# HMC977LP4E

v02.0815

## GaAs MMIC I/Q DOWNCONVERTER 20 - 28 GHz

### Typical Applications

The HMC977LP4E is ideal for:

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

### Features

Conversion Gain: 14 dB

Image Rejection: 21 dBc

2x LO to RF Isolation: 45 dB

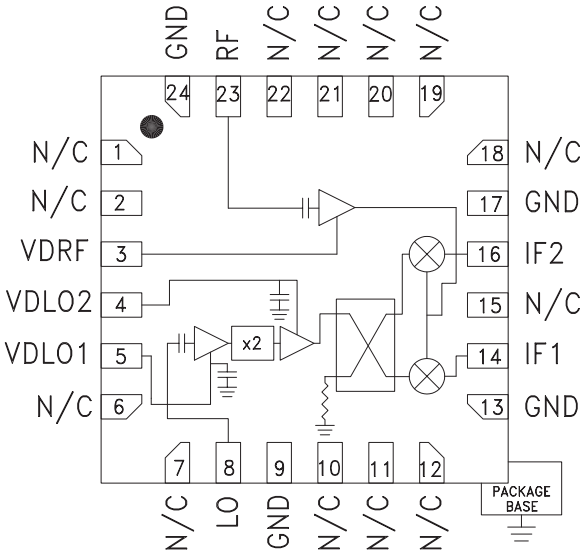
Noise Figure: 2.5 dB

Input Third-Order Intercept: 1 dBm

LO Drive Range: 2 to 6 dBm

24 Lead 4 mm x 4 mm SMT Package

### Functional Diagram




### General Description

The HMC977LP4E is a compact GaAs MMIC I/Q downconverter in a leadless RoHS compliant SMT package. This device provides a small signal conversion gain of 14 dB with a noise figure of 2.5 dB and 21 dBc of image rejection. The HMC977LP4E utilizes a low noise amplifier (LNA) followed by an image reject mixer which is driven by an active 2x multiplier. The image reject mixer eliminates the need for a filter following the LNA and removes thermal noise at the image frequency. I and Q mixer outputs are provided and an external 90° hybrid is needed to select the required sideband. The HMC977LP4E is a much smaller alternative to hybrid style image reject mixer downconverter assemblies, and is compatible with surface mount manufacturing techniques.

### Electrical Specifications, $T_A$ = +25 °C, IF = 1000 MHz, LO = 6 dBm, Vdd = 3.5 Vdc, USB [1]

| Parameter | Min. | Typ. | Max. | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|
| RF Frequency Range | 20 | | 26.5 | 26.5 | | 28 | GHz |
| LO Frequency Range | 8.3 | | 15 | 11.5 | | 15.7 | GHz |
| IF Frequency Range | DC | | 3.5 | DC | | 3.5 | GHz |
| LO Drive Range | 2 | | 6 | 2 | | 6 | dBm |
| Conversion Gain (As IRM) | 11 | 14 | | 11 | 14 | | dB |
| Noise Figure | | 2.5 | | | 3.0 | | dB |
| Image Rejection | | 21 | | | 20 | | dBc |
| Input Power for 1 dB Compression (P1dB) | | -8 | | | -7 | | dBm |
| 2x LO to RF Isolation | 35 | 45 | | 34 | 39 | | dB |
| 2x LO to IF Isolation | | 20 | | | 30 | | dB |
| Input Third-Order Intercept (IP3) | | 1 | | | 3 | | dBm |
| Amplitude Balance [2] | | 0.3 | | | 0.3 | | dB |
| Phase Balance [2] | | 17 | | | 12 | | Degree |
| Total Supply Current | | 170 | 210 | | 170 | 210 | mA |

[1] Unless otherwise noted all measurements performed as downconverter with upper sideband selected and external 90° hybrid at the IF ports.
[2] Data taken without external 90° hybrid at the IF ports.



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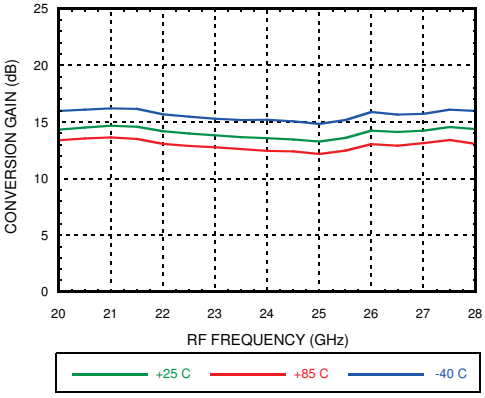
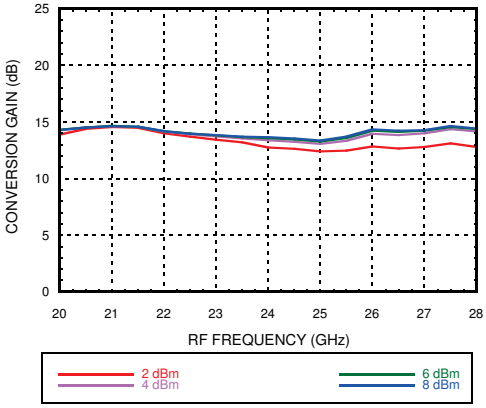
# GaAs MMIC I/Q DOWNCONVERTER 20 - 28 GHz

## Data Taken As IRM With External 90° Hybrid at The IF Ports, IF = 1000 MHz, USB

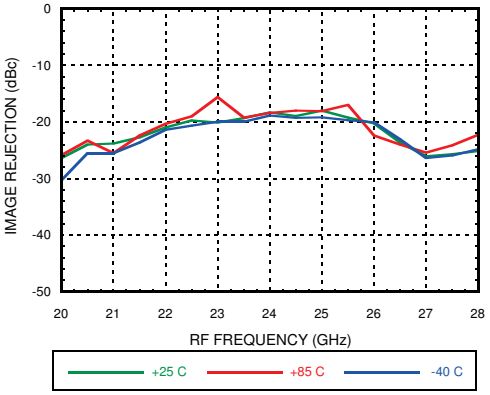
### Conversion Gain vs. RF Frequency Over Temperature, LO Drive = 6 dBm



