Digital Attenuator Die, 6-Bit, Parallel Control
0.1 - 30 GHz, 31.5 dB Attenuation Range

Features
- 6-Bit Digital Attenuator, 0.5 dB LSB
- 31.5 dB Attenuation Range
- Wide Frequency Range: 0.1 - 30 GHz
- Parallel Control:
  - Complementary Controls (per bit)
- Attenuation Accuracy: typ. +/- (0.5 + 5% 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-011036-DIE is a 6-bit, 0.5 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

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAD-011036-DIE</td>
<td>Die in Gel Pack</td>
</tr>
</tbody>
</table>

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

Freq. = 0.1 - 30 GHz, \( T_A = 25^\circ C, \ Z_0 = 50 \ \Omega, \ V_C = -5 \ \text{V} / 0 \ \text{V}, \ P_{IN} = 0 \ \text{dBm} \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Units</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Insertion Loss</td>
<td>0.1 - 18.0 GHz</td>
<td>dB</td>
<td>—</td>
<td>3.2</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>18.0 - 26.5 GHz</td>
<td></td>
<td></td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>26.5 - 30.0 GHz</td>
<td></td>
<td></td>
<td>5.2</td>
<td>6.0</td>
</tr>
<tr>
<td>RMS Attenuation Error</td>
<td>0.1 - 30.0 GHz</td>
<td>dB</td>
<td>—</td>
<td>0.6</td>
<td>—</td>
</tr>
<tr>
<td>Attenuation Accuracy</td>
<td>Relative to Insertion Loss</td>
<td>± (0.5 + 5% of attenuation setting) dB typ.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return Loss</td>
<td>All states (worst case)</td>
<td>dB</td>
<td>—</td>
<td>-12</td>
<td>—</td>
</tr>
<tr>
<td>Input P0.1dB</td>
<td>Reference State</td>
<td>dBm</td>
<td>—</td>
<td>21</td>
<td>—</td>
</tr>
<tr>
<td>( \text{IIP}_3 )</td>
<td>2-Tone, +10 dBm/tone, 1 MHz Spacing (Reference State)</td>
<td>dBm</td>
<td>—</td>
<td>43</td>
<td>—</td>
</tr>
<tr>
<td>( T_{\text{RISE}}, T_{\text{FALL}} )</td>
<td>10% to 90% RF, 90% to 10% RF</td>
<td>ns</td>
<td>—</td>
<td>15</td>
<td>—</td>
</tr>
<tr>
<td>( V_C ) Current</td>
<td>Per bit</td>
<td>( \mu A )</td>
<td>—</td>
<td>0.5</td>
<td>—</td>
</tr>
</tbody>
</table>

2. Two bond-wires are recommended on pin 2 and 5 (1 mil diameter each). Keep these bonds to a minimum length (<130 \( \mu \text{m} \)).
3. Pins 1, 3, 17, and 19 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.

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

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

Truth Table

<table>
<thead>
<tr>
<th>0.5 dB BIT</th>
<th>1 dB BIT</th>
<th>2 dB BIT</th>
<th>4 dB BIT</th>
<th>8 dB BIT</th>
<th>16 dB BIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>pin 19</td>
<td>pin 18</td>
<td>pin 17</td>
<td>pin 16</td>
<td>pin 15</td>
<td>pin 14</td>
</tr>
<tr>
<td>0</td>
<td>X</td>
<td>X</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>X</td>
<td>X</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<tr>
<td>0</td>
<td>X</td>
<td>1</td>
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<td>1</td>
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<td>0</td>
<td>X</td>
<td>0</td>
<td>X</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>X</td>
<td>1</td>
<td>X</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>X</td>
<td>0</td>
<td>X</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

5. “0” = -5.3 \( \text{V} \) to -4.3 \( \text{V} \), “1” = -0.2 \( \text{V} \) to 0 \( \text{V} \), “X” = Don’t Care.
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Absolute Maximum Ratings\(^6,7\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>31 dBm</td>
</tr>
<tr>
<td>Control Voltage</td>
<td>(-5.5 \leq V_{\text{Controls}} \leq 0.5) V</td>
</tr>
<tr>
<td>Junction Temperature</td>
<td>+150°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +150°C</td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>Pad</th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 3, 4, 6 - 19</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>2, 5</td>
<td>80</td>
<td>192</td>
</tr>
</tbody>
</table>

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.
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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

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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

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