

High Power Switch - LNA Module 0.4 - 4.0 GHz

Rev. V2

Features

- 2-Stage LNA and High Power Switch
- High RF Input Power:
 - 120 W CW @ +85°C, 2.0 GHz
 - 100 W CW @ +85°C, 2.7 GHz
- Noise Figure:
 - 0.85 dB @ 2.0 GHz
 - 1.0 dB @ 2.7 GHz
- Gain:
 - 37 dB @ 2.0 GHz
 - 34 dB @ 2.7 GHz
- OIP3: 36 dBm
- Lead-Free 5 mm 32-Lead HQFN
- Halogen-Free "Green" Mold Compound
- ROHS* Compliant

Description

The MAIA-011002 is a compact surface mount module containing a PIN diode switch and two low noise amplifiers assembled in a 5 mm 32 lead HQFN plastic package. It was designed to be used at the input of the receive chain of TDD cellular base stations.

This module operates from 0.4 GHz to 4.0 GHz and features high power handling, very low noise figure and excellent linearity.

The connection between the output of LNA1 and the input of LNA2 is made outside of the module, making it possible for the user to add an attenuator or a filter.

The MAIA-011002 is ideally suited for TD-LTE base stations at 1.9, 2.3, 2.6 and 3.5 GHz.

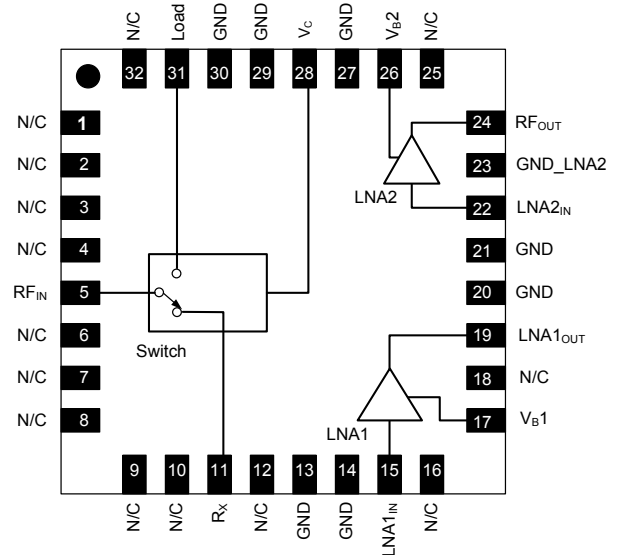
Ordering Information^{1,2}

| Part Number | Package |
|--------------------|------------------------|
| MAIA-011002-TR1000 | 1k Piece Reel |
| MAIA-011002-TR3000 | 3k Piece Reel |
| MAIA-011002-1SMB | 2 - 3 GHz Sample Board |
| MAIA-011002-2SMB | 3 - 4 GHz Sample Board |

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

* Restrictions on Hazardous Substances, European Union Directive 2011/65/EU.

Functional Schematic



Pin Configuration

| Pin No. | Pin Name | Function |
|-------------------------------|---------------------|--------------------------------|
| 1-4, 6-10, 12, 16, 18, 25, 32 | N/C ³ | No Connection |
| 5 | RF _{IN} | RF Input / Bias |
| 11 | R _X | R _X Switch Output |
| 13, 14, 20, 21, 27, 29, 30 | GND | RF Ground |
| 15 | LNA1 _{IN} | LNA1 Input |
| 17 | V _{B1} | LNA1 Bias |
| 19 | LNA1 _{OUT} | LNA1 Output / V _{DD1} |
| 22 | LNA2 _{IN} | LNA2 Input |
| 23 | GND_LNA2 | LNA2 Ground ⁴ |
| 24 | RF _{OUT} | RF Output / V _{DD2} |
| 26 | V _{B2} | LNA2 Bias |
| 28 | V _C | Switch Bias Control |
| 31 | Load | T _X Switch Output |
| 33 | Paddle | Ground ⁵ |

3. MACOM recommends connecting unused package pins (N/C) to ground.
4. Pin 23 must be connected to RF ground.
5. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.

High Power Switch - LNA Module 0.4 - 4.0 GHz

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Electrical Specifications:

$T_A = +25^\circ\text{C}$, $V_{DD\text{LNA1}} = 3\text{ V}$, $V_{B1} = 3\text{ V}$, $V_{DD\text{LNA2}} = 3\text{ V}$, $V_{B2} = 3\text{ V}$

Switch Bias = (see Bias Table), LNA1 = 70 mA, LNA2 = 60 mA, $Z_0 = 50\ \Omega$

| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|---|--|-------|------|----------------------|------|
| Input RF Power @ +85°C RF _{IN} - LOAD | 2.0 GHz 2.7 GHz 3.5 GHz | W | — | 120 100 80 | — |
| Noise Figure RF _{IN} - RF _{OUT} | 2.0 GHz 2.7 GHz 3.5 GHz | dB | — | 0.85 1.00 1.25 | — |
| Gain RF _{IN} - RF _{OUT} | 2.0 GHz 2.7 GHz 3.5 GHz | dB | — | 37 34 32 | — |
| Isolation RF _{IN} - LNA1 _{IN} | Switch State = RF _{IN} - LOAD 2.7 GHz | dB | — | 35 | — |
| Isolation LNA1 _{OUT} - LNA2 _{IN} | Switch State = RF _{IN} - RF _{OUT} 2.7 GHz | dB | — | 40 | — |
| Output IP3 RF _{IN} - RF _{OUT} | P _{IN} = -35 dBm, Tones 11 MHz apart 2.7 GHz | dBm | — | 36 | — |
| LNA Bias Current ⁶ | LNA1 Current: I _{DD1} + I _{V_{B1}} LNA2 Current: I _{DD2} + I _{V_{B2}} | mA | — | 70 60 | — |

6. Refer to LNA biasing options on page 4.

Switch Bias Table (see Alternative Bias in the Application Note AN-0004117)

