

Features

- Attenuation: 0.5 dB Steps to 15.5 dB
- Minimal Phase Variation over Attenuation Range
- Low DC Power Consumption
- Small Footprint, PQFN Package
- Integral TTL Driver
- 50 ohm Impedance
- Test Boards are Available
- RoHS* Compliant

Description

MACOM's MAAD-009170-000100 is a GaAs pHEMT 5-bit digital attenuator with integral TTL driver in an PQFN plastic surface mount package. Step size is 0.5 dB providing a 15.5 dB total attenuation range. This design has been optimized to minimize phase variation over the attenuation range. MAAD-009170-000100 is ideally suited for use where accuracy, fast switching, very low power consumption and low intermodulation products are required. Typical applications include dynamic range setting in precision receiver circuits and other gain/leveling control circuits.

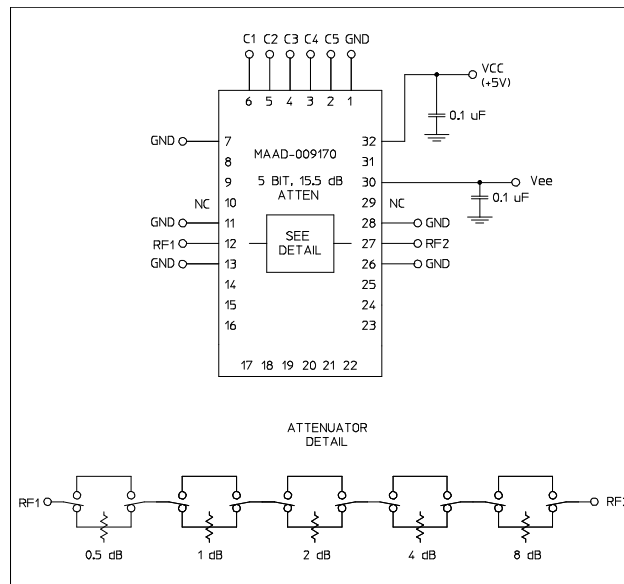
Ordering Information

| Part Number | Package |
|--------------------|-------------------|
| MAAD-009170-000100 | Bulk Packaging |
| MAAD-009170-0001TR | 1000 piece reel |
| MAAD-009170-0001TB | Sample Test Board |

Note: Reference Application Note M513 for reel size information.

* Restrictions on Hazardous Substances, European Union Directive 2002/95/EC.

Functional Schematic



Pin Configuration¹

| Pin No. | Function | Pin No. | Function |
|---------|-----------------|---------|-----------------|
| 1 | GND | 17 | NC |
| 2 | C5 | 18 | NC |
| 3 | C4 | 19 | NC |
| 4 | C3 | 20 | NC |
| 5 | C2 | 21 | NC |
| 6 | C1 | 22 | NC |
| 7 | GND | 23 | NC |
| 8 | NC | 24 | NC |
| 9 | NC | 25 | NC |
| 10 | NC ² | 26 | GND |
| 11 | GND | 27 | RF2 |
| 12 | RF1 | 28 | GND |
| 13 | GND | 29 | NC ² |
| 14 | NC | 30 | Vee |
| 15 | NC | 31 | NC |
| 16 | NC | 32 | +Vcc |

1. The exposed pad centered on the package bottom must be connected to RF and DC ground. (For PQFN Packages)
2. Pins 10 & 29 must be isolated

Digital Attenuator, Constant Phase 15.5 dB, 5-Bit, TTL Driver, DC - 4.0 GHz

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Electrical Specifications: $T_A = 25^\circ\text{C}$, $Z_0 = 50\Omega$, $V_{CC} = +5.0\text{V}$, $V_{EE} = -5.0\text{V}$