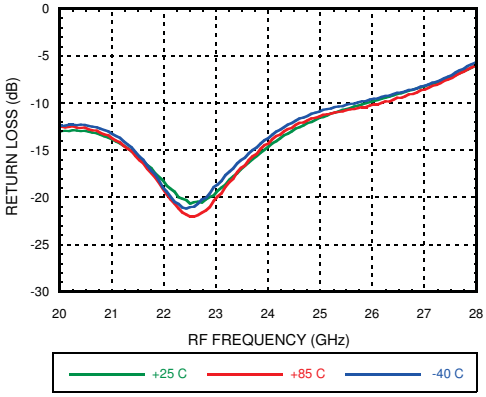

### Conversion Gain vs. RF Frequency at Various LO Drives



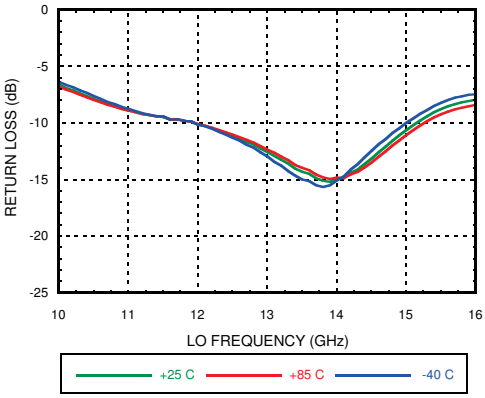

### Image Rejection vs. RF Frequency Over Temperature, LO Drive = 6 dBm



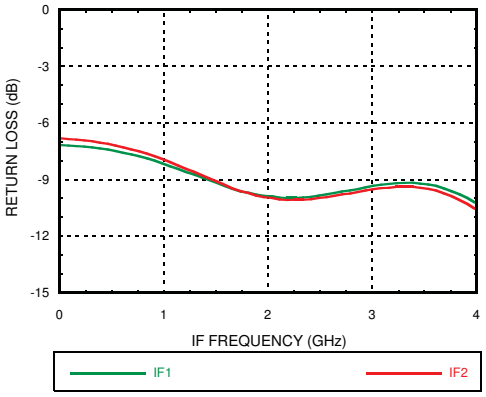

### RF Return Loss vs. RF Frequency Over Temperature, LO Frequency = 24 GHz




### LO Return Loss vs. LO Frequency Over Temperature, LO Drive = 6 dBm




### IF Return Loss vs. IF Frequency [1] LO Frequency = 24 GHz, LO Drive = 6 dBm




[1] Data taken without external 90° hybrid



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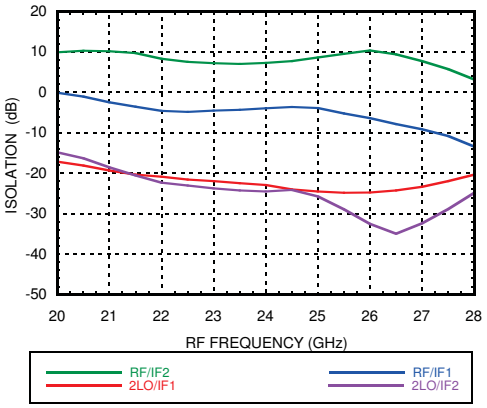
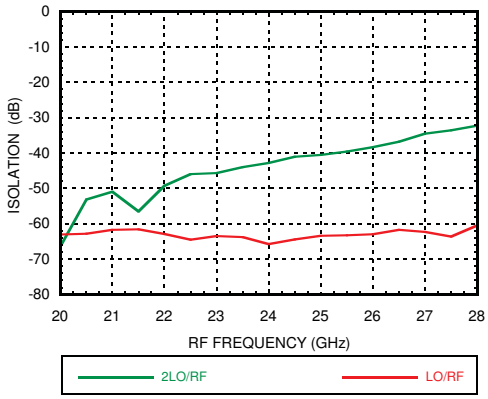
### Data Taken As IRM With External 90° Hybrid at The IF Ports, IF = 1000 MHz, USB

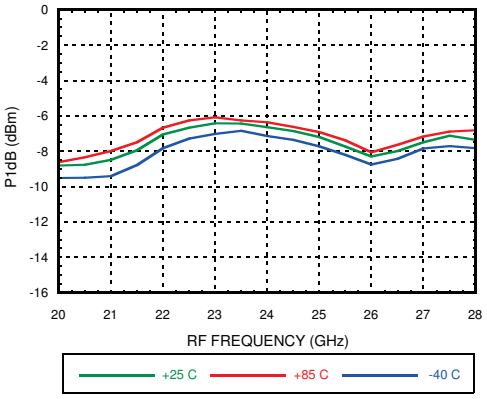
### RF to IF and LO to IF Isolation [1] vs. RF Frequency, LO Drive = 6 dBm