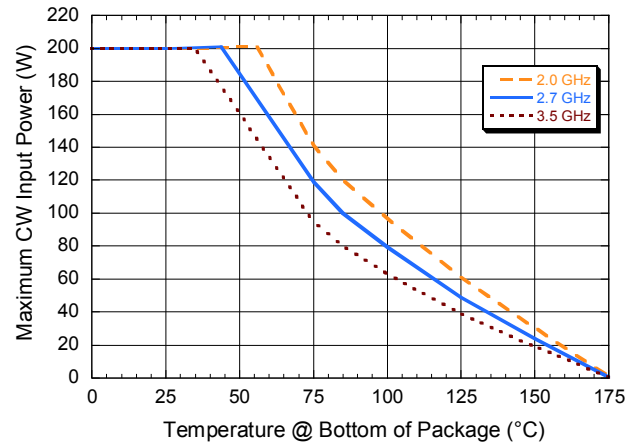
| RF _{IN} - LOAD | RF _{IN} - RF _{OUT} | LOAD | R _X | V _C | RF _{IN} |
|-------------------------|--------------------------------------|----------------|----------------|----------------|------------------|
| ON | OFF | -15 V (-50 mA) | +15 V (50 mA) | GND | GND |
| OFF | ON | +15 V (0 mA) | -15 V (-50 mA) | GND | GND |

Absolute Maximum Ratings^{7,8}

| Parameter | Absolute Maximum |
|---|-------------------------------------|
| RF Input Power RF _{IN} - RF _{OUT} RF _{IN} - LOAD | 19 dBm See Power De-rating Curve |
| Switch Reverse Voltage (RF & DC) | 160 V |
| V _{B1} & V _{B2} | 5.0 V |
| LNA _{1OUT} & RF _{OUT} | 5.5 V |
| Junction Temperature ⁹ Switch LNA | +175°C +150°C |
| Operating Temperature | -40°C to +100°C |
| Storage Temperature | -55°C to +150°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_{J1} ≤ +175°C of the switch and T_{J2} ≤ +150°C of LNA will ensure MTTF > 1 x 10⁶ hours.

T_x Input Power De-rating @ 20 dB I/O Return Loss



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.

LNA Biasing Options

LNA1 and LNA2 biases can be set in 2 different ways: using only V_{DD} , or using separate V_{DD} and V_{BIAS} [V_B] voltages. A separate V_{BIAS} voltage allows V_{B1} and V_{B2} to be used as enable pins to power LNA 1 and 2 up and down during operation.

For both bias methods, select the value of R_{BIAS1} and R_{BIAS2} to achieve the desired currents using the plots on page 5. DC blocking capacitors must be used at the LNA1 and 2 Input and output ports (see diagram).

Biasing Option - V_{DD} only

To use only V_{DD} , connect to V_{DD} [1,2] through an RF inductor and connect V_B [1,2] to the corresponding V_{DD} through bias resistor R_{BIAS} [1,2] as shown in Figure 1.

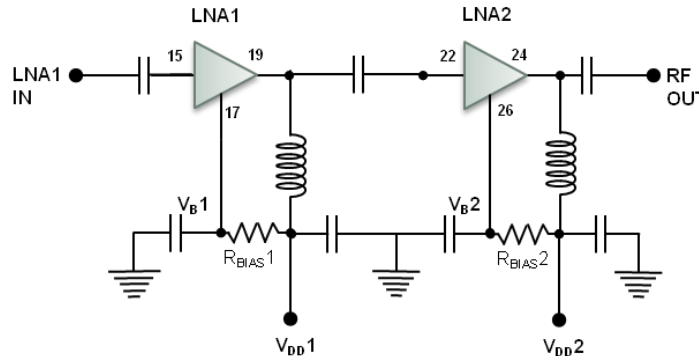


Figure 1

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

To use separate V_{DD} and V_B voltages, connect to V_{DD} [1,2] through an RF inductor and connect to V_B [1,2] through bias resistor R_{BIAS} [1,2] as shown in Figure 2. Typical current draw for V_B [1,2] is 1.4 mA @ $V_B = 3$ V, and 1 μ A @ $V_B = 0$ V. Typical current draw for V_{DD} [1,2] is < 1 μ A @ $V_{BIAS} = 0$ V and $V_{DD} = 3$ V.

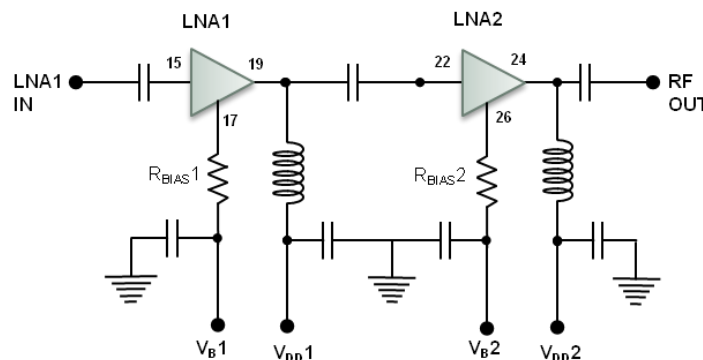
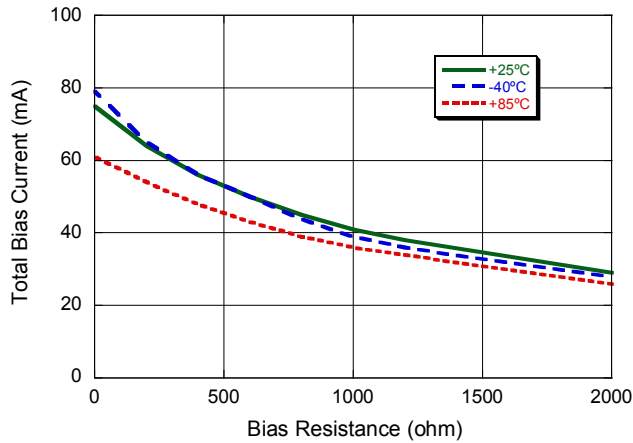