| Parameter | Test Conditions | Frequency | Units | Min | Typ | Max |
|---|--|-------------------------------|----------|--|------------|------------|
| Operating Power ³ | — | — | dBm | — | — | +20 |
| Reference Insertion Loss | — | DC - 2.0 GHz 2.0 - 4.0 GHz | dB dB | — — | — — | 4.7 5.2 |
| Attenuation Accuracy ⁴ Relative to Reference Loss State | Any Single Bit Any Combination of Bits | DC - 4.0 GHz DC - 4.0 GHz | | ±(0.25 +2% of atten setting in dB) ±(0.25 +2% of atten setting in dB) | | |
| Phase Accuracy Relative to Reference Loss State | Any Single Bit | DC - 2.0 GHz | deg | — | — | ±2° |
| | Any Single Bit | 2.0 - 4.0 GHz | deg | — | — | ±3° |
| | Any Combination of Bits | DC - 2.0 GHz | deg | — | — | ±4° |
| | Any Combination of Bits | 2.0 - 4.0 GHz | deg | — | — | ±7° |
| VSWR | Full Range | DC - 4.0 GHz | Ratio | — | — | 1.9:1 |
| Switching Speed | Ton | 1.3 V Cntl to 90% RF | ns | — | 47 | — |
| | Toff | 1.3 V Cntl to 10% RF | ns | — | 24 | — |
| | Trise | 10% RF to 90% RF | ns | — | 23 | — |
| | Tfall | 90% RF to 10% RF | ns | — | 13 | — |
| 1 dB Compression ⁵ | Reference State | 0.05 GHz | dBm | — | >+26 | — |
| | Reference State | 0.5 - 4.0 GHz | dBm | — | >+26 | — |
| Input IP3 | Two-tone inputs up to +5 dBm | 0.05-4.0 GHz | dBm | — | +43 +40 | — |
| Input IP2 | Two-tone inputs up to +5 dBm | 0.05-4.0 GHz | dBm | — | +50 +72 | — |
| Vcc | — | — | V | 4.5 | 5.0 | 5.5 |
| Vee | — | — | V | -8.0 | -5.0 | -4.5 |
| V _{IL} V _{IH} | LOW-level input voltage | — | V | 0.0 | 0.0 | 0.8 |
| | HIGH-level input voltage | — | V | 2.0 | 5.0 | 5.0 |
| I _{in} (Input Leakage Current) | V _{in} = V _{CC} or GND | — | uA | -1 | — | 1 |
| I _{cc} (Quiescent Supply Current) | V _{cntrl} = V _{CC} or GND | — | uA | — | 250 | 400 |
| ΔI _{cc} (Additional Supply Current Per TTL Input Pin) | V _{CC} = Max V _{cntrl} = V _{CC} - 2.1 V | — | mA | — | — | 1.5 |
| I _{EE} | V _{EE} min to max V _{in} = V _{IL} or V _{IH} | — | mA | -1.0 | -0.2 | — |
| Thermal Resistance θ _{jc} | — | — | °C/W | — | 35 | — |

- Maximum operating power is specified with the input applied to RF1. If the input is applied to RF2, then maximum operating power is +16 dBm.
- This attenuator is guaranteed monotonic.
- 1 dB Compression was measured up to +26 dBm, which is the absolute maximum rating for this device.

Digital Attenuator, Constant Phase 15.5 dB, 5-Bit, TTL Driver, DC - 4.0 GHz

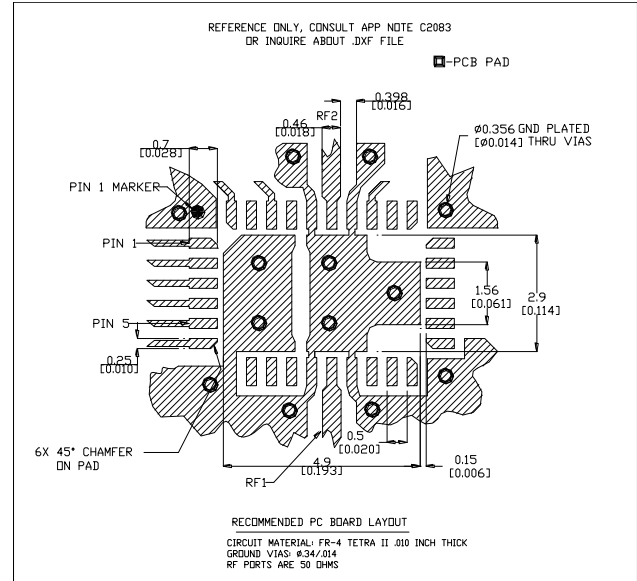
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Absolute Maximum Ratings ^{6,7}

