ANALOG DEVICES

# 2.5 GHz to 8.5 GHz, I/Q Mixer

Data Sheet

# HMC8193

## FEATURES

- **Passive I/Q mixer**
- **RF and LO range: 2.5 GHz to 8.5 GHz**
- **Wide IF range: dc to 4 GHz**
- **Single-ended RF, LO, and IF**
- **Conversion loss (downconverter): 9 dB (typical)**
- **Image rejection (downconverter): 25 dBc (typical)**
- **SSB noise figure (downconverter): 11.5 dB (typical)**
- **Input IP3 (downconverter): 20 dBm (typical)**
- **Input P1dB compression point (downconverter): 13 dBm (typical)**
- **Input IP2 (downconverter): 58 dBm (typical)**
- **RF to IF isolation (downconverter): 22 dB (typical)**
- **LO to RF isolation (downconverter): 48 dB (typical)**
- **LO to IF isolation (downconverter): 38 dB (typical)**
- **Amplitude balance (downconverter): ±0.5 dB (typical)**
- **Phase balance (downconverter): ±5° (typical)**
- **RF return loss: 13 dB (typical)**
- **LO return loss 13 dB (typical)**
- **IF return loss: 17 dB (typical)**
- **Exposed pad, 4 mm × 4 mm, 24-terminal, ceramic LCC package**

## APPLICATIONS

- **Test and measurement instrumentation**
- **Military, aerospace, and radar**
- **Direct conversion receivers**

## FUNCTIONAL BLOCK DIAGRAM

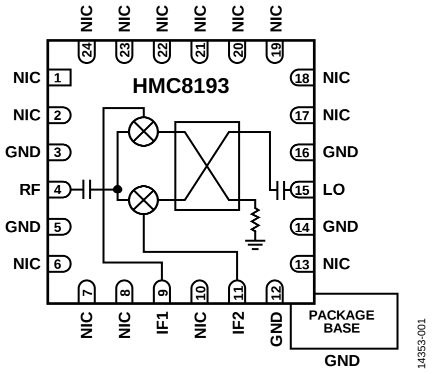

*Figure 1.*

## GENERAL DESCRIPTION

The HMC8193 is a passive, in phase/quadrature (I/Q), monolithic microwave integrated circuit (MMIC) mixer that can be used either as an image rejection mixer for receiver operations, or as a single-sideband upconverter for transmitter operations from 2.5 GHz to 8.5 GHz. The inherent I/Q architecture of the HMC8193 offers excellent image rejection and thereby eliminates the need for expensive filtering of unwanted sidebands. The mixer also provides excellent local oscillator (LO) to radio frequency (RF) and LO to intermediate frequency (IF) isolation and reduces the effect of LO leakage to ensure signal integrity.

Being the HMC8913 is a passive mixer, it does not require any dc power sources. The device offers a lower noise figure than an active mixer, ensuring superior dynamic range for high performance and precision applications.

The HMC8193 is fabricated on a gallium arsenide (GaAs), metal semiconductor field effect transistor (MESFET) process and uses Analog Devices, Inc., mixer cells and a 90° hybrid. It is available in a compact, 4 mm × 4 mm, 24-lead LCC package and operates over the −40°C to +85°C temperature range. An evaluation board for this device is also available.

**Rev. B**

Document Feedback

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## REVISION HISTORY

**5/2018—Rev. A to Rev. B**

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**1/2018—Rev. 0 to Rev. A**

Changes to Features ... 1
Changed Single-Sideband (SSB) Noise Figure Parameter from 15 dB Typical to 11.5 dB Typical, Table 1 ... 3
Changes to Ordering Guide ... 36

**8/2017—Revision 0: Initial Version**

## SPECIFICATIONS

$T_A$ = 25°C, IF = 100 MHz, and LO drive = 18 dBm; all measurements performed as downconverter with lower sideband selected, unless otherwise noted.

