



## GaAs HBT VECTOR MODULATOR 1.8 - 2.2 GHz

### Typical Applications

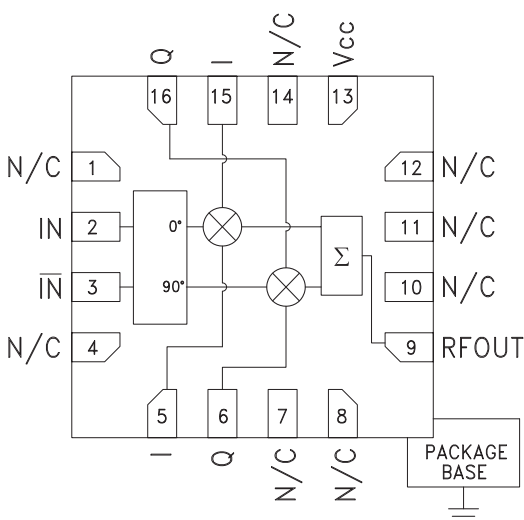
The HMC500LP3(E) is ideal for:

- Wireless Infrastructure HPA & MPCA Error Correction
- Pre-Distortion or Feed-Forward Linearization
- PCS, GSM and W-CDMA Systems
- Beam Forming or RF Cancellation Circuits

### Features

- 360° of Continuous Phase Control
- Continuous Gain Control: 40 dB
- 162 dBm/Hz Output Noise Floor
- Input IP3: +33 dBm
- 16 Lead 3x3 mm SMT Package: 9mm<sup>2</sup>

### Functional Diagram



### General Description

The HMC500LP3(E) is a high dynamic range Vector Modulator RFICs which are targeted for RF predistortion and feed-forward cancellation circuits, as well as RF cancellation and beam forming amplitude/phase correction circuits. The I & Q ports of the HMC500LP3(E) can be used to continuously vary the phase and amplitude of RF signals by up to 360 degrees and 40 dB respectively, while supporting a 3 dB modulation bandwidth of 150 MHz. With an input IP3 of +33 dBm and input noise floor of -152 dBm/Hz (at -10 dB maximum gain setting), the input IP3/noise floor ratio is 185 dB.

### Electrical Specifications, $T_A = +25^\circ\text{C}$ , $V_{CC} = +8\text{V}$

| Parameter                                 | Min. | Typ.         | Max. | Units   |
|-------------------------------------------|------|--------------|------|---------|
| Frequency Range                           |      | 1.8 - 2.2    |      | GHz     |
| Maximum Gain                              | -14  | -10          |      | dB      |
| Gain Variation Over Temperature           |      | 0.012        | 0.02 | dB / °C |
| Gain Flatness Across Any 60 MHz Bandwidth |      | 0.15         |      | dB      |
| Gain Range                                |      | 40           |      | dB      |
| Input Return Loss                         |      | 17           |      | dB      |
| Output Return Loss                        |      | 15           |      | dB      |
| Input Power for 1dB Compression (P1dB)    | 13   | 16           |      | dBm     |
| Input Third Order Intercept (IP3)         |      | 33           |      | dBm     |
| Output Noise                              |      | -162         |      | dBm/Hz  |
| Control Port Bandwidth (-3 dB)            |      | 150          |      | MHz     |
| Control Port Impedance                    |      | 1.45k        |      | Ohms    |
| Control Port Capacitance                  |      | 0.22         |      | pF      |
| Control Voltage Range                     |      | +0.5 to +2.5 |      | Vdc     |
| Group Delay Over 60 MHz Bandwidth         |      | 20           |      | ps      |
| Supply Current (Icq)                      |      | 90           |      | mA      |

Unless otherwise noted, measurements are made @ max. gain setting and 45° phase setting.

See application circuit for details.

