



MICROWAVE CORPORATION v02.0413

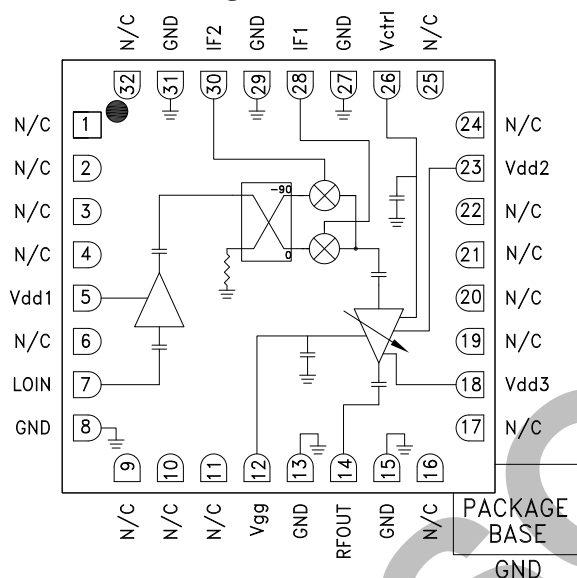


### Typical Applications

The HMC6505LC5 is ideal for:

- Point-to-Point and Point-to-Multi-Point Radio
- Military Radar, EW & ELINT
- Satellite Communications
- Sensors

### Functional Diagram



# HMC6505LC5

## GaAs MMIC I/Q UPCONVERTER 5.5 - 8.6 GHz

### Features

- High Conversion Gain: 15 dB
- Sideband Rejection: 22 dBc
- LO / RF Rejection: 14 dBc
- High Output IP3: +35 dBm
- 32 Lead 5x5 mm SMT Ceramic Package: 25 mm<sup>2</sup>

### General Description

The HMC6505LC5 is a compact GaAs MMIC I/Q upconverter in a leadless RoHS compliant SMT package. This device provides a small signal conversion gain of 15 dB with 22 dBc of sideband rejection. The HMC6505LC5 utilizes a RF amplifier preceded by an I/Q mixer where the LO is driven by a driver amplifier. IF1 and IF2 mixer inputs are provided and an external 90° hybrid is needed to select the required sideband. The I/Q mixer topology reduces the need for filtering of the unwanted sideband. The HMC6505LC5 is a much smaller alternative to hybrid style single sideband upconverter assemblies and it eliminates the need for wire bonding by allowing the use of surface mount manufacturing techniques.

### Electrical Specifications, $T_A = +25^\circ\text{C}$ , $IF = 350\text{ MHz}$ ,

$LO = +4\text{ dBm}$ ,  $Vdd2, 3 = +5V$ ,  $Idd2 + Idd3 = 120\text{ mA}$ ,  $Vdd1 = +5V$ ,  $Idd1 = 125\text{ mA}$  [1][2][6]

| Parameter                      | Min. | Typ.    | Max. | Min.       | Typ. | Max. | Units |
|--------------------------------|------|---------|------|------------|------|------|-------|
| Frequency Range, RF            |      | 5.5 - 7 |      | 7 - 8.6    |      |      | GHz   |
| Frequency Range, LO            |      | 5 - 10  |      | 6.5 - 11.6 |      |      | GHz   |
| Frequency Range, IF            |      | DC - 3  |      | DC - 3     |      |      | GHz   |
| Conversion Gain [5]            | 12   | 15      |      | 11         | 14   |      | dB    |
| Sideband Rejection             | 18   | 22      |      | 18         | 22   |      | dBc   |
| 1 dB Compression (Output)      |      | 21      |      |            | 22   |      | dBm   |
| IP3 (Output)                   | 31   | 35      |      | 31         | 35   |      | dBm   |
| LO / RF Rejection [3] [4]      | 7    | 10      |      | 11         | 14   |      | dBc   |
| RF Return Loss                 |      | 16      |      |            | 17   |      | dB    |
| LO Return Loss                 |      | 8       |      |            | 9    |      | dB    |
| IF1 Return Loss                |      | 10      |      |            | 10   |      | dB    |
| IF2 Return Loss                |      | 8       |      |            | 8    |      | dB    |
| Supply Current Idd1            |      | 125     |      |            | 125  |      | mA    |
| Supply Current Idd2 + Idd3 [2] |      | 120     |      |            | 120  |      | mA    |

[1] Unless otherwise noted all measurements performed with high side LO,  $IF = 350\text{ MHz}$  and external  $IF\ 90^\circ$  hybrid.

[2] Adjust  $V_{gg}$  between -2 to 0V to achieve  $Idd2 + Idd3 = 120\text{ mA}$  Typical.

[3] The LO / RF Rejection is defined as the LO signal level at the RF output port relative to the desired RF output signal level.

[4] The LO / RF Rejection data is with  $IF = -6\text{ dBm}$ .

[5] Data based on subtracting out board loss and loss of hybrid.

[6] +3V can also be used for  $Vdd1$ .

For price, delivery and to place orders: Hittite Microwave Corporation, 2 Elizabeth Drive, Chelmsford, MA 01824

Phone: 978-250-3343 Fax: 978-250-3373 Order On-line at [www.hittite.com](http://www.hittite.com)

Application Support: Phone: 978-250-3343 or [apps@hittite.com](mailto:apps@hittite.com)

### Electrical Specifications, (continued) <sup>[1]</sup>

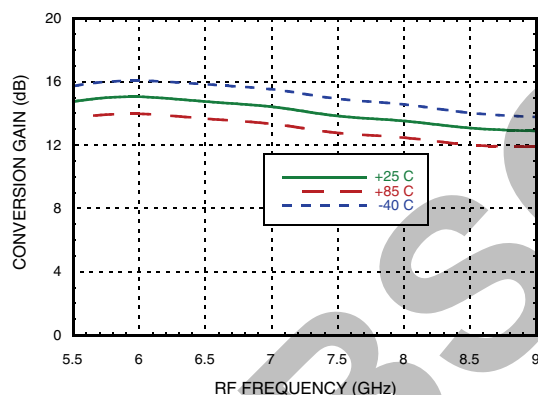
| Parameter                                     | Min. | Typ.    | Max. | Min.       | Typ. | Max. | Units |
|-----------------------------------------------|------|---------|------|------------|------|------|-------|
| Frequency Range, RF                           |      | 5.5 - 7 |      | 7 - 8.6    |      |      | GHz   |
| Frequency Range, LO                           |      | 5 - 10  |      | 6.5 - 11.6 |      |      | GHz   |
| Frequency Range, IF                           |      | DC - 3  |      | DC - 3     |      |      | GHz   |
| Dynamic Range                                 | 18   | 20      |      | 18         | 20   |      | dB    |
| V Control                                     | -4   |         | 0    | -4         |      | 0    | V     |
| LO Power                                      | -2   | 3       | 10   | -2         | 3    | 10   | dBm   |
| Gain Flatness (150 MHz Segments)              |      |         | 0.5  |            |      | 0.5  | dB    |
| Noise Figure (Min Attenuation) <sup>[7]</sup> |      | 11.5    |      |            | 12   |      | dB    |

[1] Unless otherwise noted all measurements performed with high side LO, IF = 350 MHz and external IF 90° hybrid.