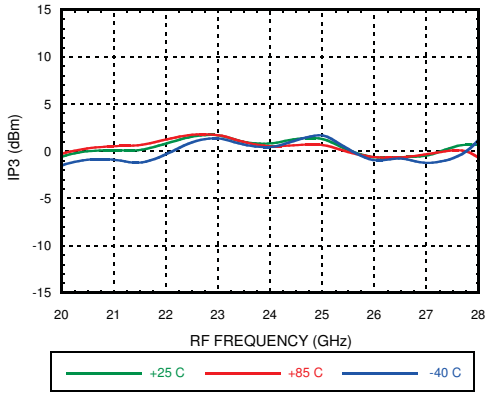

### LO to RF Isolation vs. RF Frequency [1] LO Drive = 6 dBm



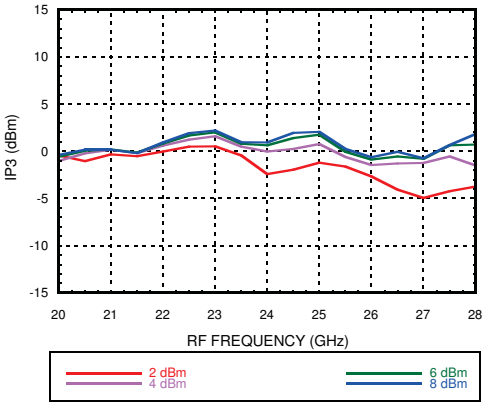

### Input P1dB vs. RF Frequency Over Temperature, LO Drive = 6 dBm



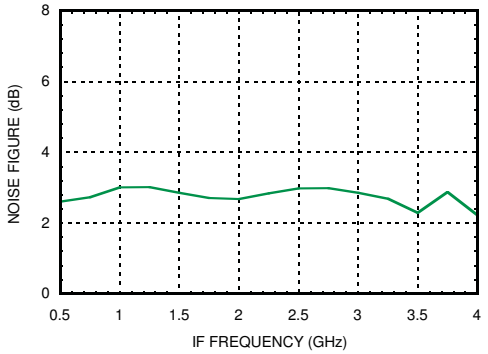

### Input IP3 vs. RF Frequency Over Temperature, LO Drive = 6 dBm




### Input IP3 vs. RF Frequency at Various LO Drives




### Noise Figure vs. IF Frequency, LO Frequency = 10 GHz, LO Drive = 6 dBm [1]




[1] Data taken without external IF 90° hybrid



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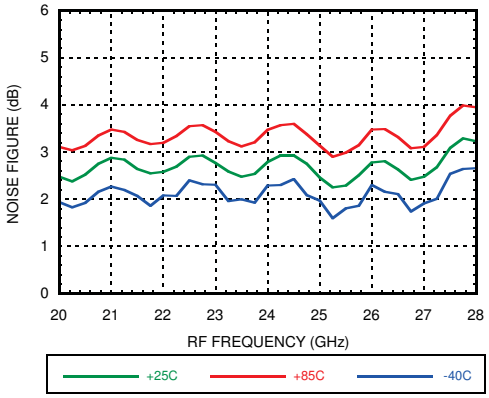
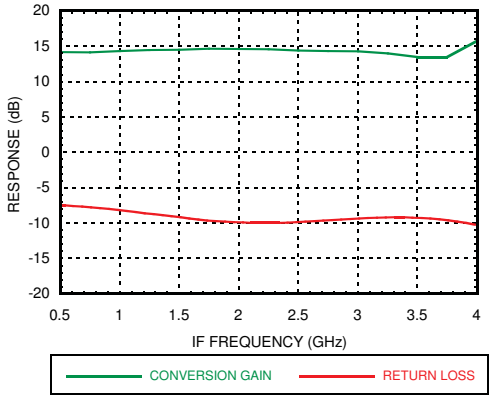
# GaAs MMIC I/Q DOWNCONVERTER 20 - 28 GHz

## Quadrature Channel Data Taken Without 90° Hybrid at The IF Ports, IF = 1000 MHz, USB

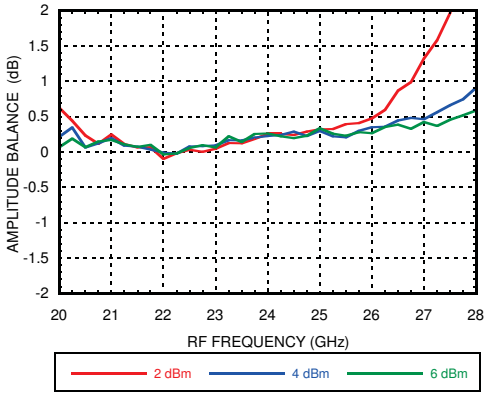
### Noise Figure vs. RF Frequency Over Temperature, LO Drive = 6 dBm



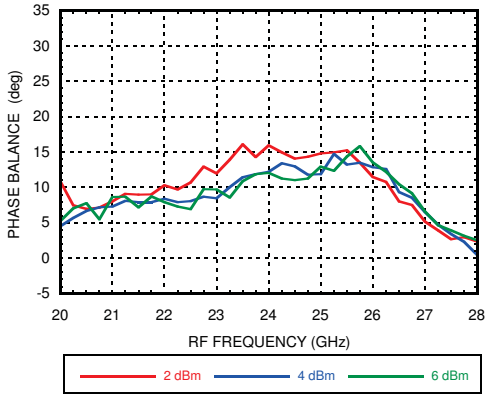

### Conversion Gain and Return Loss Over IF Bandwidth




### Amplitude Balance vs. RF Frequency at Various LO Drives




### Phase Balance vs. RF Frequency at Various LO Drives




### M x N Spurious Outputs, IF = 1000MHz

| | nLO | | | | |
|---|---|---|---|---|---|
| mRF | 0 | 1 | 2 | 3 | 4 |
| 0 | x | -22.6 | -7.4 | -28.8 | -37.2 |
| 1 | -20 | -29.3 | 0 | -33 | -37.3 |
| 2 | -72.6 | -72.6 | -57.6 | -43.6 | -51.6 |
| 3 | x | x | -74.6 | -74.6 | -74.6 |
| 4 | x | x | x | x | x |

RF = 24 GHz, RF Input Power = -20 dBm
LO Frequency = 11.5 GHz, LO Drive = 4 dBm
All values are in dBc below IF power level (RF -2 x LO)
Spur values are (M x RF) - (N x LO)





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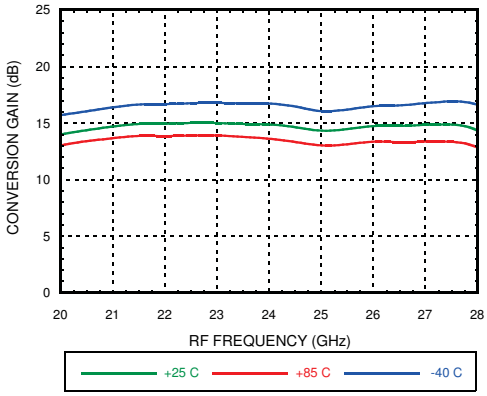
# GaAs MMIC I/Q DOWNCONVERTER 20 - 28 GHz