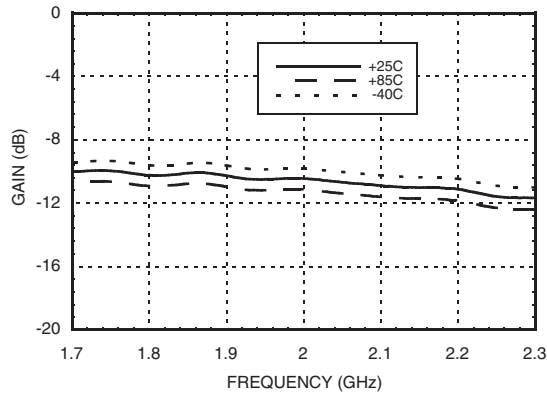
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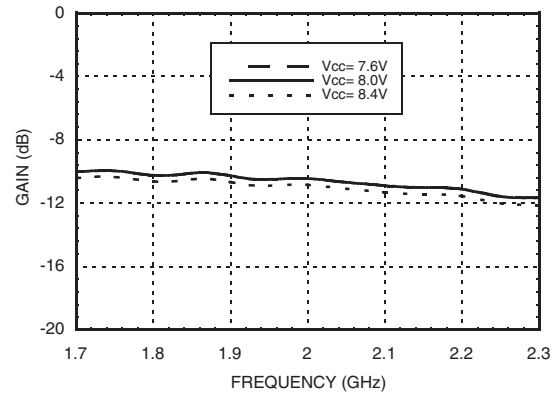


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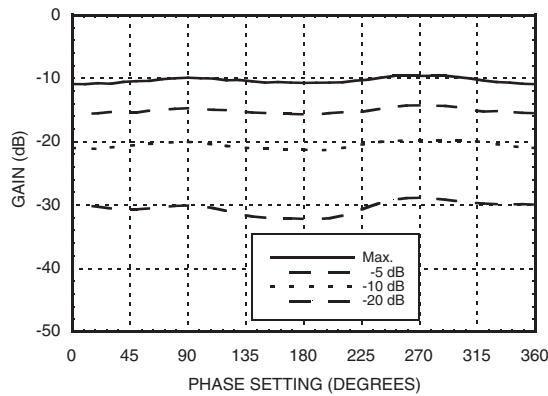
**Maximum Gain vs. Temperature**



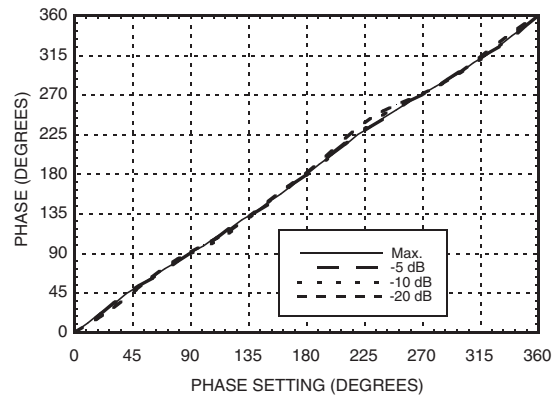
**Maximum Gain vs. Supply Voltage**



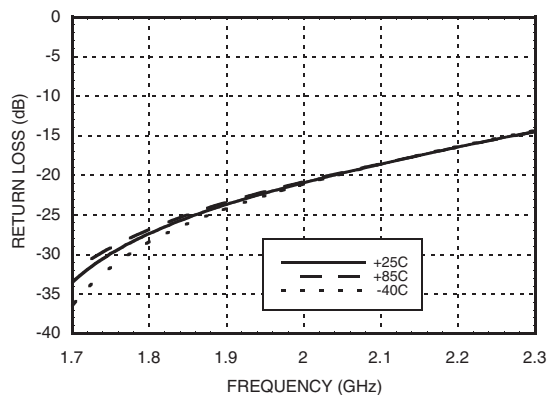
**Gain vs. Phase Settings @ F= 2 GHz**



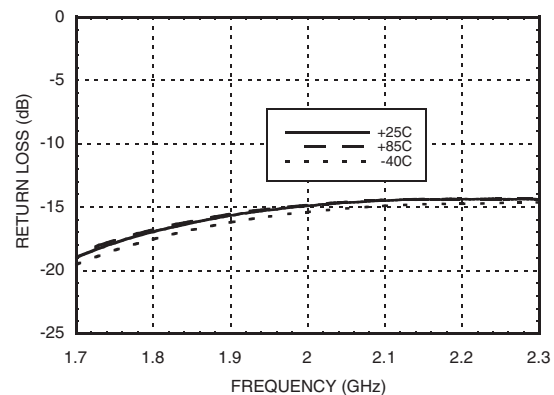
**Phase vs. Phase Settings @ F= 2 GHz  
vs. Various Gain Settings**