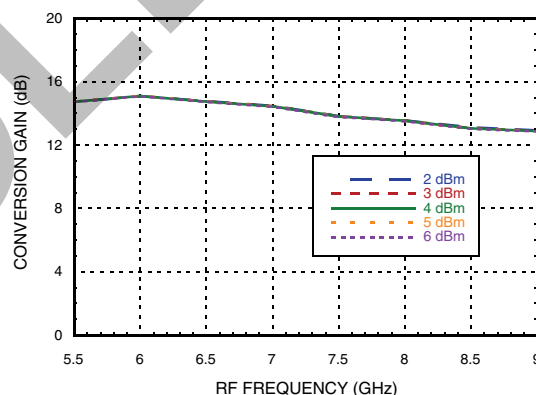
[7] Noise Figure measurement performed with high side LO, IF = 2500 MHz and external IF 90° hybrid.

### Data Taken as SSB Upconverter with External IF 90° Hybrid, IF = 350 MHz

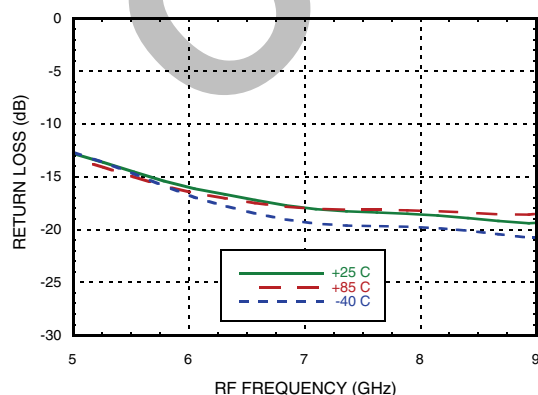
Conversion Gain, LSB vs. Temperature <sup>[8]</sup>



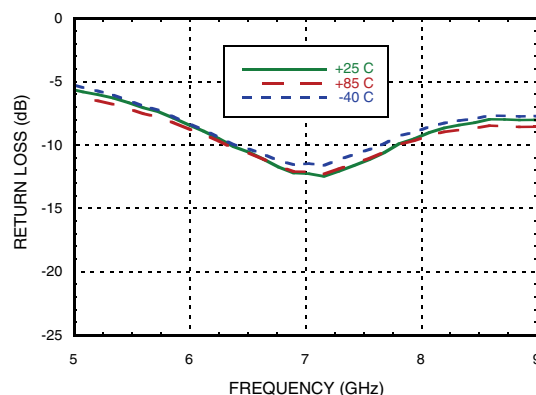
Conversion Gain, LSB vs. LO Drive <sup>[8]</sup>



RF Return Loss vs. Temperature



LO Return Loss vs. Temperature

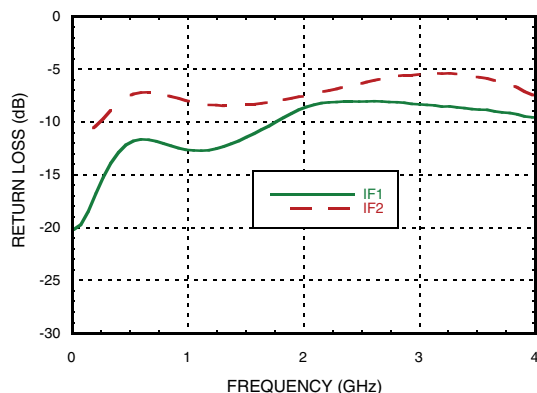


[8] Board loss and Hybrid loss not subtracted out.

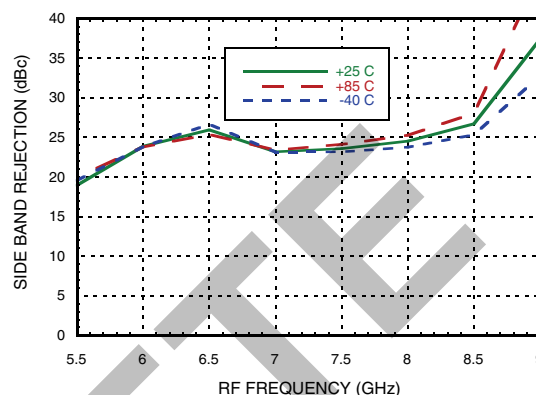
# GaAs MMIC I/Q UPCONVERTER 5.5 - 8.6 GHz

Data Taken as SSB Upconverter with External IF 90° Hybrid, IF = 350 MHz

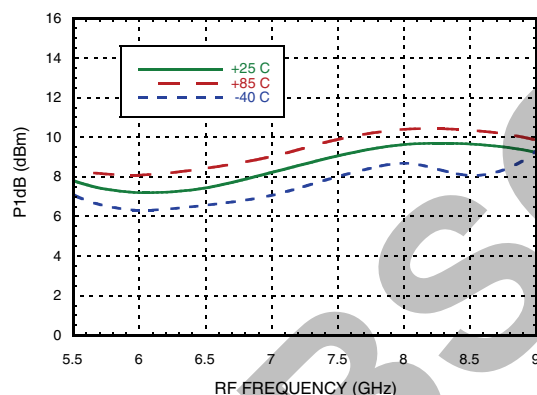
IF Return Loss [9]



