Low Noise, Low Input Impedance Pre-Amplifier 1.5T and 3T Applications

MAAL-011234
Rev. V1

Features

- Non-Magnetic Package (4 mm)
- Noise Figure: 0.35 dB
- Gain: 28 dB
- Input Resistance: 1.7 Ω
- Output Impedance: 50 Ω
- Single Voltage Bias: 10 V
- Integrated Active Bias Circuit
- Low Current: 9 mA
- Unconditionally Stable
- RoHS* Compliant

Applications

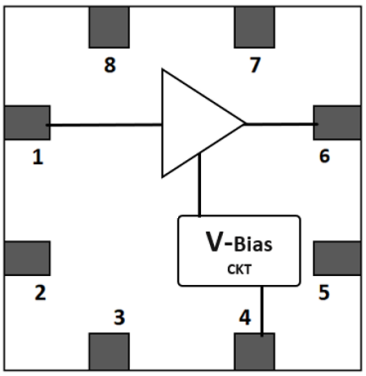
- MRI Applications

Description

The MAAL-011234 is a high dynamic range, single stage MMIC LNA. With external matching networks it exhibits excellent low noise performance, low input impedance and high gain characteristics suitable for 1.5T and 3T applications.

This low noise amplifier has an integrated active bias circuit allowing direct connection to single 10 V bias, while 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. Operation down to 5V with reduced linearity is also possible.

Functional Block Diagram



Pin Configuration[3,4]

Pin #	Pin Name
1	RF_{IN}
2, 3, 5, 7, 8	N/C
4	V_{BIAS}
6	RF_{OUT} / V_{DD}

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	Description
MAAL-011234	Production Samples
MAAL-011234-TR1000	1000 piece reel
MAAL-011234-TR3000	3000 piece reel
MAAL-011236-S15PPR	Sample Board 1.5T
MAAL-011237-SC3PPR	Sample Board 3T, 123.1 ± 1 MHz
MAAL-011237-SG3PPR	Sample Board 3T, 127.74 ± 1 MHz

1. Reference Application Note M513 for reel size information.
2. PPR sample boards contain magnetic SMT components.

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

Pin Description

Pin #	Name	Description
1	RF_{IN}	RF Input, direct connection to gate, must be DC blocked.
2, 3, 5, 7, 8	N/C	No internal connection.
4	V_{BIAS}	Bias Voltage.
6	RF_{OUT} / V_{DD}	RF Output / Drain Voltage. External bias tee required for this pin.

DC Electrical Specifications: V_{DD} = +10 V, T_C = 25°C

Parameter	Test Conditions	Units	Min.	Typ.	Max.
DC Current I_{DD} (I_{DS} + I_{BIAS})	P_{IN} = -30 dBm	mA	—	9	12.5

RF Electrical Specifications[5]:

V_{DD} = 10 V, T_C = +25ºC, Z_{LOAD} & Z_{SOURCE} = 50 Ω, tuned for 1.5T (F0 = 63.87 MHz)

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Bandwidth	Centered at 63.87 MHz	MHz	—	1	—
Noise Figure	-	dB	—	0.36	—
Gain	-	dB	—	28	—
Input Impedance	Real Z_{IN} Imaginary Z_{IN}	Ohms	—	1.7 0	—
Output Return Loss	-	dB	—	20	—
Reverse Isolation	-	dB	—	62	—
Output IP3	P_{OUT} = 0 dBm per tone, 1 MHz & 100 KHz spacing	dBm	—	27	—
Output P1dB	-	dBm	—	17	—

V_{DD} = 10 V, T_C = +25ºC, Z_{LOAD} & Z_{SOURCE} = 50 Ω, tuned for 3T (F0 = 127.74 MHz)

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Bandwidth	Centered at 127.74 MHz	MHz	—	1	—
Noise Figure	-	dB	—	0.3	—
Gain	-	dB	26.5	28	—
Input Impedance	Real Zin Imaginary Zin	Ohms	— —	1.7 0	2.2 —
Output Return Loss	-	dB	—	22	—
Reverse Isolation	-	dB	—	60	—
Output IP3	P_{OUT} = 0 dBm per tone, 1 MHz & 100 KHz spacing	dBm	—	24	—
Output P1dB	-	dBm	—	17	—

5. Using external matching components. Refer to Application section.

Recommended Operating Conditions

Parameter	Symbol	Unit	Min.	Typ.	Max.
RF Input Power	P_{IN}	dBm	—	-30	-10
DC Supply	V_{DD}	V	5	10	11
DC Bias[8]	V_{BIAS}	V	3.5	4.3	6
Junction Temperature[9, 10]	T_J	°C	—	—	+150
Operating Temperature[11]	T_C	°C	0	—	+70

Absolute Maximum Ratings[6,7]

Parameter	Symbol	Unit	Min.	Max.
RF Input Power	P_{IN}	dBm	—	26
DC Supply	V_{DD}	V	—	13
DC Bias[8]	V_{BIAS}	V	—	13
Junction Temperature[9, 10]	T_J	°C	—	+160
Operating Temperature[11]	T_C	°C	-40	+85
Storage Temperature	—	°C	-55	+150

