Digital Phase Shifter
6-Bit, 3.5 - 6.0 GHz

Features
- 6 Bit Digital Phase Shifter
- 360° Coverage with LSB = 5.6°
- Low DC Power Consumption
- Minimal Attenuation Variation over Phase Shift Range
- 50 Ω Impedance
- EAR99
- RoHS* Compliant

Description
The MAPS-010165-DIE is a GaAs pHEMT 6-bit digital phase shifter. Step size is 5.6° providing phase shift from 0° to 360° in 5.6° steps. This design has been optimized to minimize variation in attenuation over the phase shift range.

The MAPS-010165-DIE is ideally suited for use where high phase accuracy with minimum loss variation over the phase shift range are required. Typical applications include communications antennas and phased array radars.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAPS-010165-DIE</td>
<td>50 piece Gel Pak</td>
</tr>
</tbody>
</table>

Functional Schematic

Pad Configuration

<table>
<thead>
<tr>
<th>Pad #</th>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 16</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>RF_in</td>
<td>RF Input</td>
</tr>
<tr>
<td>3</td>
<td>A1</td>
<td>5.6° Control</td>
</tr>
<tr>
<td>4</td>
<td>B1</td>
<td>5.6° Control</td>
</tr>
<tr>
<td>5</td>
<td>A2</td>
<td>11.2° Control</td>
</tr>
<tr>
<td>6</td>
<td>B2</td>
<td>11.2° Control</td>
</tr>
<tr>
<td>7</td>
<td>A3</td>
<td>22.5° Control</td>
</tr>
<tr>
<td>8</td>
<td>B3</td>
<td>22.5° Control</td>
</tr>
<tr>
<td>9</td>
<td>A4</td>
<td>45° Control</td>
</tr>
<tr>
<td>10</td>
<td>B4</td>
<td>45° Control</td>
</tr>
<tr>
<td>11</td>
<td>A5</td>
<td>90° Control</td>
</tr>
<tr>
<td>12</td>
<td>B5</td>
<td>90° Control</td>
</tr>
<tr>
<td>13</td>
<td>A6</td>
<td>180° Control</td>
</tr>
<tr>
<td>14</td>
<td>B6</td>
<td>180° Control</td>
</tr>
<tr>
<td>15</td>
<td>RF_out</td>
<td>RF Output</td>
</tr>
</tbody>
</table>

1. The backside of the die must be connected to RF, DC, and thermal ground.

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.
Electrical Specifications: Freq. = 3.5 - 6.0 GHz, $T_A = 25^\circ C$, $Z_0 = 50 \, \Omega$

<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>Insertion Loss</td>
<td>Any Phase State 3.5 GHz 6.0 GHz</td>
<td>dB</td>
<td>4.9</td>
<td>5.8</td>
<td>6.5</td>
</tr>
<tr>
<td>Attenuation Variation</td>
<td>Across All Phase States</td>
<td>dB</td>
<td>—</td>
<td>± 0.8</td>
<td>—</td>
</tr>
<tr>
<td>RMS Attenuation Error $^2$</td>
<td>All Values Relative to Insertion Loss at Reference Phase</td>
<td>dB</td>
<td>—</td>
<td>0.4</td>
<td>—</td>
</tr>
<tr>
<td>RMS Phase Error $^2$</td>
<td>All Values Relative to Reference Phase</td>
<td>deg.</td>
<td>—</td>
<td>4</td>
<td>—</td>
</tr>
</tbody>
</table>

Phase Relative to Reference Loss State
- 5.6° Bit
- 11.2° Bit
- 22.5° Bit
- 45° Bit
- 90° Bit
- 180° Bit
- Sum of All Bits

deg. 4.7
10.5
23
42.5
90
182
352

VSWR
RF IN RF OUT
Ratio 1.5:1
1.5:1

1 dB Compression
Reference State
dBm 27

Input IP3
Two-tone inputs up to 5 dBm
dBm 40

$T_{RISE}, T_{FALL}$
10% to 90% RF, 90% to 10% RF
ns 50

$V_L$
LOW-level input voltage
V -5

$V_H$
HIGH-level input voltage
V 0

2. RMS is calculated across all 63 amplitude or phase states relative to the amplitude or phase in the 0° phase state at a given frequency.
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Truth Table

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>27 dBm</td>
</tr>
<tr>
<td>3.5 - 6.0 GHz</td>
<td></td>
</tr>
<tr>
<td>Operating Temp</td>
<td>-40°C to +85°C</td>
</tr>
<tr>
<td>Storage Temp</td>
<td>-65°C to +150°C</td>
</tr>
</tbody>
</table>

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 devices.

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Typical Performance Curves

**RF<sub>in</sub> Return Loss vs. Frequency (All States)**

![RF<sub>in</sub> Return Loss vs. Frequency (All States)](image)

**RF<sub>out</sub> Return Loss vs. Frequency (All States)**

![RF<sub>out</sub> Return Loss vs. Frequency (All States)](image)

**Mean RMS Phase Error vs. Frequency**

![Mean RMS Phase Error vs. Frequency](image)

**Mean RMS Amplitude Error vs. Frequency**

![Mean RMS Amplitude Error vs. Frequency](image)

**Phase Error vs. State**

![Phase Error vs. State](image)

**Amplitude Error vs. State**

![Amplitude Error vs. State](image)
Typical Performance Curves

Amplitude Variation vs. Phase State

Phase Shift vs. Frequency (All States)
Outline Drawing \(^{6,7,8,9}\)

6. Unless otherwise specified, all dimensions are um with a tolerance of ±5 µm.
7. Die thickness is 100 ±10 µm.
9. Die size reflects uncut dimensions. Saw or laser kerf reduces die size by ~25 µm each dimension.
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