

Features

- 6-bit, 0.5 dB LSB, 31.5 dB range
- DC to 30 GHz operation
- Integrated TTL 0/+5V control
- +/- 0.5 dB typical bit error
- Low RMS phase 4.3° @ 20 GHz
- Lead-Free 3 mm 16-lead PQFN package
- ESD protection for all controls and bias

Description

The MAAD-011021 is a wide band 6-bit digital attenuator covering DC to 30 GHz. The attenuation bit-values are 0.5 dB LSB (least significant bit), 1, 2, 4, 8, and 16 dB for a total attenuation of 31.5 dB. Attenuation error is typically less than +/- 0.5 dB, RMS phase error is less than 5 degrees at 20 GHz, and typical insertion loss is 7.2 dB at 15 GHz. Return loss is typically 12 dB across all frequencies and attenuation states.

The attenuator integrates an inverter to allow a single control for series/shunt attenuation. Inverter requires a -5 V supply (V_{CC}) and 17 mA typical, logic is 0 V / +5 V.

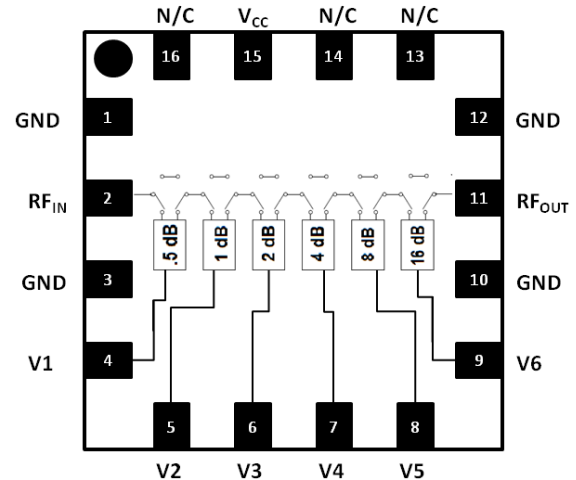
The device is also available as bare die; order part number MAAD-011021-0GPDIE.

Ordering Information^{1,2}

| Part Number | Package |
|--------------------|----------------|
| MAAD-011021 | Bulk Part |
| MAAD-011021-TR0500 | 500 piece reel |
| MAAD-011021-SMB | Sample Board |

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

Functional Schematic



Pin Configuration³

| Pin No. | Function | Pin No. | Function |
|---------|-------------|---------|--------------------|
| 1 | Ground | 9 | V6 (16 dB) |
| 2 | RF Input | 10 | Ground |
| 3 | Ground | 11 | RF Output |
| 4 | V1 (0.5 dB) | 12 | Ground |
| 5 | V2 (1 dB) | 13 | No Connection |
| 6 | V3 (2 dB) | 14 | No Connection |
| 7 | V4 (4 dB) | 15 | V_{CC} -5 V Bias |
| 8 | V5 (8 dB) | 16 | No Connection |
| | | 17 | Pad ⁴ |

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.

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

Electrical Specifications:

$T_A = +25^\circ\text{C}$, $V_{CC} = -5\text{ V}$, $Z_0 = 50\ \Omega$ (unless otherwise specified)