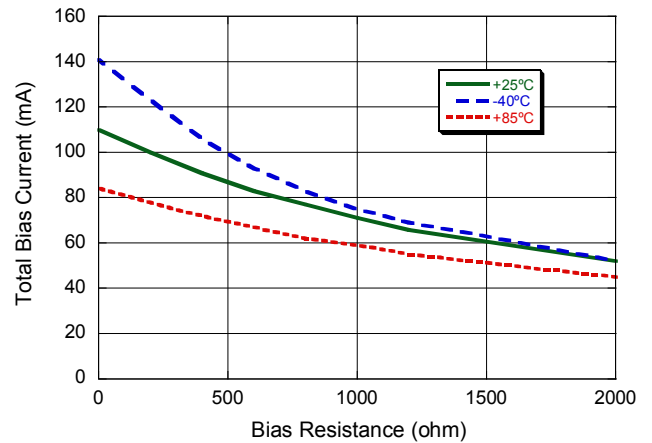
Figure 2

Typical Performance Curves: LNA1 Bias Circuit over Temperature

LNA1 Current, $V_{DD1} = 3\text{ V}$

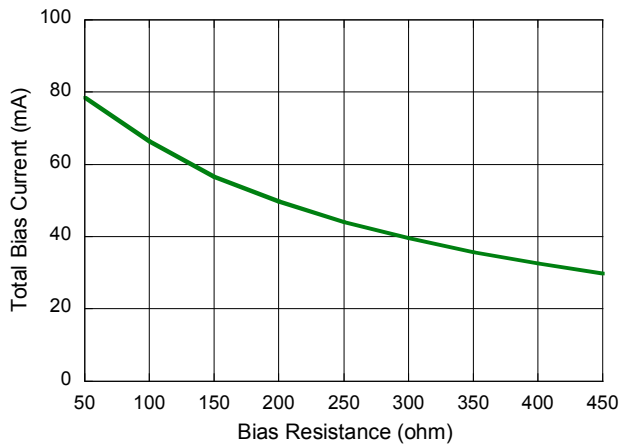


LNA1 Current, $V_{DD1} = 5\text{ V}$

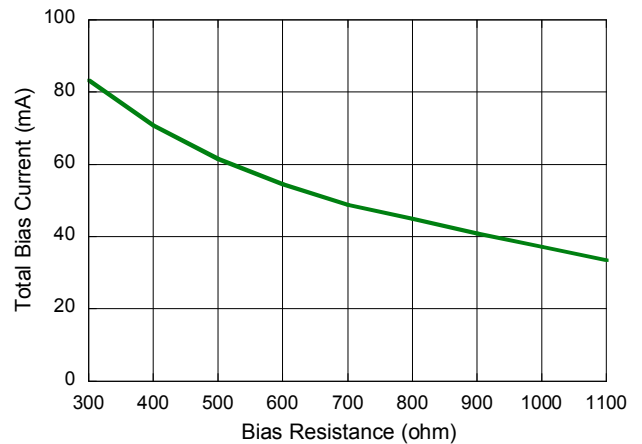


Typical Performance Curves: LNA2 Bias Circuit @ $T_A = 25^\circ\text{C}$

LNA2 Current, $V_{DD2} = 3\text{ V}$



LNA2 Current, $V_{DD2} = 5\text{ V}$

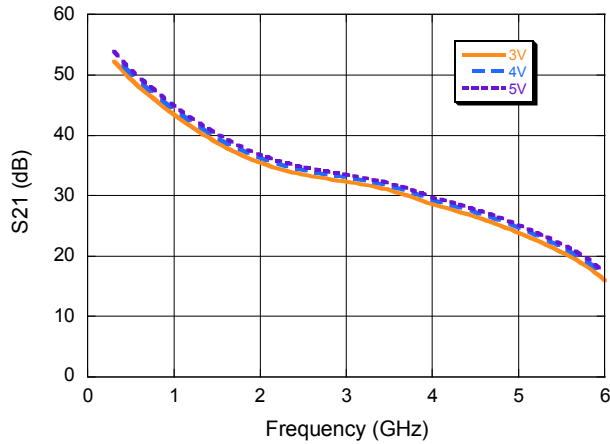


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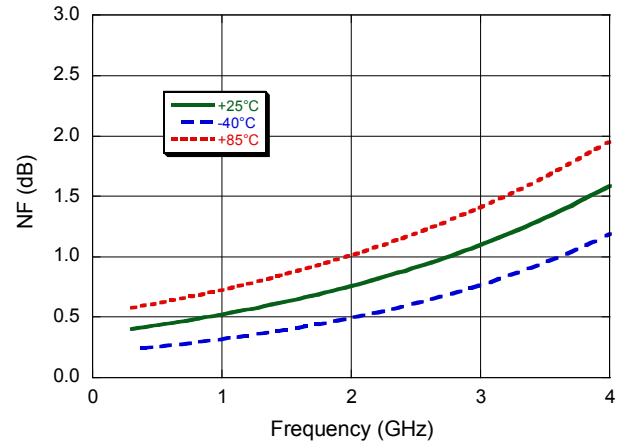
Rev. V2

Typical Performance Curves: $T_A = +25^\circ\text{C}$, $Z_0 = 50 \Omega$, $V_{DD} = 3 \text{ V}$, Switch State = $\text{RF}_{\text{IN}} - \text{RF}_{\text{OUT}}$

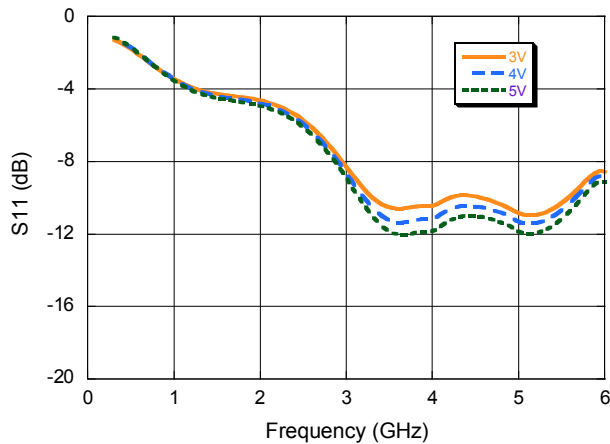
Gain vs. LNA1-2 Voltage



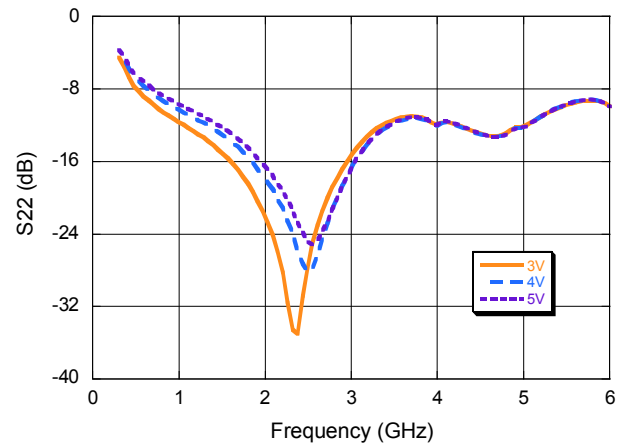
Noise Figure over Temperature, $V_{DD} = 3 \text{ V}$