**Table 1.**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| RADIO FREQUENCY | RF | 2.5 | | 8.5 | GHz |
| LOCAL OSCILLATOR | LO | | | | |
| Frequency | | 2.5 | | 8.5 | GHz |
| Drive Level | | | 18 | | dBm |
| INTERMEDIATE FREQUENCY | IF | DC | | 4 | GHz |
| RF PERFORMANCE AS DOWNCONVERTER | | | | | |
| Conversion Loss | | | 9 | 11 | dB |
| Image Rejection | | 23 | 25 | | dBc |
| Single-Sideband (SSB) Noise Figure | | | 11.5 | | dB |
| Input Third-Order Intercept | IP3 | 16 | 20 | | dBm |
| Input 1 dB Compression Point | P1dB | | 13 | | dBm |
| Input Second-Order Intercept | IP2 | | 58 | | dBm |
| Isolation | | | | | |
| RF to IF | | 13 | 22 | | dB |
| LO to RF | | 37 | 48 | | dB |
| LO to IF | | 30 | 38 | | dB |
| Amplitude Balance | | | ±0.5 | | dB |
| Phase Balance | | | ±5 | | Degrees |
| RF PERFORMANCE AS UPCONVERTER | | | | | |
| Conversion Loss | | | 8.5 | | dB |
| Sideband Rejection | | | 23 | | dBc |
| Input Third-Order Intercept | IP3 | | 21 | | dBm |
| RETURN LOSS PERFORMANCE | | | | | |
| RF | | | 13 | | dB |
| LO | | | 13 | | dB |
| IFx | | | 17 | | dB |

# ABSOLUTE MAXIMUM RATINGS

Table 2.

| Parameter | Rating |
|---|---|
| RF Input Power | 21 dBm |
| LO Input Power | 25 dBm |
| IF Input Power | 21 dBm |
| IF Source/Sink Current | 6 mA |
| Continuous Power Dissipation, $P_{DISS}$ ($T_A$ = 85°C, Derate 12.44 mW/°C Above 85°C) | 1120 mW |
| Maximum Junction Temperature | 175°C |
| Maximum Peak Reflow Temperature (MSL3) | 260°C |
| Operating Temperature Range | −40°C to +85°C |
| Storage Temperature Range | −65°C to +150°C |
| Electrostatic Discharge (ESD) Sensitivity | |
| Human Body Model (HBM) | 2000 V |
| Field Induced Charged Device Model (FICDM) | 1250 V |

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

## THERMAL RESISTANCE

Thermal performance is directly linked to printed circuit board (PCB) design and operating environment. Careful attention to PCB thermal design is required.

Table 3. Thermal Resistance

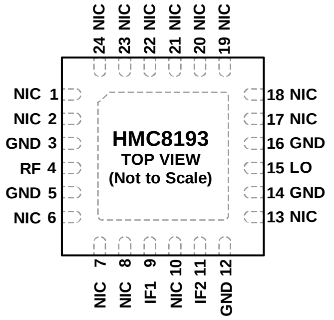
| Package Type | $\theta_{JA}$ | $\theta_{JC}$ | Unit |
|---|---|---|---|
| E-24-1[1] | 120 | 80 | °C/W |

[1] Thermal impedance simulated values are based on a JEDEC 2S2P test board with 4 × 4 thermal vias. See JEDEC JESD51-12 for additional information.

## ESD CAUTION

**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

# PIN CONFIGURATION AND FUNCTION DESCRIPTIONS



NOTES
1. NOT INTERNALLY CONNECTED. NO CONNECTION IS REQUIRED. THESE PINS CAN BE CONNECTED TO RF/DC GROUND WITHOUT AFFECTING PERFORMANCE.
2. EXPOSED PAD. THE EXPOSED PAD MUST BE CONNECTED TO RF/DC GROUND.

*Figure 2. Pin Configuration*

**Table 4. Pin Function Descriptions**

| Pin No. | Mnemonic | Description |
|---|---|---|
| 1, 2, 6 to 8, 10, 13, 17 to 24 | NIC | Not Internally Connected. No connection is required. These pins can be connected to RF/dc ground without affecting performance. |
| 3, 5, 12, 14, 16 | GND | Ground Connect. These pins and package bottom must be connected to RF/dc ground. See Figure 3 for the interface schematic. |
| 4 | RF | Radio Frequency. This pin is ac-coupled and matched to 50 Ω. See Figure 5 for the interface schematic. |
| 9 | IF1 | First and Quadrature Intermediate Frequency. This pin is dc-coupled. For applications not requiring operation to dc, dc block this port externally using a series capacitor with a value selected to pass the necessary IF frequency range. For operation to dc, this pin must not source or sink more than 6 mA of current; otherwise, the device does not function and may fail. See Figure 4 for the interface schematic. |
| 11 | IF2 | Second Quadrature Intermediate Frequency. This pin is dc-coupled. For applications not requiring operation to dc, dc block this port externally using a series capacitor with a value selected to pass the necessary IF frequency range. For operation to dc, this pin must not source or sink more than 6 mA of current; otherwise, the device does not function and may fail. See Figure 4 for the interface schematic. |
| 15 | LO | Local Oscillator. This pin is ac-coupled and matched to 50 Ω. See Figure 6 for the interface schematic. |
|  | EPAD | Exposed Pad. The exposed pad must be connected to RF/dc ground. |

