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# HMC495LP3 / 495LP3E

## SiGe WIDEBAND DIRECT MODULATOR RFIC, 250 - 3800 MHz

### Typical Applications

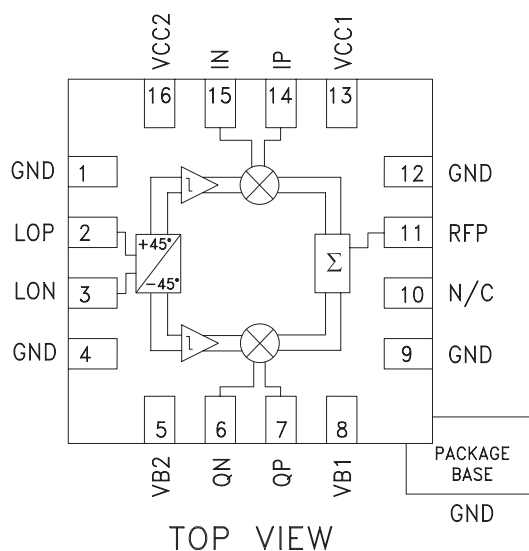
The HMC495LP3 / HMC495LP3E is suitable for various modulation systems:

- UMTS, GSM or CDMA Basestations
- Fixed Wireless or WLL
- ISM Transceivers, 900 & 2400 MHz
- GMSK, QPSK, QAM, SSB Modulators

### Features

- Wideband RF Frequency Range
- High Carrier Suppression: 38 dBc
- Very Low Noise Floor: -158 dBm/Hz
- Low LO Power: -6 to +6 dBm
- Differential or Single Ended LO Input
- Single Low Current Supply: +3.3V@ 108 mA

### Functional Diagram



### General Description

The HMC495LP3 & HMC495LP3E are low noise Wideband Direct Quadrature Modulator RFICs which are ideal for digital modulation applications from 250 - 3800 MHz including; Cellular/3G, Broadband Wireless Access & ISM circuits. Housed in a compact 3x3 mm (LP3) SMT QFN package, the RFIC requires minimal external components & provides a low cost alternative to more complicated double upconversion architectures. The RF output port is single-ended and matched to 50 Ohms with no external components. The LO requires -6 to +6 dBm and can be driven in either differential or single-ended mode while the Baseband inputs will support modulation inputs from DC - 250 MHz typical. This device is optimized for a supply voltage of +3.3V @ 108 mA and will provide stable performance over a +3V to +3.6V range.

### Electrical Specifications, See Test Conditions on following page herein.

| Parameter                           | Min. | Typ.      | Max. | Min.        | Typ. | Max. | Min.        | Typ. | Max. | Min.        | Typ. | Max. | Units  |
|-------------------------------------|------|-----------|------|-------------|------|------|-------------|------|------|-------------|------|------|--------|
| Frequency Range, RF                 |      | 450 - 960 |      | 1800 - 2200 |      |      | 2100 - 2700 |      |      | 3400 - 3800 |      |      | MHz    |
| Output Power                        | -7   | -5        |      | -8          | -6   |      | -9          | -7   |      | -11         | -9   |      | dBm    |
| Output P1dB                         |      | 2         |      | 1           |      |      | 0           |      |      | -2          |      |      | dBm    |
| Output IP3                          |      | 17        |      | 14          |      |      | 14          |      |      | 13          |      |      | dBm    |
| Output Noise Floor                  |      | -159      |      | -158        |      |      | -158        |      |      | -157        |      |      | dBm/Hz |
| Carrier Suppression (uncalibrated)  |      | 38        |      | 38          |      |      | 35          |      |      | 34          |      |      | dBc    |
| Sideband Suppression (uncalibrated) |      | 34        |      | 31          |      |      | 30          |      |      | 28          |      |      | dBc    |
| IM3 Suppression                     |      | 59        |      | 50          |      |      | 50          |      |      | 56          |      |      | dBc    |
| RF Port Return Loss                 |      | 18        |      | 17          |      |      | 16          |      |      | 13          |      |      | dB     |
| LO Port Return Loss                 |      | 13        |      | 8           |      |      | 7           |      |      | 5           |      |      | dB     |
| <b>CDMA IS95</b>                    |      |           |      |             |      |      |             |      |      |             |      |      |        |
| ACPR@ 880 MHz & 1960 MHz            |      | -72       |      | -71.5       |      |      | N/A         |      |      | N/A         |      |      | dBc    |
| Channel Power                       |      | -15       |      | -18.4       |      |      | N/A         |      |      | N/A         |      |      | dBm    |
| <b>W-CDMA 3GPP</b>                  |      |           |      |             |      |      |             |      |      |             |      |      |        |
| ACPR@ 1960 & 2140 MHz               |      | N/A       |      | -60         |      |      | -59         |      |      | N/A         |      |      | dBc    |
| Channel Power                       |      | N/A       |      | -17.3       |      |      | -14.4       |      |      | N/A         |      |      | dBm    |

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20 Alpha Road, Chelmsford, MA 01824 Phone: 978-250-3343 Fax: 978-250-3373  
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### Electrical Specifications, (continued)