**Input Return Loss vs. Temperature**



**Output Return Loss vs. Temperature**

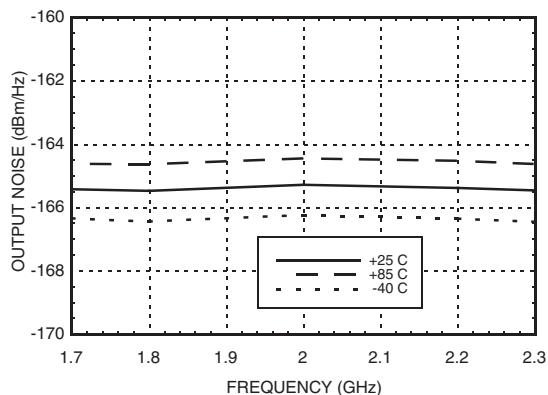




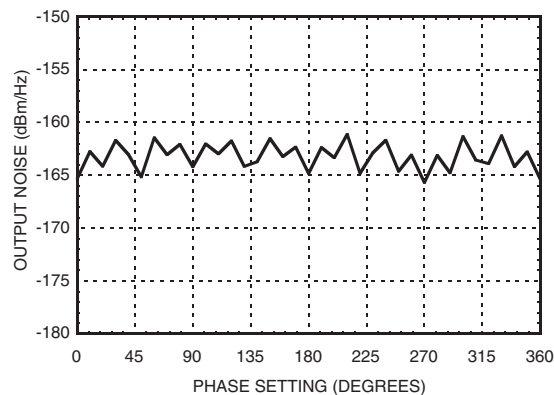
# HMC500LP3 / 500LP3E

## GaAs HBT VECTOR MODULATOR 1.8 - 2.2 GHz

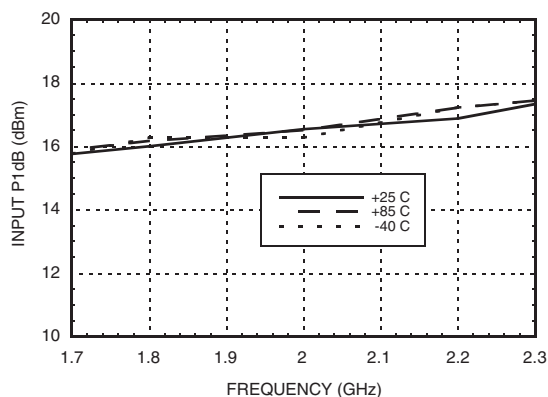
**Output Noise vs. Temperature**



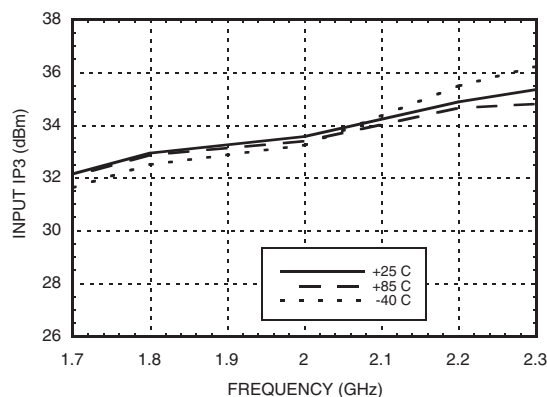
**Output Noise vs. Phase Settings @ F= 2 GHz**



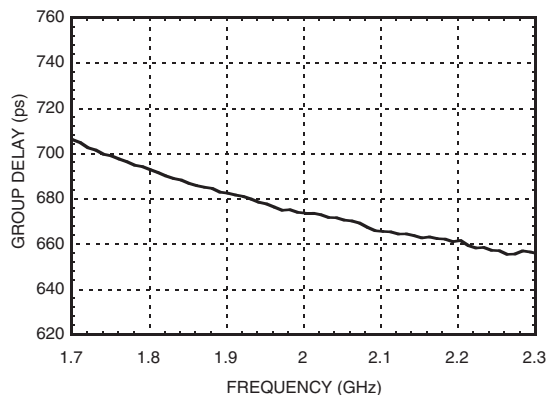
**Input P1dB vs. Temperature**



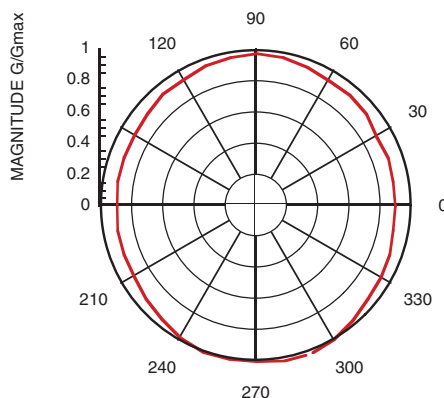
**Input IP3 vs. Temperature**



**Group Delay**



**Linear Gain vs. Phase Setting**



### Typical Supply Current vs. Vcc

| Vcc (V) | Icc (mA) |
|---------|----------|
| 7.6     | 85       |
| 8.0     | 90       |
| 8.4     | 95       |

Note:

Modulator will operate over full voltage range shown above.