6. Exceeding any one or combination of these limits may cause permanent damage to this device.
7. MACOM does not recommend sustained operation near these survivability limits.
8. V_{BIAS} is the voltage after R_{BIAS} at pin 4 on page 5.
9. Operating at nominal conditions with $T_J \leq +150°C$ will ensure MTTF > 1 x 10^6 hours.
10. Junction Temperature (T_J) = $T_C + \Theta_{JC} * ((V * I))$
    Typical thermal resistance (Θ_{JC}) = 97°C/W.
    a) For T_C = +25°C,
    T_J = 34°C @ 10 V, 9 mA
    b) For T_C = +70°C,
    T_J = 79°C @ 10 V, 9 mA
11. Operating temperature is defined at the back of device paddle.

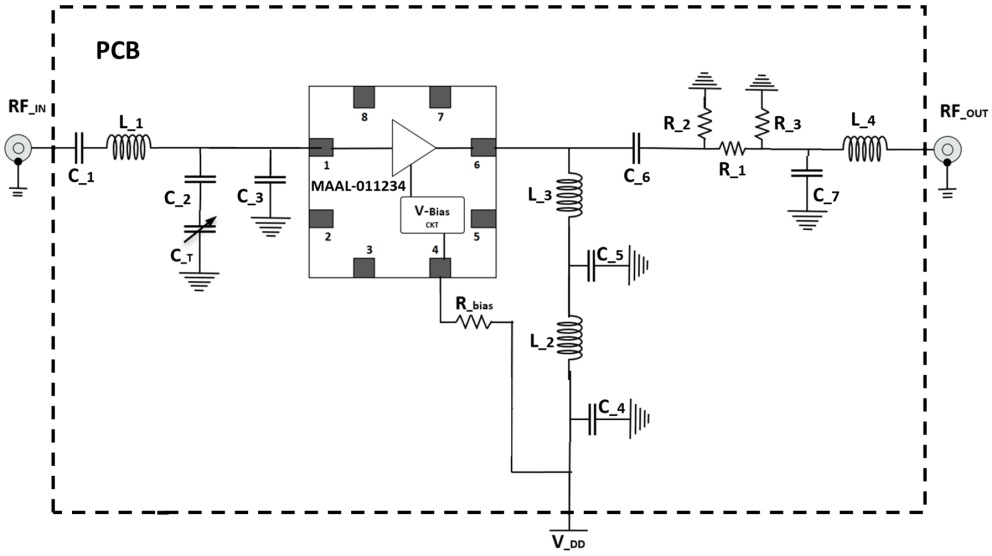
Handling Procedures

Please observe the following precautions to avoid damage:

Static Sensitivity

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

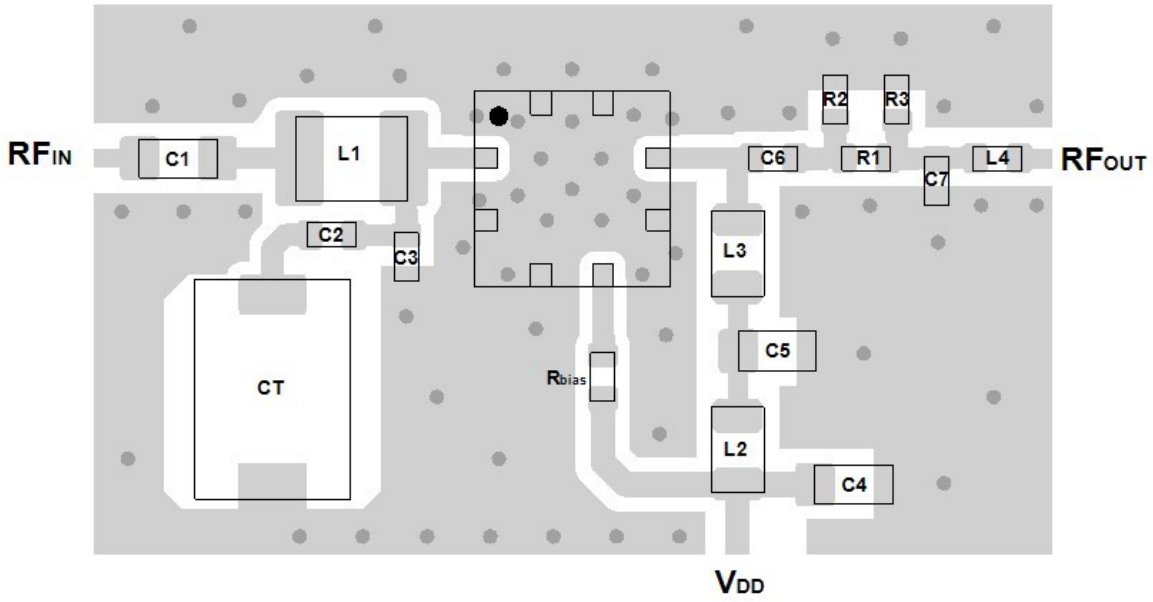
Recommended Circuit Board Schematic



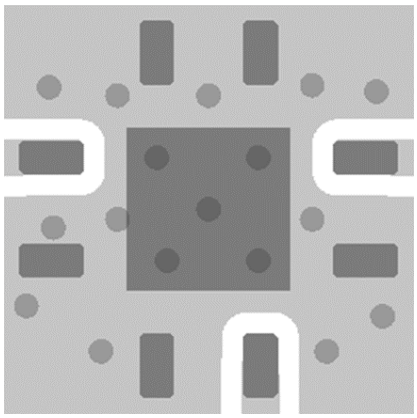
Component Values for 1.5T and 3T Applications

Component	1.5T Value	3T Value	Case Size	Vendor
C1	1000 pF	1000 pF	0603	Vishay Vitramon, non-magnetic (COG)
C2	0 Ω	0 Ω	0402	Vishay Vitramon, non-magnetic (COG)
CT	4.5 - 20 pF	4.5 - 20 pF	3 mm	PPI 46 Series 3mm Surfacae Mount
C3	12 pF	DNI	0402	Vishay Vitramon, non-magnetic (COG)
C4, C5	0.01 µF	0.01 µF	0603	Vishay Vitramon, non-magnetic (XR7)
C6	39 pF	12 pF	0402	Vishay Vitramon, non-magnetic (COG/XR7)
C7	68 pF	4.7 pF	0402	Vishay Vitramon, non-magnetic (COG)
L1	150 nH	100 nH	0805	CoilCraft 0805HP Series (2012)
L2	390 nH	390 nH	0603	CoilCraft 0603HP Series (1608)
L3	200 nH	110 nH	0603	CoilCraft 0603HP Series (1608)
L4	0 Ω	0 Ω	0402	CoilCraft 0402HP Series (1005)
R_{BIAS}	7.15k Ω	7.15k Ω	0402	Vishay PNM Dale Thin Film, non-magnetic
R1	10 Ω	38.3 Ω	0402	Vishay PNM Dale Thin Film, non-magnetic
R2, R3	1000 Ω	825 Ω	0402	Vishay PNM Dale Thin Film, non-magnetic

Recommended PCB Layout



Recommended PCB Land Pattern

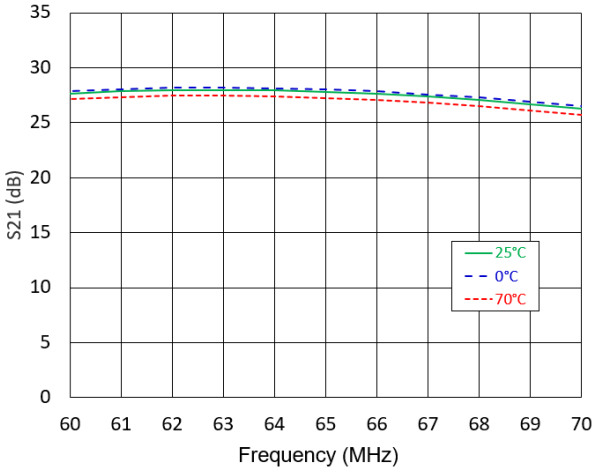


Substrate recommended:

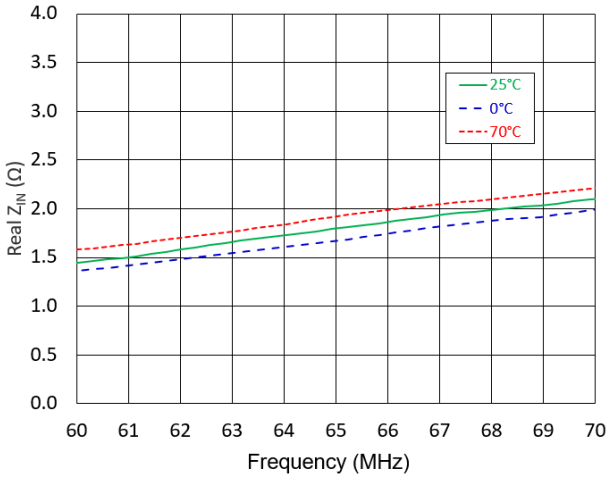
- FR4, 0.020" CORE
- 1.5 oz. Cu

Typical 1.5T Performance Curves (63.87 MHz)