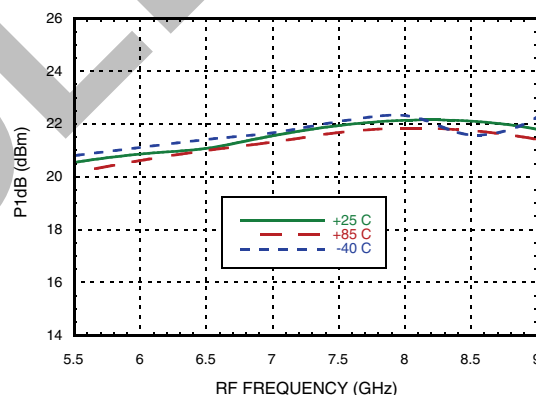
Sideband Rejection vs. Temperature



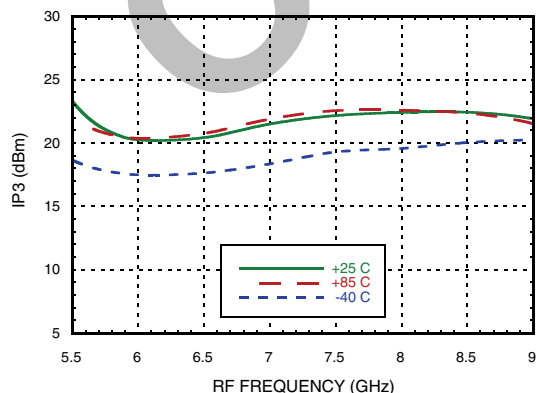
Input P1dB, LSB vs. Temperature



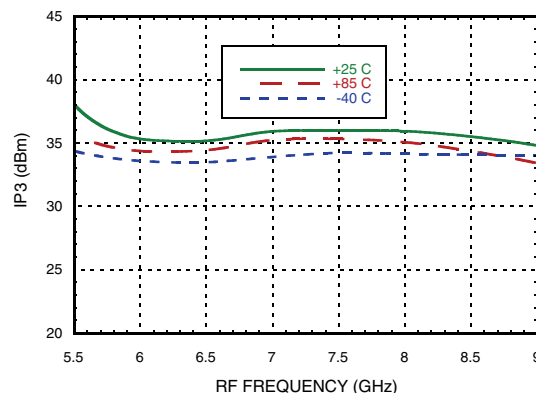
Output P1dB, LSB vs. Temperature



Input IP3, LSB vs. Temperature



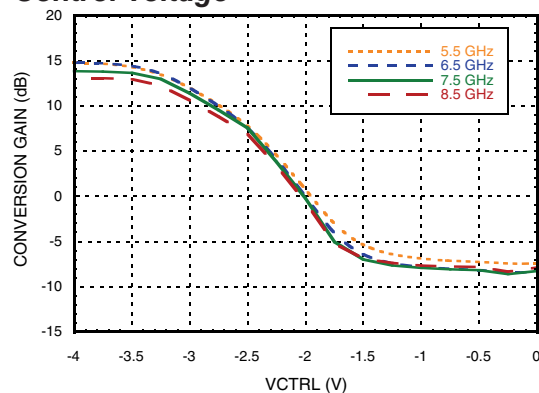
Output IP3, LSB vs. Temperature



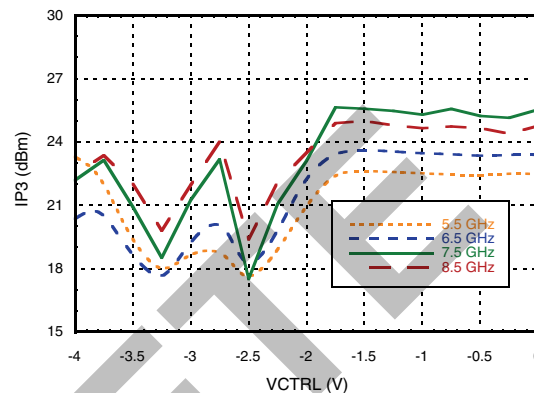
[9] Data taken without external IF 90° hybrid

*Data Taken as SSB Upconverter with External IF 90° Hybrid, IF = 350 MHz*

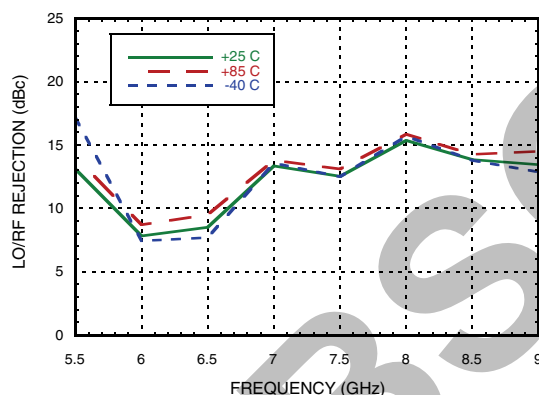
**Conversion Gain, LSB vs. Control Voltage [8]**



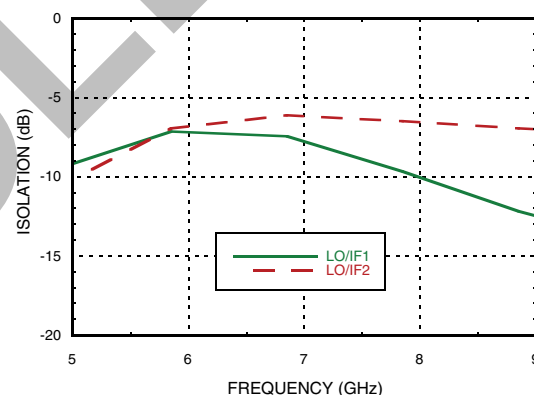
**Input IP3, LSB vs. Control Voltage**



**LO/RF Rejection, LSB**



**Isolation**



[8] Board loss and Hybrid loss not subtracted out.



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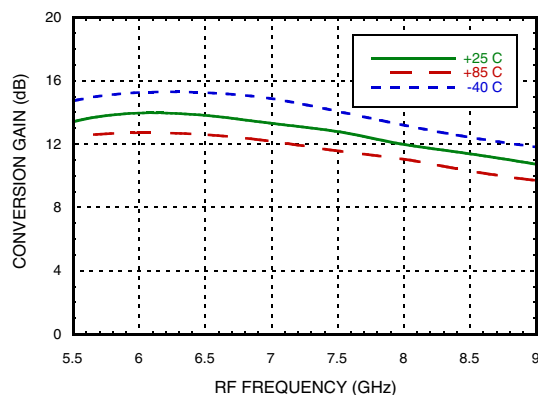


# HMC6505LC5

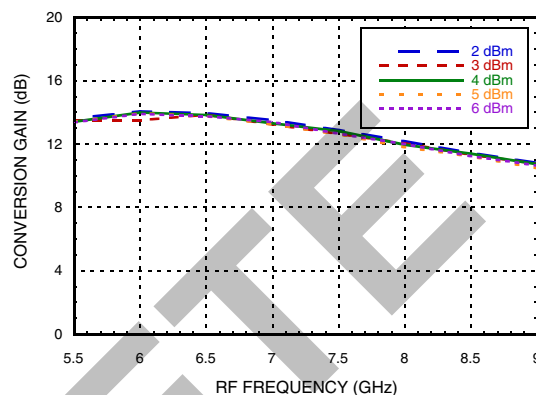
## GaAs MMIC I/Q UPCONVERTER 5.5 - 8.6 GHz

Data Taken as SSB Upconverter with External IF 90° Hybrid, IF = 2500 MHz

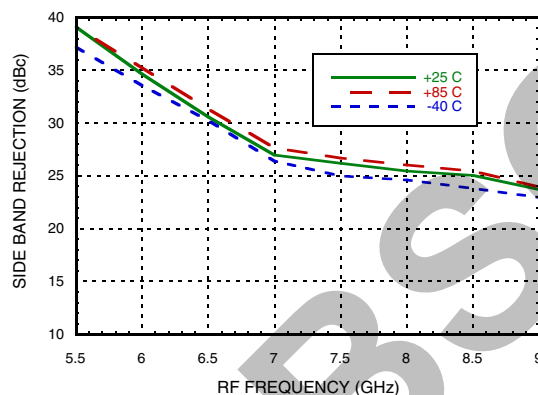
Conversion Gain, LSB vs. Temperature [8]



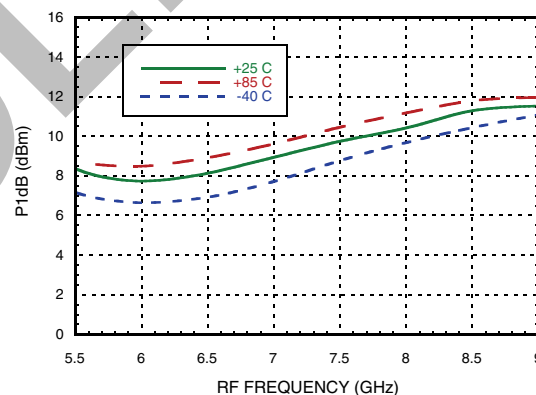
Conversion Gain, LSB vs. LO Drive [8]



