Digital Attenuator Die, 5-Bit, Parallel Control
0.1 - 30 GHz, 31 dB Attenuation Range

MAAD-011035-DIE
Rev. V3

Features

- 5-Bit Digital Attenuator, 1 dB LSB
- 31 dB Attenuation Range
- Wide Frequency Range: 0.1 - 30 GHz
- Parallel Control:
  Complementary Controls (per bit)
- Attenuation Accuracy: typ.
  +/-(0.3 + 4% of Attenuation Setting) dB
- Die Size: 2.73 x 1.38 x 0.10 mm

Applications

- Test Equipment (instrumentation)
- Communications (commercial and military) :
  Cellular Infrastructure
  Radars
  Radios (MMW)
- General Purpose

Description

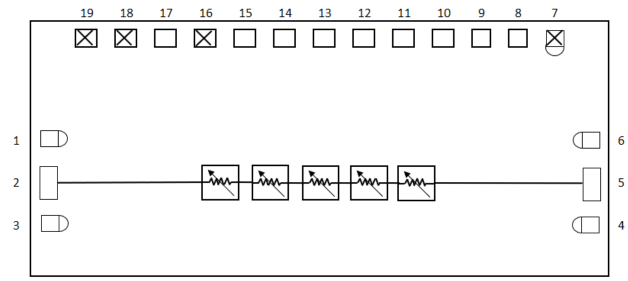
The MAAD-011035-DIE is a 5-bit, 1 dB step GaAs pHEMT MMIC digital attenuator covering a large frequency range from 0.1 to 30 GHz with excellent insertion loss and attenuation accuracy.

This device is ideally suited for use where high accuracy, very low power consumption, and low intermodulation products are required.

Ordering Information

Part Number	Package
MAAD-011035-DIE	Die in Gel Pack

Functional Schematic



Pin Configuration

Pin #	Function	Description
1, 3, 4, 6	GND	Ground[1]
2	RF IN	Input RF
5	RF OUT	Output RF
7, 16, 18, 19	NC	No Connection
8	Vcontrol_B5	16 dB BIT Vcontrol_B5
9	Vcontrol_A5	16 dB BITVcontrol_A5
10	Vcontrol_B4	8 dB BIT Vcontrol_B4
11	Vcontrol_A4	8 dB BIT Vcontrol_A4
12	Vcontrol_B3	4 dB BIT Vcontrol_B3
13	Vcontrol_A3	4 dB BIT Vcontrol_A3
14	Vcontrol_B2	2 dB BIT Vcontrol_B2
15	Vcontrol_A2	2 dB BIT Vcontrol_A2
17	Vcontrol_A1	BIT 1 dB Control_A1

1. All GND bondpads are connected to the secondary side of the die with substrate vias.

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

Electrical Specifications[2,3,4]

Freq. = 0.1 - 30 GHz, T_A = 25°C, Z_0 = 50 Ω, V_C = -5 V / 0 V, P_{IN} = 0 dBm

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Reference Insertion Loss	0.1 - 18.0 GHz 18.0 - 26.5 GHz 26.5 - 30.0 GHz	dB	—	3.1 4.0 4.8	4.2 — 5.8
RMS Attenuation Error	0.1 - 30.0 GHz	dB	—	0.4	—
Attenuation Accuracy	Relative to Insertion Loss	± (0.3 + 4% of attenuation setting) dB typ.			
Return Loss	All states (worst case)	dB	—	-12	—
Input P0.1dB	Reference State	dBm	—	21	—
IIP_3	2-Tone, +10 dBm/tone, 1 MHz Spacing (Reference State)	dBm	—	43	—
T_{RISE}, T_{FALL}	10% to 90% RF, 90% to 10% RF	ns	—	15	—
V_C Current	Per bit	µA	—	0.5	—

2. Two bond-wires are recommended on pin 2 and 5 (1 mil diameter each). Keep these bonds to a minimum length (<130 µm).
3. Pins 1, 3 ,4 and 6 must be RF/DC grounded thru bond wires (1 mil), one bond wire per GND pin.
4. RMS Calculation Discussion:
   RMS Error is used directly to calculate system parameters. To derive RMS error, first normalize the attenuation for all conditions to the minimum loss condition. Next calculate an absolute error by taking the difference between the normalized measurement and the ideal attenuator loss for each state. By using this with the equation below, the RMS Error can be determined.

$$\text{RMS ERROR, mean} = \sqrt{\frac{1}{n}\sum (Er_i - Er_{Ave})^2}$$

Er_i = Ideal Error, Er_{Ave} = Normalized Error, n= number of attenuator bits (attenuator states = 2^(n-1))