| Parameter | Absolute Maximum |
|---|---|
| Max. Input Power ⁸ DC - 4.0 GHz | +26 dBm |
| V_{CC} | $-0.5V \leq V_{CC} \leq +7.0V$ |
| V_{EE} | $-8.5V \leq V_{EE} \leq +0.5V$ |
| $V_{CC} - V_{EE}$ | $-0.5V \leq V_{CC} - V_{EE} \leq 14.5V$ |
| V_{in} ⁹ | $-0.5V \leq V_{in} \leq V_{CC} + 0.5V$ |
| Operating Temperature | -40°C to +85°C |
| Storage Temperature | -65°C to +125°C |

- Exceeding any one or combination of these limits may cause permanent damage to this device.
- M/A-COM does not recommend sustained operation near these survivability limits.
- The maximum operating power is specified with the input applied to RF1. If the input is applied to RF2, then maximum operating power is +22 dBm
- Standard CMOS TTL interface, latch-up will occur if logic signal is applied prior to power supply.

Recommended PCB Configuration ¹⁰



- Application Note S2083 is available on line at www.macom.com

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 devices.

Moisture Sensitivity

The MSL rating for this part is defined as Level 2 per IPC/JEDEC J-STD-020. Parts shall be stored and/or baked as required for MSL Level 2 parts.

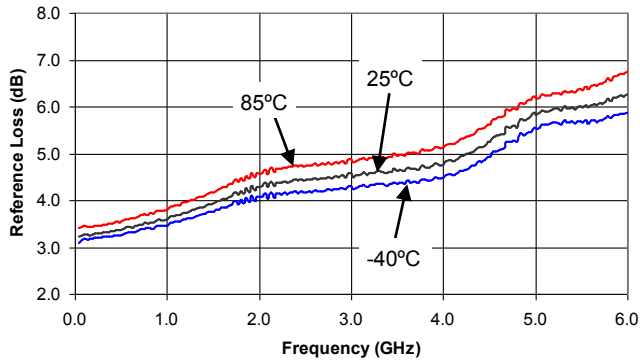
Truth Table (Digital Attenuator)

| C5 | C4 | C3 | C2 | C1 | Attenuation |
|----|----|----|----|----|-----------------|
| 0 | 0 | 0 | 0 | 0 | Loss, Reference |
| 0 | 0 | 0 | 0 | 1 | 0.5 dB |
| 0 | 0 | 0 | 1 | 0 | 1.0 dB |
| 0 | 0 | 1 | 0 | 0 | 2.0 dB |
| 0 | 1 | 0 | 0 | 0 | 4.0 dB |
| 1 | 0 | 0 | 0 | 0 | 8.0 dB |
| 1 | 1 | 1 | 1 | 1 | 15.5 dB |