| Parameter | Test Conditions | Units | Min. | Typ. | Max. |
|--------------------------|-------------------------|-------|------|--------|------|
| Insertion Loss | DC - 15 GHz | dB | — | 6.0 | — |
| | 15 - 30 GHz | | | 8.0 | — |
| | 1 GHz | | | 5.0 | 5.5 |
| | 10 GHz | | | 7.0 | 8.0 |
| | 15 GHz | | | 7.5 | 8.5 |
| Return Loss | DC - 30 GHz | dB | — | 15 | — |
| Attenuation Bits | 10 GHz | dB | 0.3 | 0.4 | 0.5 |
| | LSB: 0.5 dB | | 0.8 | 1.0 | 1.1 |
| | Bit 2: 1 dB | | 1.8 | 2.0 | 2.2 |
| | Bit 4: 4 dB | | 3.8 | 4.0 | 4.2 |
| | Bit 5: 8 dB | | 7.6 | 8.3 | 8.9 |
| | Bit 6: 16 dB | | 16.0 | 17.0 | 18.0 |
| Attenuation Error RMS | DC - 15 GHz | dB | — | 0.3 | — |
| | 15 - 30 GHz | | | 1.2 | — |
| Phase Error RMS | DC - 15 GHz | deg | — | 2.6 | — |
| | 15 - 30 GHz | | | 7.2 | — |
| Input $P_{0.1\text{dB}}$ | DC - 30 GHz | dBm | — | 24 | — |
| Input IP3 | DC - 30 GHz | dBm | — | 38 | — |
| Switching Time | — | ns | — | 45 | — |
| Control Logic | — | V | — | 0 / +5 | — |
| Control Current | each control bit @ +5 V | mA | — | 6 | — |
| Supply Current | Supply = -5 V | mA | — | 17 | 45 |

Absolute Maximum Ratings^{5,6}

| Parameter | Absolute Maximum |
|-----------------------|------------------|
| Input Power | +35 dBm |
| Operating Voltage | -5 V |
| Control Voltage | 0 / +5 V |
| Operating Temperature | -40°C to +85°C |
| Storage Temperature | -65°C to +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.

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 1A devices.

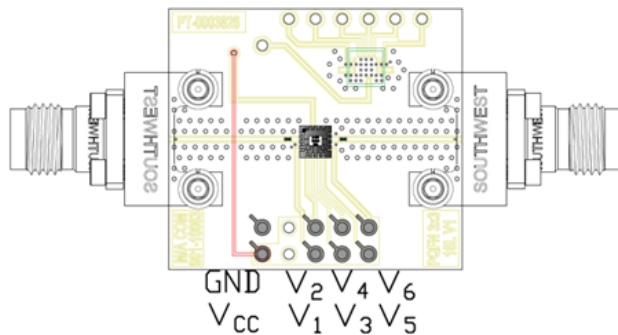
Truth Table^{7,8}

| V1 0.5 dB | V2 1 dB | V3 2 dB | V4 4 dB | V5 8 dB | V6 16 dB | State |
|--------------|------------|------------|------------|------------|-------------|---------|
| low | low | low | low | low | low | 0 dB |
| high | low | low | low | low | low | 0.5 dB |
| low | high | low | low | low | low | 1 dB |
| low | low | high | low | low | low | 2 dB |
| low | low | low | high | low | low | 4 dB |
| low | low | low | low | high | low | 8 dB |
| low | low | low | low | low | high | 16 dB |
| high | high | high | high | high | high | 31.5 dB |

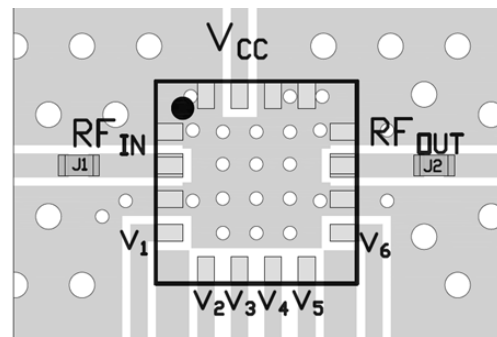
7. high = +5 V @ 5.7 mA, low = 0 V @ 1.0 mA.