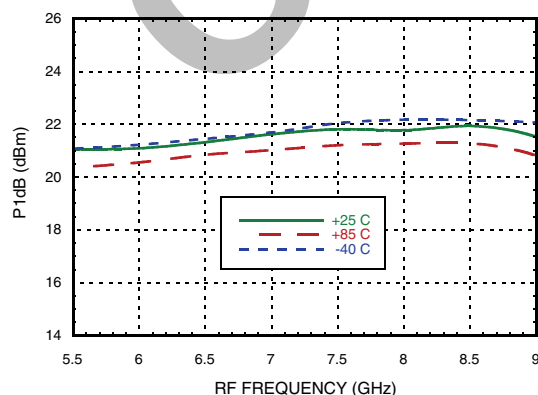
Sideband Rejection vs. Temperature



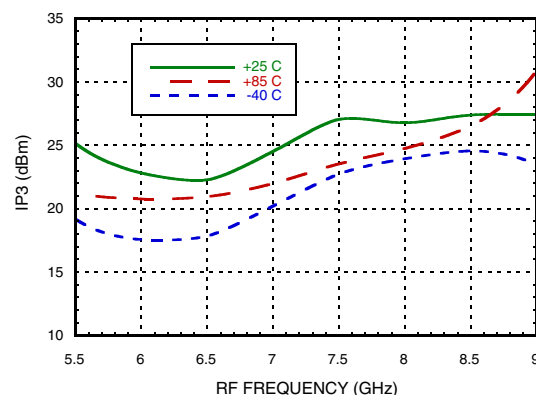
Input P1dB, LSB vs. Temperature



Output P1dB, LSB vs. Temperature



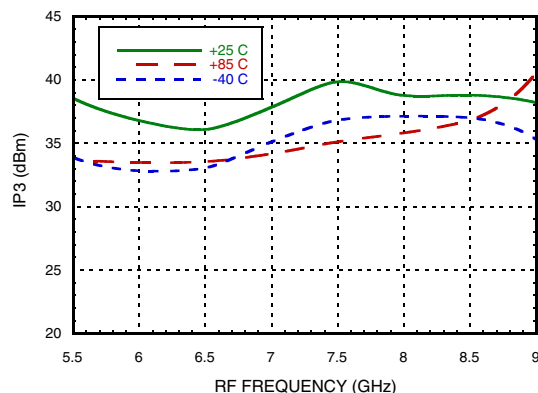
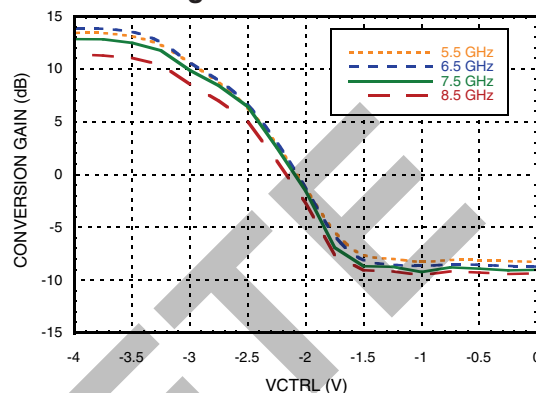
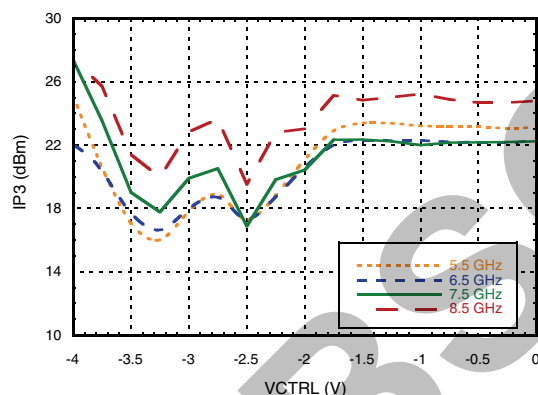
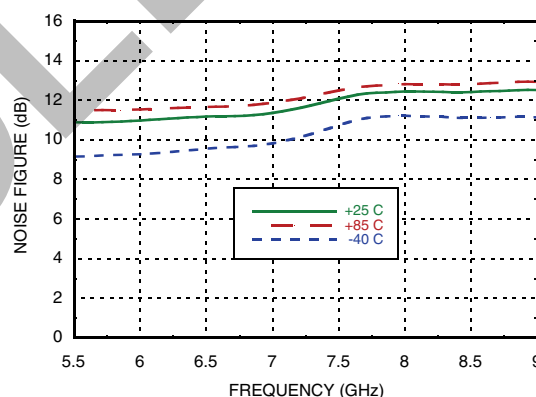
Input IP3, LSB vs. Temperature



[8] Board loss and Hybrid loss not subtracted out.

**GaAs MMIC I/Q UPCONVERTER**  
**5.5 - 8.6 GHz**

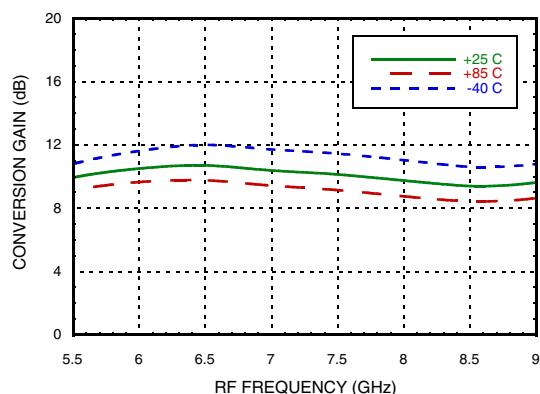
*Data Taken as SSB Upconverter with External IF 90° Hybrid, IF = 2500 MHz*

**Output IP3, LSB vs. Temperature**

**Conversion Gain, LSB vs. Control Voltage [8]**

**Input IP3, LSB vs. Control Voltage**

**Noise Figure, LSB vs. Temperature**  
**Minimum Attenuation**


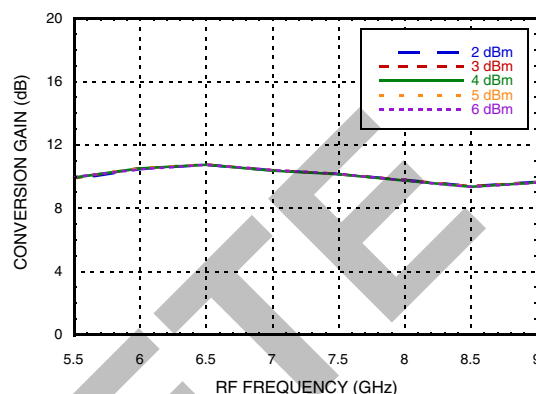
[8] Board loss and Hybrid loss not subtracted out.

*Data Taken as SSB Upconverter with External IF 90° Hybrid, IF = 350 MHz*

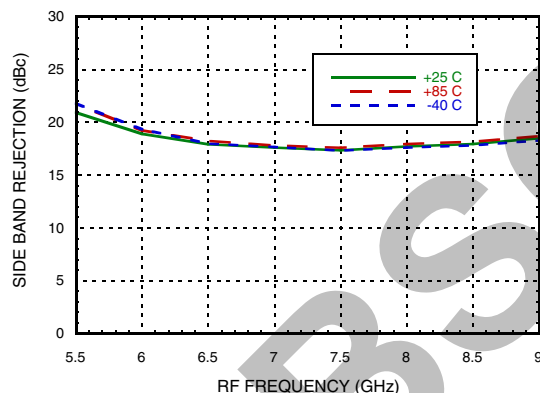
**Conversion Gain, USB vs. Temperature [8]**



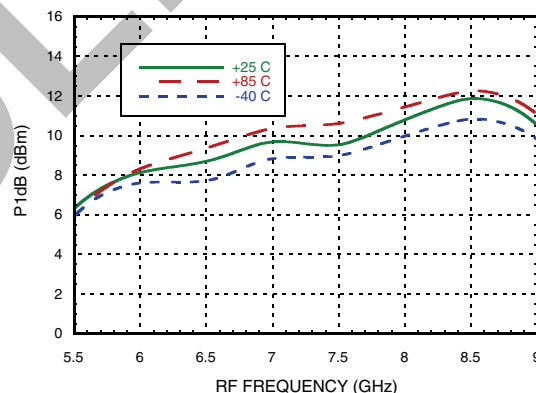
**Conversion Gain, USB vs. LO Drive [8]**