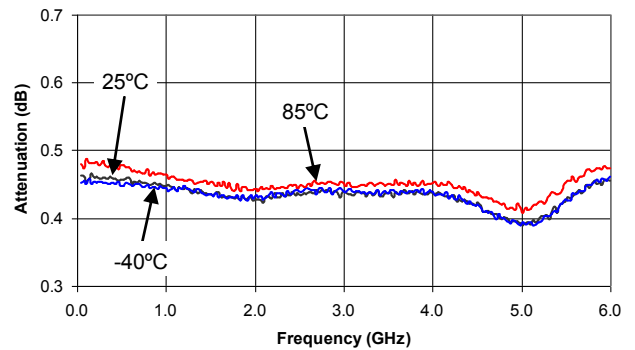
0 = TTL Low; 1 = TTL High

Typical Performance Curves

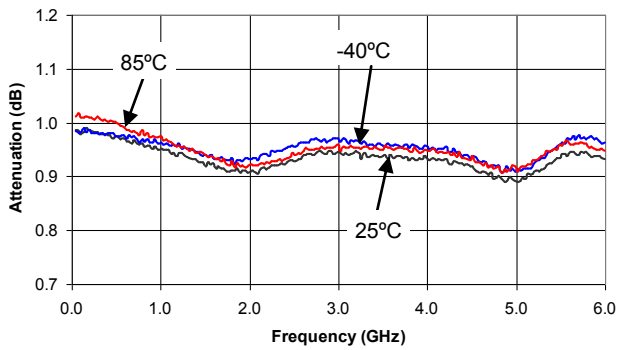
Reference Loss vs. Frequency



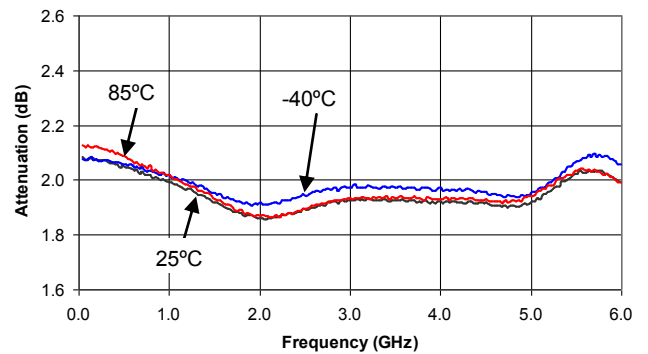
Attenuation - 0.5 dB Bit vs. Frequency



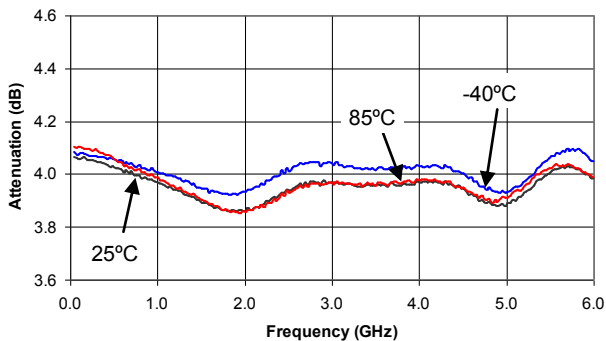
Attenuation - 1 dB Bit vs. Frequency



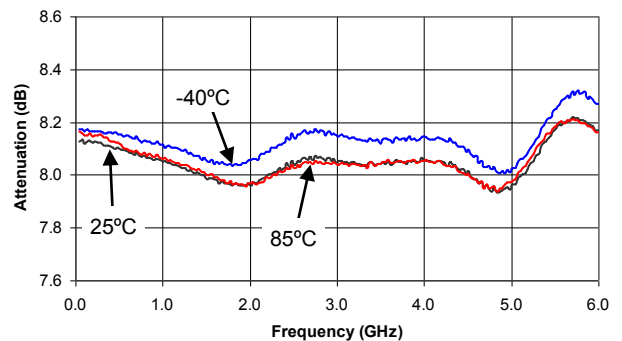
Attenuation - 2 dB Bit vs. Frequency



Attenuation - 4 dB Bit vs. Frequency

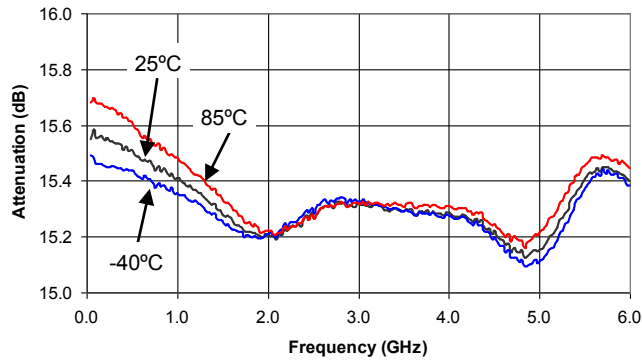