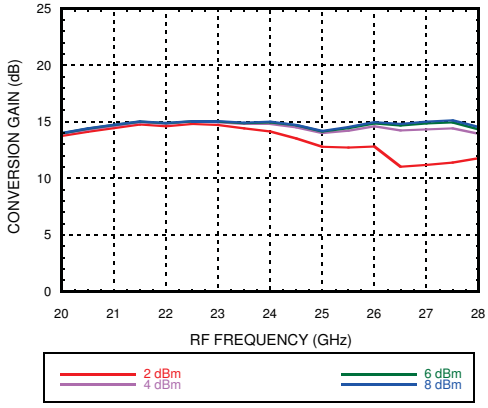


## Data Taken As IRM With External 90° Hybrid at The IF Ports, IF = 1000 MHz, LSB

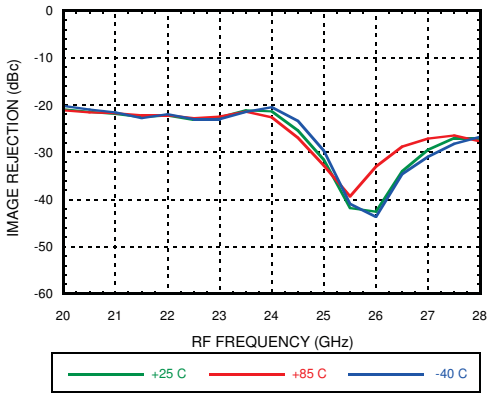
### Conversion Gain vs. RF Frequency Over Temperature, LO Drive = 6 dBm



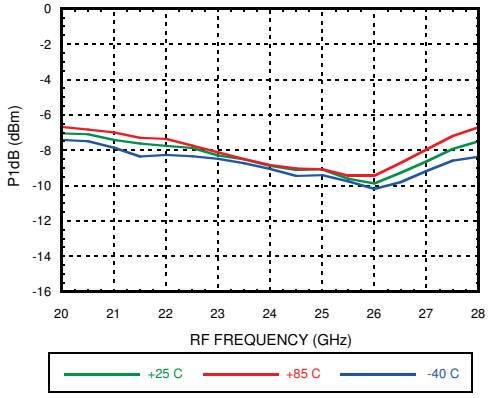

### Conversion Gain vs. RF Frequency at Various LO Drives



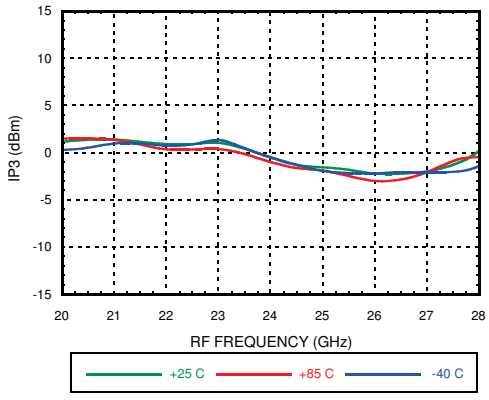

### Image Rejection vs. RF Frequency Over Temperature, LO Drive = 6 dBm



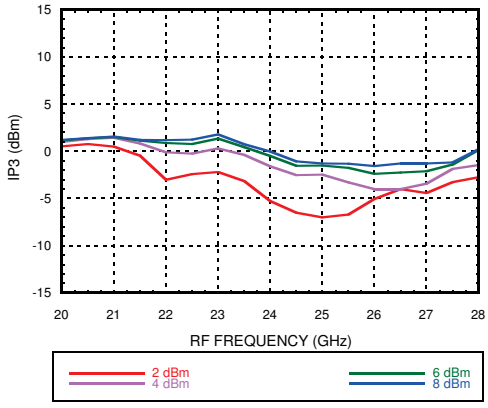

### Input P1dB vs. RF Frequency Over Temperature, LO Drive = 6 dBm




### Input IP3 vs. RF Frequency Over Temperature, LO Drive = 6 dBm




### Input IP3 vs. RF Frequency at Various LO Drives



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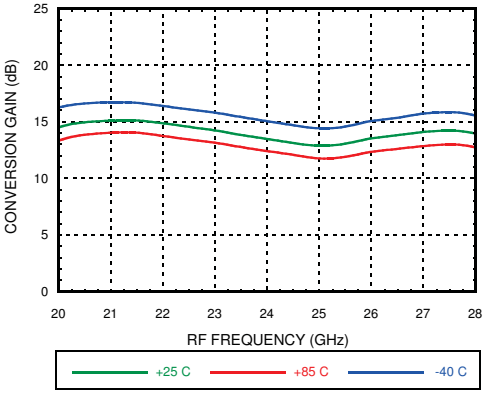
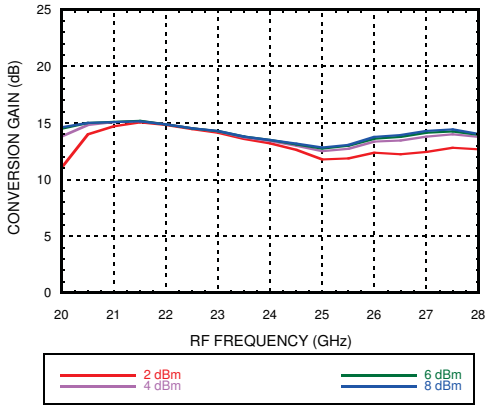
## GaAs MMIC I/Q DOWNCONVERTER 20 - 28 GHz

### Data Taken As IRM With External 90° Hybrid at The IF Ports, IF = 2000 MHz, USB

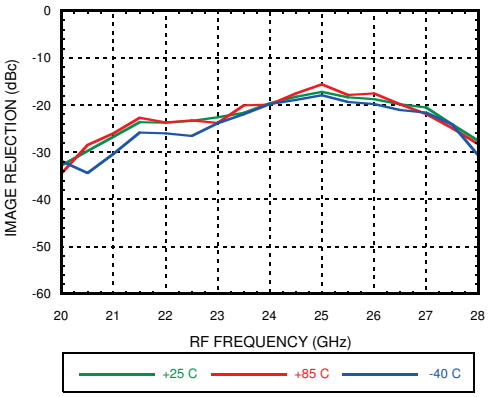
#### Conversion Gain vs. RF Frequency Over Temperature, LO Drive = 6 dBm



