**HMC928LP5E**

**450° ANALOG PHASE SHIFTER, 2 - 4 GHz**

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**Typical Applications**
The HMC928LP5E is ideal for:
- EW Receivers
- Military Radar
- Test Equipment
- Satellite Communications
- Beamforming Modules

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**Features**
- Octave Bandwidth: 2 - 4 GHz
- 450° Phase Shift
- Low Insertion Loss: 3.5 dB
- Low Phase Error: ±5 Typical
- Single Positive Voltage Control
- 32 Lead 5x5 mm SMT Package: 25 mm²

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**General Description**
The HMC928LP5E is an Analog Phase Shifter which is controlled via an analog control voltage from 0 to +13V. The HMC928LP5E provides a continuously variable phase shift of 0 to 450 degrees from 2 to 4 GHz, with extremely consistent low insertion loss versus phase shift and frequency. The high accuracy HMC928LP5E is monotonic with respect to control voltage and features a typical low phase error of ±5 degrees over an octave bandwidth. The HMC928LP5E is housed in an RoHS compliant 5x5 mm QFN leadless package.

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**Functional Diagram**

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**Electrical Specifications, T_A = +25° C, 50 Ohm System**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Frequency (GHz)</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase Shift Range</td>
<td>2 - 4 GHz</td>
<td>450</td>
<td></td>
<td></td>
<td>deg</td>
</tr>
<tr>
<td>Insertion Loss</td>
<td>2 - 4 GHz</td>
<td>3.5</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Return Loss (Input &amp; Output)</td>
<td>2 - 4 GHz</td>
<td>15</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Control Voltage Range</td>
<td>2 - 4 GHz</td>
<td>0</td>
<td></td>
<td>13</td>
<td>V</td>
</tr>
<tr>
<td>Control Current Range</td>
<td>2 - 4 GHz</td>
<td>±1.0</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Maximum Input Power for Linear Operation</td>
<td>2 - 4 GHz</td>
<td></td>
<td>10</td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td>Phase Voltage Sensitivity</td>
<td>2 - 4 GHz</td>
<td>35</td>
<td></td>
<td></td>
<td>deg/V</td>
</tr>
<tr>
<td>Phase Error *</td>
<td>2 - 4 GHz</td>
<td>±5</td>
<td></td>
<td></td>
<td>deg</td>
</tr>
<tr>
<td>Phase Error (average)</td>
<td>2 - 4 GHz</td>
<td>±3</td>
<td></td>
<td></td>
<td>deg</td>
</tr>
<tr>
<td>Modulation Bandwidth</td>
<td>2 - 4 GHz</td>
<td>20</td>
<td></td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>Insertion Phase Temperature Sensitivity</td>
<td>2 - 4 GHz</td>
<td>0.10</td>
<td></td>
<td></td>
<td>deg/°C</td>
</tr>
</tbody>
</table>

* Up to a phase shift range of 400 degrees.

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Application Support: Phone: 1-800-ANALOG-D

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Downloaded from Arrow.com.
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**Insertion Loss vs. Frequency**

**Insertion Loss vs. Vctl, F = 3 GHz**

**Phase Shift vs. Vctl**

**Phase Shift vs. Frequency @ Vctl = 6V (Relative to Vctl = 0V)**

**Phase Shift vs. Frequency (Relative to Vctl = 0V) Vctl = 0.5 to 13V**

**Phase Error vs. Frequency, Fmean = 3 GHz**

[1] 0 - 10V provides 0 - 400 degrees phase shift range

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Second Harmonics vs. Vctl, F = 6 GHz