| Parameter                                              | Conditions                                                                                               | Min. | Typ. | Max. | Units |
|--------------------------------------------------------|----------------------------------------------------------------------------------------------------------|------|------|------|-------|
| <b>RF Output</b>                                       |                                                                                                          |      |      |      |       |
| RF Frequency Range                                     |                                                                                                          | 0.25 |      | 3.8  | GHz   |
| RF Return Loss                                         |                                                                                                          |      | 16   |      | dB    |
| <b>LO Input</b>                                        |                                                                                                          |      |      |      |       |
| LO Frequency Range                                     |                                                                                                          | 0.25 |      | 3.8  | GHz   |
| LO Input Power                                         | With 68 Ohm shunt resistor on LO port.                                                                   | -6   | 0    | +6   | dBm   |
| LO Port Return Loss                                    | With 68 Ohm shunt resistor on LO port.                                                                   |      | 7    |      | dB    |
| <b>Baseband Input Port</b>                             |                                                                                                          |      |      |      |       |
| Baseband Port Bandwidth                                | With 50Ω source & external 10 pF shunt cap to ground. Refer to HMC495LP3 Application Circuit.            | DC   |      | 250  | MHz   |
| Baseband Input DC Voltage (Vbbdc)                      | This parameter can be varied in order to optimize the device performance over temperature and/or supply. | 1.0  | 1.15 | 1.2  | V     |
| Baseband Input DC Bias Current (Ibbdc)                 | Single-ended.                                                                                            |      | 40   |      | μA    |
| Single-ended Baseband Input Capacitance                | De-embed to the lead of the device.                                                                      |      | 0.5  |      | pF    |
| <b>DC Power Requirements</b> See Test Conditions Below |                                                                                                          |      |      |      |       |
| Supply Voltage (Vcc1, Vcc2, Vb1, Vb2)                  |                                                                                                          | 3    | 3.3  | 3.6  | V     |
| Supply Current (Icc1, Icc2, Ib1, Ib2)                  |                                                                                                          |      | 108  |      | mA    |

### Test Conditions: Unless Otherwise Specified, the Following Test Conditions Were Used

| Parameter                                                                           | Condition                                       |
|-------------------------------------------------------------------------------------|-------------------------------------------------|
| Temperature                                                                         | +25 °C                                          |
| Baseband Input Frequency                                                            | 200 kHz                                         |
| Baseband Input DC Voltage (Vbbdc)                                                   | 1.15V                                           |
| Baseband Input AC Voltage (Peak to Peak Differential, I and Q)                      | 800 mV                                          |
| Baseband Input AC Voltage for OIP3 Measurement (Peak to Peak Differential, I and Q) | 400 mV per tone @ 150 & 250 kHz                 |
| Frequency Offset for Output Noise Measurements                                      | 20 MHz                                          |
| Supply & Bias Voltage (Vb1, Vb2, Vcc1, Vcc2)                                        | 3.3V                                            |
| LO Input Power                                                                      | 0 dBm                                           |
| LO Input Mode                                                                       | Single-Ended                                    |
| Mounting Configuration                                                              | Refer to HMC495LP3 Application Schematic Herein |
| Sideband & Carrier Feedthrough                                                      | Uncalibrated                                    |

### Calibrated vs. Uncalibrated Test Results

During the Uncalibrated Sideband and Carrier Suppression tests, care is taken to ensure that the I/Q signal paths from the Vector Signal Generator (VSG) to the Device Under Test (DUT) are equal. The "Uncalibrated, +25 °C" Sideband and Carrier Suppression plots were measured at room temperature, while the "Uncalibrated, over Temperature" Sideband and Carrier Suppression plots represent the worst case uncalibrated suppression levels measured at T= -40 °C, +25 °C, and +85 °C.

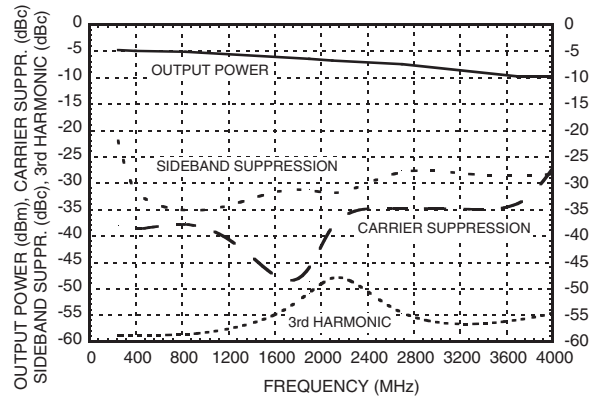
The "Calibrated, + 25 °C" Sideband Suppression data was plotted after a manual adjustment of the I/Q amplitude balance and I/Q phase offset (skew) at +25 °C, and at each LO input power level. The +25 °C adjustment settings were held constant during tests over temperature. The "Calibrated, over Temperature" plots represent the worst case calibrated Sideband Suppression levels at T= -40 °C, +25 °C, and +85 °C.

The "Calibrated, +25 °C" Carrier Suppression data was plotted after a manual adjustment of the Ip/In & Qp/Qn DC offsets at +25 °C, and at each LO input power level. The +25 °C adjustment settings were held constant during tests over temperature. The "Calibrated, over Temperature" plots represent the worst case Carrier Suppression levels measured at T= -40 °C, +25 °C, and +85 °C.