Truth Table[5]

1 dB BIT		2 dB BIT		4 dB BIT		8 dB BIT		16 dB BIT		Attenuation (dB)
pin 17	pin 16	pin 15	pin 14	pin 13	pin 12	pin 11	pin 10	pin 9	Pin 8	
0	X	0	1	0	1	0	1	0	1	Reference IL
1	X	0	1	0	1	0	1	0	1	1
0	X	1	0	0	1	0	1	0	1	2
0	X	0	1	1	0	0	1	0	1	4
0	X	0	1	0	0	1	0	0	1	8
0	X	0	1	0	1	0	1	1	0	16
1	X	1	0	1	0	1	0	1	0	31

5. "0" = -5.3 V to -4.3 V, "1" = -0.2 V to 0 V, "X" = Don't Care.

Absolute Maximum Ratings[6,7]

Parameter	Absolute Maximum
Input Power	31 dBm
Control Voltage	$-5.5\ V \leq V_{Controls} \leq 0.5\ V$
Junction Temperature	+150°C
Operating Temperature	-40°C to +85°C
Storage Temperature	-65°C to +150°C

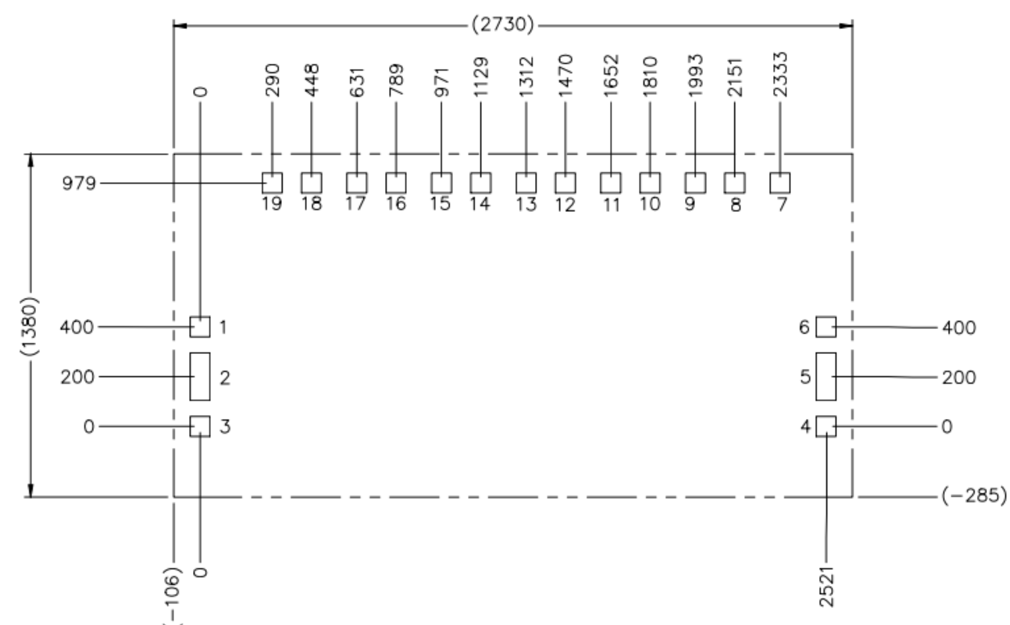
6. Exceeding any one or combination of these limits may cause permanent damage to this device.
7. MACOM does not recommend sustained operation near these survivability limits.

Mounting and Bonding Information

The DIE should be directly attached to the RF/DC ground plane; either with solder (AuSn) or a thin application of conductive epoxy. Avoid overflows.

Any connecting microstrip (50 Ω Transmission Line) substrate should be brought as close as possible to the die in order to minimize bond wire inductance. A typical spacing between die and microstrip substrate should be kept between 75 - 125 µm for best RF behavior. All bonds should be kept as short as possible. Use minimum ultrasonic energy for reliable wire bonds.