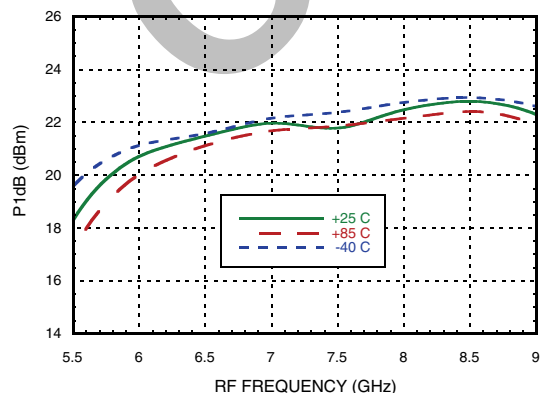
**Sideband Rejection vs. Temperature**



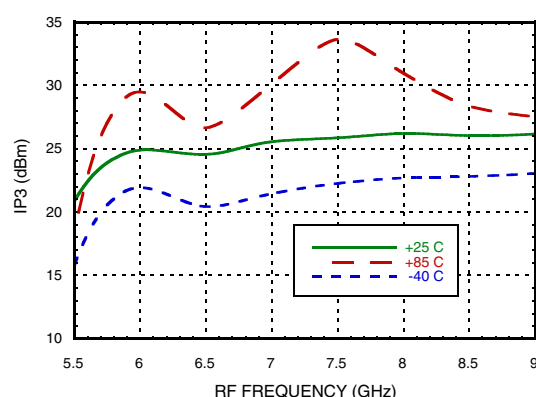
**Input P1dB, USB vs. Temperature**



**Output P1dB, USB vs. Temperature**



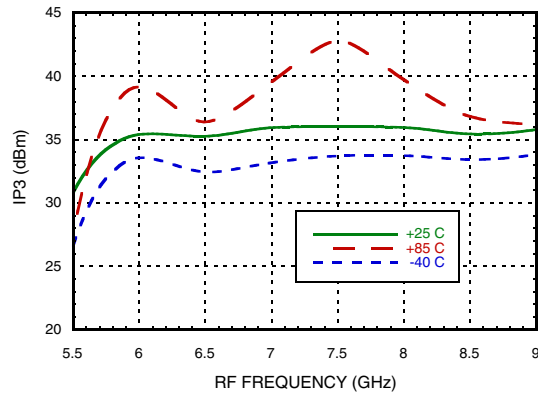
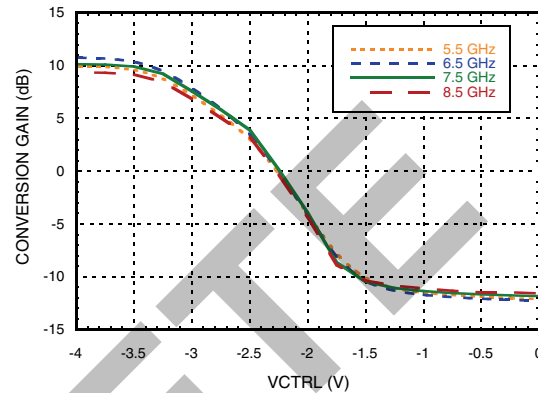
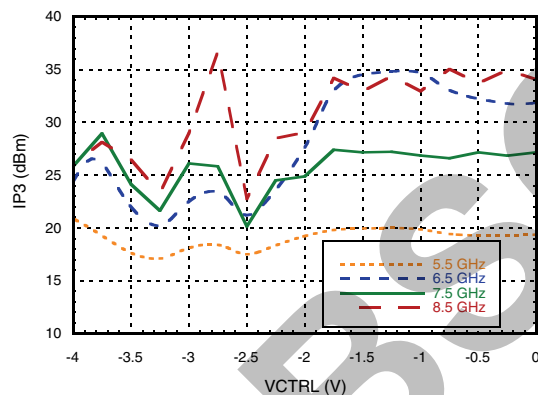
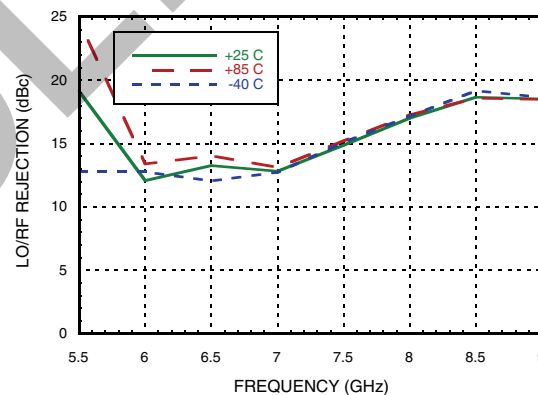
**Input IP3, USB vs. Temperature**



[8] Board loss and Hybrid loss not subtracted out.

**GaAs MMIC I/Q UPCONVERTER  
5.5 - 8.6 GHz**

**Data Taken as SSB Upconverter with External IF 90° Hybrid, IF = 350 MHz**

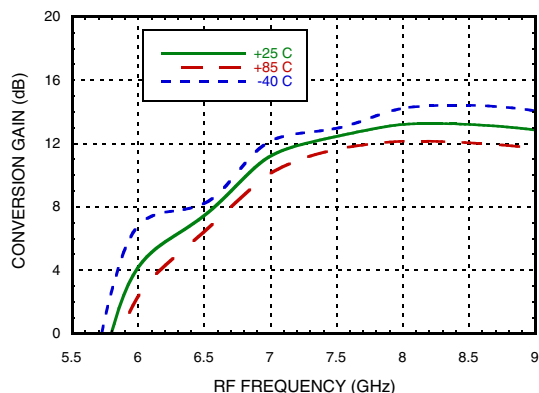
**Output IP3, USB vs. Temperature**

**Conversion Gain, USB vs.  
Control Voltage [8]**

**Input IP3, USB vs. Control Voltage**

**LO/RF Rejection, USB**


[8] Board loss and Hybrid loss not subtracted out.

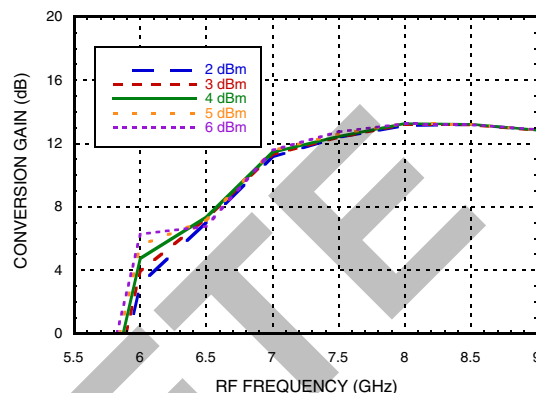


Data Taken as SSB Upconverter with External IF 90° Hybrid, IF = 2500 MHz

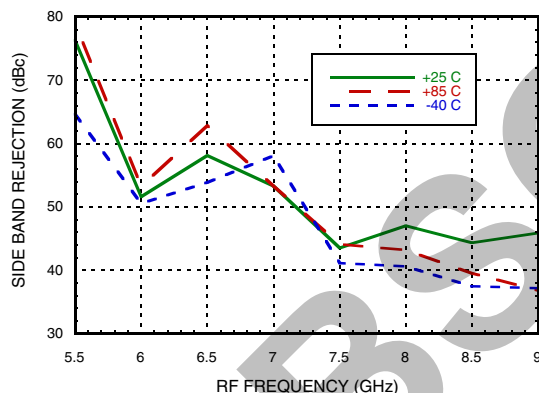
Conversion Gain, USB vs. Temperature [8]



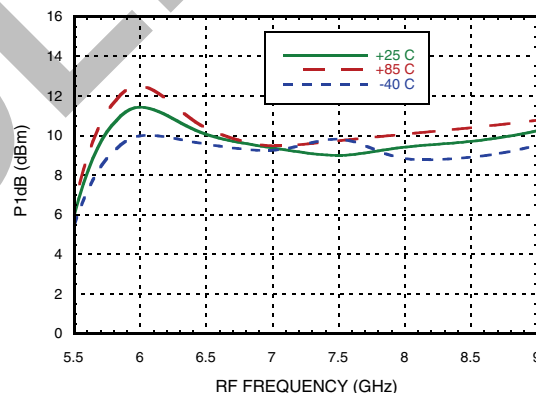
Conversion Gain, USB vs. LO Drive [8]