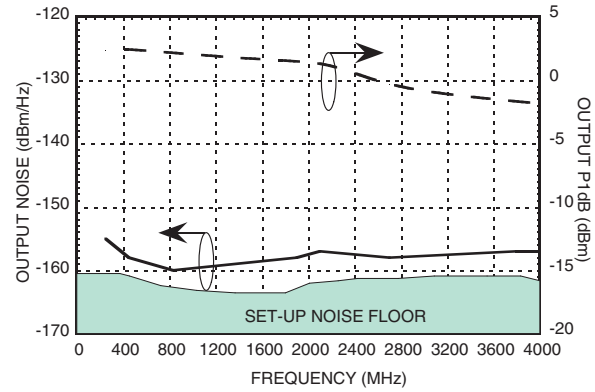
## HMC495LP3 / 495LP3E

### SiGe WIDEBAND DIRECT MODULATOR RFIC, 250 - 3800 MHz

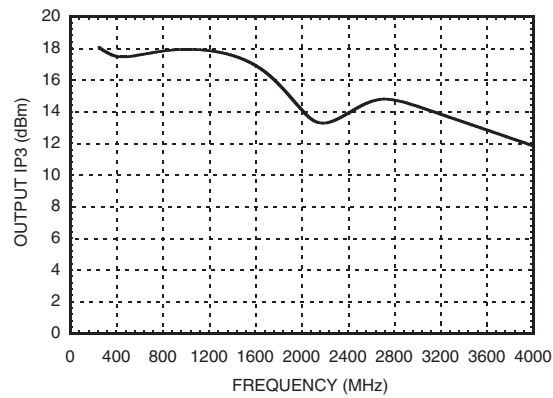
#### Wideband Performance vs. Frequency



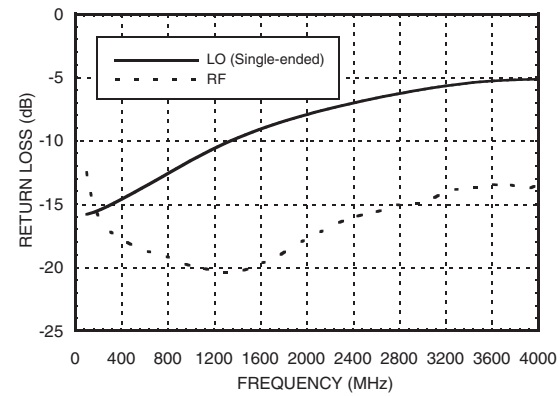
#### Output Noise Floor and P1dB vs. Frequency



#### Output IP3 vs. Frequency



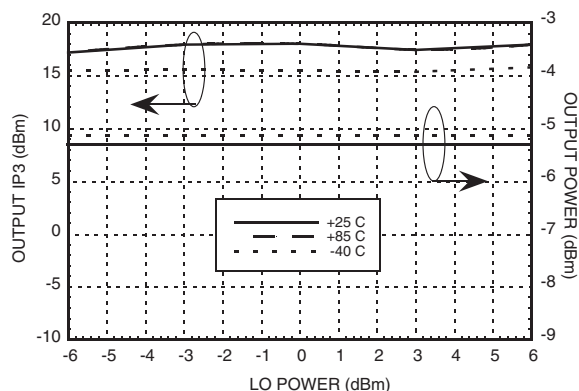
#### Return Loss



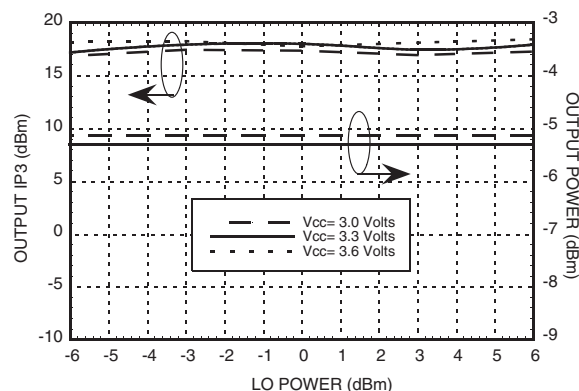
## HMC495LP3 / 495LP3E

### SiGe WIDEBAND DIRECT MODULATOR RFIC, 250 - 3800 MHz

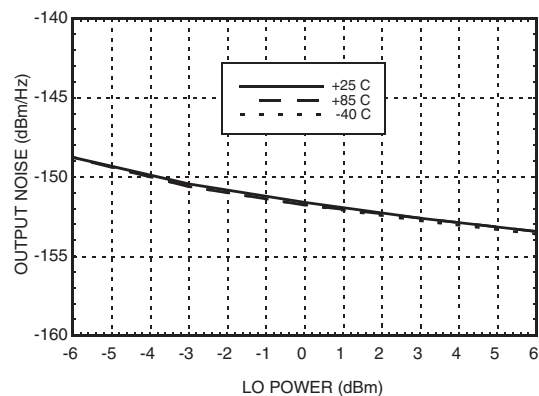
**Output IP3 & Output Power vs.  
LO Power Over Temperature@ 830 MHz**



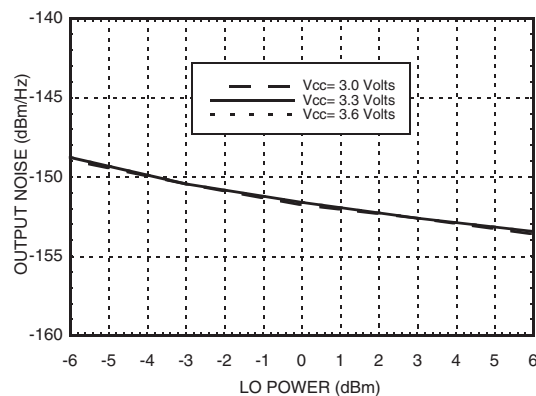
**Output IP3 & Output Power vs.  
LO Power Over Supply@ 830 MHz**



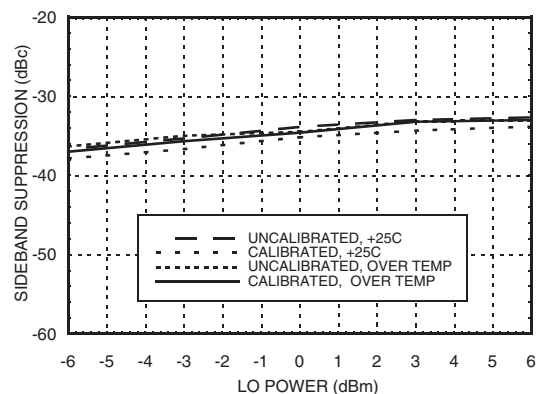
**Output Noise vs. LO Power  
Over Temperature@ 830 MHz**



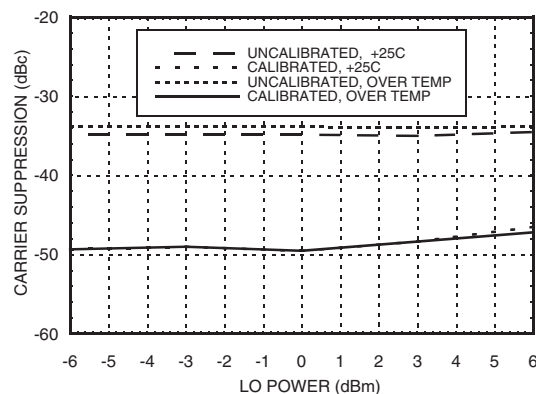
**Output Noise vs. LO Power  
Over Supply@ 830 MHz**



