 50 Ω

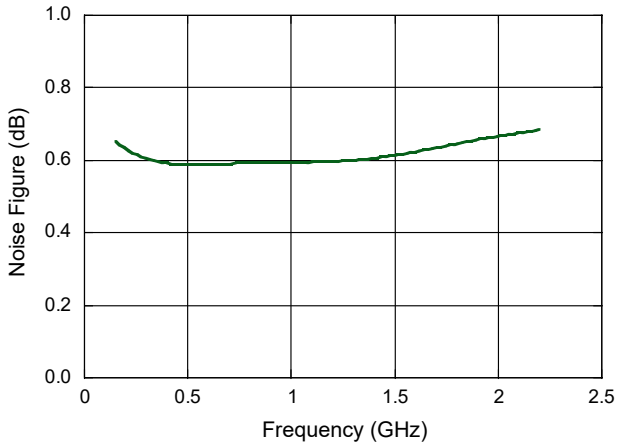
Parameter	Test Conditions	Units	Min.	Typ.	Max.
Noise Figure	-	dB	—	0.6	—
Gain	-	dB	—	23.5	—
Input Return Loss	-	dB	—	14	—
Output Return Loss	-	dB	—	15	—
Output P1dB	-	dBm	—	18.7	—
OIP3	-	dBm	—	30	—
Total Current	$I_{DQ} = I_{DD} + I_{BIAS}$	mA	—	50	—

Typical Performance Curves: Broadband performance (0.15 - 2.2 GHz evaluation board)

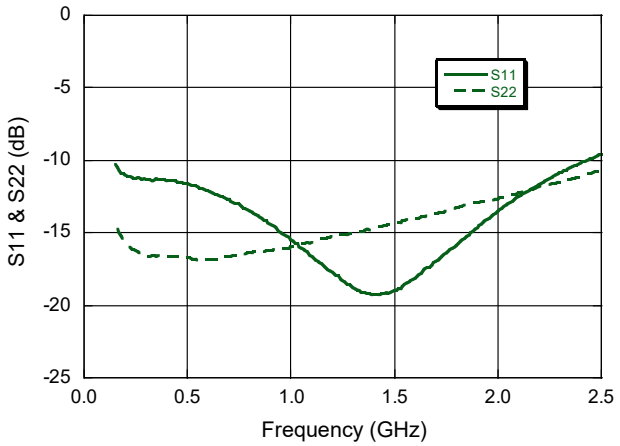
Gain



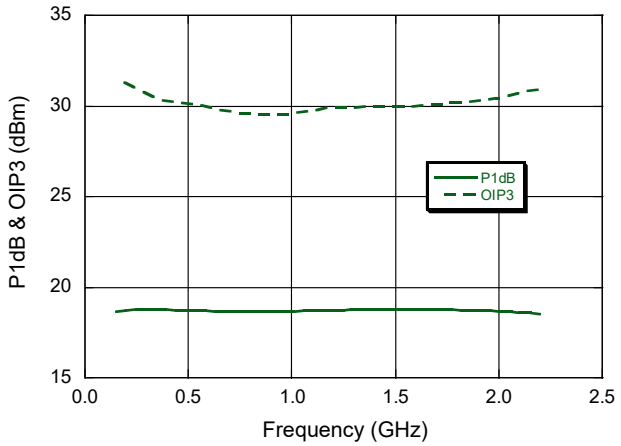
Noise Figure



Return Loss



P1dB & OIP3



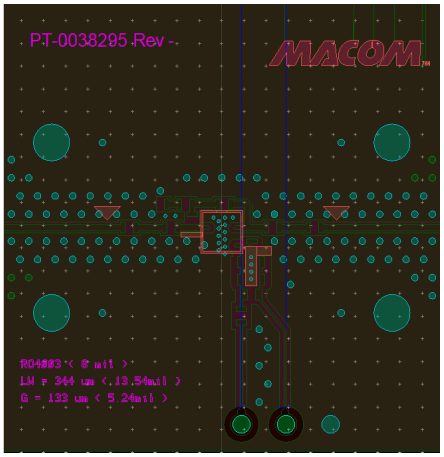
Application Section: 76 - 240 MHz

The MAAL-011207 is designed to work as a low noise gain block over a wide range of frequencies in a 50 Ω environment.