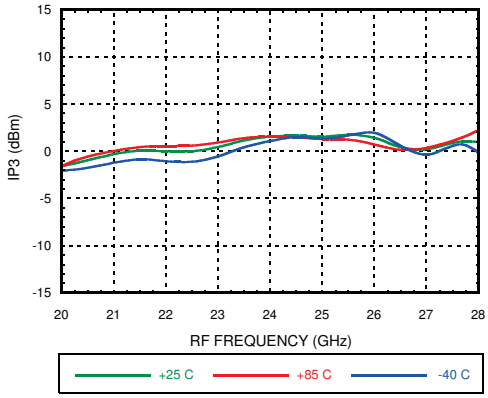

#### Conversion Gain vs. RF Frequency at Various LO Drives



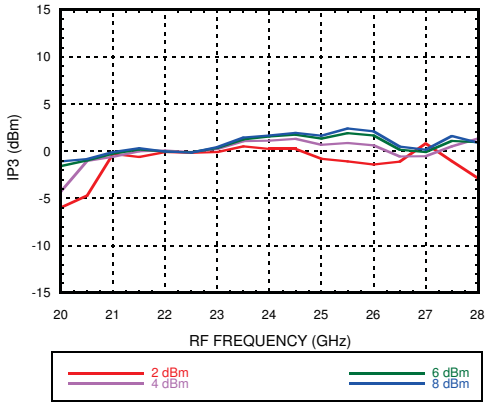

#### Image Rejection vs. RF Frequency Over Temperature, LO Drive = 6 dBm




#### Input IP3 vs. RF Frequency Over Temperature, LO Drive = 6 dBm




#### Input IP3 vs. RF Frequency at Various LO Drives





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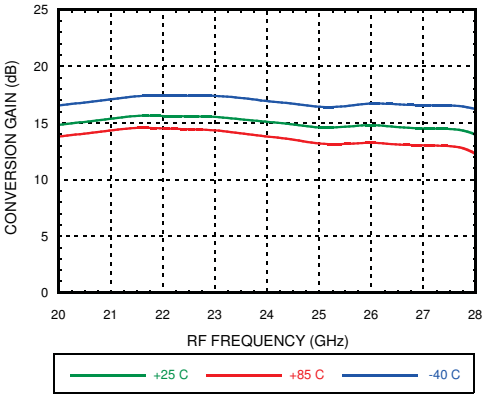
## GaAs MMIC I/Q DOWNCONVERTER 20 - 28 GHz

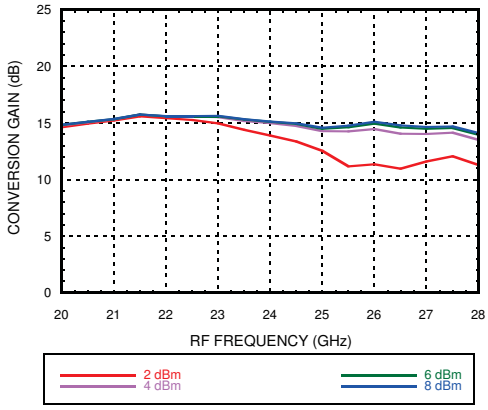


### Data Taken As IRM With External 90° Hybrid at The IF Ports, IF = 2000 MHz, LSB

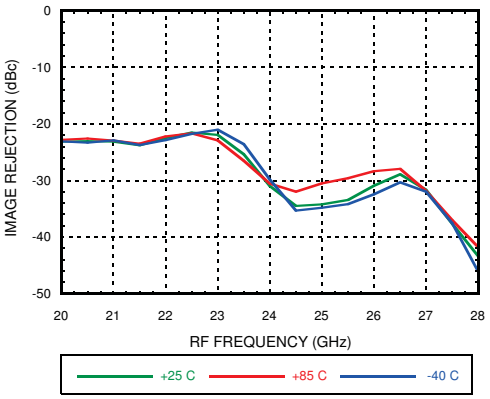
#### Conversion Gain vs. RF Frequency Over Temperature, LO Drive = 6 dBm