**Sideband Suppression\*  
vs. LO Power@ 830 MHz**



**Carrier Suppression\*  
vs. LO Power@ 830 MHz**

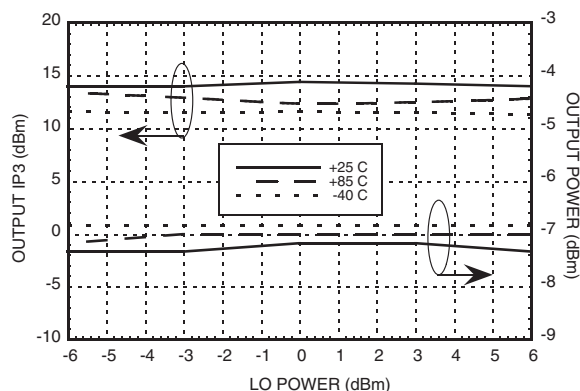


\* See note titled "Calibrated vs. Uncalibrated test results" herein.

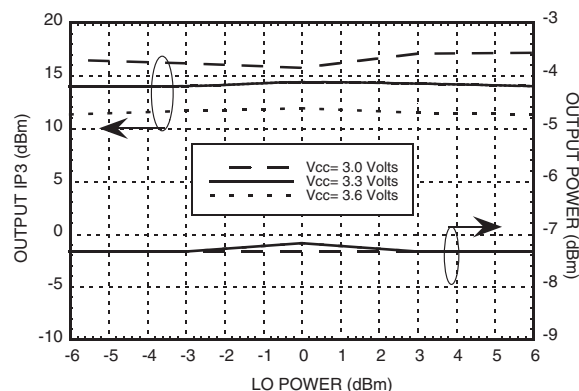
# HMC495LP3 / 495LP3E

## SiGe WIDEBAND DIRECT MODULATOR RFIC, 250 - 3800 MHz

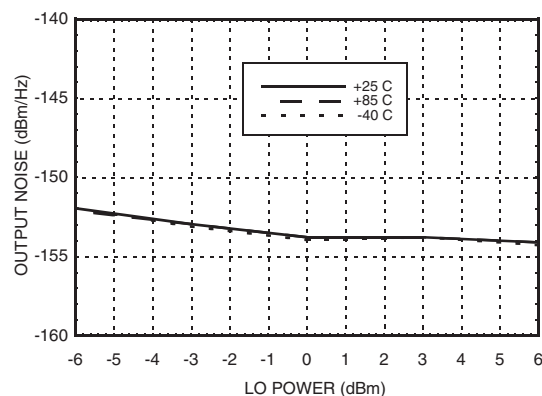
**Output IP3 & Output Power vs.  
LO Power Over Temperature@ 1900 MHz**



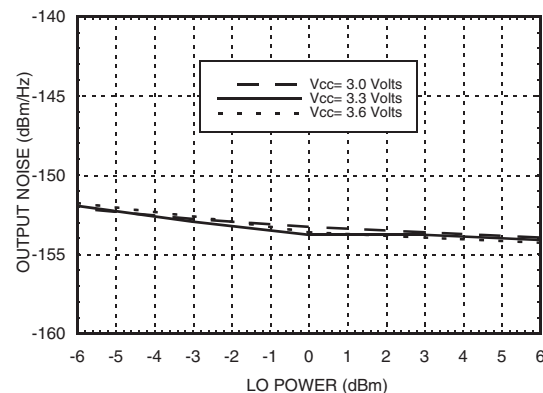
**Output IP3 & Output Power vs.  
LO Power Over Supply@ 1900 MHz**



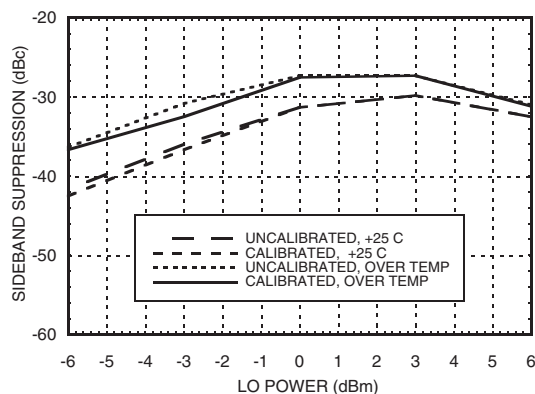
**Output Noise vs. LO Power  
Over Temperature@ 1900 MHz**



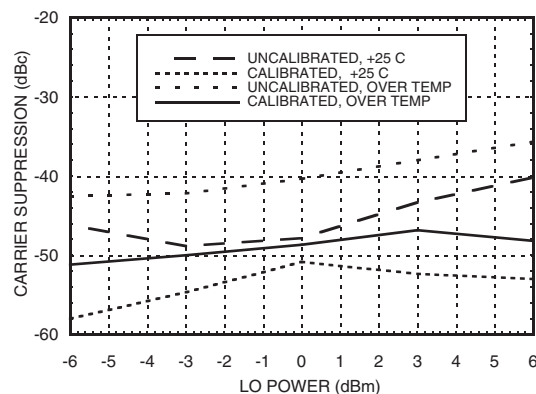
**Output Noise vs. LO Power  
Over Supply@ 1900 MHz**



**Sideband Suppression\*  
vs. LO Power@ 1900 MHz**



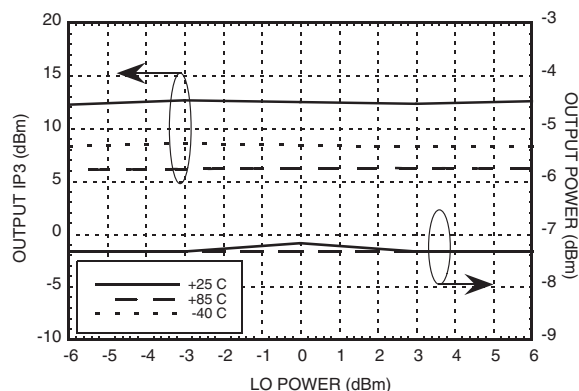
**Carrier Suppression\*  
vs. LO Power@ 1900 MHz**