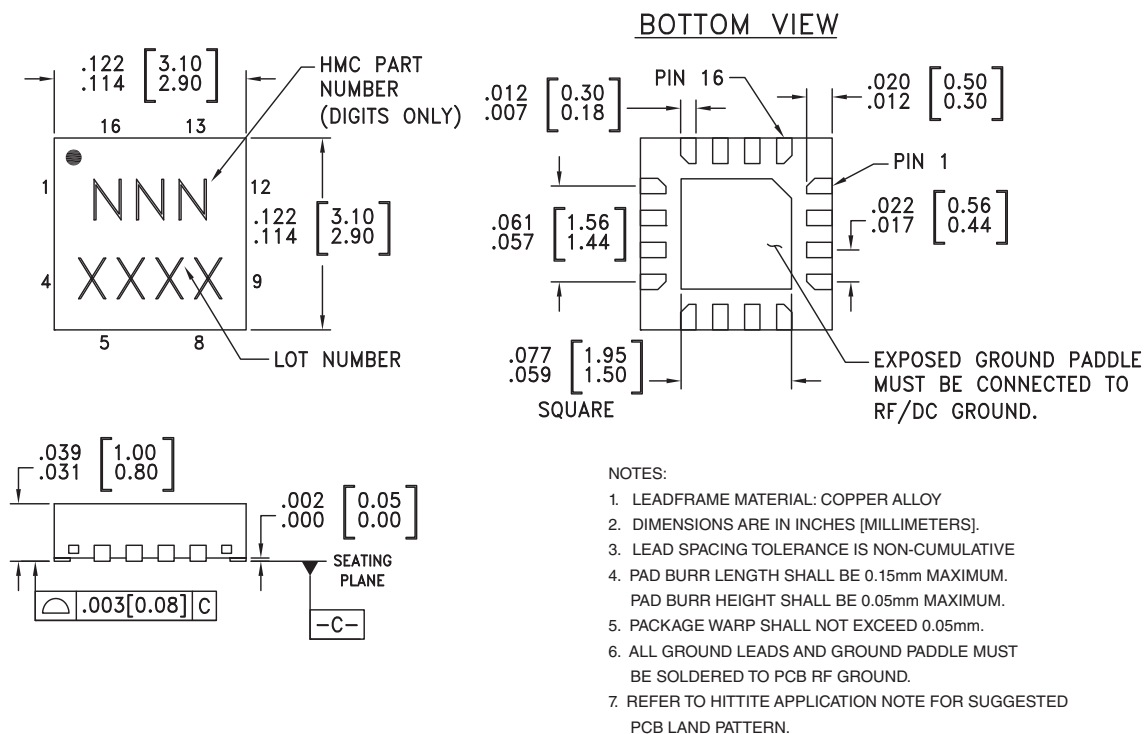


**ELECTROSTATIC SENSITIVE DEVICE  
OBSERVE HANDLING PRECAUTIONS**

### Absolute Maximum Ratings

|                                                                         |                |
|-------------------------------------------------------------------------|----------------|
| RF Input (Vcc = +8V)                                                    | 27 dBm         |
| Supply Voltage (Vcc)                                                    | +10V           |
| I & Q Input                                                             | -0.5V to +5.0V |
| Channel Temperature (Tc)                                                | 135 °C         |
| Continuous P <sub>diss</sub> (T = 85°C)<br>(Derate 25 mW/°C above 85°C) | 1.25 W         |
| Thermal Resistance (R <sub>th</sub> )<br>(junction to ground paddle)    | 40 °C/W        |
| Storage Temperature                                                     | -65 to +150 °C |
| Operating Temperature                                                   | -40 to +85 °C  |