8. Any combination of the above states will provide attenuation approximately equal to the sum of the bits selected.

Evaluation Board



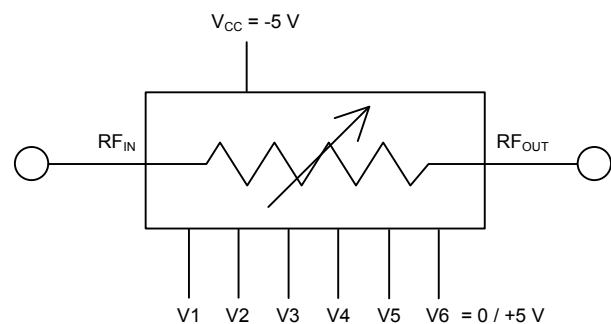
PCB Layout



Parts List

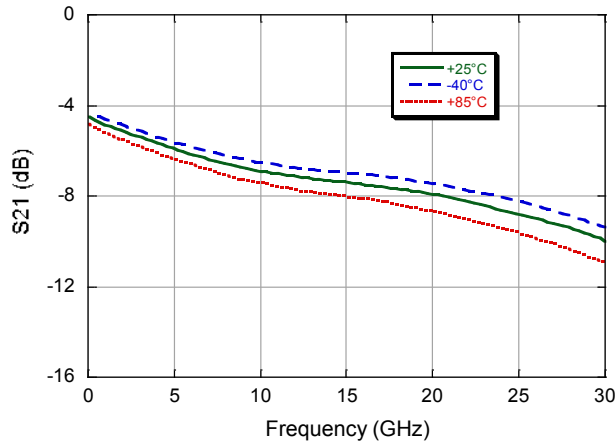
| Part | Value | Case Style |
|--------|-------|------------|
| J1, J2 | 0 Ω | 0201 |