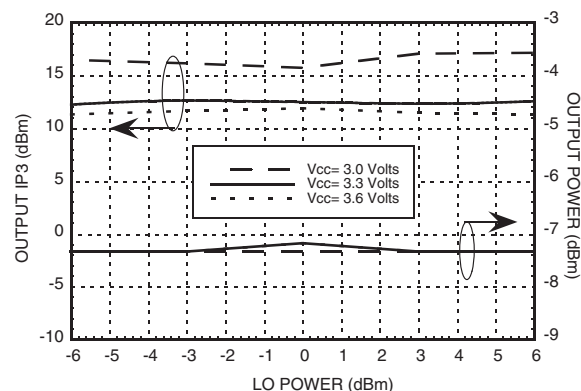
\* See note titled "Calibrated vs. Uncalibrated test results" herein.

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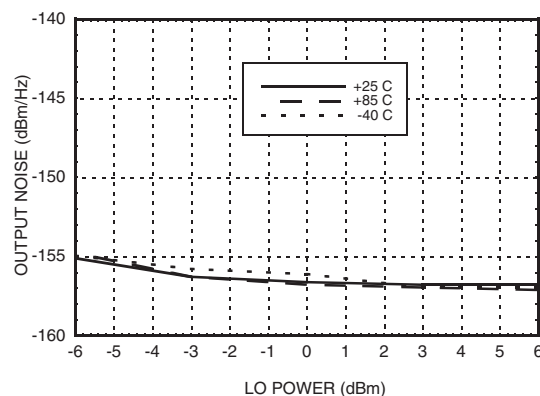
**Output IP3 & Output Power vs.  
LO Power Over Temperature@ 2100 MHz**



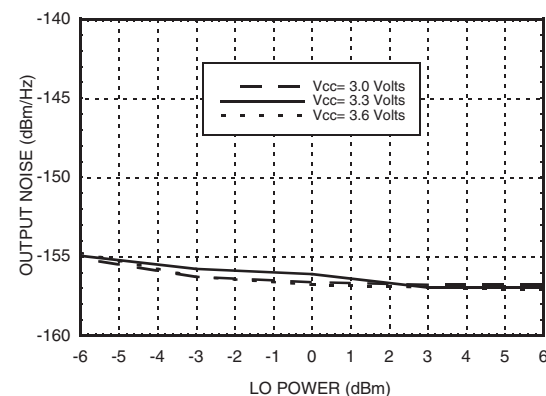
**Output IP3 & Output Power vs.  
LO Power Over Supply@ 2100 MHz**



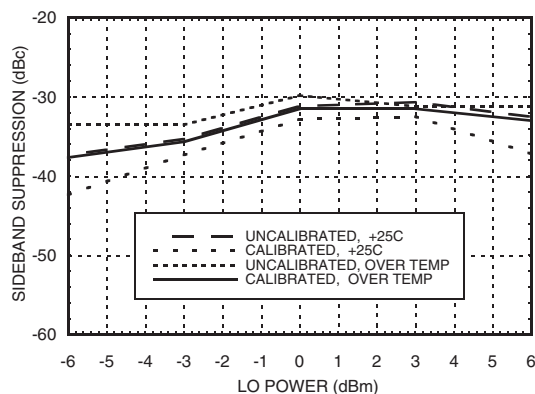
**Output Noise vs. LO Power  
Over Temperature@ 2100 MHz**



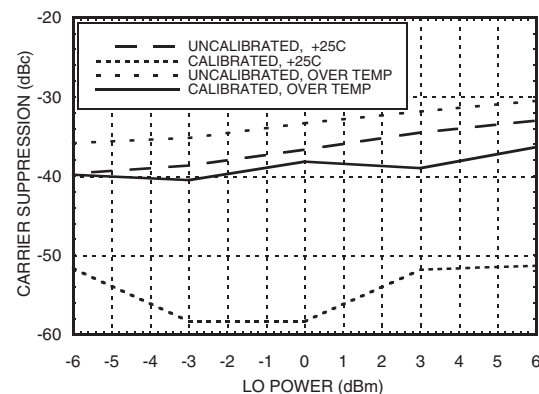
**Output Noise vs. LO Power  
Over Supply@ 2100 MHz**



**Sideband Suppression\*  
vs. LO Power@ 2100 MHz**



**Carrier Suppression\*  
vs. LO Power@ 2100 MHz**



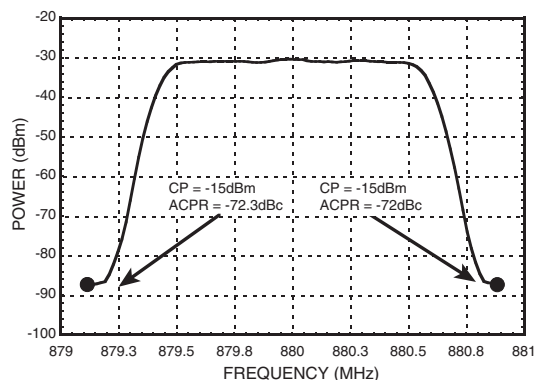
\* See note titled "Calibrated vs. Uncalibrated test results" herein.