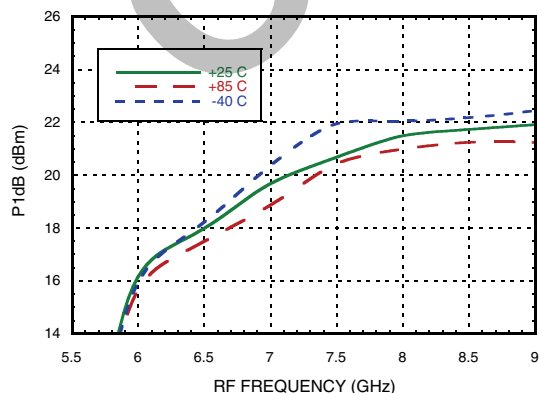
Sideband Rejection vs. Temperature



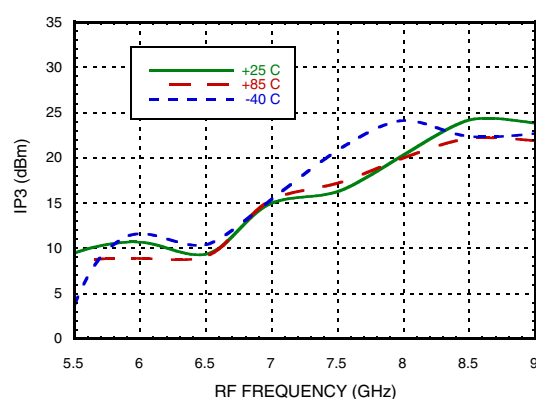
Input P1dB, USB vs. Temperature



Output P1dB, USB vs. Temperature



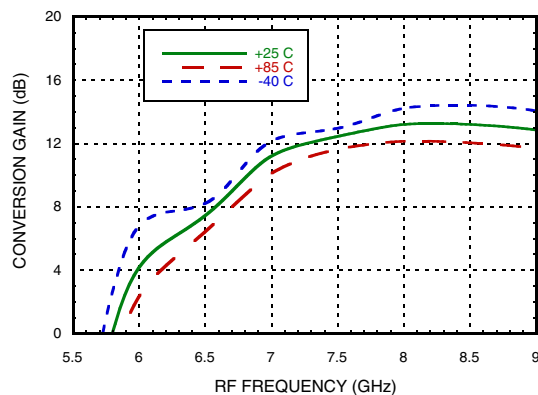
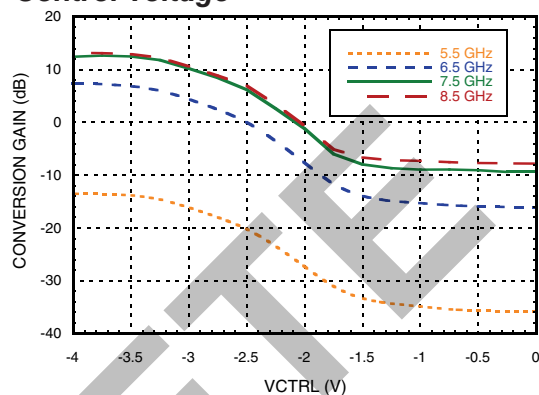
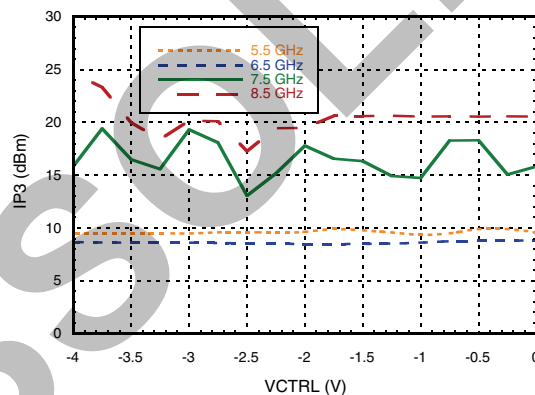
Input IP3, USB vs. Temperature



[8] Board loss and Hybrid loss not subtracted out.

**GaAs MMIC I/Q UPCONVERTER**  
**5.5 - 8.6 GHz**

*Data Taken as SSB Upconverter with External IF 90° Hybrid, IF = 2500 MHz*

**Output IP3, USB vs. Temperature**

**Conversion Gain, USB vs. Control Voltage [8]**

**Input IP3, USB vs. Control Voltage**


[8] Board loss and Hybrid loss not subtracted out.

**MxN Spurious Outputs [1][2]**

|     | nLO  |       |      |      |      |
|-----|------|-------|------|------|------|
| mIF | 0    | 1     | 2    | 3    | 4    |
| 0   | x    | 17.3  | 35.1 | 57.5 | 62.6 |
| +1  | 80.6 | 0     | 39.6 | 66.4 | 93.3 |
| +2  | 49.9 | 64.3  | 40.6 | 72.3 | 91.5 |
| +3  | 96.7 | 57.8  | 87.4 | 78.5 | 89.8 |
| +4  | 88.5 | 100.8 | 89.3 | 94.2 | 91.7 |

IF = 0.35 GHz @ -6 dBm

LO = 8.5 GHz @ 0 dBm

|     | nLO  |       |      |      |      |
|-----|------|-------|------|------|------|
| mIF | 0    | 1     | 2    | 3    | 4    |
| 0   | x    | 15.1  | 36.4 | 50.4 | 61.5 |
| +1  | 66.7 | 0     | 42.9 | 56.5 | 83.2 |
| +2  | 49.2 | 47.1  | 39.9 | 76.5 | 84.6 |
| +3  | 95.2 | 58.9  | 79.4 | 76   | 94.2 |
| +4  | 86.9 | 102.5 | 86.5 | 96.8 | 96.1 |

IF = 0.35 GHz @ -6 dBm

LO = 7.7 GHz @ 0 dBm

|     | nLO  |      |      |      |      |
|-----|------|------|------|------|------|
| mIF | 0    | 1    | 2    | 3    | 4    |
| 0   | x    | 11.6 | 23.6 | 38.4 | 60.1 |
| +1  | 59.8 | 0    | 42.9 | 45.4 | 70.9 |
| +2  | 48.5 | 50.4 | 39.4 | 79.9 | 76.7 |
| +3  | 86.9 | 61   | 87.5 | 76.2 | 94.3 |
| +4  | 85.2 | 82.4 | 86.2 | 97   | 95.7 |

IF = 0.35 GHz @ -6 dBm

LO = 7.0 GHz @ 0 dBm

**MxN Spurious Outputs [1][3]**

|     | nLO  |       |      |      |      |
|-----|------|-------|------|------|------|
| mIF | 0    | 1     | 2    | 3    | 4    |
| 0   | x    | 17.3  | 35.1 | 56.5 | 62.7 |
| -1  | 80.6 | 0     | 42.8 | 62.9 | 93   |
| -2  | 49.9 | 53.3  | 39.3 | 72.9 | 90.3 |
| -3  | 96.9 | 56    | 90   | 75   | 93   |
| -4  | 88.2 | 101.9 | 89.4 | 96.1 | 91.1 |