## INTERFACE SCHEMATICS

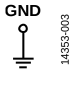


*Figure 3. GND Interface Schematic*

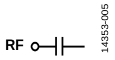


*Figure 5. RF Interface Schematic*

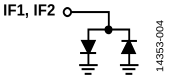


*Figure 4. IF1, IF2 Interface Schematic*

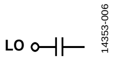


*Figure 6. LO Interface Schematic*

# TYPICAL PERFORMANCE CHARACTERISTICS

## DOWNCONVERTER PERFORMANCE

### *Downconverter Performance at IF = 100 MHz, Lower Sideband*

Data taken at LO drive = 18 dBm and TA = 25°C, unless otherwise noted.

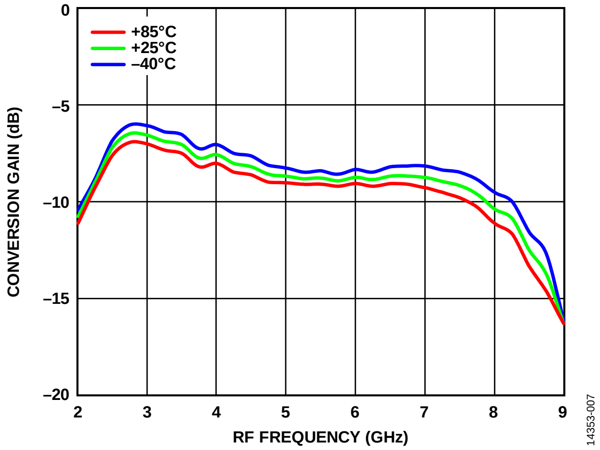


*Figure 7. Conversion Gain vs. RF Frequency at Various Temperatures*

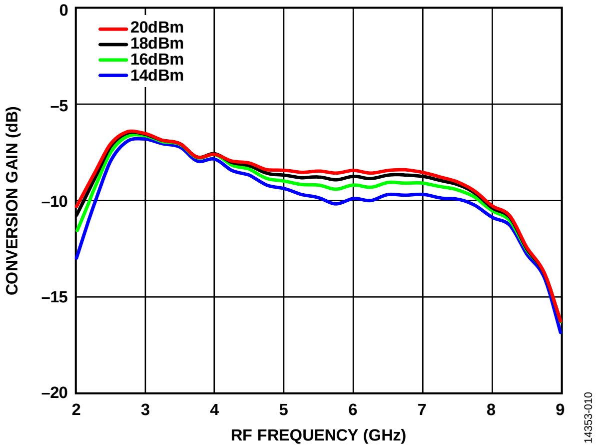