## HMC495LP3 / 495LP3E

### SiGe WIDEBAND DIRECT MODULATOR RFIC, 250 - 3800 MHz

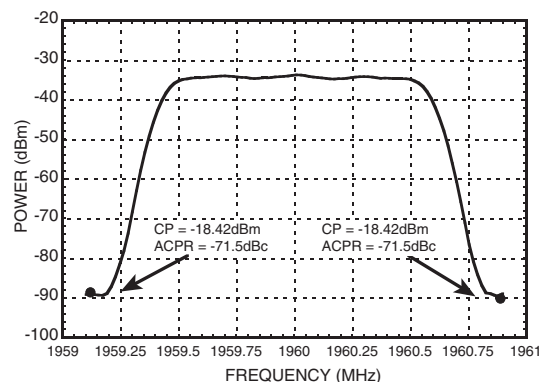
#### Cellular CDMA @ 880 MHz

ACPR @ 885 kHz,  $V_{cc} = 3.3V$ ,  $V_{dc} = 1.15V$



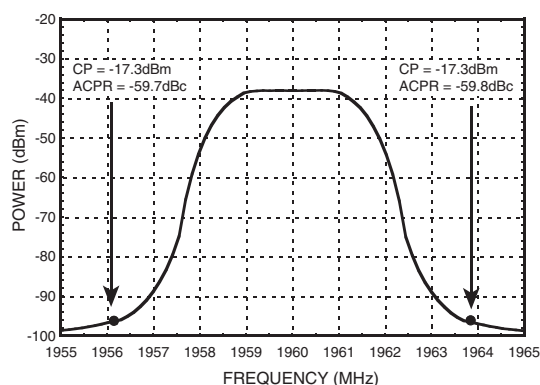
#### PCS CDMA @ 1960 MHz

ACPR @ 885 kHz,  $V_{cc} = 3.3V$ ,  $V_{dc} = 1.15V$



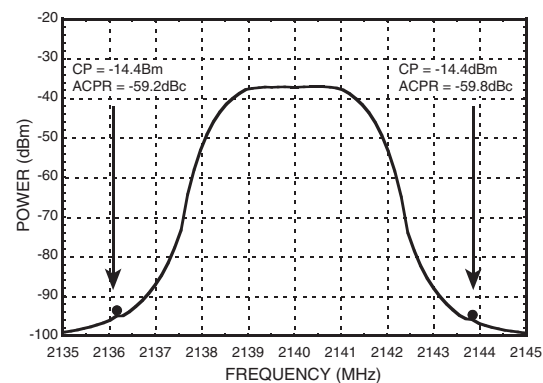
#### W-CDMA @ 1960 MHz

ACPR @ 3.84 MHz,  $V_{cc} = 3.3V$ ,  $V_{dc} = 1.15V$



#### W-CDMA @ 2140 MHz

ACPR @ 3.84 MHz,  $V_{cc} = 3.3V$ ,  $V_{dc} = 1.15V$



Note 1: W-CDMA (Modulation Set-up for ACPR Mode); The Baseband I and Q input signals were generated using "Test Model 1 with 64 channels" settings in the Agilent E3844C.

Note 2: CDMA (Modulation Set-up for ACPR Mode); The Baseband I and Q input signals were generated using the "9 channels forward" settings in the Agilent E3844C (pilot, paging, sync and 6 traffic channels).

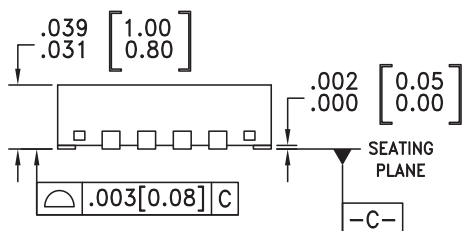
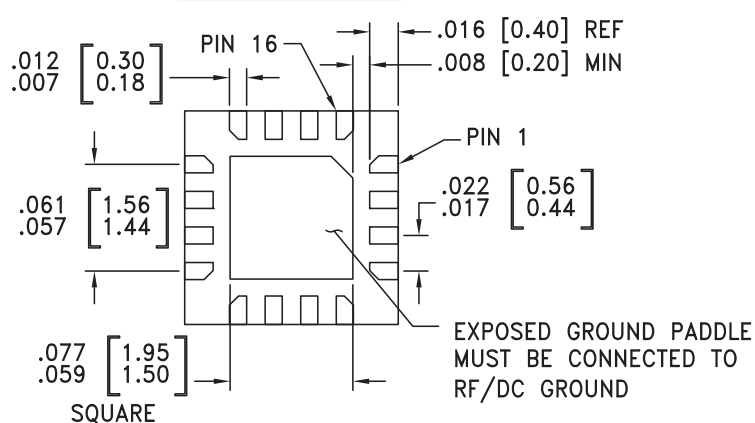


**SiGe WIDEBAND DIRECT  
MODULATOR RFIC, 250 - 3800 MHz**

10

# MODULATORS - SMT

BOTTOM VIEW



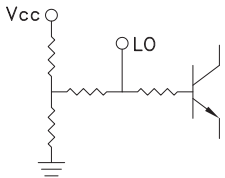
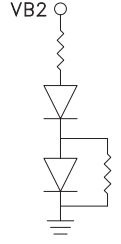
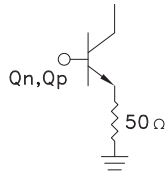
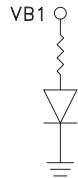
1. LEADFRAME MATERIAL: COPPER ALLOY
2. DIMENSIONS ARE IN INCHES [MILLIMETERS].
3. LEAD SPACING TOLERANCE IS NON-CUMULATIVE
4. PAD BURR LENGTH SHALL BE 0.15mm MAXIMUM.
5. PAD BURR HEIGHT SHALL BE 0.05mm MAXIMUM.
6. PACKAGE WARP SHALL NOT EXCEED 0.05mm.
7. ALL GROUND LEADS AND GROUND PADDLE MUST BE SOLDERED TO PCB RF GROUND.
8. REFER TO HITTITE APPLICATION NOTE FOR SUGGESTED PCB LAND PATTERN.

| Part Number | Package Body Material                              | Lead Finish   | MSL Rating          | Package Marking <sup>[3]</sup> |
|-------------|----------------------------------------------------|---------------|---------------------|--------------------------------|
| HMC495LP3   | Low Stress Injection Molded Plastic                | Sn/Pb Solder  | MSL1 <sup>[1]</sup> | 495<br>XXXX                    |
| HMC495LP3E  | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL1 <sup>[2]</sup> | <u>495</u><br>XXXX             |

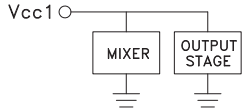
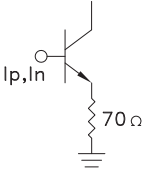
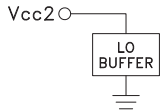
[3] 4-Digit lot number XXXX