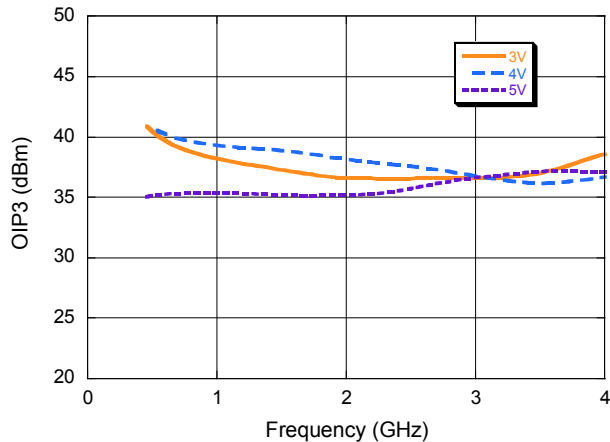
Input Return Loss vs. LNA1-2 Voltage



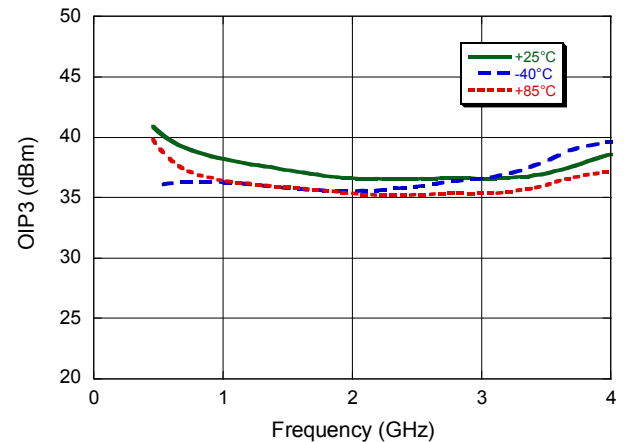
Output Return Loss vs. LNA1-2 Voltage



OIP3 vs. LNA1-2 Voltage



OIP3 over Temperature, $V_{DD} = 3 \text{ V}$

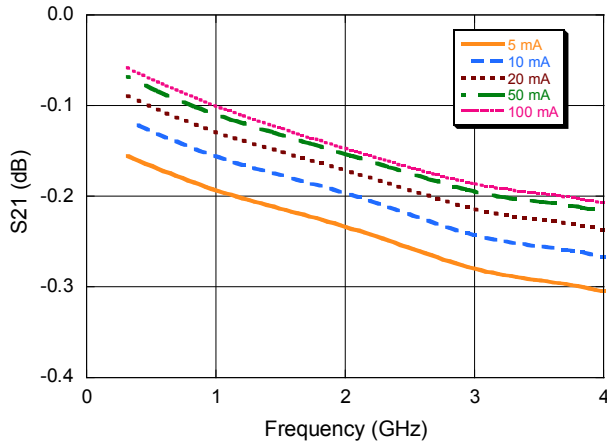


High Power Switch - LNA Module 0.4 - 4.0 GHz

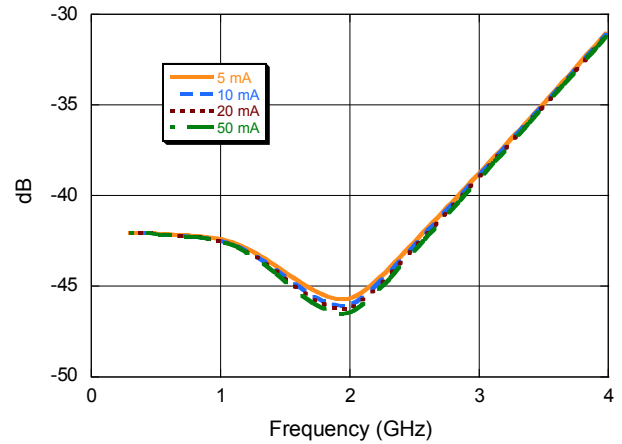
Rev. V2

Typical Performance Curves: $T_A = +25^\circ\text{C}$, $Z_0 = 50 \Omega$, $V_{DD} = 3 \text{ V}$, $RF_{IN} - \text{LOAD}$

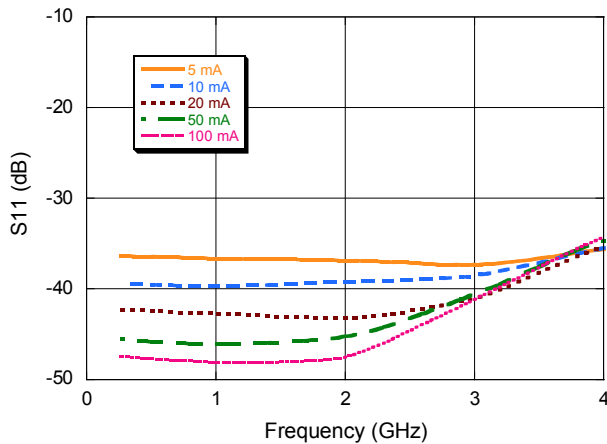
S21 vs. Switch Bias Current



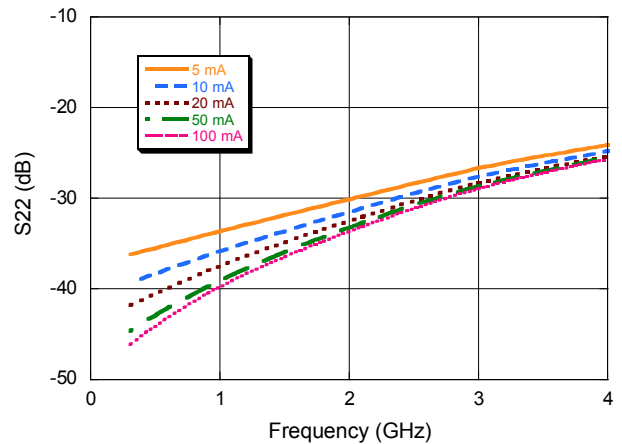
Isolation, RF_{IN} to LNA1 $_{IN}$ vs. Bias Current