Application Schematic

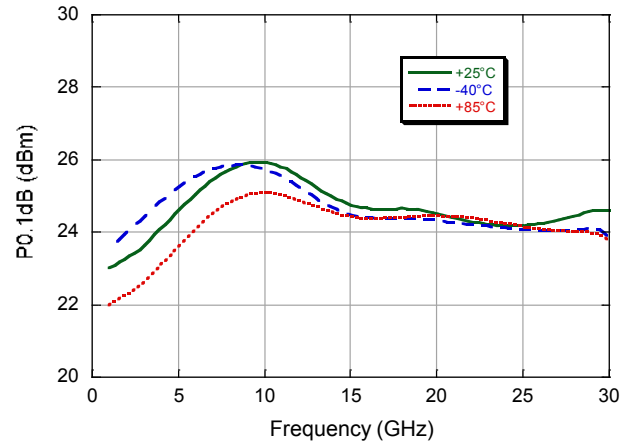


Typical Performance Curves

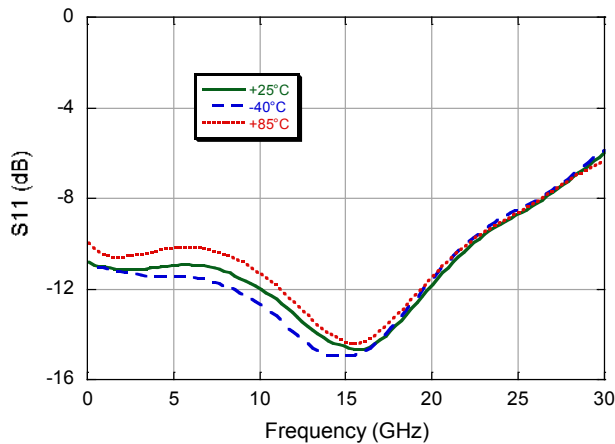
Insertion Loss



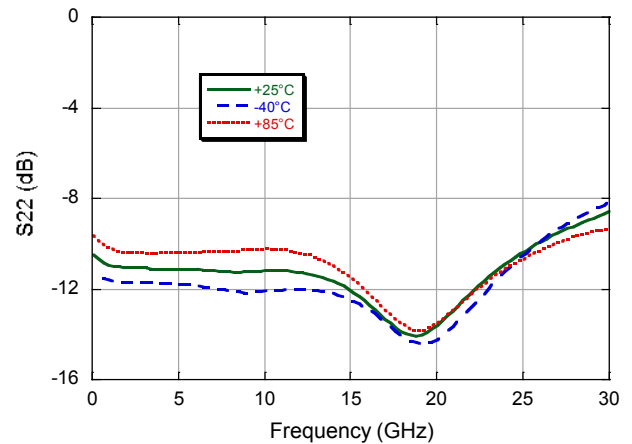
P0.1dB Compression



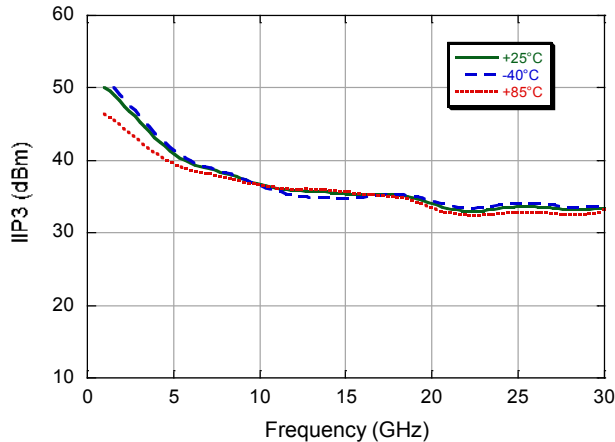
Maximum Input Return Loss (all states)



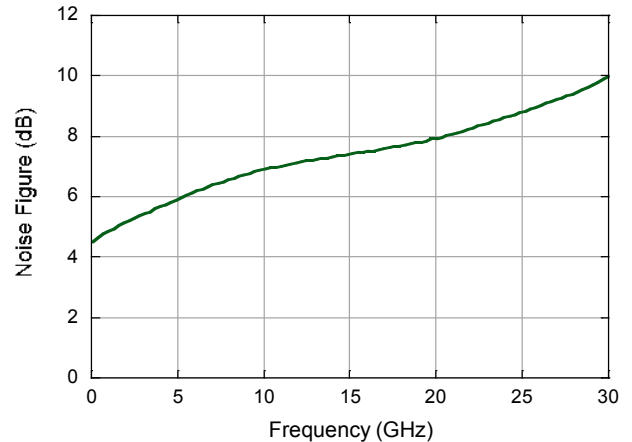
Maximum Output Return Loss (all states)



Input IP3 (reference states)

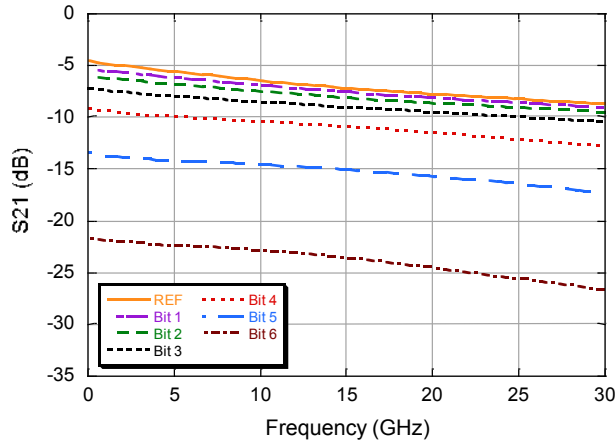


Noise Figure (reference states)