### Outline Drawing



### Package Information

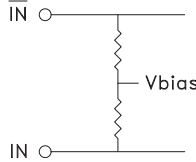
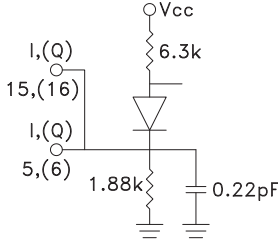
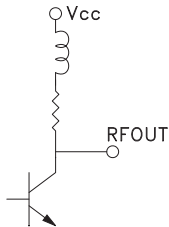
| Part Number | Package Body Material                              | Lead Finish   | MSL Rating          | Package Marking <sup>[3]</sup> |
|-------------|----------------------------------------------------|---------------|---------------------|--------------------------------|
| HMC500LP3   | Low Stress Injection Molded Plastic                | Sn/Pb Solder  | MSL1 <sup>[1]</sup> | 500<br>XXXX                    |
| HMC500LP3E  | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL1 <sup>[2]</sup> | 500<br>XXXX                    |

[1] Max peak reflow temperature of 235 °C

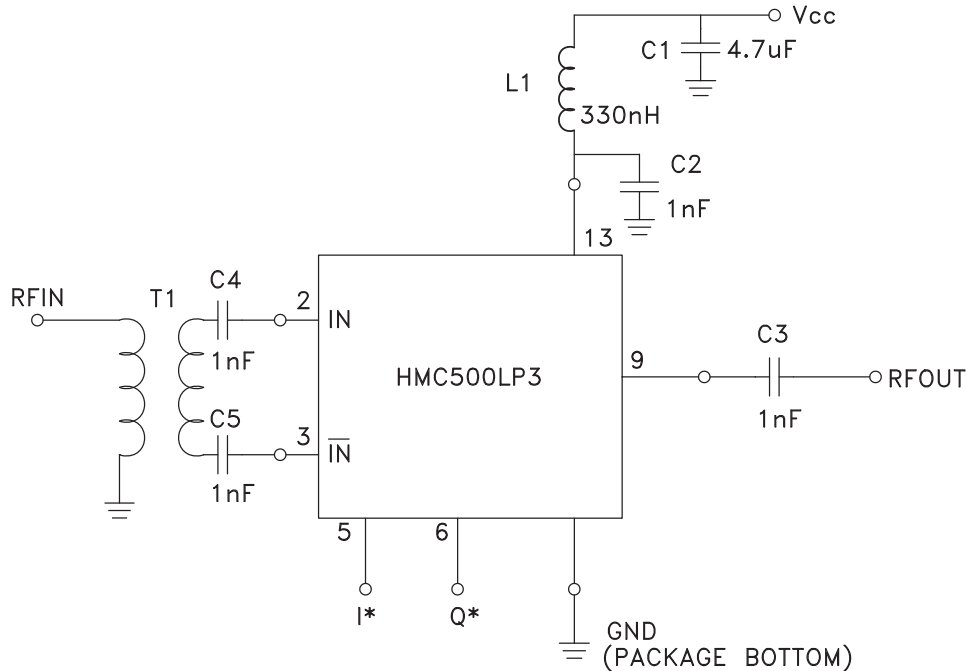
[2] Max peak reflow temperature of 260 °C

[3] 4-Digit lot number XXXX


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**Pin Description**

| Pin Number                 | Function                   | Description                                                                                        | Interface Schematic                                                                   |
|----------------------------|----------------------------|----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 1, 4, 7, 8,<br>10 - 12, 14 | N/C                        | No connection. These pins may be connected to RF/DC ground. Performance will not be affected       |                                                                                       |
| 2, 3                       | IN, $\overline{\text{IN}}$ | Differential RF inputs, 50 Ohms. Must be DC blocked.                                               |    |
| 5, 15                      | I                          | In-phase control input. Pins 5 and 15 are redundant. Either input can be used.                     |    |
| 6, 16                      | Q                          | Quadrature control input. Pins 6 and 16 are redundant. Either input can be used.                   |                                                                                       |
| 9                          | RFOUT                      | RF Output: Must be DC blocked.                                                                     |   |
| 13                         | Vcc                        | Supply Voltage                                                                                     |                                                                                       |
|                            | GND                        | Ground: Backside of package has exposed metal ground slug which must be connected to RF/DC ground. |  |

**Application Circuit**



\* Pins 15 & 16 are redundant I & Q inputs.