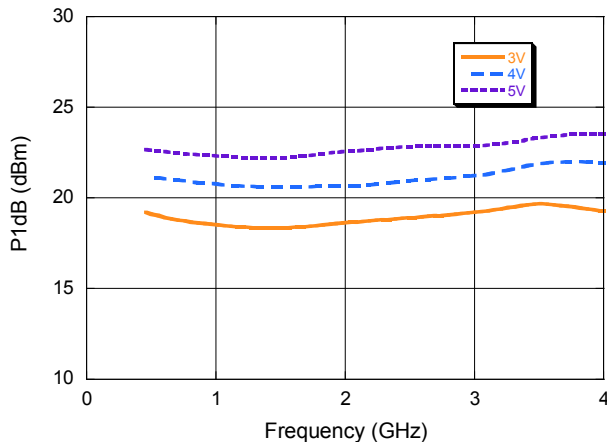
S11 vs. Switch Bias Current



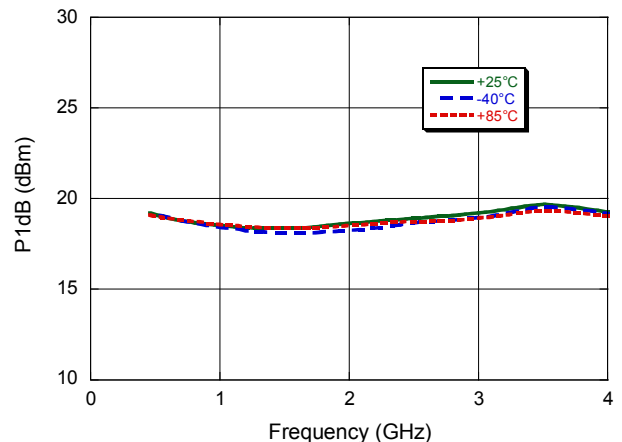
S22 vs. Switch Bias Current



P1dB vs. LNA1-2 Voltage, State = $RF_{IN} - RF_{OUT}$



P1dB vs. Temperature, State = $RF_{IN} - RF_{OUT}$



High Power Switch - LNA Module 0.4 - 4.0 GHz

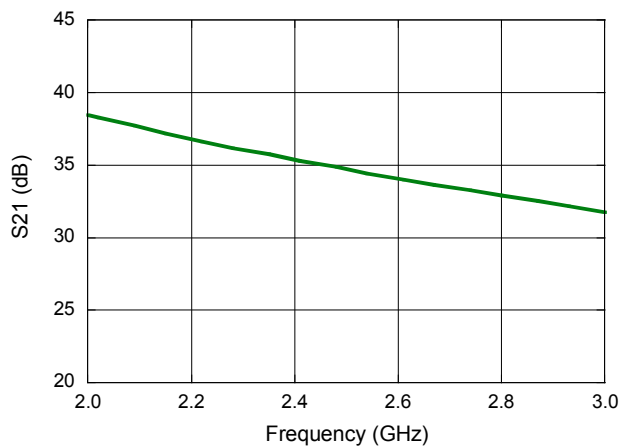
Rev. V2

Electrical Specifications: $T_A = +25^\circ\text{C}$, $V_{DD\text{LNA1}} = 3\text{ V}$, $V_{B1} = 3\text{ V}$, $V_{DD\text{LNA2}} = 3\text{ V}$, $V_{B2} = 3\text{ V}$,
Switch Bias = (see Bias Table), LNA1 = 70 mA, LNA2 = 60 mA; Tuned for 2 - 3 GHz band

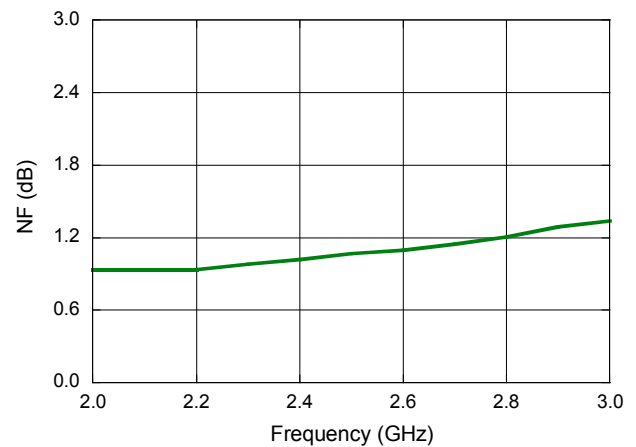
| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|--------------------|-------------------------------|-------|------|------|------|
| Gain | $RF_{IN} - RF_{OUT}$, 2.7GHz | dB | 31 | 34 | - |
| Noise Figure | $RF_{IN} - RF_{OUT}$, 2.7GHz | dB | - | 1.1 | 1.5 |
| Input Return Loss | $RF_{IN} - RF_{OUT}$, 2.7GHz | dB | - | 11 | - |
| Output Return Loss | $RF_{IN} - RF_{OUT}$, 2.7GHz | dB | - | 18 | - |