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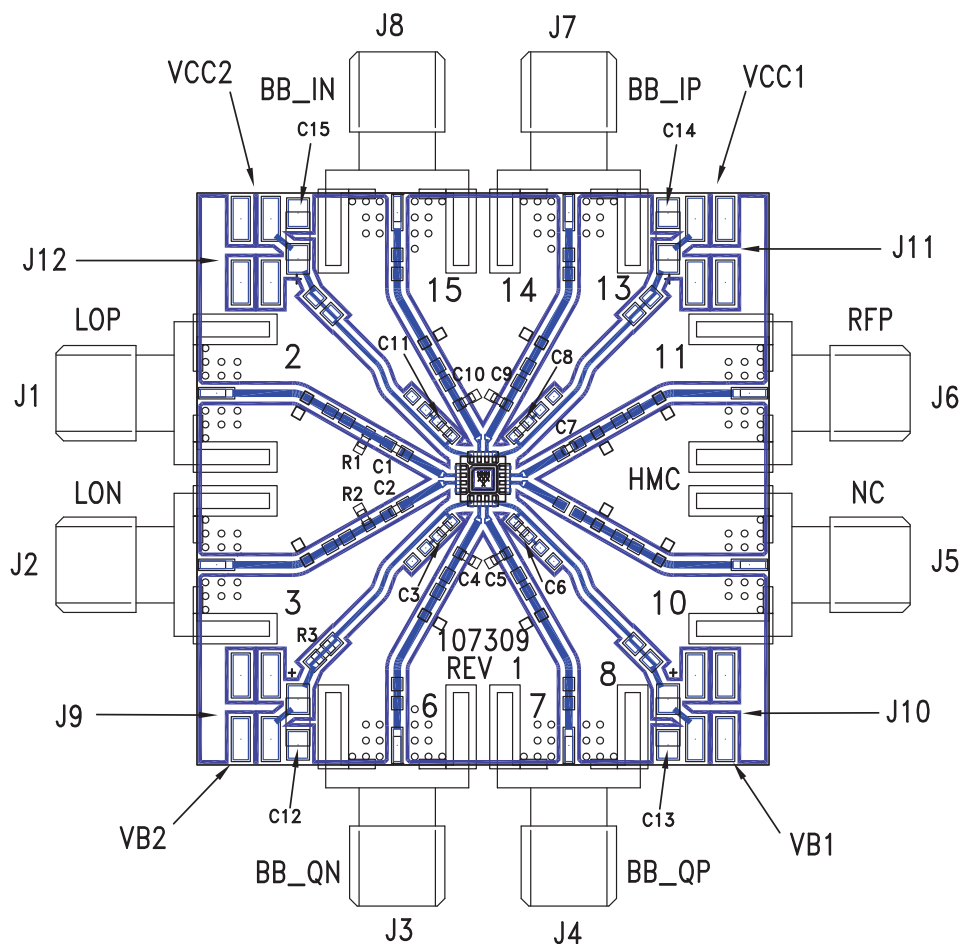
## Pin Descriptions

| Pin Number  | Function | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Interface Schematic                                                                   |
|-------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 1, 4, 9, 12 | GND      | These pins and the ground paddle must be connected to a high quality RF/DC ground.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |    |
| 2, 3        | LOP, LON | Differential LO input ports. This device may be driven in either differential or single ended mode. In single ended mode, one port should be driven by the LO source while the other port may be terminated with a 50Ω resistor to ground. An external shunt 68Ω resistor is used to improve VSWR, while an external 100 pF capacitor is required to prevent DC supply voltage from appearing on the customer's PC board.                                                                                                                                                                                                         |    |
| 5           | VB2      | Bias Voltage for the LO stage. This voltage will affect the Sideband Suppression, the Output Noise Floor and the Power Consumption. The ideal voltage range for this port is between +2.7 Vdc and +3.0 Vdc. The nominal current for this port is 5.3 mA.                                                                                                                                                                                                                                                                                                                                                                          |   |
| 6, 7        | Qn, Qp   | Differential Quadrature baseband input. These are high impedance ports. The nominal recommended bias voltage is between 1.0 - 1.15V. The nominal recommended baseband input voltage is 800 mV peak to peak differential. By adjusting the DC bias voltage on ports Qn & Qp, the Carrier Suppression of the device can be optimized for a specific frequency band and LO power level. The typical offset voltage for optimization is less than 5 mV. The amplitude and phase difference between the I and Q inputs can be adjusted in order to optimize the Sideband Suppression for a specific frequency band and LO power level. |  |
| 8           | VB1      | Bias Voltage for the output stage. This voltage should be connected to the Vcc supply. Nominal supply voltage is 3.3 Vdc. The nominal current for this port is 2.4 mA.                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  |
| 10          | N/C      | No connect.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                       |
| 11          | RFP      | RF Output port. This port is matched to 50Ω. A series capacitor should be connected to this port in order to prevent the DC supply voltage from appearing on the customer's PC board.                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                       |

### Pin Descriptions (continued)

| Pin Number | Function | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Interface Schematic                                                                  |
|------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 13         | Vcc1     | Supply voltage for the mixer and output stages. Set to 3.3V for nominal operation. The nominal current for this port is 37 mA.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |   |
| 14, 15     | Ip, In   | Differential In-Phase baseband input. These are high impedance ports. The nominal recommended bias voltage is between 1.0 - 1.15V. The nominal recommended baseband input voltage is 800 mV peak to peak differential. By adjusting the DC bias voltage on ports In & Ip, the Carrier Suppression of the device can be optimized for a specific frequency band and LO power level. The typical offset voltage for optimization is less than 5 mV. The amplitude and phase difference between the I and Q inputs can be adjusted in order to optimize the Sideband Suppression for a specific frequency band and LO power level. |   |
| 16         | Vcc2     | Supply voltage for the LO stage. Set to 3.3V for nominal operation. The nominal current for this port is 64 mA.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |