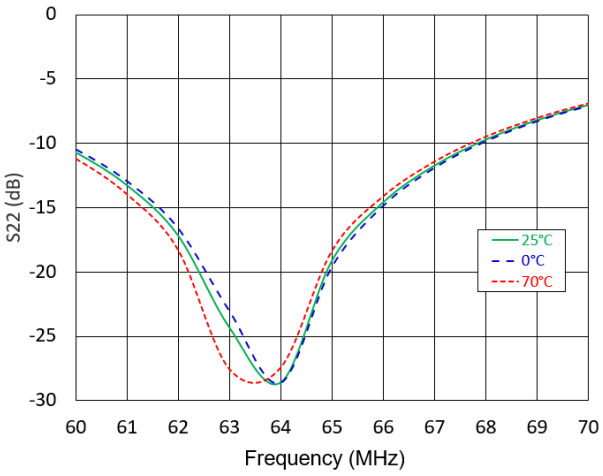
Gain



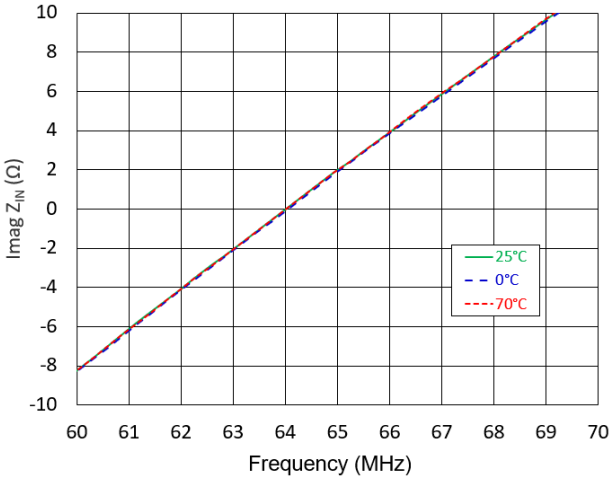
Real Z_{IN}



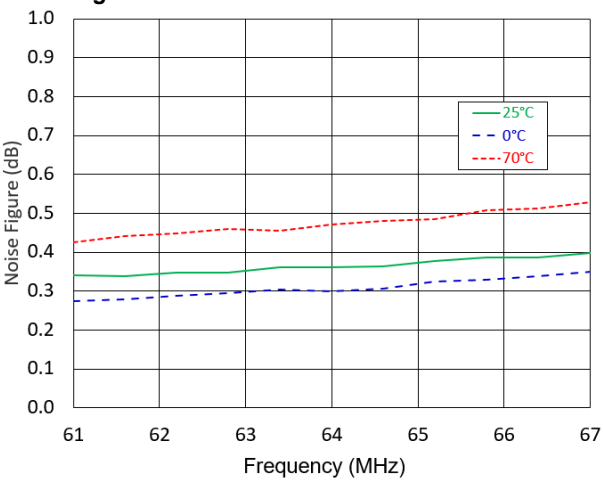
Output Return Loss



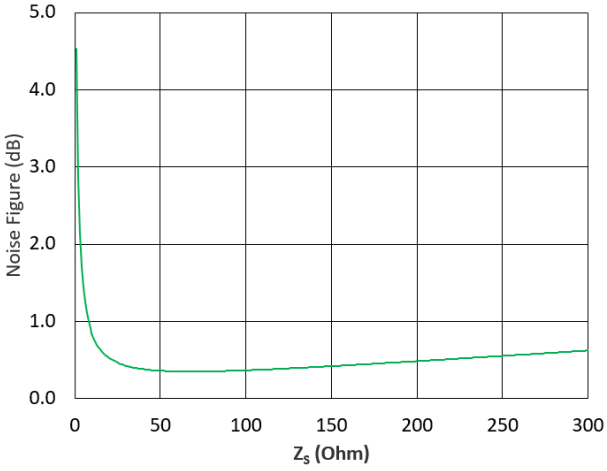
Imaginary Z_{IN}



Noise Figure

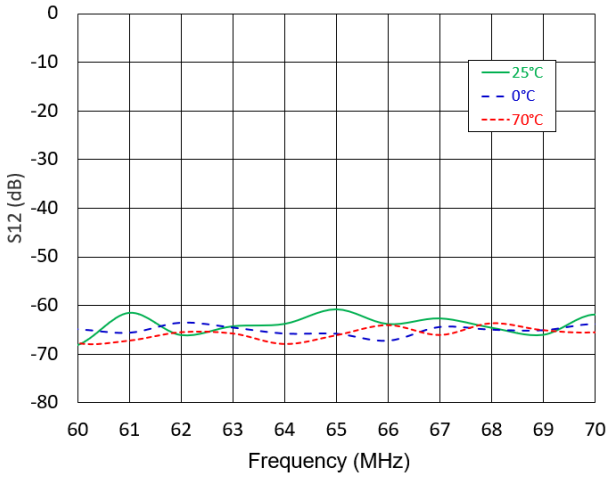


Noise Figure vs Source Impedance, Z_S @25C

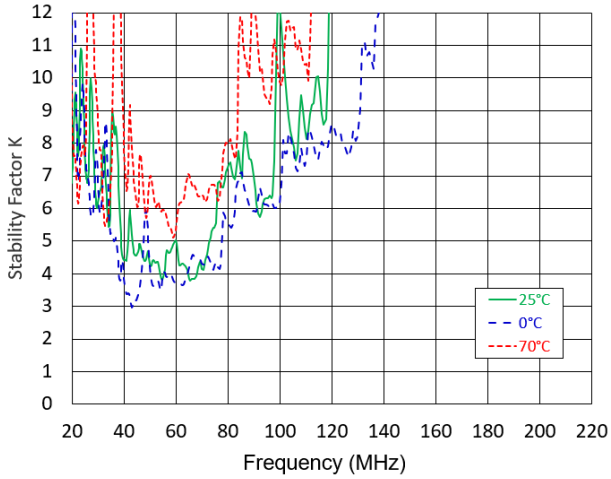


Typical 1.5T Performance Curves (63.87 MHz)