Typical Performance Curves: 2 - 3 GHz tuned Sample Board, $RF_{IN} - RF_{OUT}$

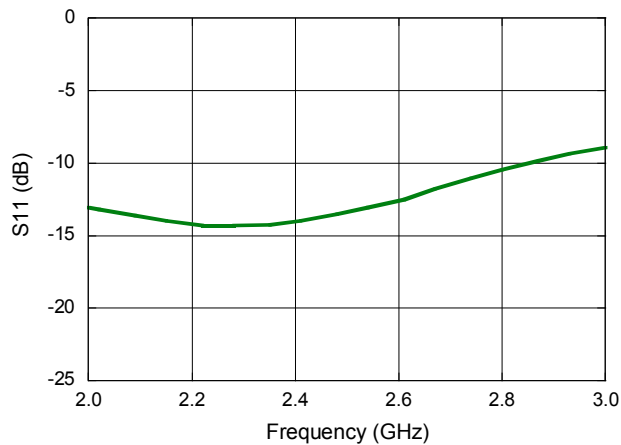
Gain



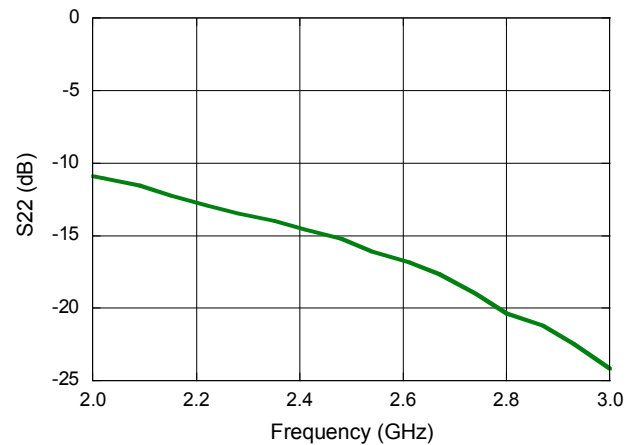
Noise Figure



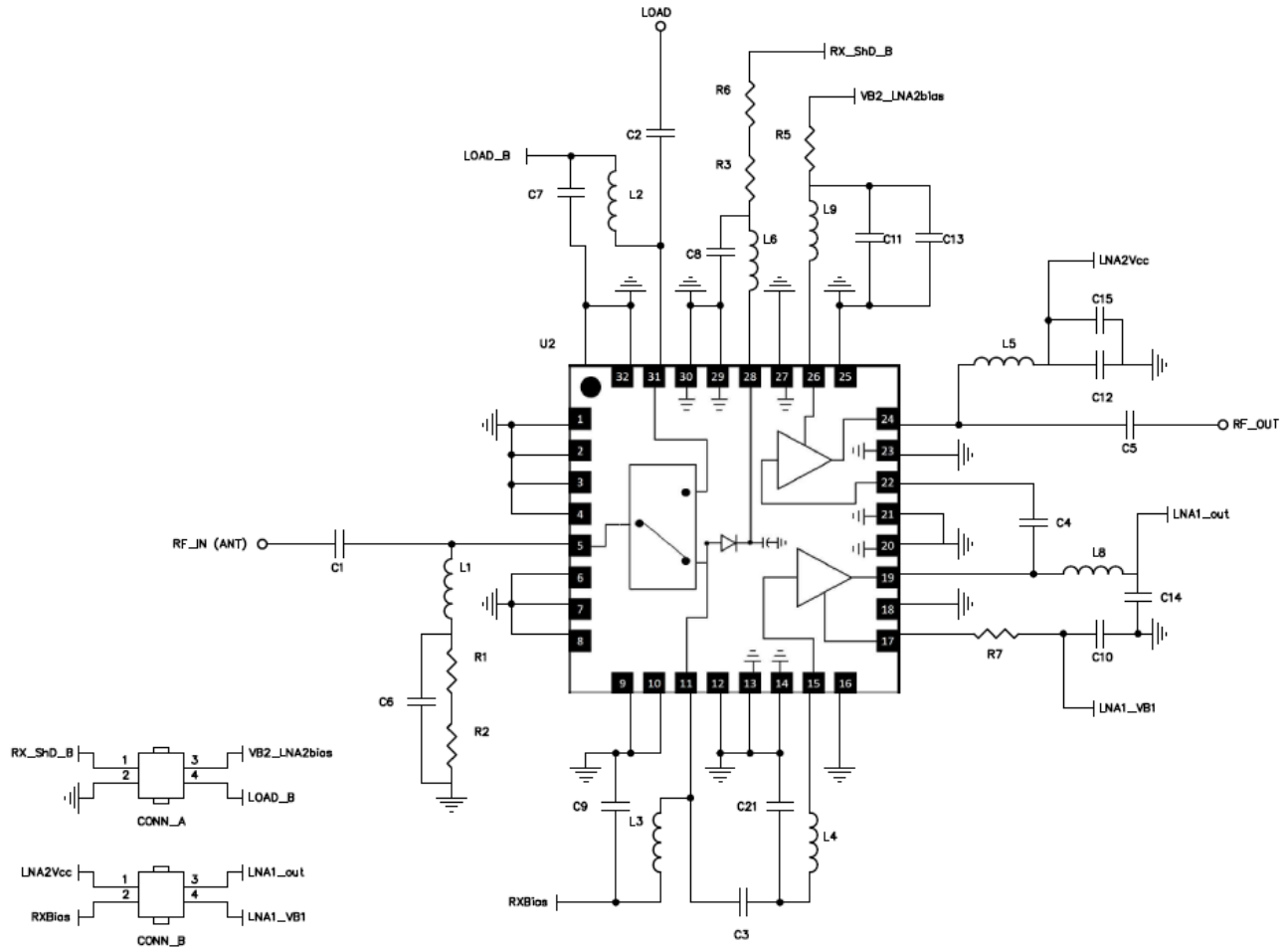
Input Return Loss



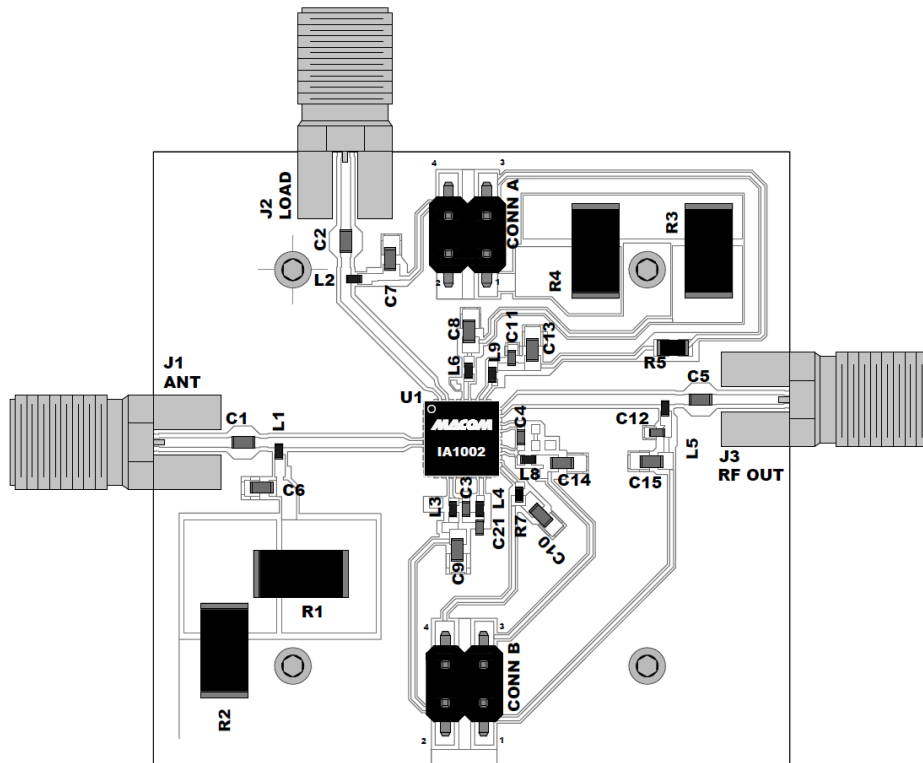
Output Return Loss



Schematic: MAIA-011002 Sample Board



Sample Board - PCB Layout



Sample Board Parts List* for 2 - 3 GHz Tuned PCB

| Part | Value | Description | MFR Part # |
|--|-----------------------|--------------------|--------------------|
| C1, C2, C5, | 27 pF / 250 V | 0603 SMT Capacitor | ATC600S270GT250T |
| C3 | 22 pF / 250 V | 0402 SMT Capacitor | ATC600L220FT200T |
| C4 | 3.3 pF / 50 V | 0402 SMT Capacitor | GRM1555C1H3R3BA01D |
| C6, C7, C8, C9, C10, C13, C14, C15 | 4.7 μ F / 35 V | 0603 SMT Capacitor | — |
| C11 | 10 nF / 25V | 0402 SMT Capacitor | — |
| C12 | 1 nF / 25V | 0402 SMT Capacitor | — |
| C21 | 0.40 pF \pm 0.1 pF | 0402 SMT Capacitor | GJM1555C1HR40BB01 |
| L1, L2, L3, L5, L6, L9 | 68 nH / 100 mA | 0402 SMT Inductor | 0402CS-68NXJLW |
| L4 | 2.7 nH | 0402 SMT Inductor | 0402CS-2N7XJLU |
| L8 | 2.0 nH | 0402 SMT Inductor | 0402CS-2N0XJLU |
| R1, R2, R3, R4 | 133 Ω / 1.50 W | 2512 SMT Resistor | — |
| R5 | 133 Ω | 0805 SMT Resistor | — |
| R7 | 100 Ω | 0402 SMT Resistor | — |
| J1 - J3 | SMA END LAUNCH | RF CONNECTOR | 142-0761-821 |
| C16, C18, C19, C20, C22 | do not populate | | |
| * Aluminum heat sink mounted to backside of PCB is not shown | | | |

