

# Analog Devices Welcomes Hittite Microwave Corporation

NO CONTENT ON THE ATTACHED DOCUMENT HAS CHANGED



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### Typical Applications

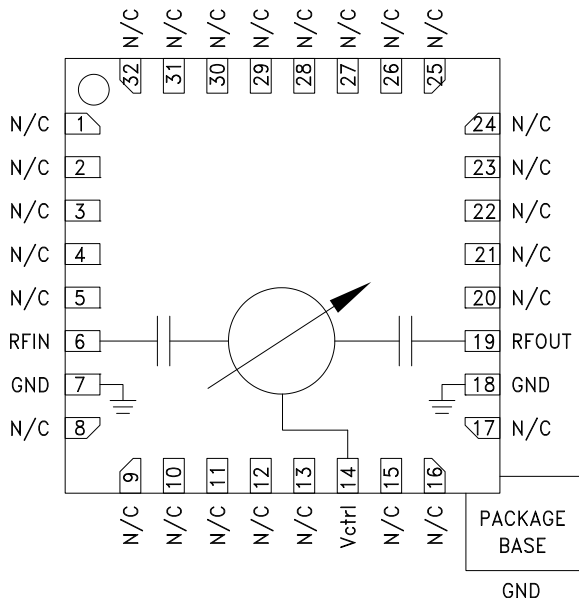
The HMC928LP5E is ideal for:

- EW Receivers
- Military Radar
- Test Equipment
- Satellite Communications
- Beamforming Modules

### 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 mm<sup>2</sup>

### Functional Diagram



### 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.

### Electrical Specifications, $T_A = +25^\circ\text{C}$ , 50 Ohm System

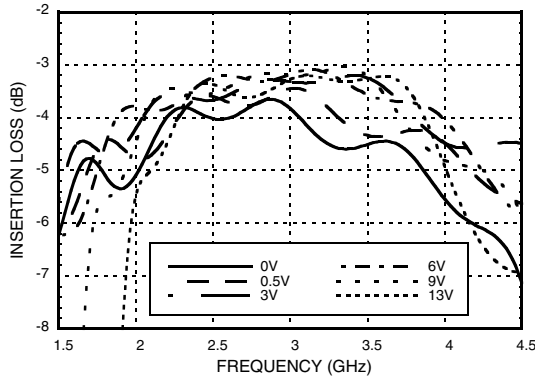
| Parameter                                | Frequency (GHz) | Min. | Typ. | Max.  | Units  |
|--|-----------------|------|------|-------|--------|
| Phase Shift Range                        | 2 - 4 GHz       |      | 450  |       | deg    |
| Insertion Loss                           | 2 - 4 GHz    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

\* Up to a phase shift range of 400 degrees.