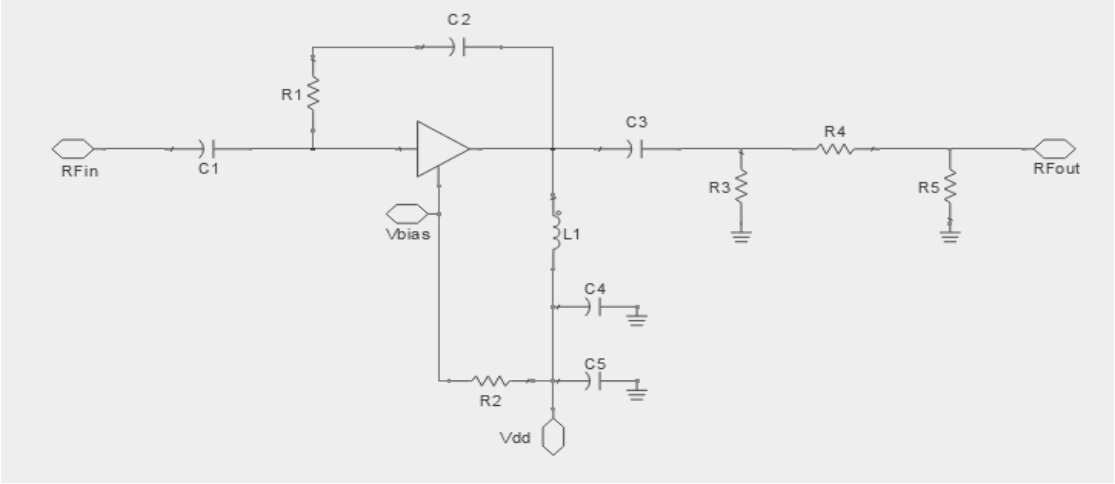
Input and output can be tuned to improve return loss over a specific frequency band.

The evaluation board shown has been designed for tuning flexibility. The parts list on page 25 details the components needed to tune the MAAL-011207 for operation from 76 - 240 MHz.

Evaluation Board PT-0038295



Schematic: 76 - 240 MHz



Parts List

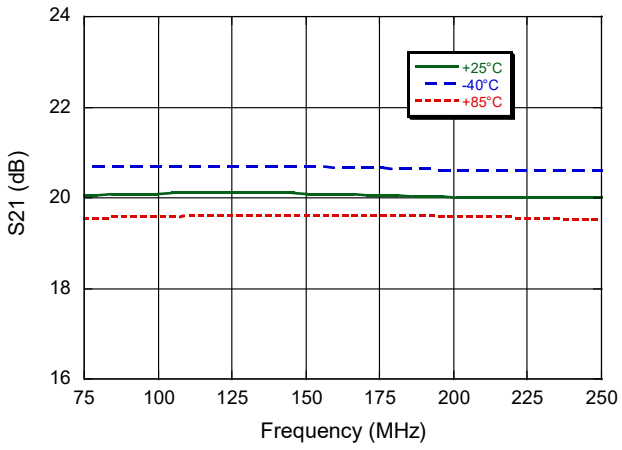
Component	Value	Size	Component	Value	Size
L1	BLM15HG601SN1	0402	R3	294 Ω	0402
C1	3 nF	0402	C4	0.1 µF	0402
R1	750 Ω	0402	C5	100 pF	0402
C2	110 pF	0402	R4	17 Ω	0402
C3	1.5 nF	0402	R5	294 Ω	0402
R2	3 kΩ	0402	-	-	-

Electrical Specifications: Freq = 76 - 240 MHz, V_{DD} = 5 V, +25ºC, Z_0 = 50 Ω

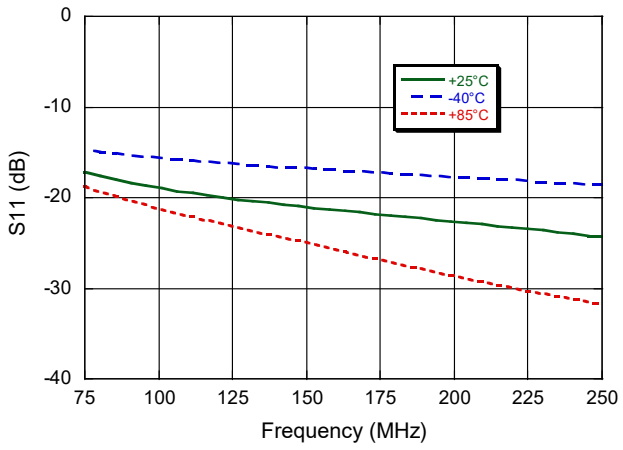
Parameter	Test Conditions	Units	Min.	Typ.	Max.
Noise Figure	-	dB	—	0.8	—
Gain	-	dB	—	20	—
Input Return Loss	-	dB	—	26	—
Output Return Loss	-	dB	—	21	—
Output P1dB	-	dBm	—	15.5	—
OIP3	-	dBm	—	27	—
Total Current	$I_{DQ} = I_{DD} + I_{BIAS}$	mA	—	40	—

Typical Performance Curves: Broadband Performance (76 - 240 MHz evaluation board)