IF = 0.35 GHz @ -6 dBm

LO = 8.5 GHz @ 0 dBm

|     | nLO  |      |      |      |      |
|-----|------|------|------|------|------|
| mIF | 0    | 1    | 2    | 3    | 4    |
| 0   | x    | 15   | 36.4 | 50.6 | 60.1 |
| -1  | 66.6 | 0    | 48.2 | 51.4 | 82.8 |
| -2  | 49.2 | 47   | 38.1 | 79.7 | 79.9 |
| -3  | 95.9 | 56.7 | 86.7 | 75.4 | 93.1 |
| -4  | 86.9 | 94   | 88.3 | 97.4 | 93.8 |

IF = 0.35 GHz @ -6 dBm

LO = 7.7 GHz @ 0 dBm

|     | nLO  |      |      |      |      |
|-----|------|------|------|------|------|
| mIF | 0    | 1    | 2    | 3    | 4    |
| 0   | x    | 11.6 | 23.5 | 38.3 | 58.7 |
| -1  | 59.7 | 0    | 46.7 | 36.9 | 73.4 |
| -2  | 48.6 | 53   | 37.7 | 75.2 | 69.1 |
| -3  | 87   | 58   | 75   | 70.9 | 91.1 |
| -4  | 84.8 | 87   | 83.6 | 99.5 | 93.1 |

IF = 0.35 GHz @ -6 dBm

LO = 7.0 GHz @ 0 dBm

[1] Data taken without external IF 90° hybrid

[2] All values in dBc below RF power level (LO + IF) USB

[3] All values in dBc below RF power level (LO - IF) LSB

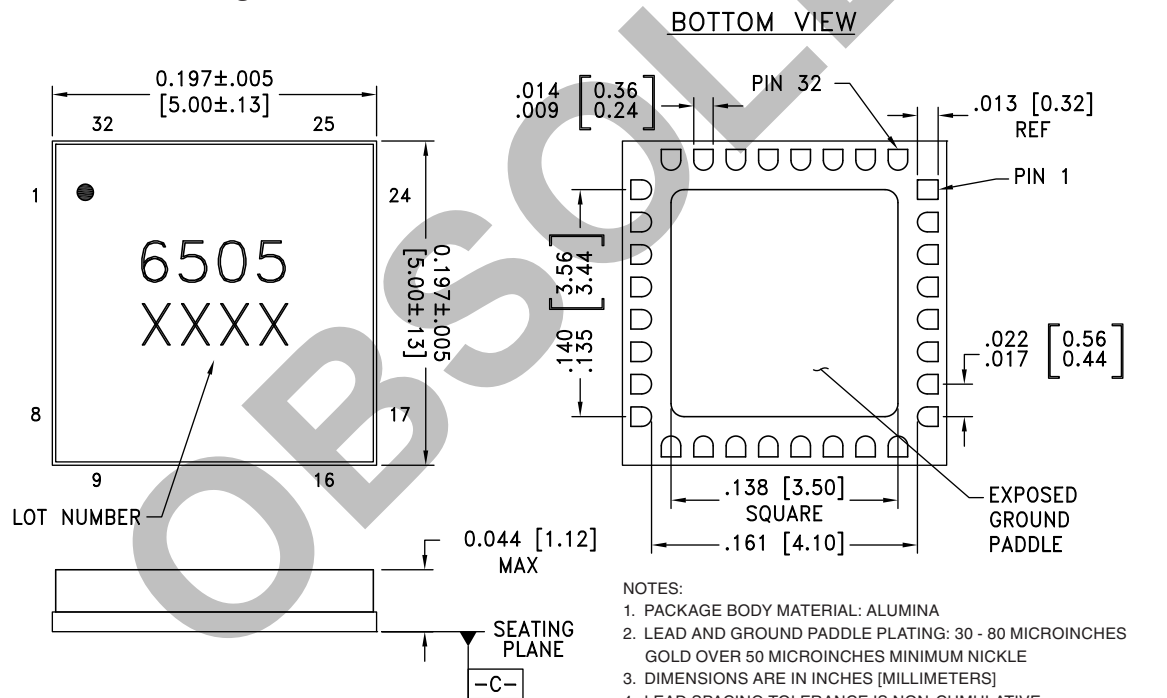
### Absolute Maximum Ratings

|                                                                           |                |
|---------------------------------------------------------------------------|----------------|
| IF Input                                                                  | +20 dBm        |
| LO Input                                                                  | +10 dBm        |
| Vctrl                                                                     | -5V to +0.3V   |
| Vdd1                                                                      | +5.5V          |
| Vdd2 and Vdd3                                                             | +5.5V          |
| Vgg                                                                       | -3V to 0V      |
| Channel Temperature                                                       | 175 °C         |
| Continuous P <sub>diss</sub> (T = 85°C)<br>(derate 18.3 mW/°C above 85°C) | 1.65 W         |
| Thermal Resistance<br>(channel to ground paddle)                          | 54.6 °C/W      |
| Storage Temperature                                                       | -65 to +150 °C |
| Operating Temperature                                                     | -40 to +85 °C  |
| ESD Sensitivity (HBM)                                                     | Class1A        |



ELECTROSTATIC SENSITIVE DEVICE  
OBSERVE HANDLING PRECAUTIONS

### Outline Drawing



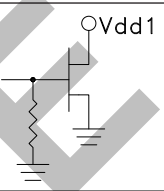
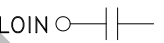
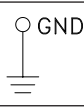
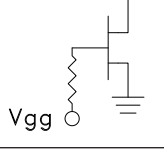
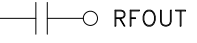
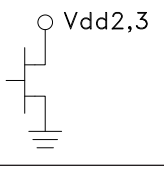
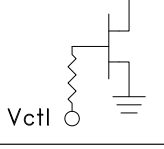
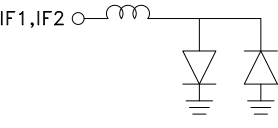
### Package Information

| Part Number | Package Body Material | Lead Finish      | MSL Rating          | Package Marking <sup>[2]</sup> |
|-------------|-----------------------|------------------|---------------------|--------------------------------|
| HMC6505LC5  | Alumina, White        | Gold over Nickel | MSL3 <sup>[1]</sup> | 6505<br>XXXX                   |

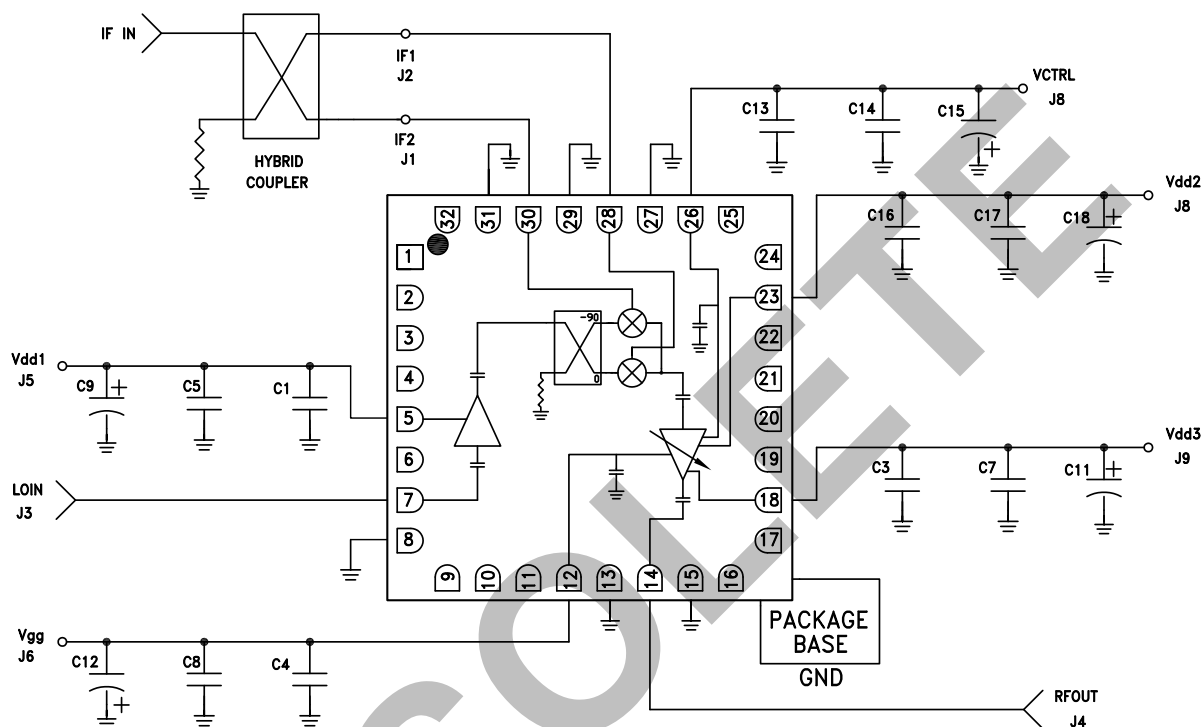
[1] Max peak reflow temperature of 260 °C