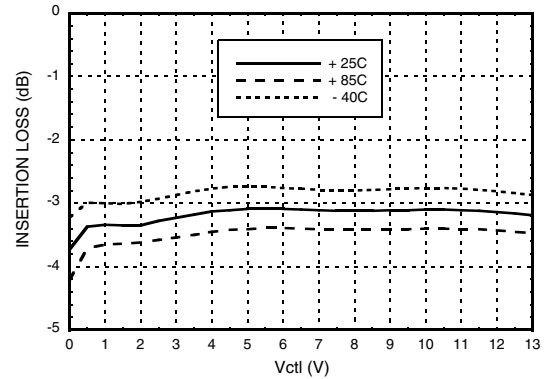


## 450° ANALOG PHASE SHIFTER, 2 - 4 GHz

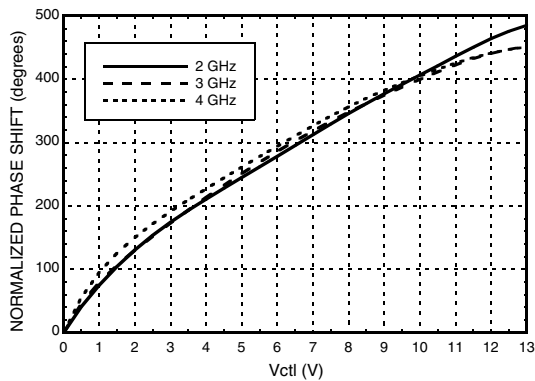
**Insertion Loss vs. Frequency**



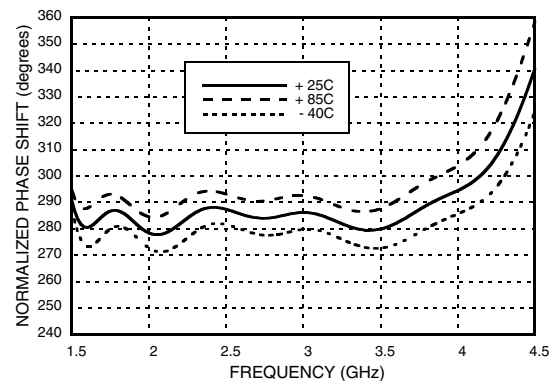
**Insertion Loss vs. Vctl, F = 3 GHz**



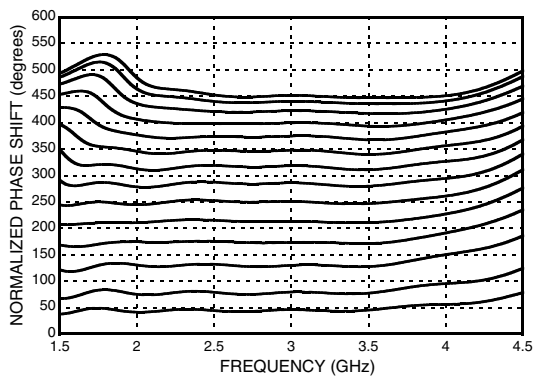
**Phase Shift vs. Vctl**



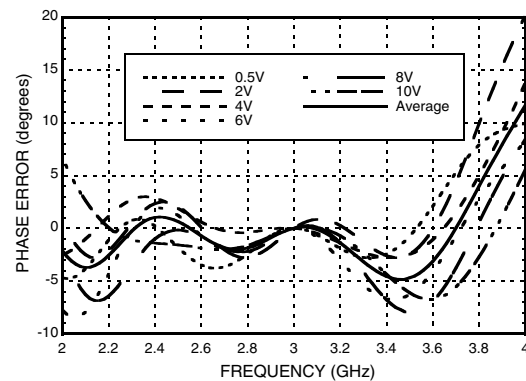
**Phase Shift vs. Frequency @ Vctl = 6V  
(Relative to Vctl = 0V)**



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



**Phase Error vs. Frequency, Fmean = 3 GHz [1]**

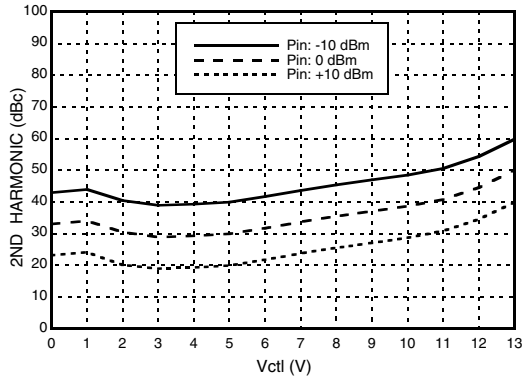


[1] 0 - 10V provides 0 - 400 degrees phase shift range

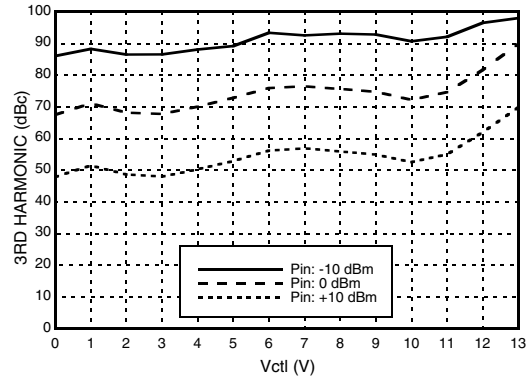


## 450° ANALOG PHASE SHIFTER, 2 - 4 GHz

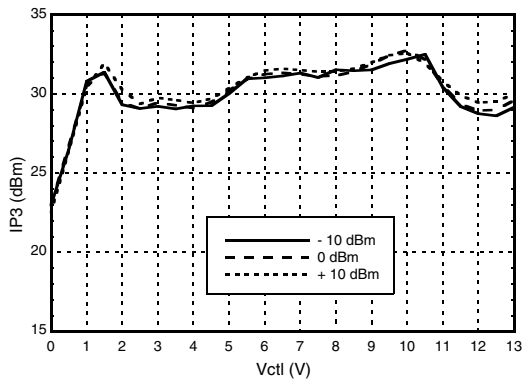
**Second Harmonics vs. Vctl, F = 6 GHz**