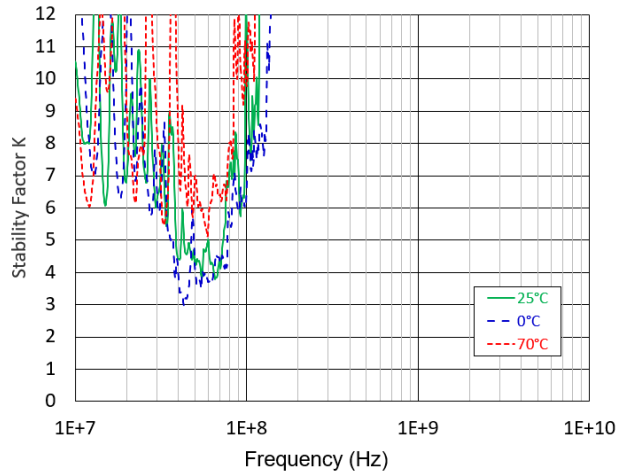
Reverse Isolation



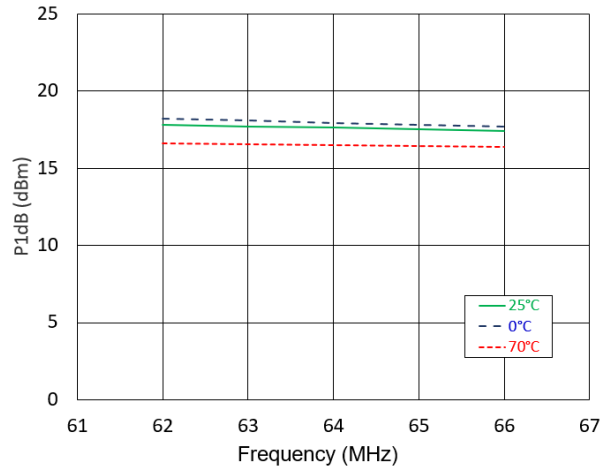
Stability Factor K



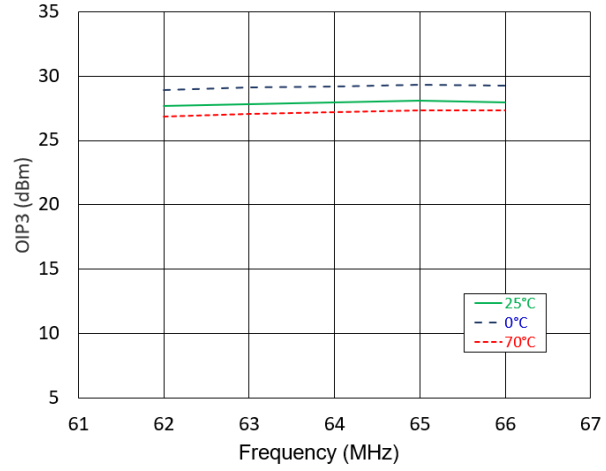
Stability Factor K to 10 GHz



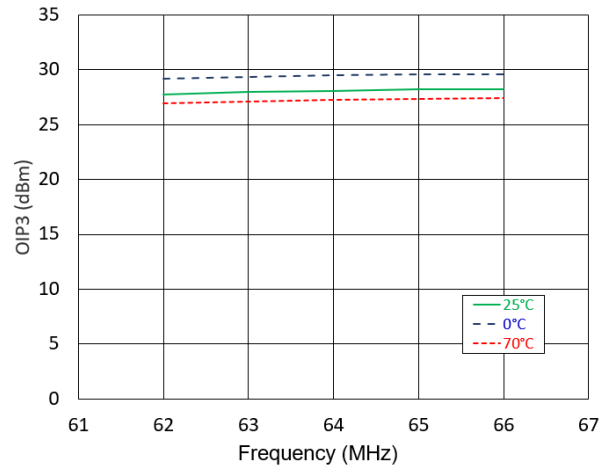
P1dB



OIP3 (P_{out} = 0 dBm / Tone, 100 kHz spacing)

