Digital Attenuator, 6-Bit, Serial / Parallel Control
0.1 - 30 GHz, 31.5 Attenuation Range

Features
- 6-Bit, 0.5 dB LSB, 31.5 dB Range
- Integrated CMOS Driver
- Parallel or Serial (P/S) Control
- Low DC Power Consumption
- Attenuation Accuracy:
  \( +/-(0.4 + 7\% \text{ of attenuation setting}) \) dB
- Lead-Free 4 mm 24-Lead PQFN Package
- RoHS* Compliant

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

Description
The MAAD-011036 is a wide band 6-bit, 0.5 dB step MMIC digital attenuator in a lead-free 4 mm 24 lead PQFN surface mount plastic package. This device is ideally suited for use where high accuracy, very low power consumption, and low intermodulation products are required.

This attenuator is controlled with either a SPI compatible serial interface or a 6 bit parallel word.

Pin Configuration\(^{1,2}\)

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VSS</td>
</tr>
<tr>
<td>2, 4, 6, 13, 15, 17</td>
<td>GND</td>
</tr>
<tr>
<td>3</td>
<td>P/S</td>
</tr>
<tr>
<td>7 - 12</td>
<td>N/C</td>
</tr>
<tr>
<td>5</td>
<td>RF IN</td>
</tr>
<tr>
<td>14</td>
<td>RF OUT</td>
</tr>
<tr>
<td>16</td>
<td>SER OUT</td>
</tr>
<tr>
<td>18</td>
<td>VCC</td>
</tr>
<tr>
<td>19</td>
<td>D6</td>
</tr>
<tr>
<td>20</td>
<td>D5</td>
</tr>
<tr>
<td>21</td>
<td>D4</td>
</tr>
<tr>
<td>22</td>
<td>D3 or LE</td>
</tr>
<tr>
<td>23</td>
<td>D2 or CLK</td>
</tr>
<tr>
<td>24</td>
<td>D1 or SER IN</td>
</tr>
</tbody>
</table>

1. MACOM recommends grounding all N/C (no connection) pins
2. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAD-011036-TR0500</td>
<td>500 piece reel</td>
</tr>
<tr>
<td>MAAD-011036-001SMB</td>
<td>Sample Board</td>
</tr>
</tbody>
</table>

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.
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0.1 - 30 GHz, 31.5 Attenuation Range

Electrical Specifications:
Freq. = 0.1 - 30 GHz, \( T_A = 25^\circ C \), \( Z_0 = 50 \, \Omega \), \( V_{CC} = +5 \, V \), \( V_{SS} = -5 \, V \), \( P_{IN} = 0 \, \text{dBm} \)

<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(^3)</td>
<td>0.1 - 18.0 GHz</td>
<td>dB</td>
<td>—</td>
<td>3.6</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>18.0 - 26.5 GHz</td>
<td></td>
<td>4.8</td>
<td></td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>26.5 - 30.0 GHz</td>
<td></td>
<td>5.5</td>
<td></td>
<td>6.7</td>
</tr>
<tr>
<td>RMS Attenuation Error(^4)</td>
<td>0.1 - 30.0 GHz (RMS, mean)</td>
<td>dB</td>
<td>—</td>
<td>0.5</td>
<td>—</td>
</tr>
<tr>
<td>Attenuation Accuracy</td>
<td>Relative to Insertion Loss (0.1 - 30 GHz)</td>
<td>± (0.4 + 7% of attenuation setting), typ.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return Loss (IN &amp; OUT)</td>
<td>All states</td>
<td>dB</td>
<td>—</td>
<td>-12</td>
<td>—</td>
</tr>
<tr>
<td>Input P0.1dB</td>
<td>Reference State (beyond 1 GHz)</td>
<td>dBm</td>
<td>—</td>
<td>23</td>
<td>—</td>
</tr>
<tr>
<td>( I_{IP3} )</td>
<td>2-Tone, +10 dBm/tone, 1 MHz Spacing Reference State (beyond 1 GHz)</td>
<td>dBm</td>
<td>—</td>
<td>41</td>
<td>—</td>
</tr>
<tr>
<td>( T_{RISE}, T_{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_{CC} )</td>
<td></td>
<td>V</td>
<td>+3.0</td>
<td>-</td>
<td>+5.5</td>
</tr>
<tr>
<td>( I_{CC} )</td>
<td></td>
<td>( \mu A )</td>
<td>5</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>( V_{SS} )</td>
<td></td>
<td>V</td>
<td>-5.5</td>
<td>-5.0</td>
<td>-3.0</td>
</tr>
<tr>
<td>( I_{SS} )</td>
<td></td>
<td>mA</td>
<td>—</td>
<td>-0.1</td>
<td>—</td>
</tr>
<tr>
<td>( V_H )</td>
<td>HIGH level control voltage</td>
<td>V</td>
<td>0.7 X ( V_{CC} )</td>
<td>—</td>
<td>( V_{CC} )</td>
</tr>
<tr>
<td>( V_L )</td>
<td>LOW level control voltage</td>
<td>V</td>
<td>0.0</td>
<td>—</td>
<td>0.3 X ( V_{CC} )</td>
</tr>
<tr>
<td>ESD</td>
<td>HBM</td>
<td>V</td>
<td>—</td>
<td>Class 1A</td>
<td>—</td>
</tr>
</tbody>
</table>