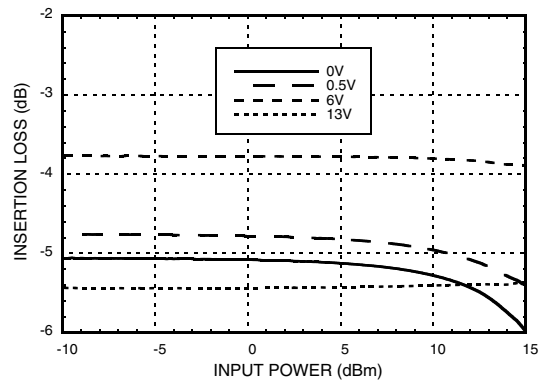
**Third Harmonics vs. Vctl, F = 3 GHz**



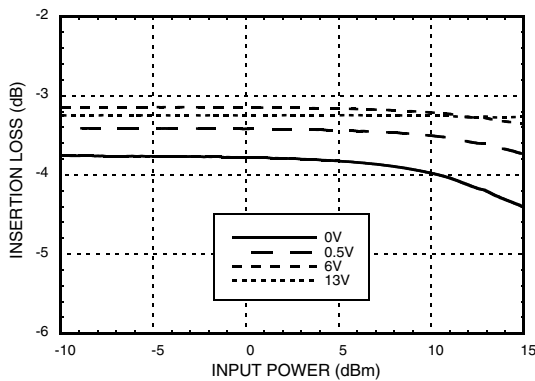
**Input IP3 vs. Vctl, F = 3 GHz**



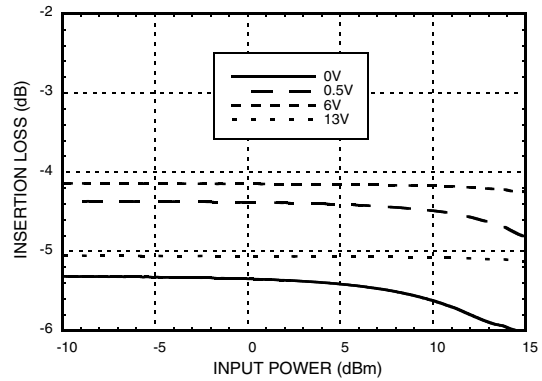
**Insertion Loss vs. Pin @ 2 GHz**



**Insertion Loss vs. Pin @ 3 GHz**



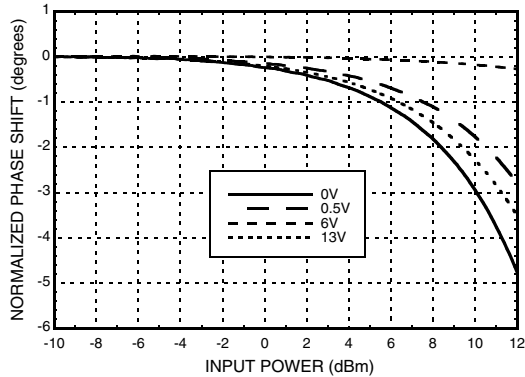
**Insertion Loss vs. Pin @ 4 GHz**



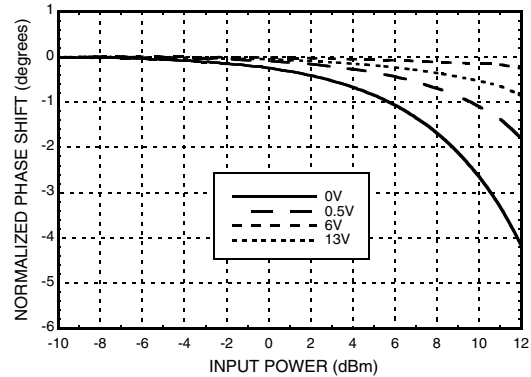


## 450° ANALOG PHASE SHIFTER, 2 - 4 GHz

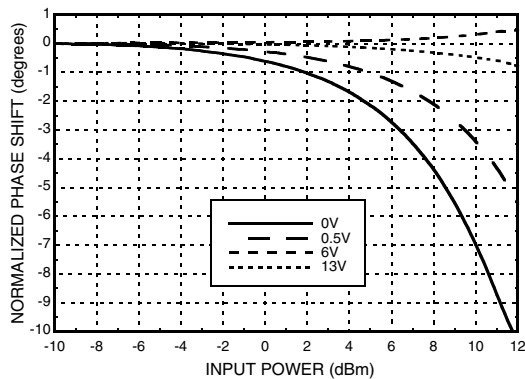
**Phase Shift vs. Pin @ 2 GHz**



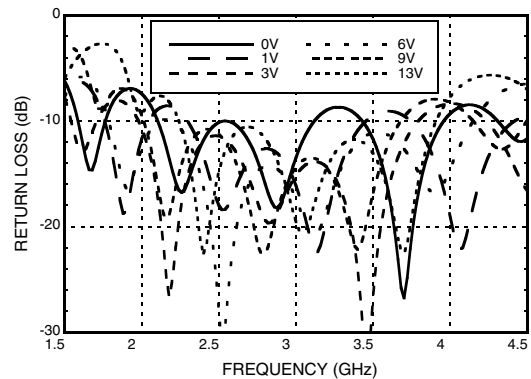
**Phase Shift vs. Pin @ 3 GHz**



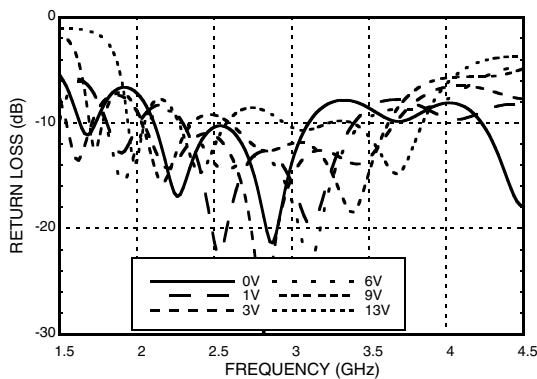