High Power Switch - LNA Module 0.4 - 4.0 GHz

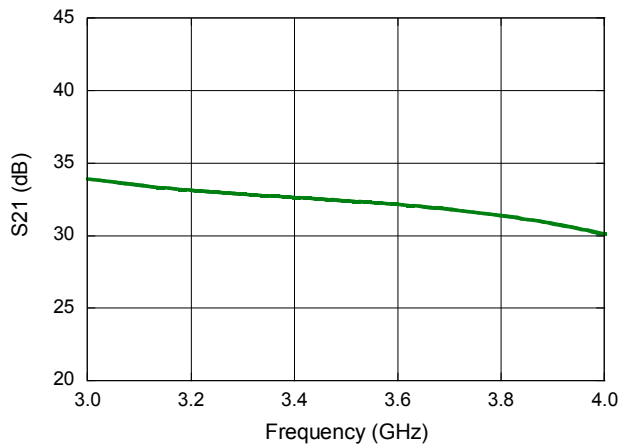
Rev. V2

Electrical Specifications: $T_A = +25^\circ\text{C}$, $V_{DD\text{LNA1}} = 3\text{ V}$, $V_{B1} = 3\text{ V}$, $V_{DD\text{LNA2}} = 3\text{ V}$, $V_{B2} = 3\text{ V}$,
Switch Bias = (see Bias Table), LNA1 = 70 mA, LNA2 = 60 mA; Tuned for 3 - 4 GHz band

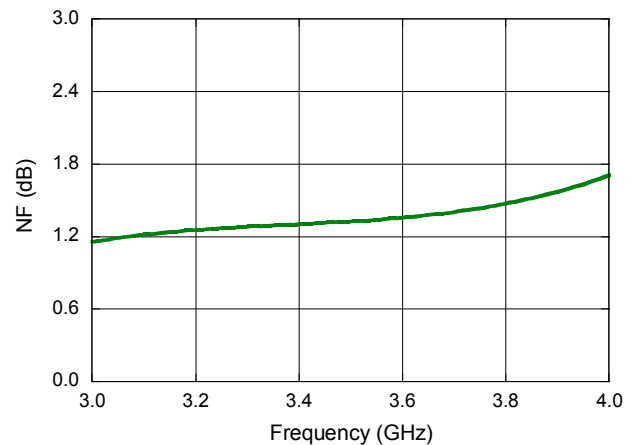
| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|--------------------|--------------------------------|-------|------|------|------|
| Gain | $RF_{IN} - RF_{OUT}$, 3.5 GHz | dB | — | 32 | — |
| Noise Figure | $RF_{IN} - RF_{OUT}$, 3.5 GHz | dB | — | 1.3 | — |
| Input Return Loss | $RF_{IN} - RF_{OUT}$, 3.5 GHz | dB | — | 12 | — |
| Output Return Loss | $RF_{IN} - RF_{OUT}$, 3.5 GHz | dB | — | 14 | — |