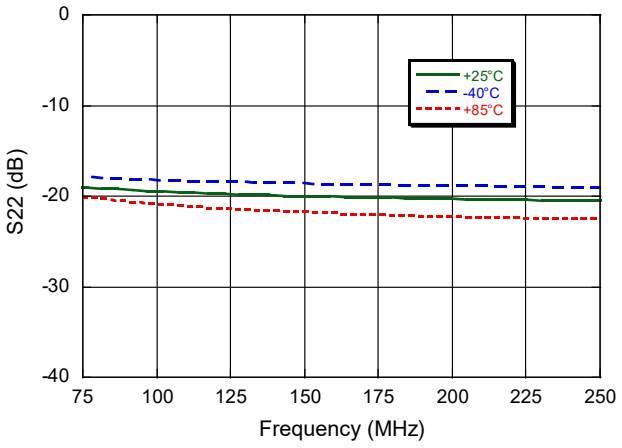
Gain



Input Return Loss

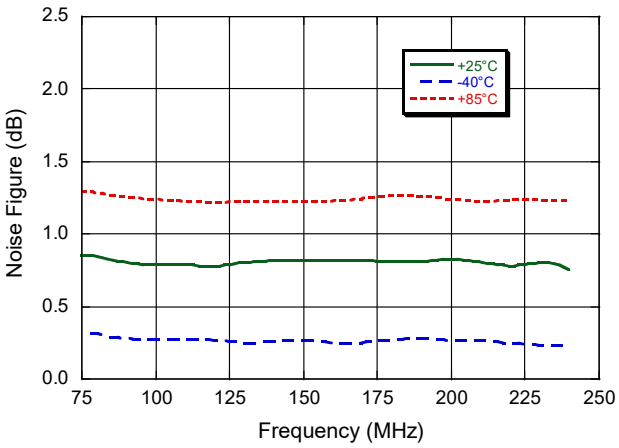


Output Return Loss

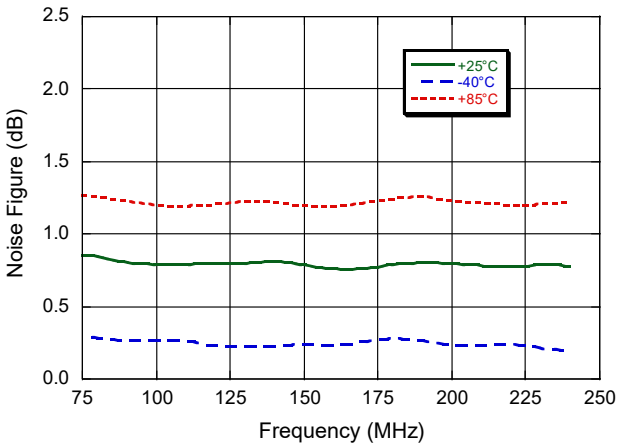


Typical Performance Curves: Broadband Performance (76 - 240 MHz evaluation board)

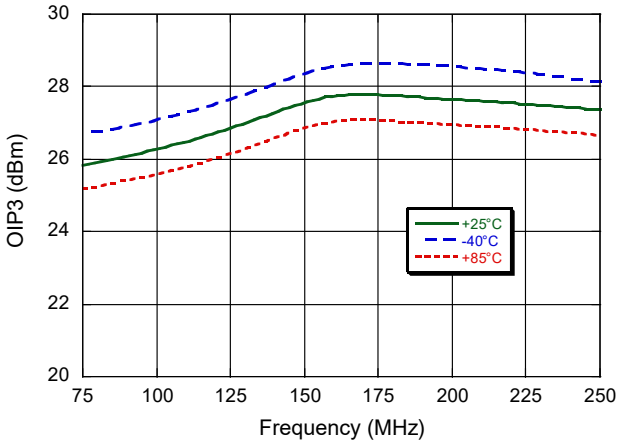
Noise Figure @ 3 V



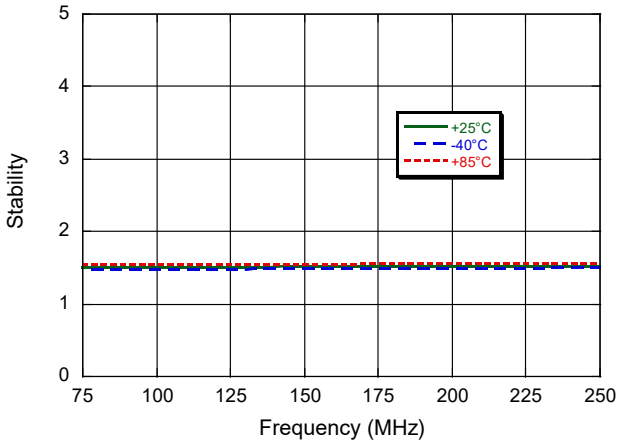
Noise Figure @ 5 V



OIP3

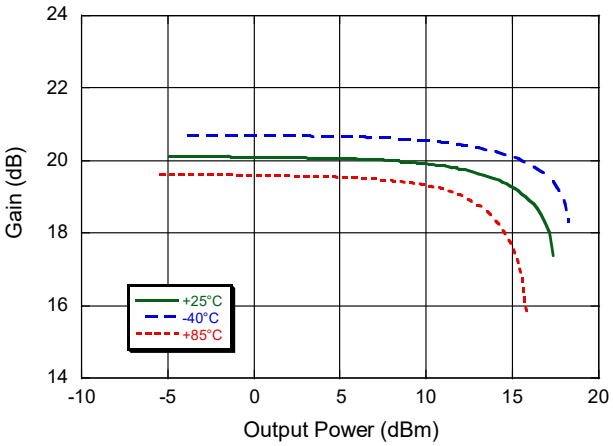


Stability



Typical Performance Curves

Gain vs. Output Power @ 5 V, 100 MHz



Supply Current vs. Output Power @ 5 V, 100 MHz