**Phase Shift vs. Pin @ 4 GHz**



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



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



### Reliability Information

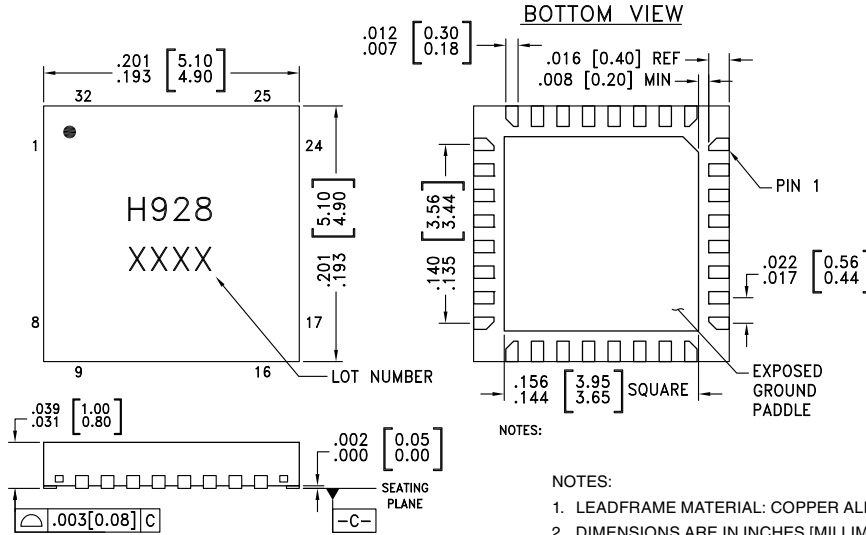
|   |               |
|---|---------------|
| Junction Temperature (Tj)                                 | 150 °C        |
| Nominal Junction Temperature (T = 85° C and Pin = 10 dBm) | 87 °C         |
| Thermal Resistance (Junction to GND paddle)               | 45 °C/W       |
| Operating Temperature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