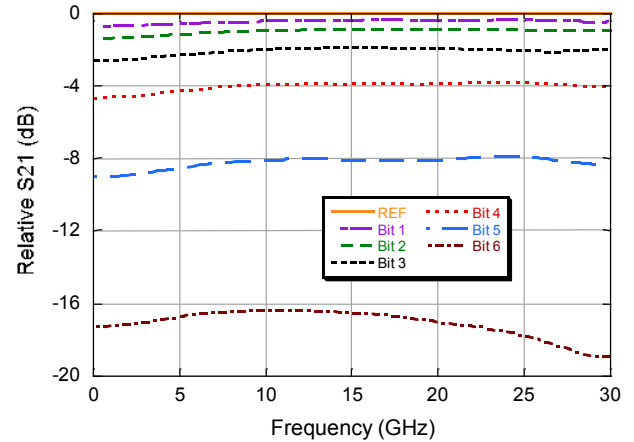


Typical Performance Curves

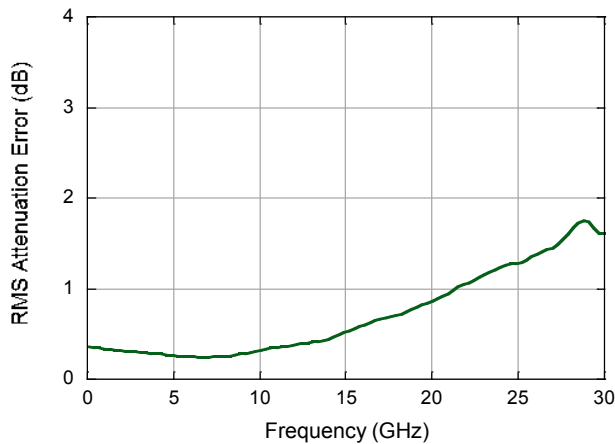
Attenuation



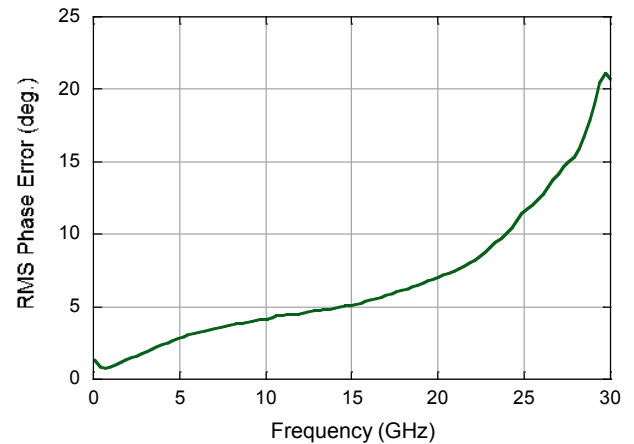
Relative Attenuation



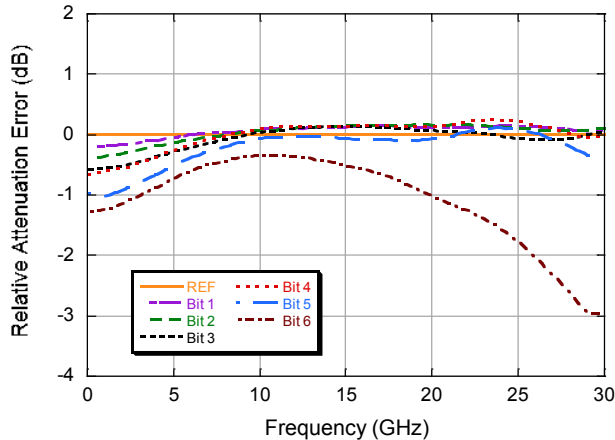
RMS Attenuation Error



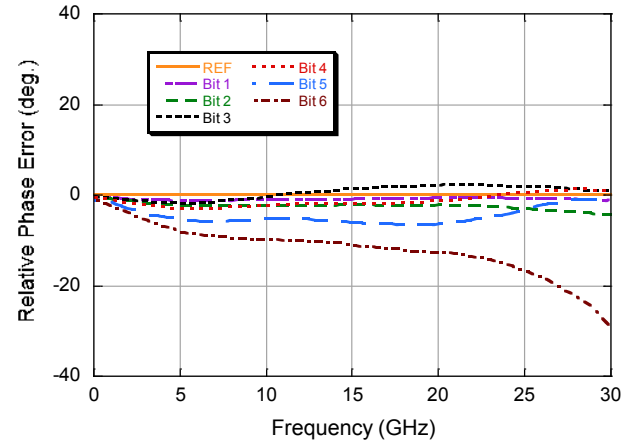
RMS Phase Error



Relative Attenuation Error