Attenuation - 8 dB Bit vs. Frequency

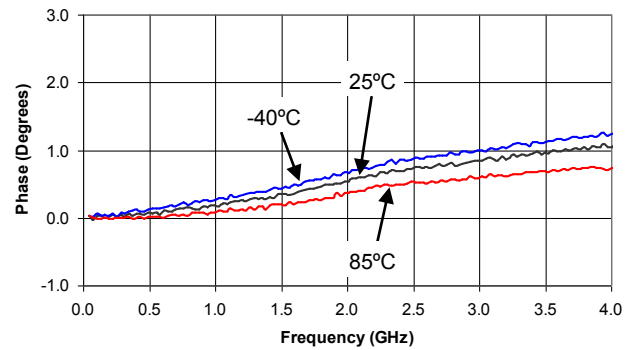


Typical Performance Curves

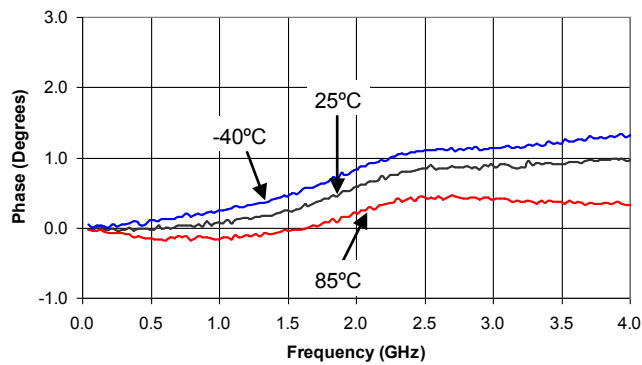
Attenuation - 15.5 dB Attenuation vs. Frequency



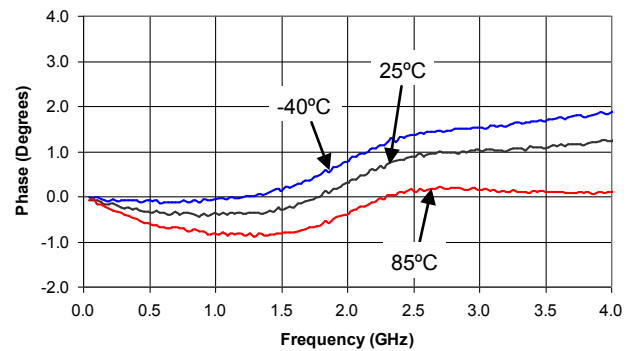
Phase - 0.5 dB Bit vs. Frequency Relative to Reference Loss State



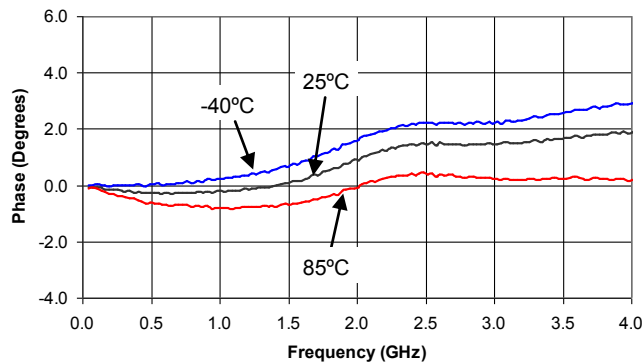
Phase - 1 dB Bit vs. Frequency Relative to Reference Loss State



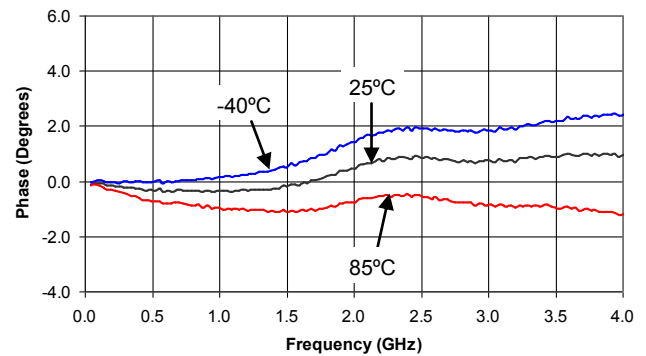
Phase - 2 dB Bit vs. Frequency Relative to Reference Loss State