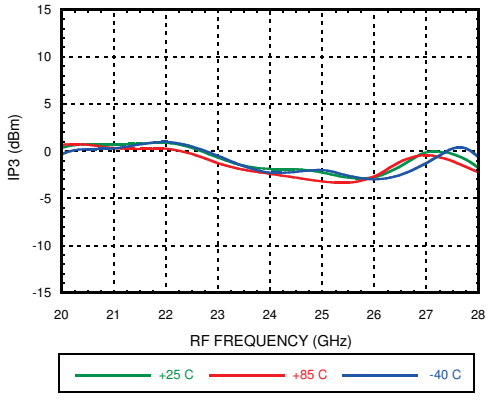

#### Conversion Gain vs. RF Frequency at Various LO Drives



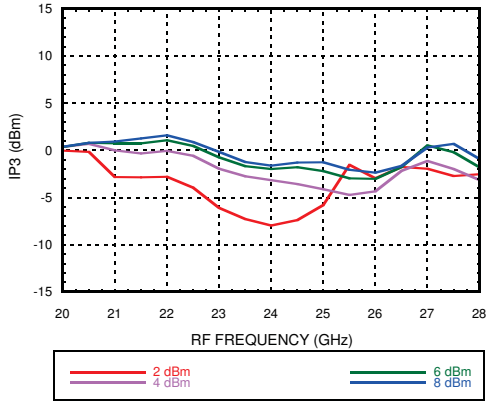

#### Image Rejection vs. RF Frequency Over Temperature, LO Drive = 6 dBm




#### Input IP3 vs. RF Frequency Over Temperature, LO Drive = 6 dBm




#### Input IP3 vs. RF Frequency at Various LO Drives



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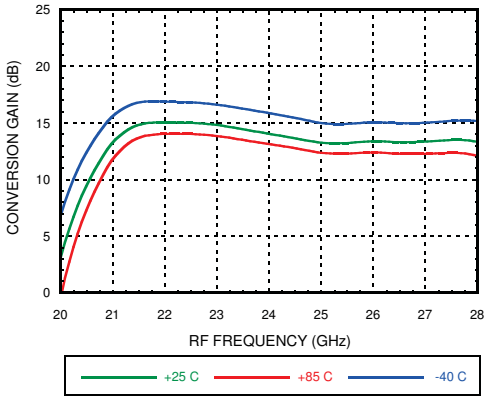
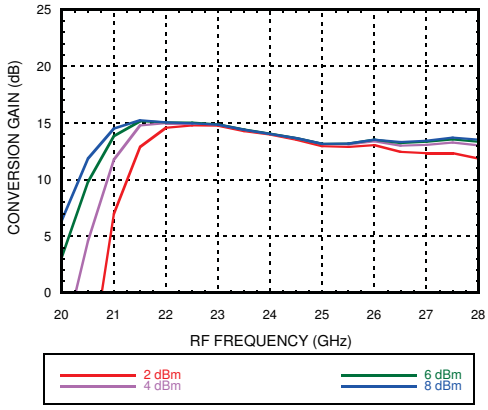
## GaAs MMIC I/Q DOWNCONVERTER 20 - 28 GHz

### Data Taken As IRM With External 90° Hybrid at The IF Ports, IF = 3300 MHz, USB

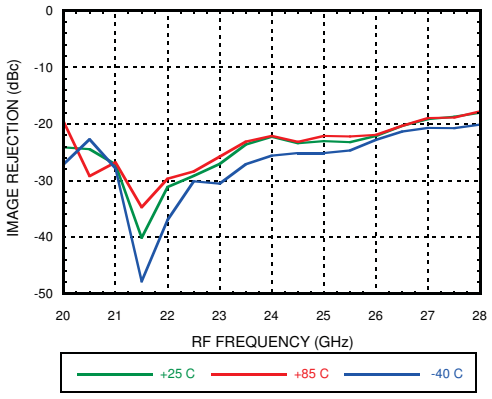
#### Conversion Gain vs. RF Frequency Over Temperature, LO Drive = 6 dBm



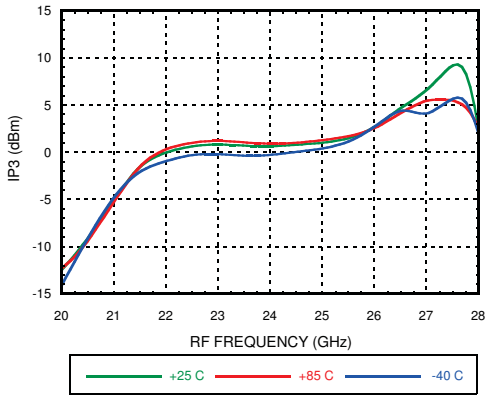

#### Conversion Gain vs. RF Frequency at Various LO Drives



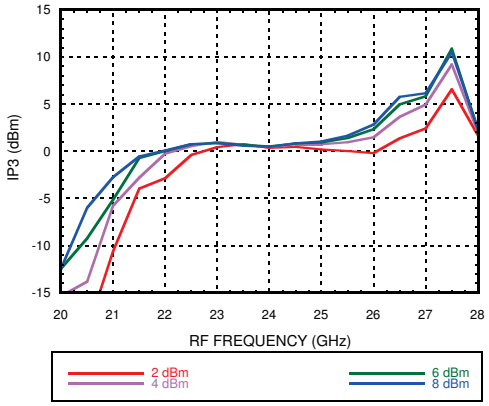

#### Image Rejection vs. RF Frequency Over Temperature, LO Drive = 6 dBm




#### Input IP3 vs. RF Frequency Over Temperature, LO Drive = 6 dBm




#### Input IP3 vs. RF Frequency at Various LO Drives





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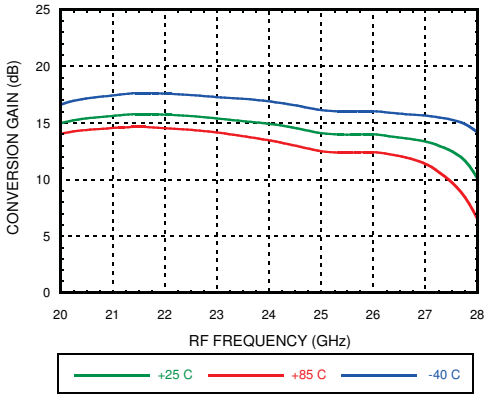
## GaAs MMIC I/Q DOWNCONVERTER 20 - 28 GHz

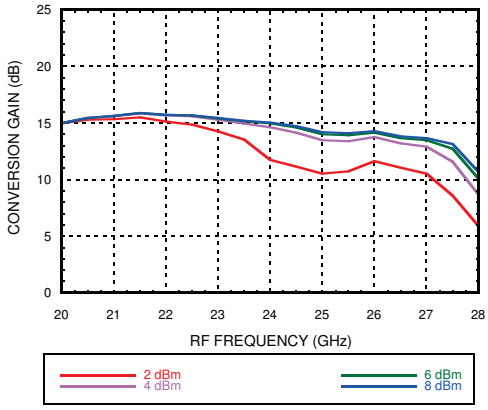


### Data Taken As IRM With External 90° Hybrid at The IF Ports, IF = 3300 MHz, LSB

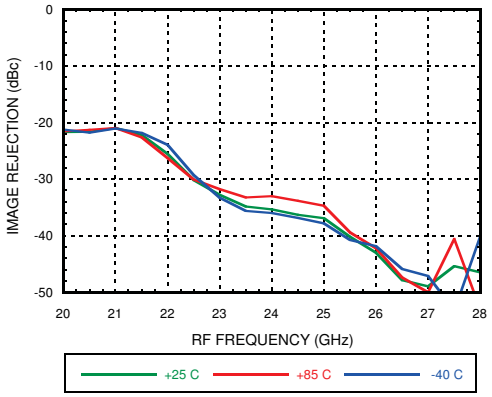
#### Conversion Gain vs. RF Frequency Over Temperature, LO Drive = 6 dBm