## Evaluation PCB



## List of Materials for Evaluation PCB 107413 [1]

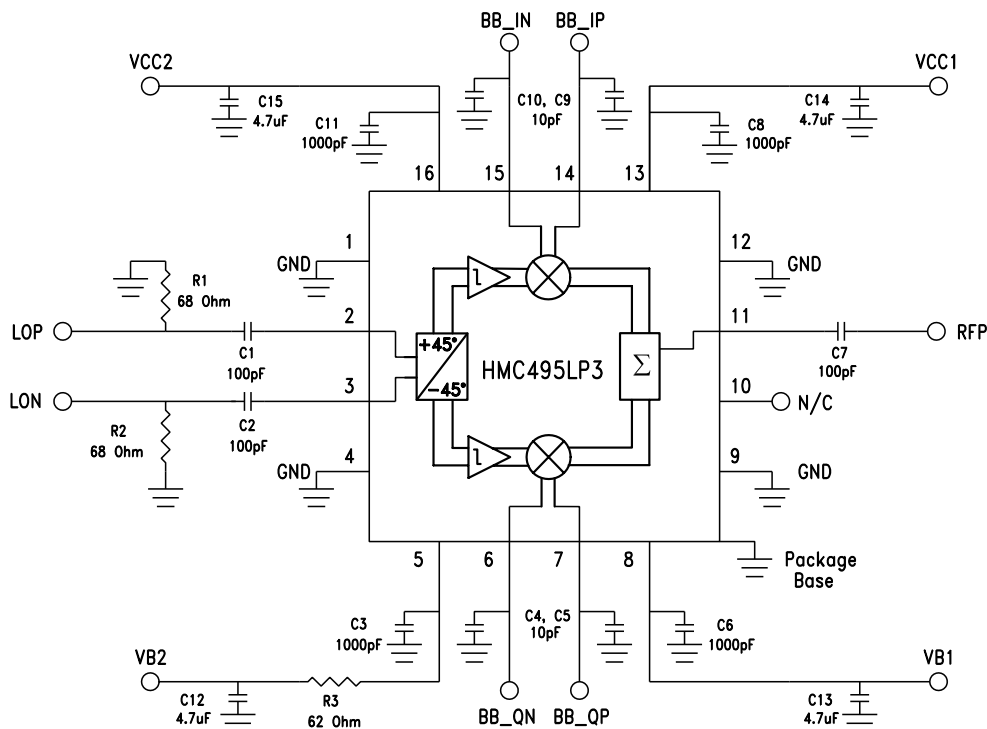
| Item            | Description                       |
|-----------------|-----------------------------------|
| J1 - J8         | PCB Mount SMA Connector           |
| J9 - J12        | DC Molex Connector                |
| C1, C2, C7      | 100 pF Chip Capacitor, 0402 Pkg.  |
| C3, C6, C8, C11 | 1000 pF Chip Capacitor, 0402 Pkg. |
| C4, C5, C9, C10 | 10 pF Chip Capacitor, 0402 Pkg.   |
| C12 - C15       | 4.7 uF, Case A, Tantalum          |
| R1, R2          | 68 Ohms, 0402 Pkg.                |
| R3              | 62 Ohms, 0402 Pkg.                |
| U1              | HMC495LP3 / HMC495LP3E Modulator  |
| PCB [2]         | 107309 Eval Board                 |

[1] Reference this number when ordering complete evaluation PCB

[2] Circuit Board Material: Rogers 4350

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 circuit board shown is available from Hittite upon request.

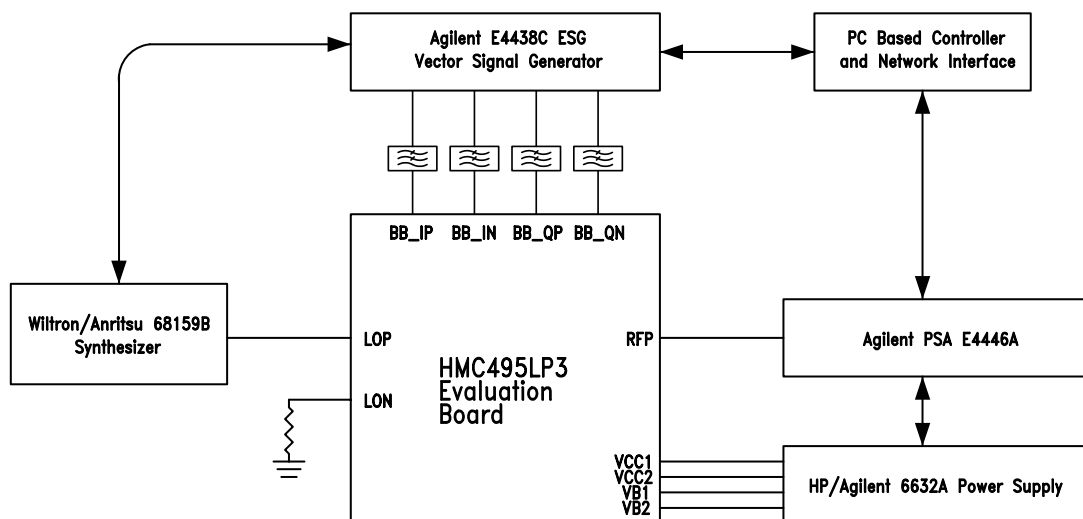
### Application & Evaluation PCB Schematic



Note:

Baseband input frequency range is dependent on value of C4, C5, C9 and C10. The value of 10 pF was chosen to give a typical response of DC - 250 MHz. Input frequency range can be extended up to 1 GHz with possible degradation of LO leakage and broadband noise floor response by decreasing the value of C4, C5, C9 & C10.

### Characterization Set-up



For price, delivery, and to place orders, please contact Hittite Microwave Corporation:  
 20 Alpha Road, Chelmsford, MA 01824 Phone: 978-250-3343 Fax: 978-250-3373  
 Order On-line at [www.hittite.com](http://www.hittite.com)

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