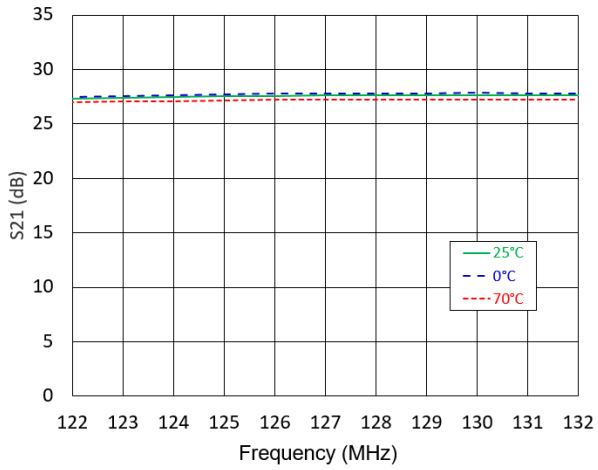


OIP3 (P_{out} = 0 dBm / Tone, 1 MHz spacing)

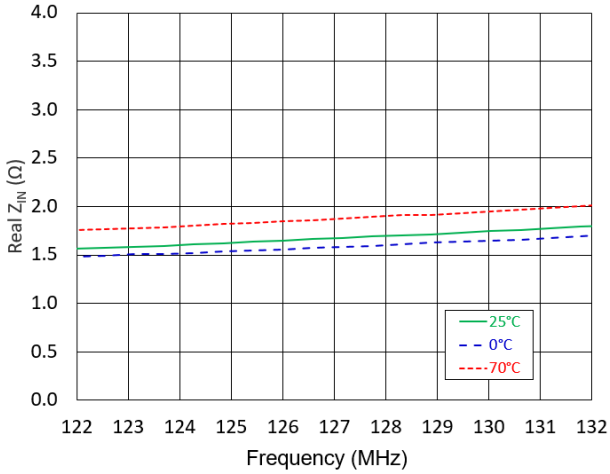


Typical 3T Performance Curves (127.74 MHz)