[2] 4-Digit lot number XXXX

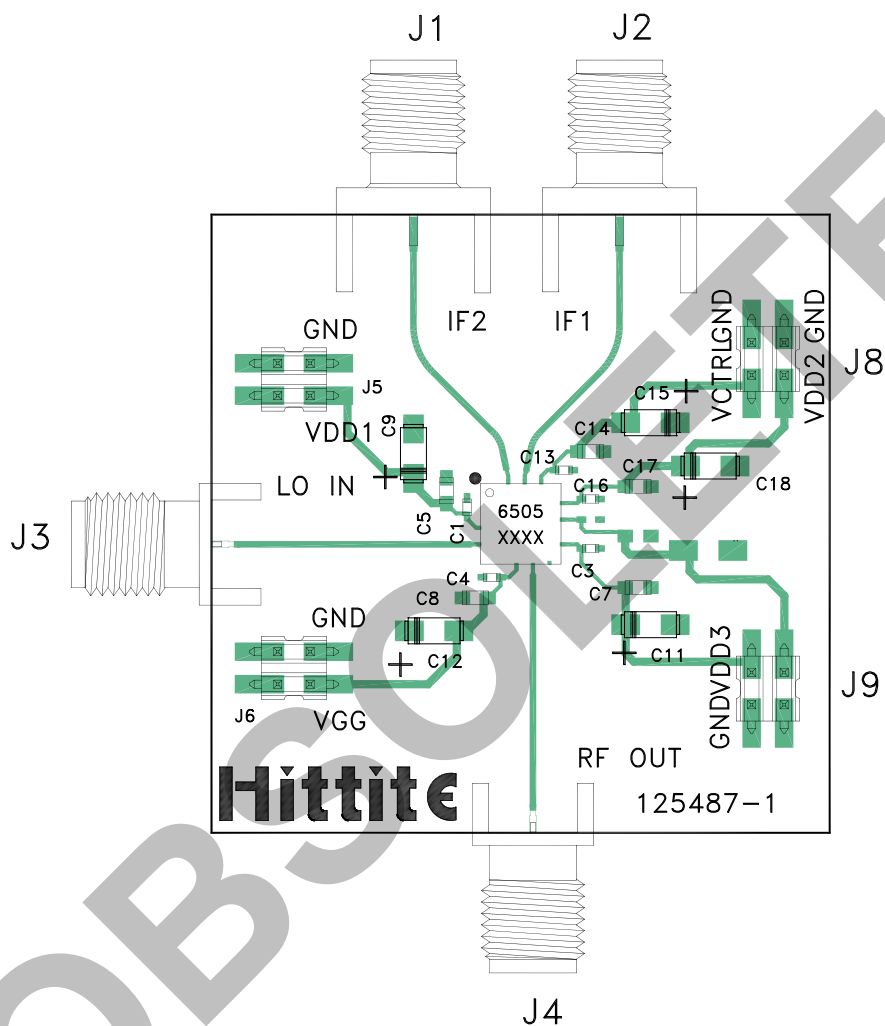
## Pin Descriptions

| Pin Number                                                 | Function      | Description                                                                                                                                                                                                                                                          | Interface Schematic                                                                   |
|------------------------------------------------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 1 - 4, 6, 9 - 11,<br>16, 17, 19, 20, 21,<br>22, 24, 25, 32 | N/C           | No connection required. The pins are not connected internally; however, all data shown herein was measured with these pins connected to RF/DC ground externally.                                                                                                     |                                                                                       |
| 5                                                          | Vdd1          | Power supply voltage for LO amplifier. See application circuit for required external components.                                                                                                                                                                     |    |
| 7                                                          | LOIN          | This pin is AC coupled and matched to 50 Ohms.                                                                                                                                                                                                                       |    |
| 8, 13, 15,<br>27, 29, 31                                   | GND           | These pins and package bottom must be connected to RF/DC ground.                                                                                                                                                                                                     |    |
| 12                                                         | Vgg           | Gate control for RF amplifier, please follow "MMIC Amplifier Biasing Procedure" application note. See application circuit for required external components.                                                                                                          |   |
| 14                                                         | RFOUT         | This pin is AC coupled and matched to 50 Ohms.                                                                                                                                                                                                                       |  |
| 18, 23                                                     | Vdd3,<br>Vdd2 | Power supply voltage for RF amplifier. See application circuit for required external components.                                                                                                                                                                     |  |
| 26                                                         | Vctrl         | Gain Control Voltage for RF Amplifier                                                                                                                                                                                                                                |  |
| 28                                                         | IF1           | Differential IF input pins. For applications not requiring operation to DC, an off chip DC blocking capacitor should be used. For operation to DC this pin must not source/sink more than 3mA of current or part non function and possible part failure will result. |  |
| 30                                                         | IF2           |                                                                                                                                                                                                                                                                      |                                                                                       |

### Typical Application



|                        |                                    |
|------------------------|------------------------------------|
| C1, C3, C4, C13, C16   | 100 pF Capacitor, 0402 Pkg.        |
| C5, C7, C8, C14, C17   | 1000 pF Capacitor, 0603 Pkg.       |
| C9, C11, C12, C15, C18 | 2.2 $\mu$ F Capacitor, Case A Pkg. |

**Evaluation PCB**

**List of Materials for Evaluation PCB Eval01-HMC6505LC5 [1]**

| Item                   | Description                   |
|------------------------|-------------------------------|
| J1, J2                 | SMA Connector                 |
| J3, J4                 | K-Connector SRI               |
| J5, J6, J8, J9         | DC Pins                       |
| C1, C3, C4, C13, C16   | 100 pF Capacitor, 0402 Pkg.   |
| C5, C7, C8, C14, C17   | 1000 pF Capacitor, 0603 Pkg.  |
| C9, C11, C12, C15, C18 | 2.2 $\mu$ F Capacitor, Case A |
| U1                     | HMC6505LC5 Upconverter        |
| PCB [2]                | 125487 Evaluation Board       |

[1] Reference this number when ordering complete evaluation PCB

[2] Circuit Board Material: Arlon 25FR, FR4 or 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 circuit board shown is available from Hittite upon request.



MICROWAVE CORPORATION v02.0413



## HMC6505LC5

**GaAs MMIC I/Q UPCONVERTER**  
**5.5 - 8.6 GHz**

### Notes:

OBSOLETE

MIXERS - I/Q MIXERS, IRMS & RECEIVERS - SMT



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