Typical Applications
The HMC931LP4E is ideal for:
• EW Receivers
• Military Radar
• Test Equipment
• Satellite Communications
• Beam Forming Modules

Functional Diagram

Features
Wide Bandwidth: 8 - 12 GHz
410° Phase Shift
Low Insertion Loss: 3.5 dB
Low Phase Error: +12 / -7 deg Typ.
Single Positive Voltage Control
24 Lead 4x4 mm QFN Package: 16 mm²

General Description
The HMC931LP4E is an Analog Phase Shifter which is controlled via an analog control voltage from 0 to +13V. The HMC931LP4E provides a continuously variable phase shift of 0 to 410 degrees from 8 to 12 GHz, with extremely consistent low insertion loss versus phase shift and frequency. The high accuracy HMC931LP4E is monotonic with respect to control voltage and features a typical low phase error of +12 / -7 degrees over a wide bandwidth. The HMC931LP4E is housed in an RoHS compliant 4x4 mm QFN leadless package.

Electrical Specifications, \( T_a = +25^\circ C, 50 \text{ Ohm System} \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Range</td>
<td>8</td>
<td>12</td>
<td>GHz</td>
<td></td>
</tr>
<tr>
<td>Phase Shift Range</td>
<td>410</td>
<td>deg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insertion Loss</td>
<td>3.5</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return Loss (input and output)</td>
<td>12</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Voltage Range</td>
<td>0</td>
<td>13</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Control Current Range</td>
<td>±1</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input IP3</td>
<td>32</td>
<td>dBm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Power @ - 5° Shift In Insertion Phase (Vctl = 0V)</td>
<td>11.2</td>
<td>dBm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Power @ - 2° Shift In Insertion Phase (Vctl = 0.5V)</td>
<td>12</td>
<td>dBm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase Voltage Sensitivity</td>
<td>32</td>
<td>deg/V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase Error (peak) *</td>
<td>+15 / -7</td>
<td>deg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase Error (average) *</td>
<td>+12 / -1</td>
<td>deg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modulation Bandwidth</td>
<td>50</td>
<td>MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insertion Phase Temperature Sensitivity</td>
<td>0.12</td>
<td>deg/°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Up to a phase shift range of 360 degrees.
**HMC931LP4E**

**410° ANALOG PHASE SHIFTER, 8 - 12 GHz**

**Insertion Loss vs. Frequency**

![Insertion Loss vs. Frequency](image)

**Insertion Loss vs. Vctl, F = 10 GHz**

![Insertion Loss vs. Vctl, F = 10 GHz](image)

**Phase Shift vs. Vctl**

![Phase Shift vs. Vctl](image)

**Phase Shift vs. Frequency @ Vctl = 6V**

(Relative to Vctl = 0V)

![Phase Shift vs. Frequency @ Vctl = 6V](image)

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

![Phase Shift vs. Frequency](image)

**Phase Error vs. Frequency, Fmean = 10 GHz \(^1\)**

![Phase Error vs. Frequency](image)

\(^1\) 0 to 10V provides 0 - 360 degrees phase shift range

---

For price, delivery and to place orders: Hittite Microwave Corporation, 20 Alpha Road, Chelmsford, MA 01824  
Phone: 978-250-3343  Fax: 978-250-3373  Order On-line at www.hittite.com  
Application Support: Phone: 978-250-3343 or apps@hittite.com
HMC931LP4E

410° ANALOG PHASE SHIFTER,
8 - 12 GHz

Second Harmonics vs. Vctl, F = 10 GHz

Third Harmonics vs. Vctl, F = 10 GHz

Input IP3 vs. Vctl, F = 10 GHz

Insertion Loss vs. Pin @ 8 GHz

Insertion Loss vs. Pin @ 10 GHz

Insertion Loss vs. Pin @ 12 GHz
**HMC931LP4E**

**410° ANALOG PHASE SHIFTER, 8 - 12 GHz**

### Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power (RFIN)</td>
<td>+26 dBm</td>
</tr>
<tr>
<td>Control Voltage (Vctl)</td>
<td>-0.5V to +15V</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65 to +150 °C</td>
</tr>
<tr>
<td>ESD Sensitivity (HBM)</td>
<td>Class 1B</td>
</tr>
</tbody>
</table>

### Reliability Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junction Temperature (Tj)</td>
<td>150 °C</td>
</tr>
<tr>
<td>Nominal Junction Temperature</td>
<td>87 °C</td>
</tr>
<tr>
<td>(T = 85 °C, Pin = 10 dBm)</td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance (Junction to GND Paddle)</td>
<td>80 °C/W</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40 to +85 °C</td>
</tr>
</tbody>
</table>

### Phase Shift vs. Pin @ 8 GHz

- Normalized Phase Shift (degrees) vs. Input Power (dBm)

### Phase Shift vs. Pin @ 10 GHz

- Normalized Phase Shift (degrees) vs. Input Power (dBm)

### Phase Shift vs. Pin @ 12 GHz

- Normalized Phase Shift (degrees) vs. Input Power (dBm)

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

- Return Loss (dB) vs. Frequency (GHz)
Phase shifters - aNaLOG - sMt

Pin Number function Description Interface schematic

1, 5 - 14, 18 - 20, 22 - 24 N/C No connection required. These pins may be connected to RF/DC ground without affecting performance.

2, 4, 15, 17 GND 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.

3 RFIN Port is DC blocked.

16 RFOUT Port is DC blocked.

21 Vctl 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.

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.

For price, delivery and to place orders: Hittite Microwave Corporation, 20 Alpha Road, Chelmsford, MA 01824
Phone: 978-250-3343  Fax: 978-250-3373  Order On-line at www.hittite.com
Application Support: Phone: 978-250-3343 or apps@hittite.com
Evaluation PCB

List of Materials for Evaluation PCB 108812

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1, J2</td>
<td>PCB Mount SMA Connector, SRI</td>
</tr>
<tr>
<td>J3</td>
<td>PCB Mount SMA Connector</td>
</tr>
<tr>
<td>U1</td>
<td>HMC931LP4E Analog Phase Shifter</td>
</tr>
<tr>
<td>PCB [2]</td>
<td>111296 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.