Third Harmonics vs. Vctl, F = 3 GHz

Input IP3 vs. Vctl, F = 3 GHz

Insertion Loss vs. Pin @ 2 GHz

Insertion Loss vs. Pin @ 3 GHz

Insertion Loss vs. Pin @ 4 GHz
Phase Shift vs. Pin @ 2 GHz

Phase Shift vs. Pin @ 3 GHz

Phase Shift vs. Pin @ 4 GHz

Input Return Loss vs. Frequency, Vctl = 0 to +13V

Output Return Loss vs. Frequency, Vctl = 0 to +13V

Reliability Information

- Junction Temperature (Tj): 150 °C
- Nominal Junction Temperature (T = 85 °C and Pin = 10 dBm): 87 °C
- Thermal Resistance (Junction to GND paddle): 45 °C/W
- Operating Temperature: -40 to +85 °C

Absolute Maximum Ratings

- Input Power (RFIN): +27 dBm
- Control Voltage (Vctl): -0.5V to +15V
- Storage Temperature: -65 to +150 °C
- ESD Sensitivity (HBM): Class 1B

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Outline Drawing

Package Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package Body Material</th>
<th>Lead Finish</th>
<th>MSL Rating</th>
<th>Package Marking (^{(1)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMC928LP5E</td>
<td>RoHS-compliant Low Stress Injection Molded Plastic</td>
<td>100% matte Sn</td>
<td>MSL1 (^{(2)})</td>
<td>H928 XXXX</td>
</tr>
</tbody>
</table>

\(^{(1)}\) 4-Digit lot number XXXX
\(^{(2)}\) Max peak reflow temperature of 260 °C

Pin Descriptions

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Function</th>
<th>Description</th>
<th>Interface Schematic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 5, 8 - 13, 15 - 17, 20 - 32</td>
<td>N/C</td>
<td>No connection required. These pins may be connected to RF/DC ground without affecting performance.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>RFIN</td>
<td>Port is DC blocked.</td>
<td>RFIN —</td>
</tr>
<tr>
<td>7, 8</td>
<td>GND</td>
<td>Ground: Backside of package has exposed metal ground slug that must be connected to ground thru a short path. Vias under the device are required.</td>
<td>O GND</td>
</tr>
<tr>
<td>14</td>
<td>Vctl</td>
<td>Phase shift control pin. Application of a voltage between 0 and 13 volts causes the transmission phase to change. The DC equivalent circuit is a series connected diode and resistor.</td>
<td>31 nF 200 Ω 16 pF 36 pF</td>
</tr>
<tr>
<td>19</td>
<td>RFOUT</td>
<td>Port is DC blocked.</td>
<td>— — —</td>
</tr>
</tbody>
</table>

Notes:
1. LEADFRAME MATERIAL: COPPER ALLOY
2. DIMENSIONS ARE IN INCHES [MILLIMETERS].
3. DIMENSION DOES NOT INCLUDE MOLDFLASH OF 0.15mm PER SIDE.
4. DIMENSION DOES NOT INCLUDE MOLDFLASH OF 0.25mm PER SIDE.
5. ALL GROUND LEADS MUST BE SOLDERED TO PCB RF GROUND.
6. CLASSIFIED AS MOISTURE SENSITIVITY LEVEL (MSL) 1.
Evaluation PCB

List of Materials for Evaluation PCB 131046

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1 - J3</td>
<td>PCB Mount SMA Connector</td>
</tr>
<tr>
<td>U1</td>
<td>HMC928LP5E Analog Phase Shifter</td>
</tr>
<tr>
<td>C1, C2</td>
<td>Capacitor, 100 pF, 0402 Pkg.</td>
</tr>
<tr>
<td>PCB [2]</td>
<td>127338 Evaluation PCB</td>
</tr>
</tbody>
</table>

[1] Reference this number when ordering complete evaluation PCB

The circuit board used in the application should use RF circuit design techniques. Signal lines should have 50 Ohm impedance while the package ground leads and exposed paddle should be connected directly to the ground plane similar to that shown. A sufficient number of via holes should be used to connect the top and bottom ground planes. The evaluation board should be mounted to an appropriate heat sink. The evaluation circuit board shown is available from Hittite upon request.