3. Test frequencies = 1 GHz, 18 GHz, and 30 GHz.
4. RMS calculation, mean:

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

Truth Table\(^5\)

<table>
<thead>
<tr>
<th>D6</th>
<th>D5</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D1</th>
<th>Attenuation (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Reference IL</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>31.5</td>
</tr>
</tbody>
</table>

5. “0” = CMOS Low, “1” = COMS High (see specifications table).

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>( V_{CC} ) Voltage</td>
<td>6 V</td>
</tr>
<tr>
<td>Control Voltage</td>
<td>-0.5 ( V \leq V_C \leq 5.5 , 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.
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DC-0012542
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**BIT Error vs. Attenuation State**
0.1 - 18 GHz, @ +25°C

**RMS Error vs. Frequency (mean)**

![Graph showing BIT Error vs. Attenuation State and RMS Error vs. Frequency](image)

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

**Input 0.1dB Compression over Temp**

![Graph showing BIT Error vs. Attenuation State and Input 0.1dB Compression over Temp](image)

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

**Input IP3 over Temperature**

![Graph showing BIT Error vs. Attenuation State and Input IP3 over Temperature](image)
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Modes of Operation
Serial and Direct Parallel

Mode Truth Table

<table>
<thead>
<tr>
<th>P/S</th>
<th>LE</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td>Serial</td>
</tr>
<tr>
<td>0</td>
<td>N/A</td>
<td>Direct Parallel</td>
</tr>
</tbody>
</table>

8. In the serial mode: D4, D5, and D6 should be tied to ground or to Vcc.

Direct Parallel Mode

The parallel mode is enabled when P/S is set low. In the direct parallel mode, the digital attenuator is controlled by the parallel control inputs directly. When P/S is set low, pins 22, 23, and 24 have the D3, D2, and D1 function.

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 HBM Class 1A devices.

Serial Mode

The serial control interface (SERI IN, CLK, LE, SER OUT) is compatible with the SPI protocol. SPI mode is activated when P/S is kept high. The 6-bit serial word must be loaded with the MSB first. After shifting in the 6 bit word, a rising edge on LE will set the digital attenuator to the desired state. While LE is high the CLK is masked to protect the data while implementing the change. SER OUT is SER IN delayed by 6 clock cycles.

When P/S is low, the serial control interface is disabled. When P/S is set high, pins 22, 23, and 24 have the LE, CLK, and SER IN function.

In serial mode operation, the outputs will stay constant while LE is kept low.
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Functionality
Modes of Operation: Serial and Direct Parallel

Serial Input Interface Timing Diagram

Serial Interface Timing Characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>t_SCK</td>
<td>Min. Serial Clock Period</td>
<td>ns</td>
</tr>
<tr>
<td>t_CS</td>
<td>Min. Control Set-up Time</td>
<td>ns</td>
</tr>
<tr>
<td>t_CH</td>
<td>Min. Control Hold Time</td>
<td>ns</td>
</tr>
<tr>
<td>t_LS</td>
<td>Min. LE Set-up Time</td>
<td>ns</td>
</tr>
<tr>
<td>t_LEW</td>
<td>Min. LE Pulse Width</td>
<td>ns</td>
</tr>
<tr>
<td>t_LH</td>
<td>Min. Serial Clock Hold Time from LE</td>
<td>ns</td>
</tr>
<tr>
<td>t_LES</td>
<td>Min. LE Pulse Spacing</td>
<td>ns</td>
</tr>
</tbody>
</table>
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MAAD-011036
Rev. V1

Lead Free 4 mm 24-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.
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