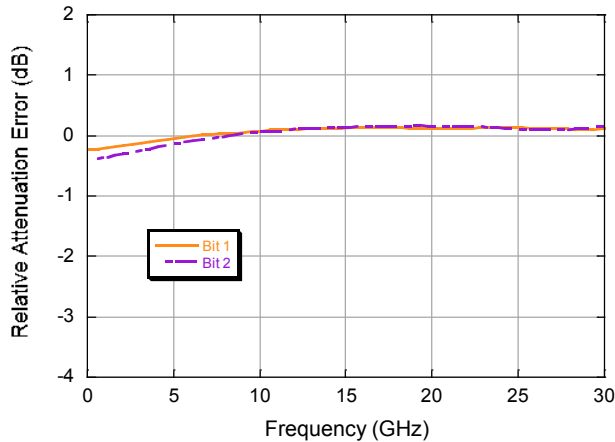


Relative Phase Error

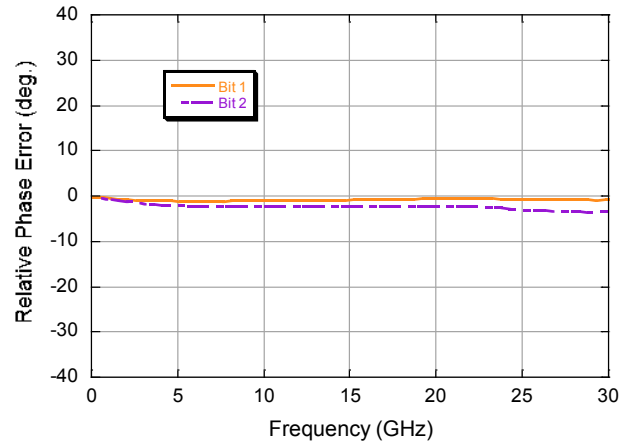


Typical Performance Curves

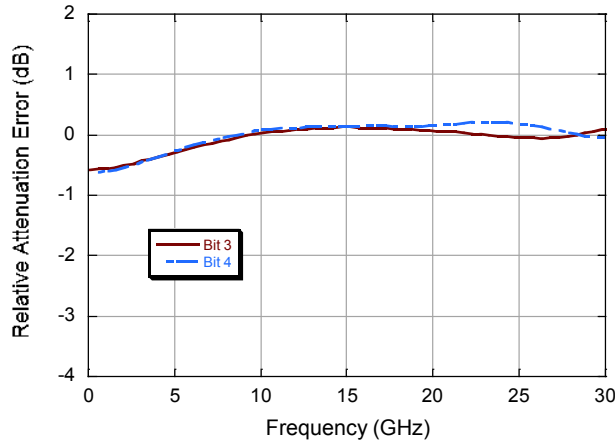
Relative Attenuation Error (Bit 1, 2)



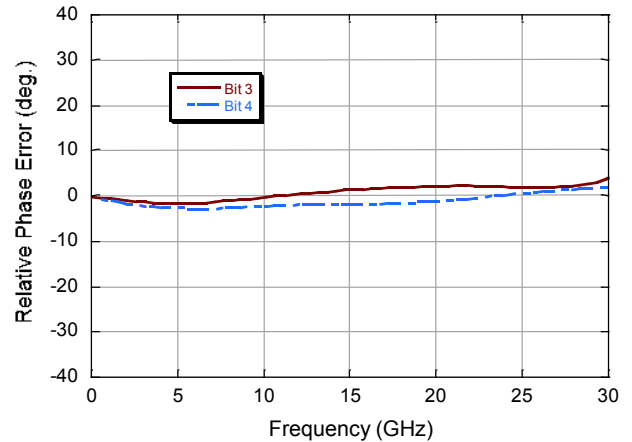
Relative Phase Error (Bit 1, 2)



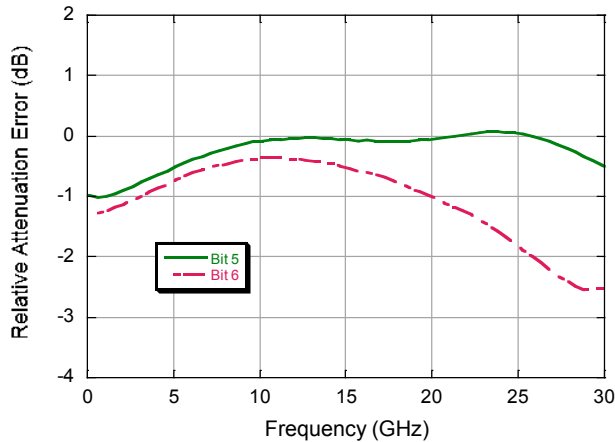
Relative Attenuation Error (Bit 3, 4)