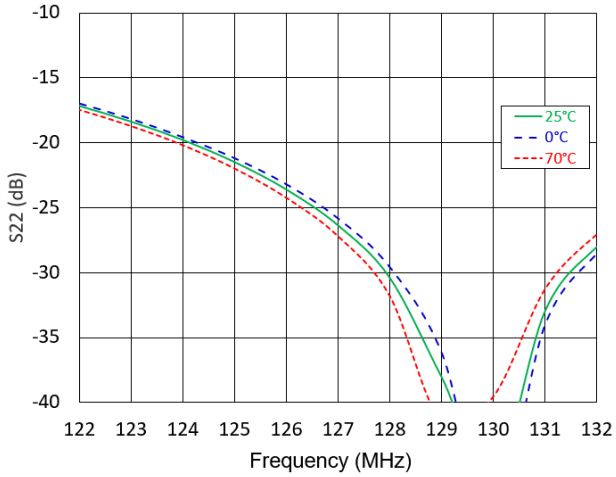
Gain



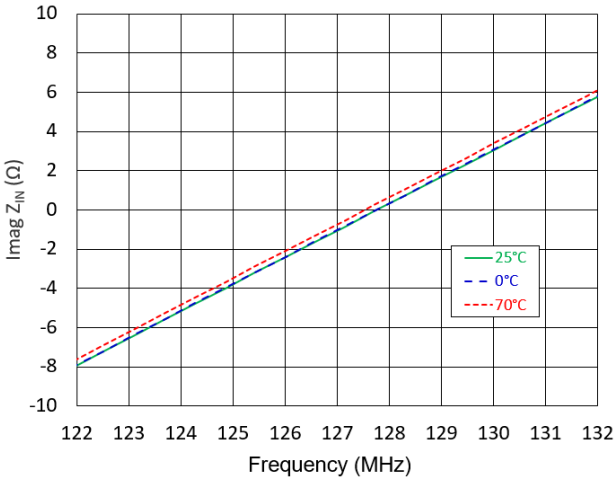
Real Z_{IN}



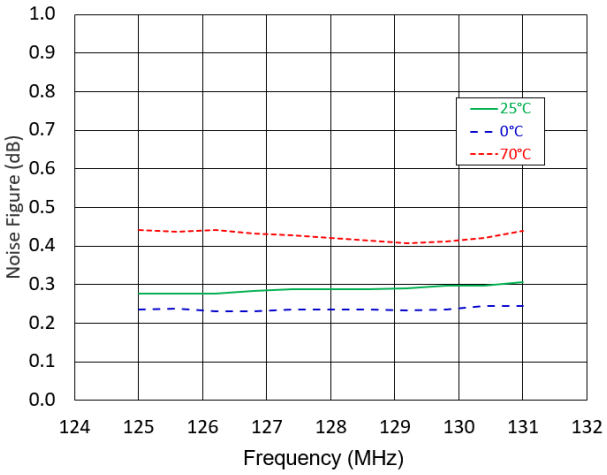
Output Return Loss



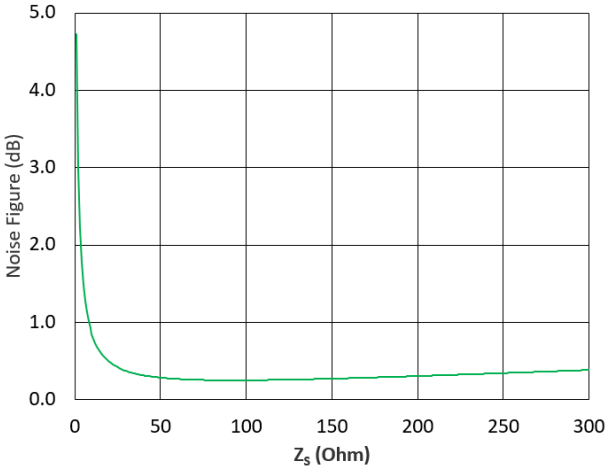
Imaginary Z_{IN}



Noise Figure

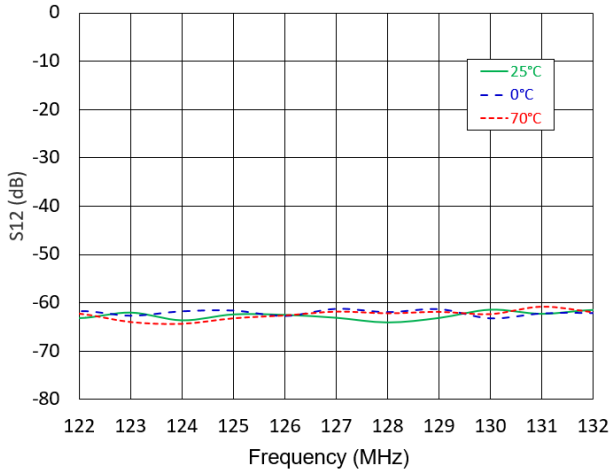


Noise Figure vs Source Impedance, Z_S @25C

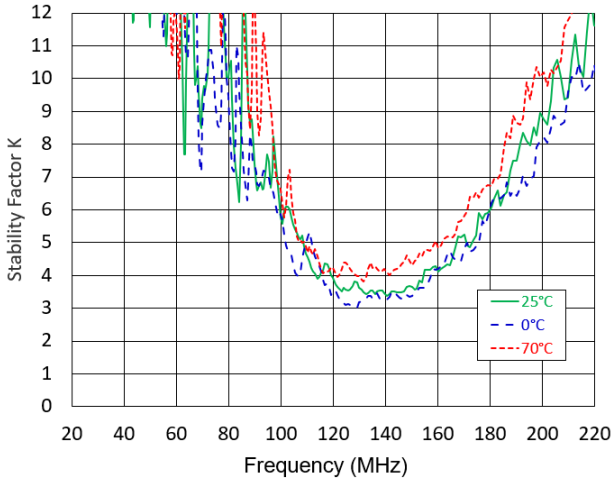


Typical 3T Performance Curves (127.747 MHz)