ELECTROSTATIC SENSITIVE DEVICE  
OBSERVE HANDLING PRECAUTIONS


**Outline Drawing**

**Package Information**

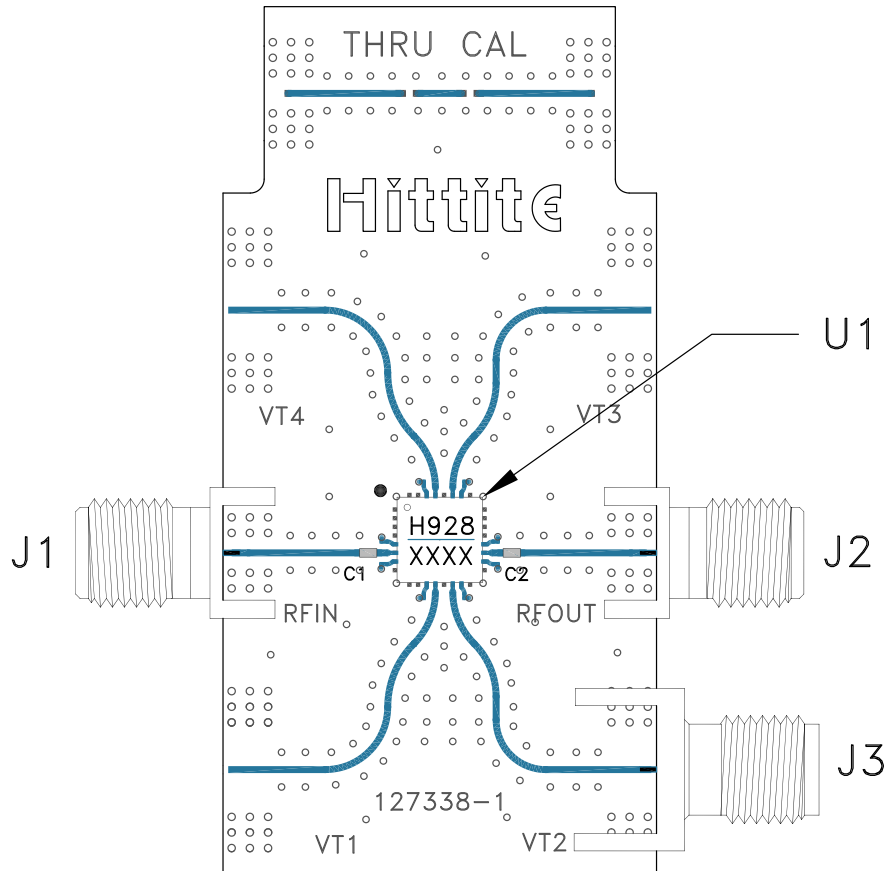
| Part Number | Package Body Material                              | Lead Finish   | MSL Rating          | Package Marking <sup>[1]</sup> |
|-------------|--|---------------|---------------------|--------------------------------|
| HMC928LP5E  | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL1 <sup>[2]</sup> | H928<br>XXXX                   |

[1] 4-Digit lot number XXXX

[2] Max peak reflow temperature of 260 °C

**Pin Descriptions**

| Pin Number                         | Function | Description   | Interface Schematic                           |
|------------------------------------|----------|---|---|
| 1 - 5, 8 - 13,<br>15 - 17, 20 - 32 | N/C      | No connection required. These pins may be connected to RF/DC ground without affecting performance.  |   |
| 6                                  | RFIN     | Port is DC blocked.   | RFIN ○— —                                     |
| 7, 8                               | 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.                                     | ○ GND<br> <br>                                |
| 14                                 | 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. | Vctl ○—31nH—200Ω— —36pF<br> <br>16pF<br> <br> |
| 19                                 | RFOUT    | Port is DC blocked.   | — —  ○ RFOUT                                  |

**Evaluation PCB**

**List of Materials for Evaluation PCB 131046 [1]**

| Item    | Description                     |
|---------|---------------------------------|
| J1 - J3 | PCB Mount SMA Connector         |
| U1      | HMC928LP5E Analog Phase Shifter |
| C1, C2  | Capacitor, 100 pF, 0402 Pkg.    |
| PCB [2] | 127338 Evaluation PCB           |

[1] Reference this number when ordering complete evaluation PCB

[2] Circuit Board Material: Rogers 4350

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.