Phase - 4 dB Bit vs. Frequency Relative to Reference Loss State

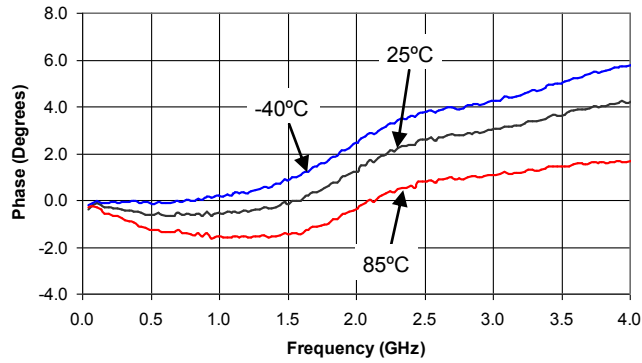


Phase - 8 dB Bit vs. Frequency Relative to Reference Loss State

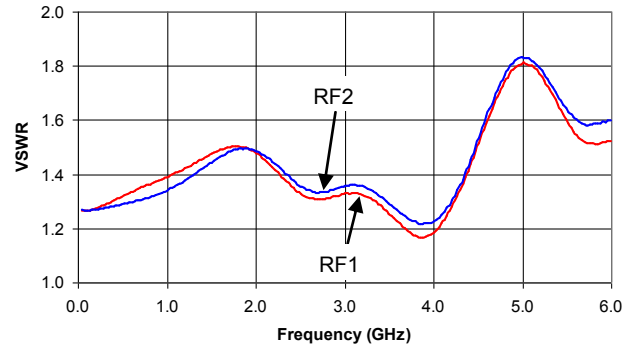


Typical Performance Curves

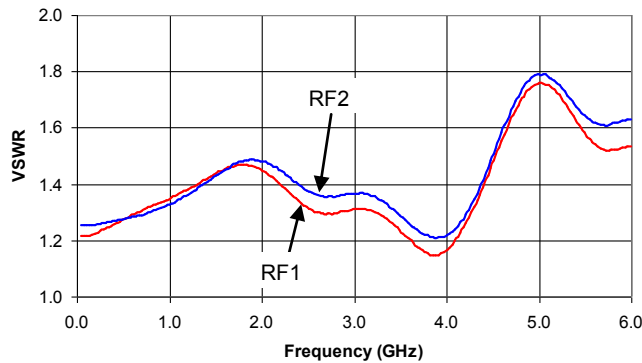
Phase - 15.5 dB Attenuation vs. Frequency
Relative to Reference Loss State