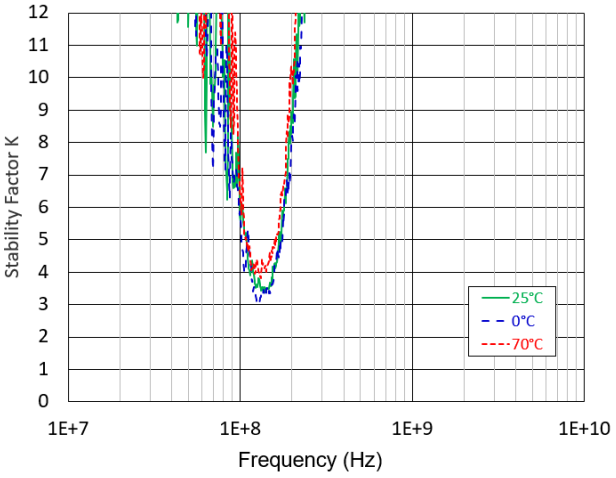
Reverse Isolation



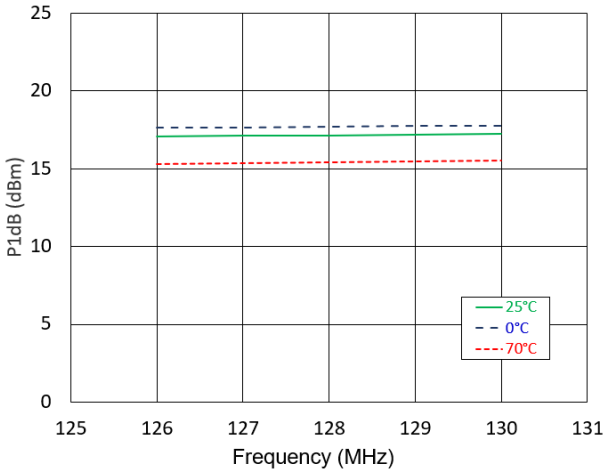
Stability Factor K



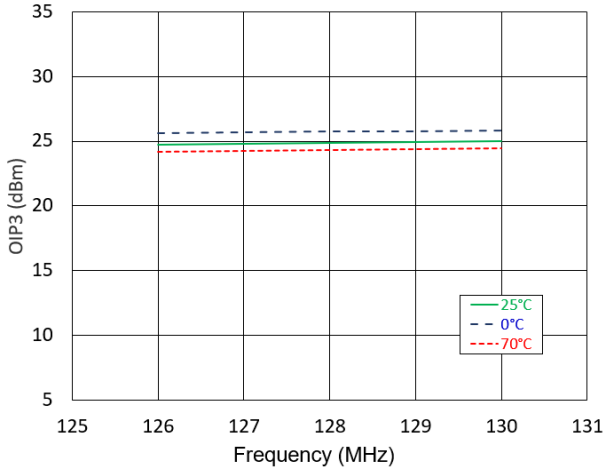
Stability Factor K to 10 GHz



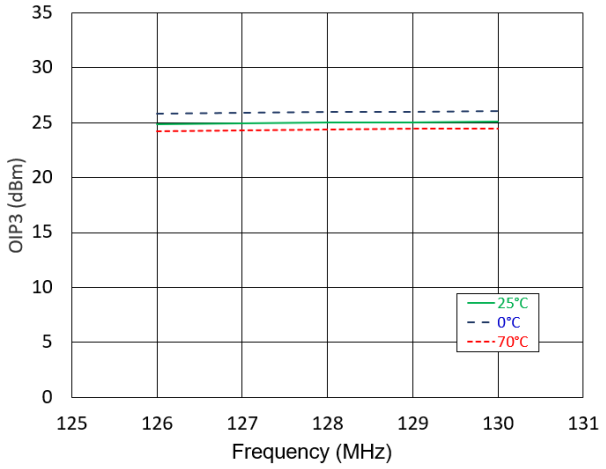
P1dB



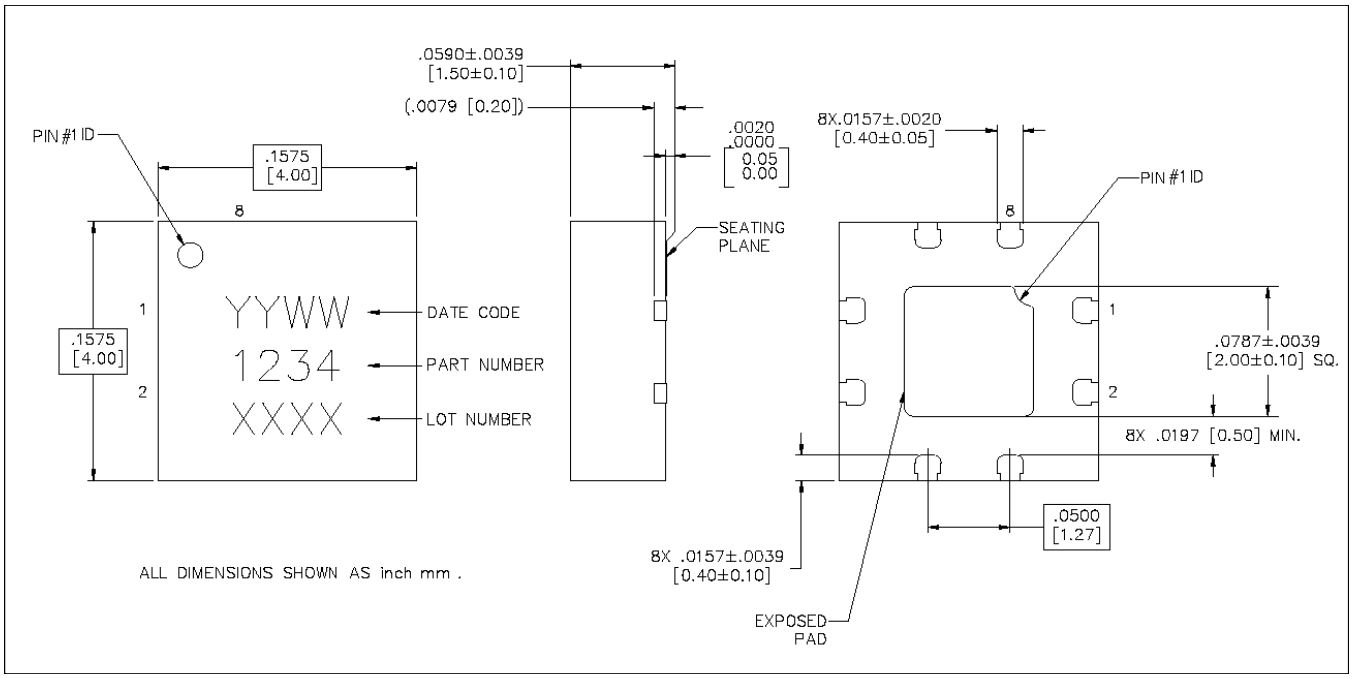
OIP3 (P_{out} = 0 dBm / Tone, 100 kHz spacing)



OIP3 (P_{out} = 0 dBm / Tone, 1 MHz spacing)



Non-Magnetic 4 mm, 8-Lead SMT Package



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

Revision history

Rev	Date	Change description
V1	June 2024	Initial Release