Outline Drawing

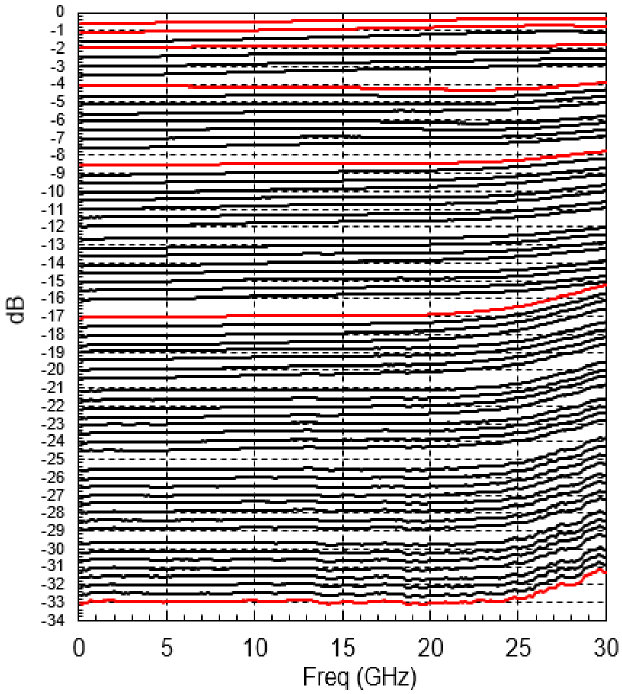


Bond Pad Dimensions (µm)

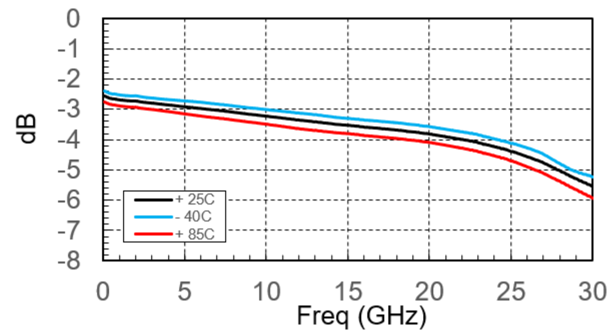
Pad	X	Y
1, 3, 4, 6 - 19	80	80
2, 5	80	192

Unless otherwise specified, all dimensions shown are µm with a tolerance of ±5 µm.
Die thickness is 100 µm ±10 µm.
Bond pad/backside metallization is gold.
Die size reflects un-cut dimensions. Saw, or laser kerf reduces die size by ~25 µm each dimension.

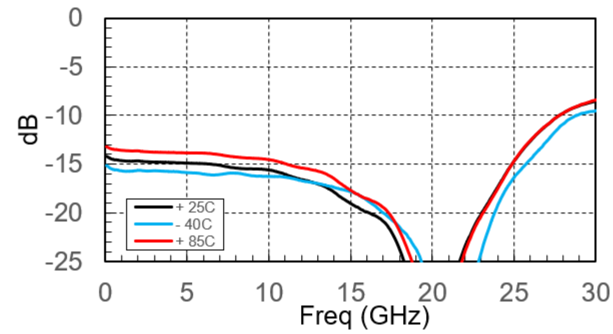
Relative Attenuation (normalized S21) @ +25°C



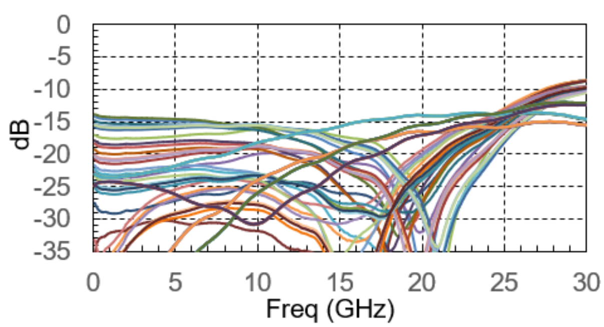
S21 vs. Temperature (reference state)



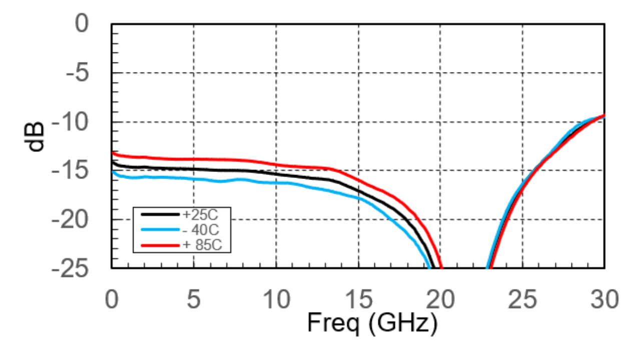
S11 vs. Frequency (reference state)