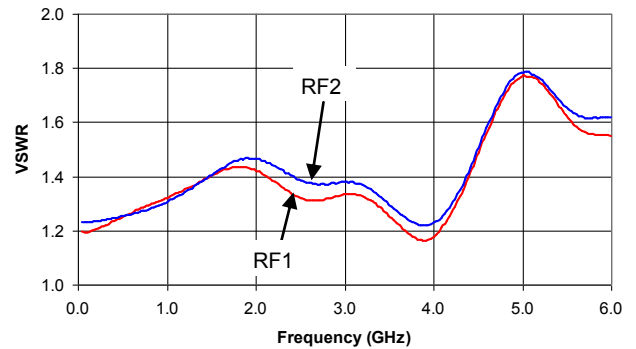
VSWR - Reference State vs. Frequency



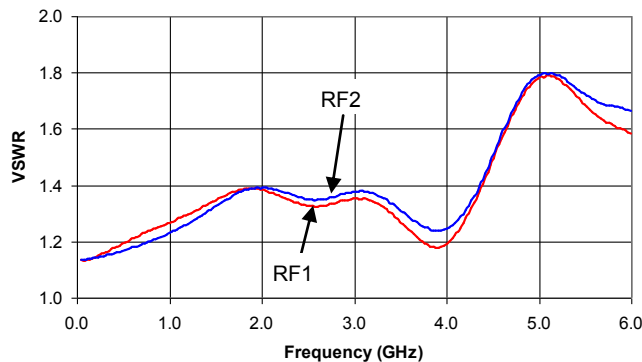
VSWR - 0.5 dB Bit vs. Frequency



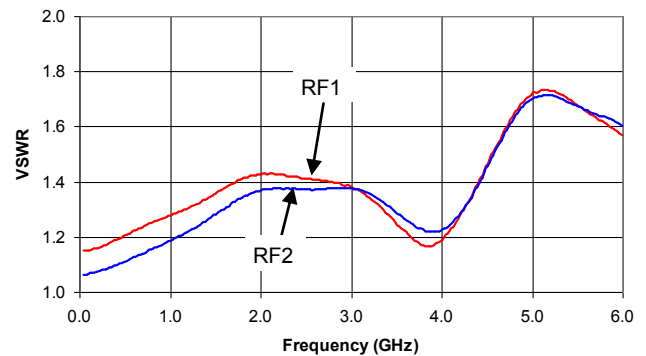
VSWR - 1 dB Bit vs. Frequency



VSWR - 2 dB Bit vs. Frequency

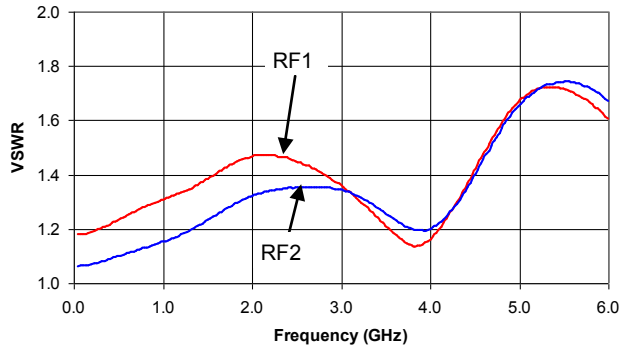


VSWR - 4 dB Bit vs. Frequency

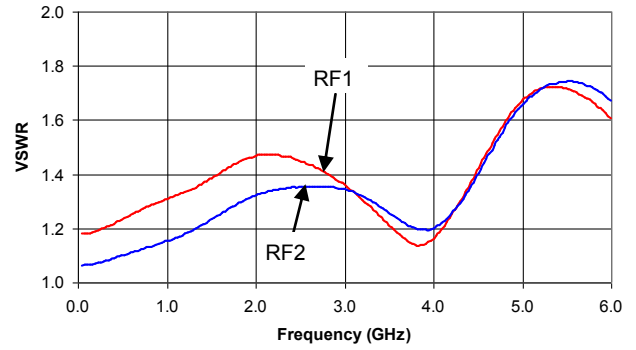


Typical Performance Curves

VSWR - 8 dB Bit vs. Frequency



VSWR - 15.5 dB Attenuation vs. Frequency



Typical Input IP2 and IP3 at Room Temperature¹¹

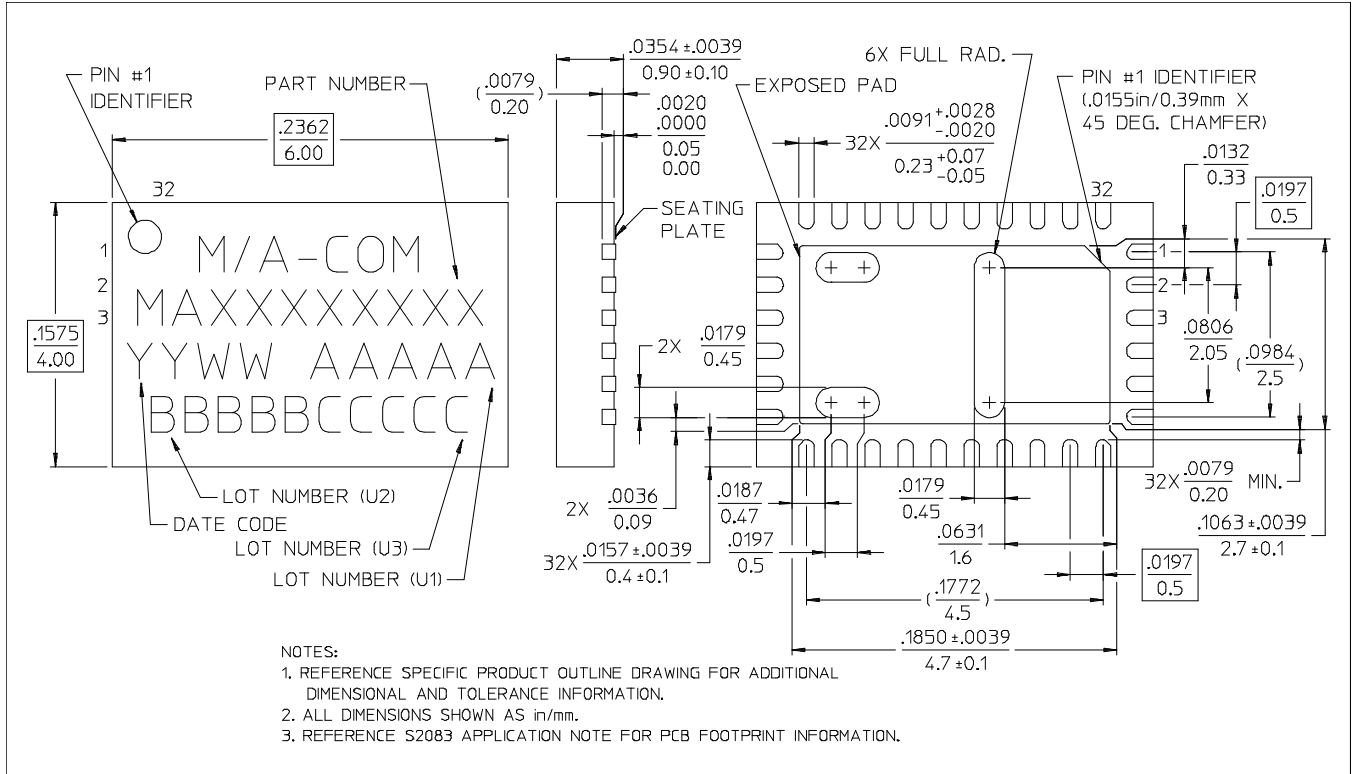
| Attenuation | IP2 | | | IP3 | | | Units |
|-----------------|--------|---------|-------|--------|---------|-------|-------|
| | 50 MHz | 500 MHz | 2 GHz | 50 MHz | 500 MHz | 2 GHz | |
| Reference State | 50 | 72 | 73 | 43 | 40 | 44 | dBm |
| 0.5 dB | 51 | 73 | 74 | 43 | 41 | 44 | dBm |
| 1 dB | 51 | 73 | 75 | 43 | 41 | 44 | dBm |
| 2 dB | 51 | 73 | 74 | 43 | 41 | 45 | dBm |
| 4 dB | 51 | 73 | 74 | 43 | 41 | 45 | dBm |
| 8 dB | 50 | 71 | 75 | 41 | 43 | 41 | dBm |
| 15.5 dB | 53 | 74 | 79 | 43 | 42 | 44 | dBm |

11. IP2 and IP3 are measured with two-tone inputs F1 and F2 up to +5 dBm with 1 MHz spacing.

Digital Attenuator, Constant Phase
15.5 dB, 5-Bit, TTL Driver, DC - 4.0 GHz

Rev. V2

CSP-1, 4 x 6 mm, 32-lead PQFN[†]



[†] Reference Application Note M538 for lead-free solder reflow recommendations.

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