Gain and Phase control are applied through the I and Q control ports. For a given linear gain (G) and phase ( $\theta$ ) setting, the voltages applied to these ports in all measurements are calculated as follows:

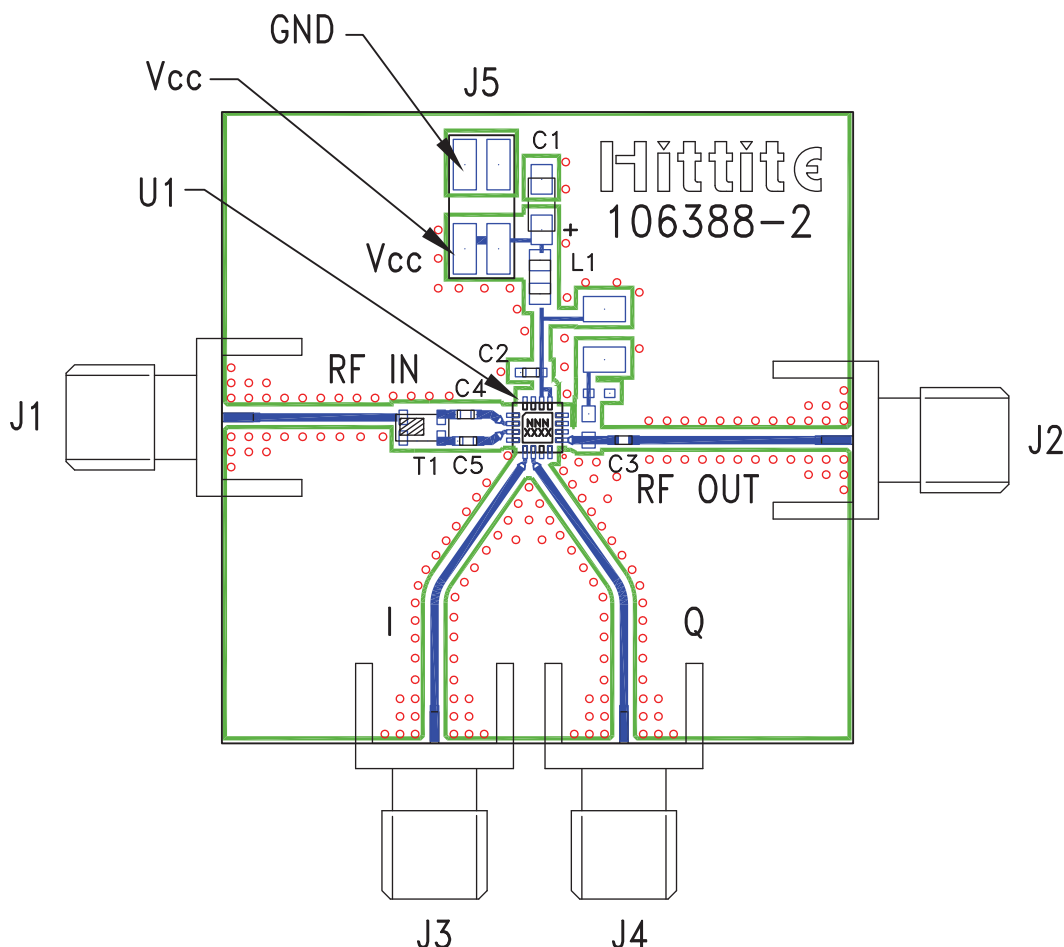
$$I(G, \theta) = V_{mi} + 1.0V \frac{G}{G_{max}} \cos(\theta)$$

$$Q(G, \theta) = V_{mq} + 1.0V \frac{G}{G_{max}} \sin(\theta)$$

Where  $V_{mi}$  and  $V_{mq}$  are the I and Q voltage settings corresponding to maximum isolation at room temperature and  $F = 2$  GHz.

Note that  $G = 10^x$  and  $G_{max} = 10^y$  where  $x = \frac{\text{Gain Setting (dB)}}{20}$  and  $y = \frac{\text{Max Gain Setting (dB)}}{20}$ . Nominally  $V_{mi} = V_{mq} = 1.5V$ ,  $G_{max} = 0.316$ .

**Evaluation PCB**



**List of Materials for Evaluation PCB 106395 [1]**

| Item    | Description                             |
|---------|-----------------------------------------|
| J1 - J4 | PCB Mount SMA Connector                 |
| J5      | 2 mm DC Header                          |
| C1      | 4.7 $\mu$ F Capacitor, Tantalum         |
| C2 - C5 | 1 nF Capacitor, 0402 Pkg.               |
| T1      | Balun, 1206 Pkg.                        |
| L1      | 330 nH Inductor, 0805 Pkg.              |
| U1      | HMC500LP3 / HMC500LP3E Vector Modulator |
| PCB [2] | 106388 Evaluation PCB                   |

[1] Reference this number when ordering complete evaluation PCB

[2] Circuit Board Material: Rogers 4350, Er = 3.48

The circuit board used in the final 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.



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10

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