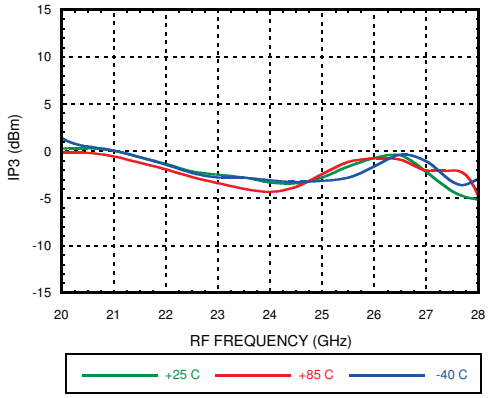

#### Conversion Gain vs. RF Frequency at Various LO Drives



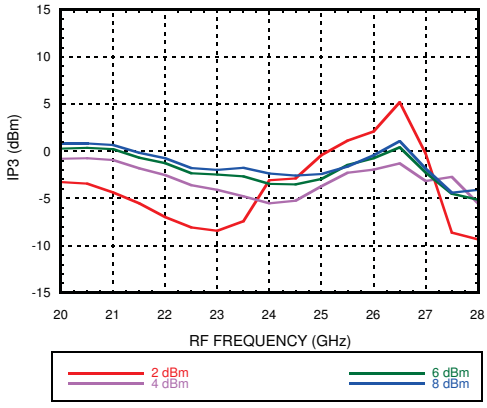

#### Image Rejection vs. RF Frequency Over Temperature, LO Drive = 6 dBm




#### Input IP3 vs. RF Frequency Over Temperature, LO Drive = 6 dBm




#### Input IP3 vs. RF Frequency at Various LO Drives



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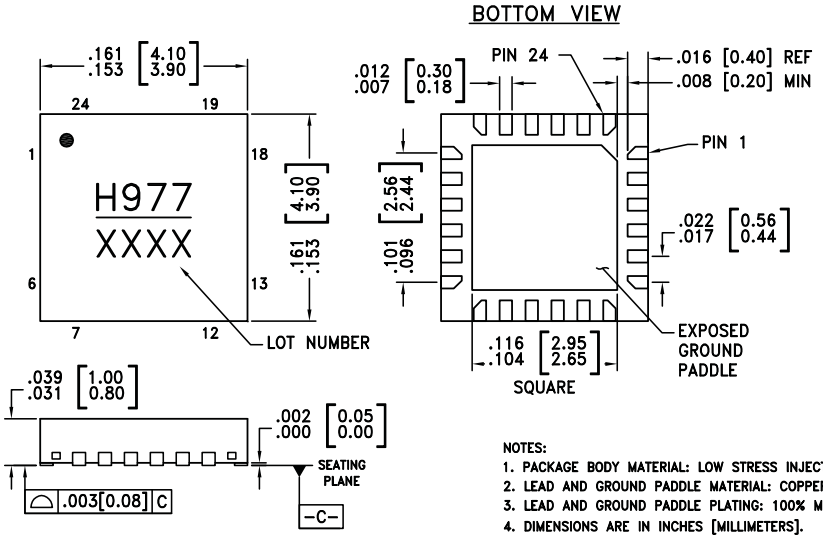
## Absolute Maximum Ratings

| | |
|---|---|
| RF Input Power | 2 dBm |
| LO Drive | 10 dBm |
| Drain Bias (Vdd) | 5.0 V |
| Channel Temperature | 175 °C |
| Continuous Pdiss (T=85°C) (derate 17.7 mW/°C above 85°C) | 1.6 W |
| Thermal Resistance ($R_{TH}$) (channel to package bottom) | 56.3 °C/W |
| Storage Temperature Range | -65 °C to +150 °C |
| Operating Temperature Range | -40 °C to +85 °C |
| ESD Sensitivity (HBM) | Class 1A (250 V) |

ELECTROSTATIC SENSITIVE DEVICE
OBSERVE HANDLING PRECAUTIONS

## Outline Drawing




NOTES:
1. PACKAGE BODY MATERIAL: LOW STRESS INJECTION MOLDED PLASTIC SILICA AND SILICON IMPREGNATED.
2. LEAD AND GROUND PADDLE MATERIAL: COPPER ALLOY.
3. LEAD AND GROUND PADDLE PLATING: 100% MATTE TIN
4. DIMENSIONS ARE IN INCHES [MILLIMETERS].
5. LEAD SPACING TOLERANCE IS NON-CUMULATIVE.
6. CHARACTERS TO BE HELVETICA MEDIUM, .025 HIGH, WHITE INK, OR LASER MARK LOCATED APPROX. AS SHOWN.
7. PAD BURR LENGTH SHALL BE 0.15mm MAX. PAD BURR HEIGHT SHALL BE 0.05mm MAX.
8. PACKAGE WARP SHALL NOT EXCEED 0.05mm
9. ALL GROUND LEADS AND GROUND PADDLE MUST BE SOLDERED TO PCB RF GROUND.
10. REFER TO HITTITE APPLICATION NOTE FOR SUGGESTED PCB LAND PATTERN.