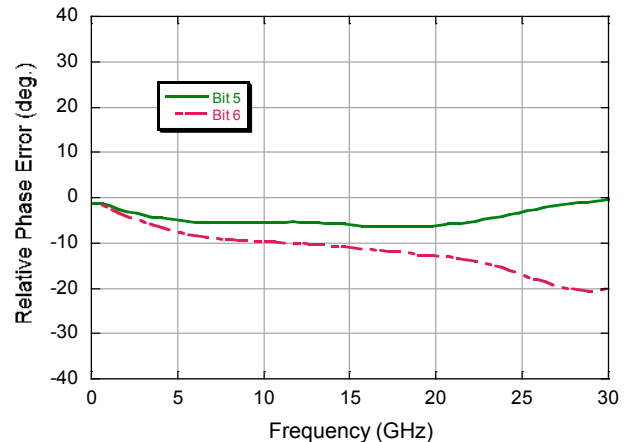
Relative Phase Error (Bit 3, 4)



Relative Attenuation Error (Bit 5, 6)

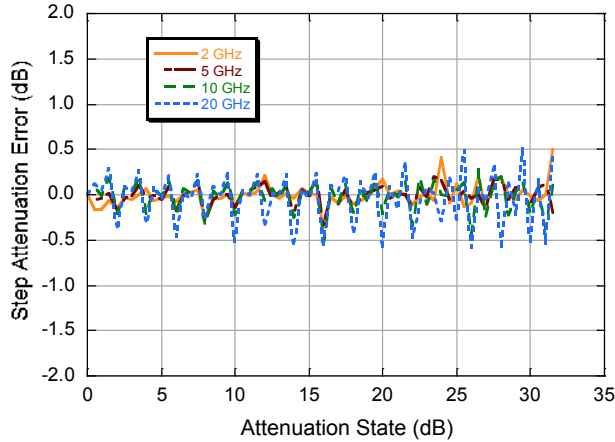


Relative Phase Error (Bit 5, 6)