Typical Performance Curves: 3 - 4 GHz tuned Sample Board, $RF_{IN} - RF_{OUT}$

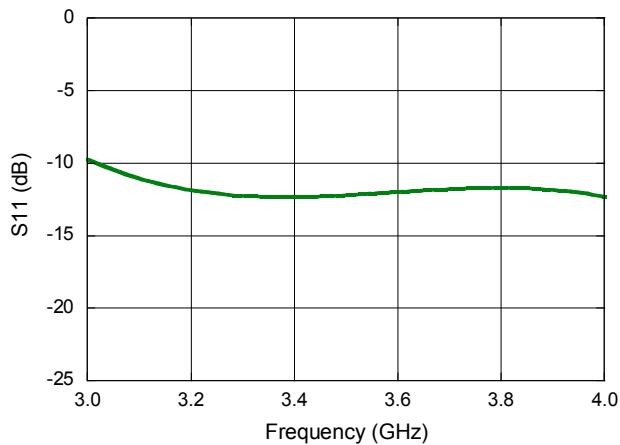
Gain



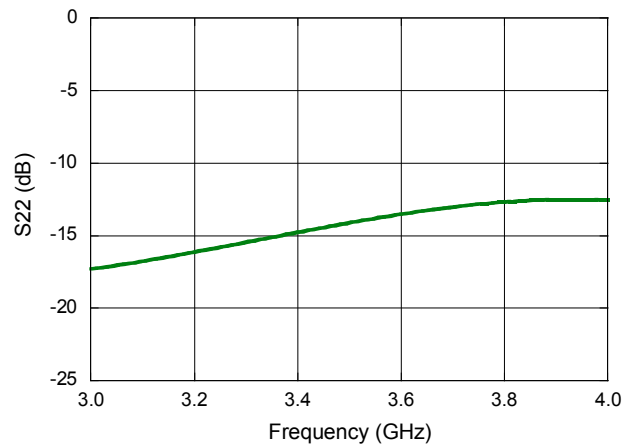
Noise Figure



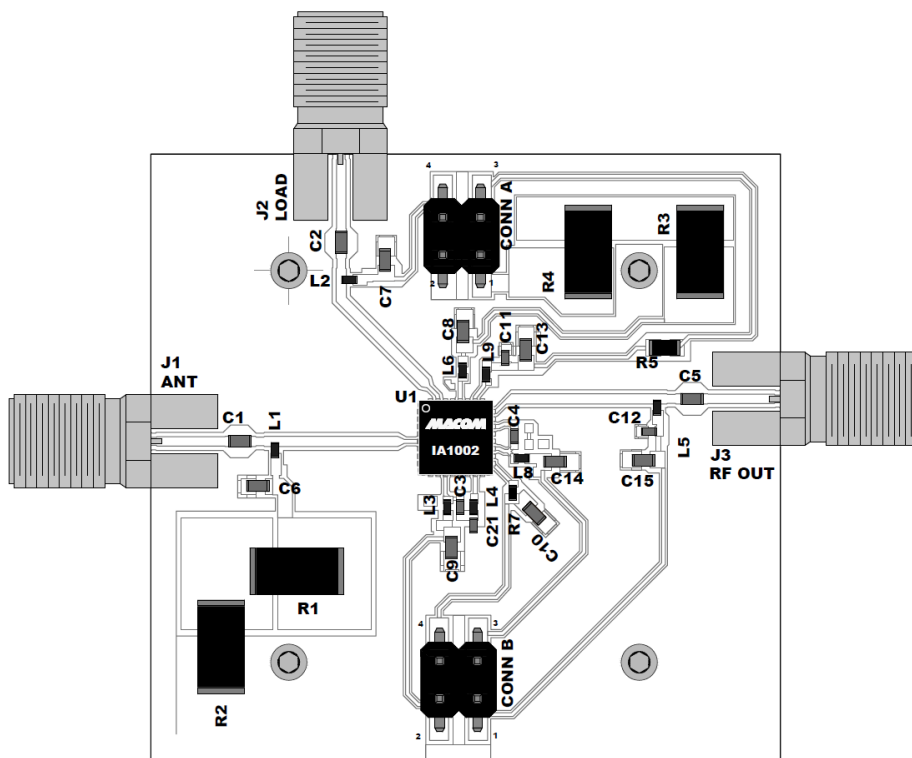
Input Return Loss



Output Return Loss



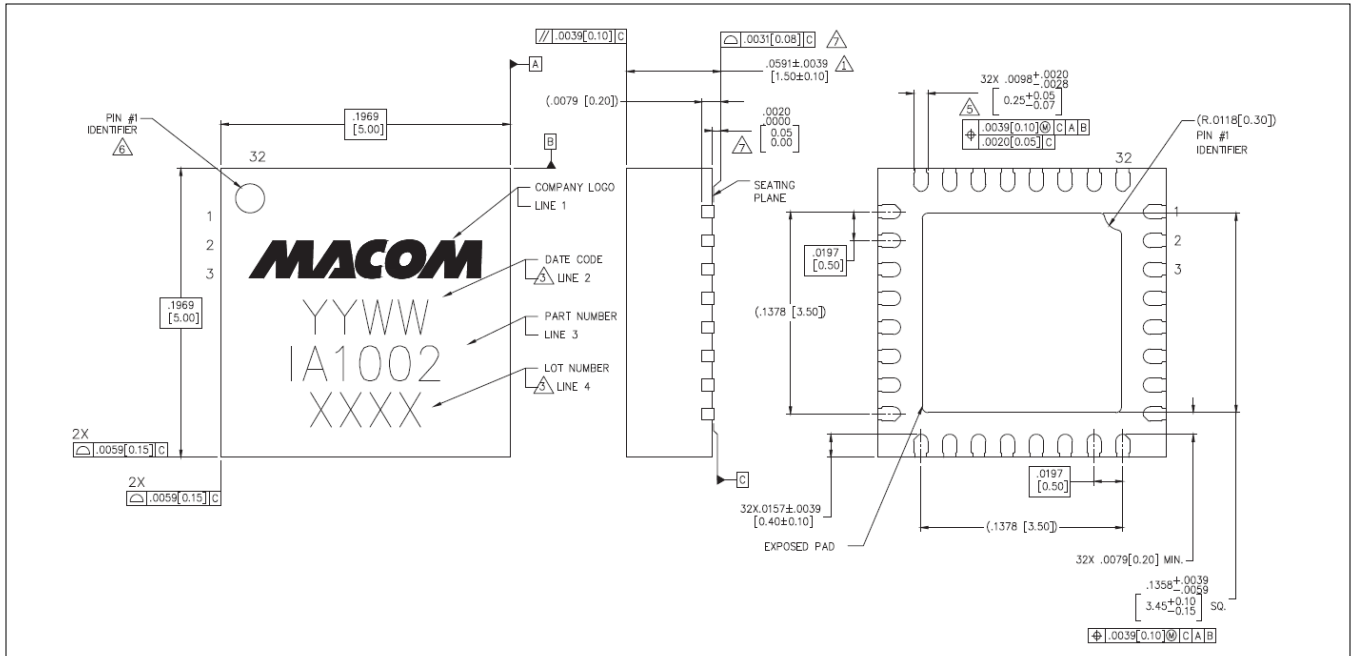
Sample Board - PCB Layout



Sample Board Parts List* for 3 - 4 GHz Tuned PCB

| Part | Value | Description | MFR Part # |
|--|-----------------|--------------------|--------------------|
| C1, C2, C5 | 27 pF / 250 V | 0603 SMT Capacitor | ATC600S270GT250T |
| C3 | 22 pF / 250 V | 0402 SMT Capacitor | ATC600L220FT200T |
| C4 | 3.3 pF / 50 V | 0402 SMT Capacitor | GRM1555C1H3R3BA01D |
| C6, C7, C8, C9, C10, C13, C14, C15 | 4.7 µF / 35 V | 0603 SMT Capacitor | - |
| C11 | 10 nF / 25V | 0402 SMT Capacitor | - |
| C12 | 1 nF / 25V | 0402 SMT Capacitor | - |
| C21 | 0.40 pF ±0.1 pF | 0402 SMT Capacitor | GJM1555C1HR40BB01 |
| L1, L2, L3, L5, L6, L9 | 68 nH / 100 mA | 0402 SMT Inductor | 0402CS-68NXJLW |
| L4 | 1.2 nH | 0402 SMT Inductor | 0402CS-1N2XJLU |
| L8 | 2.0 nH | 0402 SMT Inductor | 0402CS-2N0XJLU |
| R1, R2, R3, R4 | 133 Ω / 1.50 W | 2512 SMT Resistor | - |
| R5 | 133 Ω | 0805 SMT Resistor | - |
| R7 | 100 Ω | 0402 SMT Resistor | - |
| J1 –J3 | SMA END LAUNCH | RF CONNECTOR | 142-0761-821 |
| C16, C18, C19, C20, C22 | | do not populate | |
| * Aluminum heat sink mounted to backside of PCB is not shown | | | |

Lead-Free 5 mm 32-Lead HQFN[†]



[†] Reference Application Note M538 for lead-free solder reflow recommendations.
 Meets JEDEC moisture sensitivity level 1 requirements.
 Plating is NiPdAuAg

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