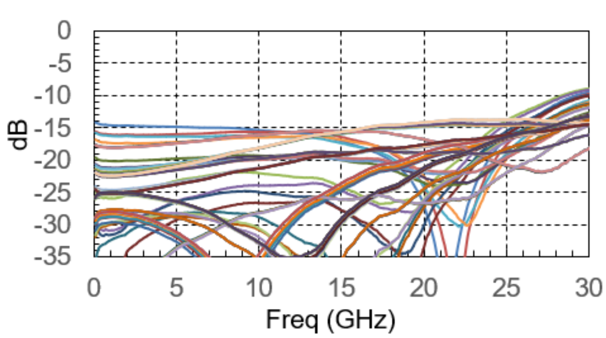
S11 vs. Frequency (all states) @ +25°C



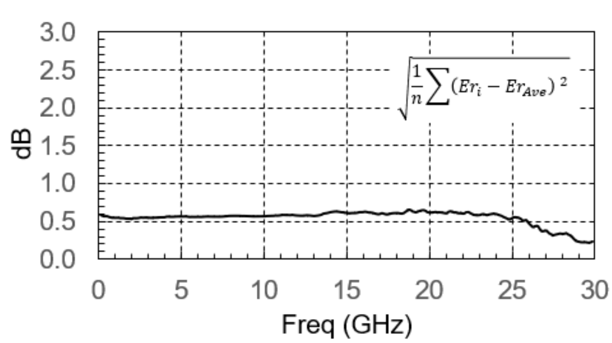
S22 vs. Frequency (reference state)



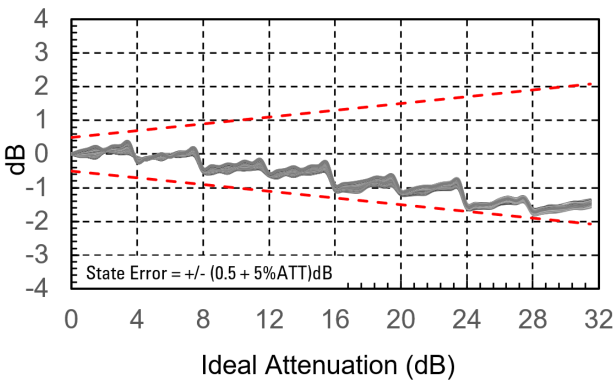
S22 vs. Frequency (all states) @ +25°C



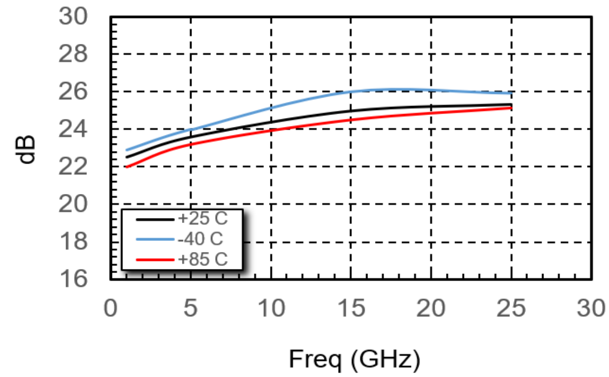
RMS Error vs. Frequency (mean) @ +25°C



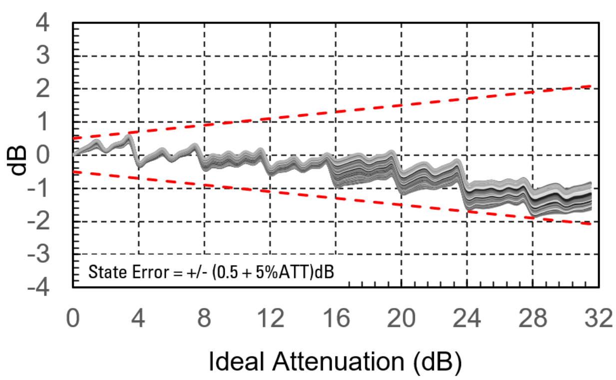
BIT Error vs. Attenuation State, 0.1 - 18 GHz, @ +25°C



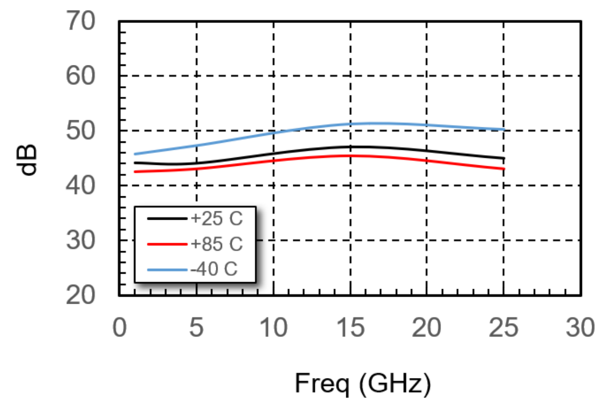
Input 0.1dB Compression vs. Frequency (reference state)



BIT Error vs. Attenuation State, 18 - 26.5 GHz, @ +25°C



Input IP3 vs. Frequency (reference state)



BIT Error vs. Attenuation State, 26.5 - 30 GHz, @ +25°C