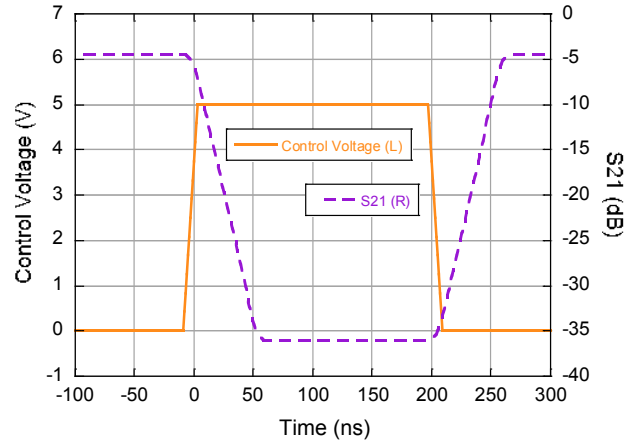


Typical Performance Curves

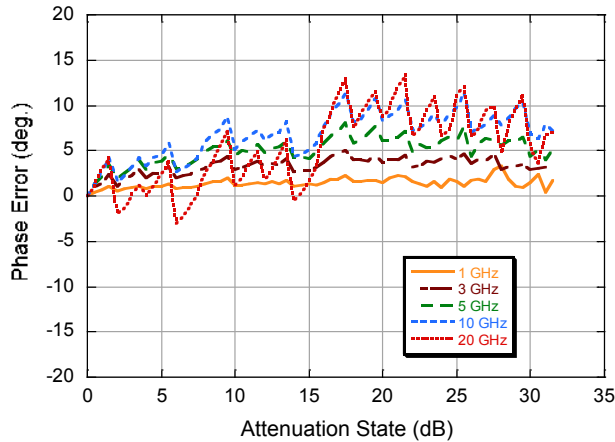
Step Error Between Successive States



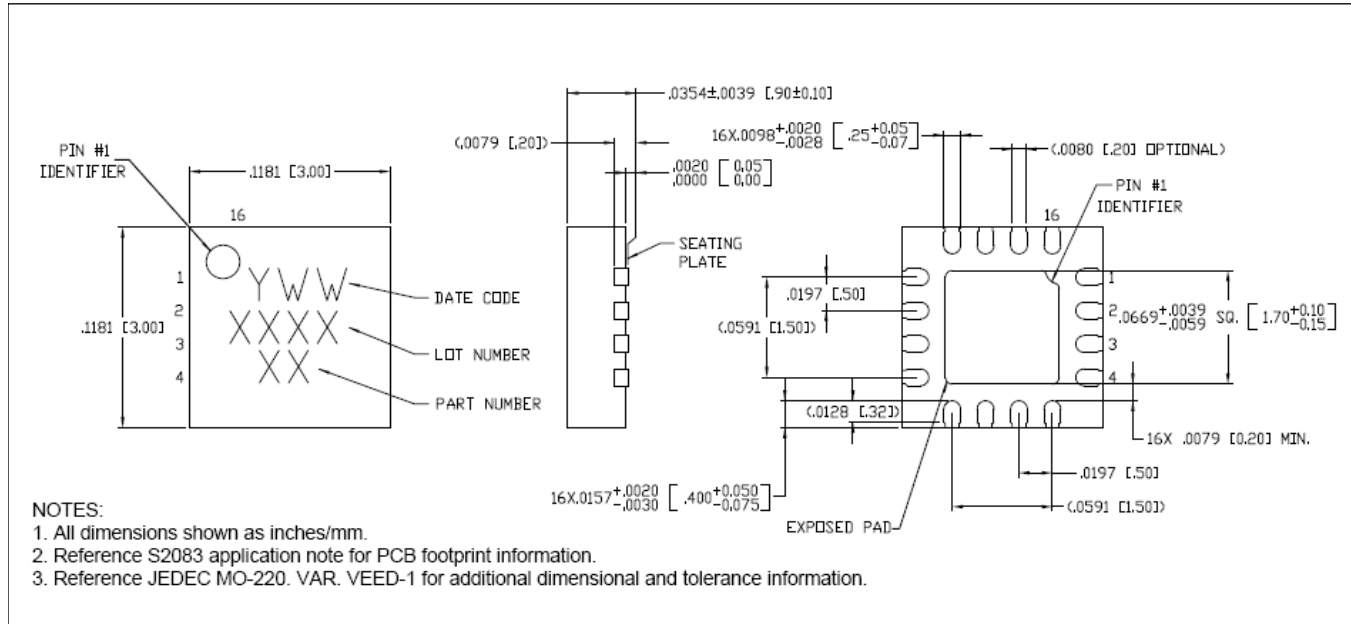
Switching Time



Phase Error over Attenuation States



Lead-Free 3 mm 16-Lead PQFN†



† 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 Information

The MAAD-011021 is designed for extremely wide band and robust attenuation applications. It uses a combination of series and shunt cold channel, multiple-gate FETs to achieve high linearity and accurate attenuation repeatability. We recommend using double bonds at both RF input and output, as well as keeping bondwires as short as possible. This part is the most accurate for X-band applications.

The MAAD-011021 has a built in inverter function which allows a single +5 V / 0 V single control for each bit. This is useful if you require very fast switching times and have +5 V / 0 V available.

The MAAD-011021 is DC-coupled at both RF_{IN} and RF_{OUT}. If operation at DC is desired, 0 Ω jumpers (or continuous 50 Ω RF lines) should be used in series with RF_{IN} and RF_{OUT}. Customer should take extra care to ensure that the voltage at both RF_{IN} and RF_{OUT} are 0 V; excess voltage can damage the part. If operation at DC is not required, simply use series blocking capacitors.

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JONHON

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