## Package Information

| Part Number | Package Body Material | Lead Finish | MSL Rating | Package Marking [1] |
|---|---|---|---|---|
| HMC977LP4E | RoHS-Compliant Low Stress Injection Molded Plastic | 100% Matte Sn | MSL1 [2] | H977<br>XXXX |

[1] 4-Digit lot number XXXX
[2] Max peak reflow temperature of 260 °C



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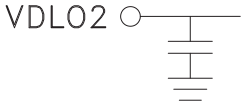
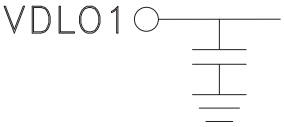
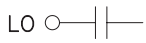
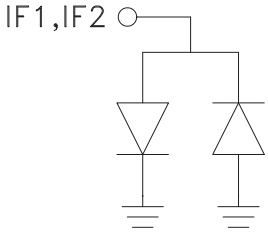
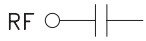
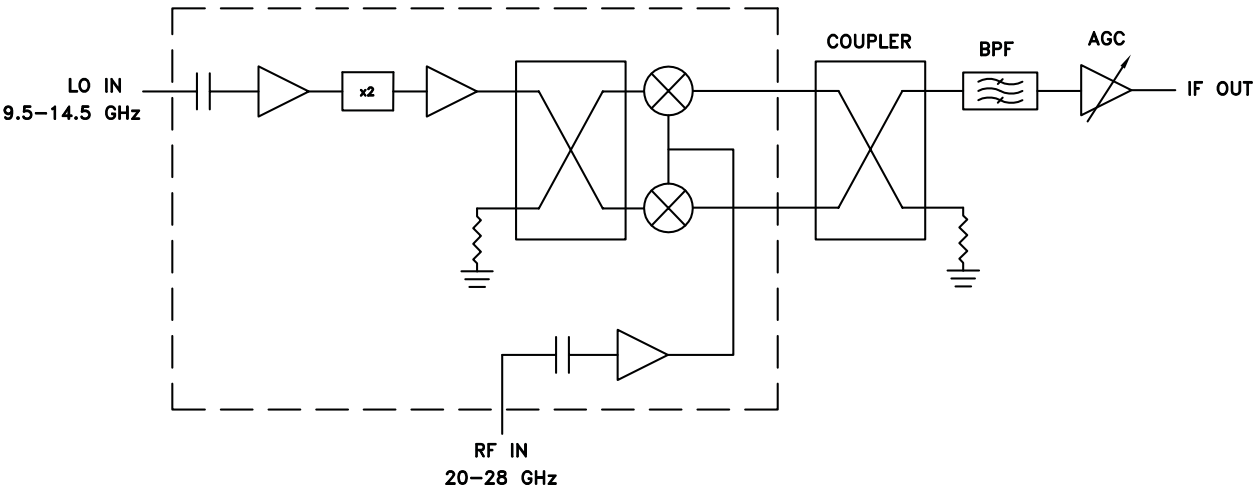
## Pin Descriptions

| Pin Number | Function | Description | Interface Schematic |
|---|---|---|---|
| 1, 2, 6, 7, 10 - 12, 15,18 - 22 | N/C | No Connection. The pins are not connected internally. | |
| 3 | VDRF | Power supply for the RF low noise amplifier. |   |
| 4 | VDLO2 | Power supply for the second stage LO amplifier. |   |
| 5 | VDLO1 | Power supply for the first stage LO amplifier. |   |
| 8 | LO | Local Oscillator. This pin is ac-coupled and matched to 50 Ohms. |   |
| 9, 13, 17, 24 | GND | Ground Connect. Connect these pins and the package bottom to RF/dc ground. |   |
| 16 | IF2 | Second and First Intermediate Frequency Port. These pins are dc-coupled. For applications not requiring operation to dc, block these pins externally using a series capacitor with a value chosen to pass the necessary IF frequency range. For operation to dc, these pins must not source or sink more than 3 mA of current or device non-functionality or device failure may result. |   |
| 14 | IF1 | | |
| 23 | RF | Radio Frequency Port. This pin is ac-coupled and matched to 50 Ohms. |   |

## Typical Application Circuit



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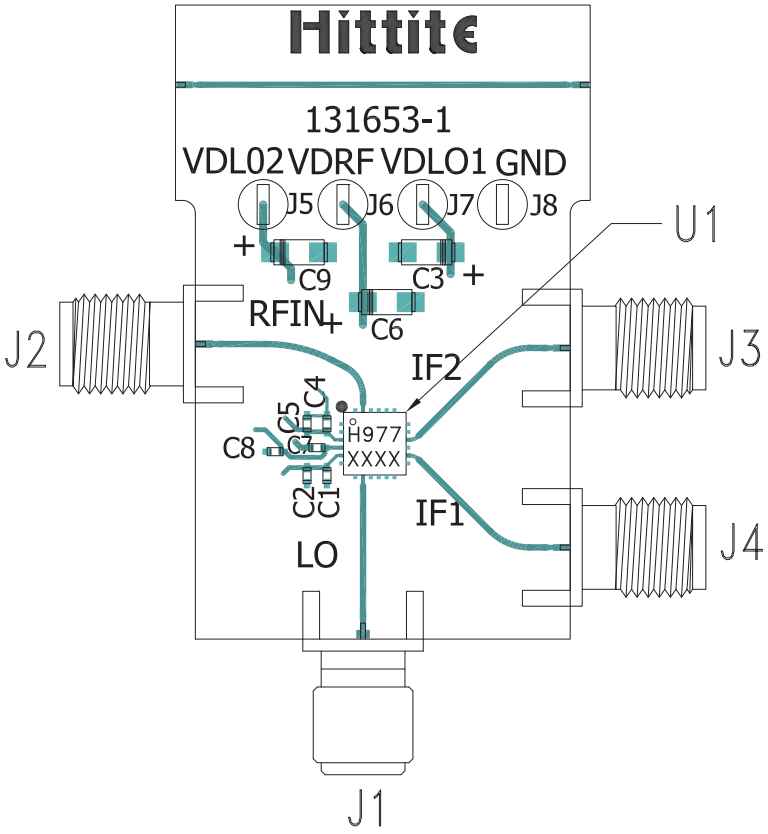
## Evaluation PCB




## List of Materials for Evaluation PCB 131656 [1]

| Item | Description |
|---|---|
| J1 | PCB Mount SMA RF Connector, SRI |
| J2, J3 | PCB Mount K Connector, SRI |
| J5 - J8 | DC Pin |
| C1, C4, C7 | 100 pF Capacitor, 0402 Pkg. |
| C2, C5, C8 | 10 nF Capacitor, 0402 Pkg. |
| C3, C6, C9 | 4.7 µF Capacitor, Case A Pkg. |
| U1 | HMC977LP4E |
| PCB [2] | 161653 Evaluation Board |

[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 circuit board shown is available from Analog Devices upon request.



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