*Figure 10. Conversion Gain vs. RF Frequency at Various LO Drives*

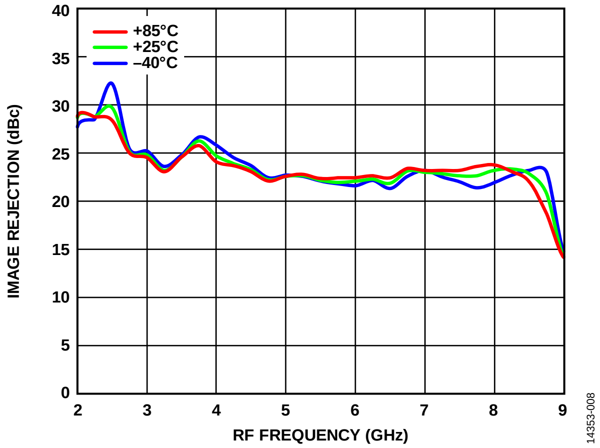


*Figure 8. Image Rejection vs. RF Frequency at Various Temperatures*

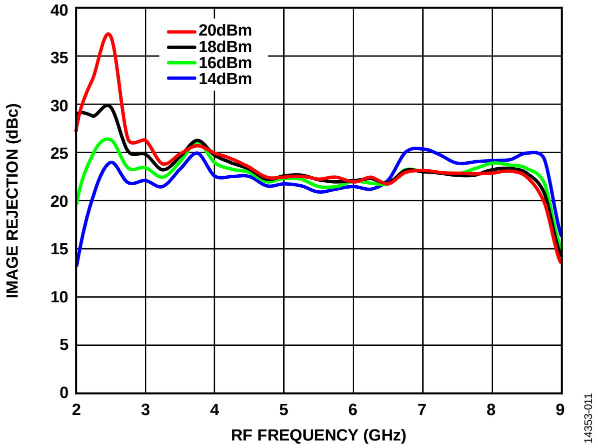


*Figure 11. Image Rejection vs. RF Frequency at Various LO Drives*

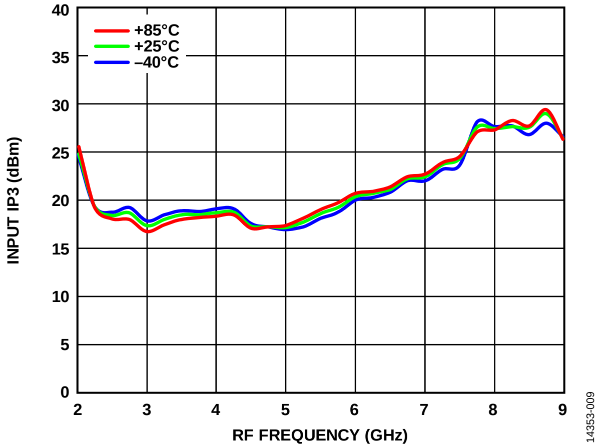


*Figure 9. Input IP3 vs. RF Frequency at Various Temperatures*

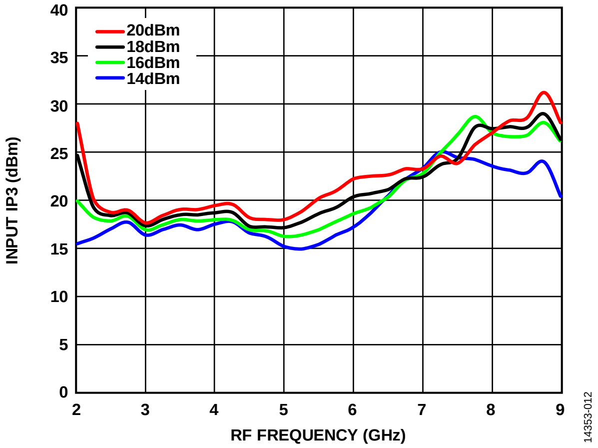


*Figure 12. Input IP3 vs. RF Frequency at Various LO Drives*

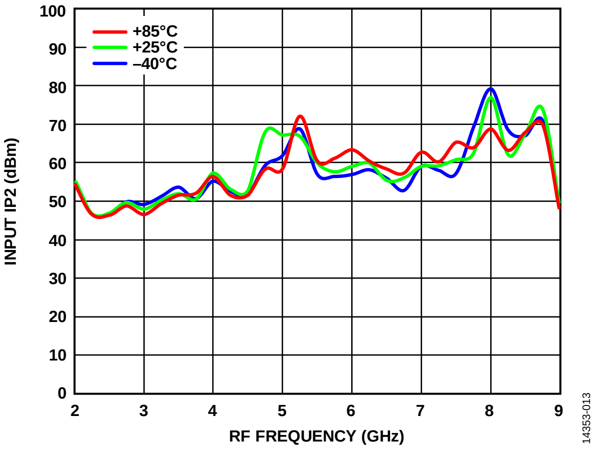


*Figure 13. Input IP2 vs. RF Frequency at Various Temperatures*

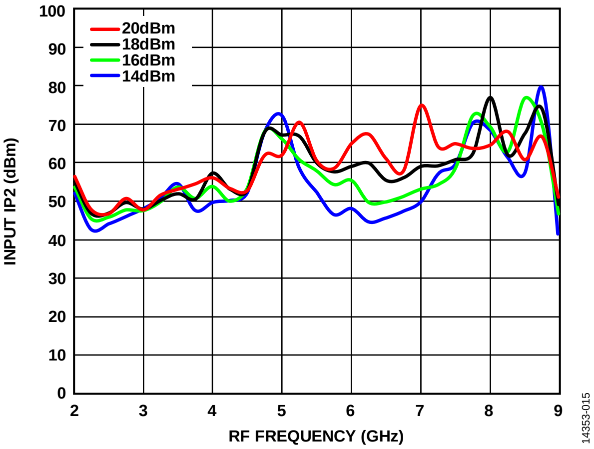


*Figure 15. Input IP2 vs. RF Frequency at Various LO Drives*

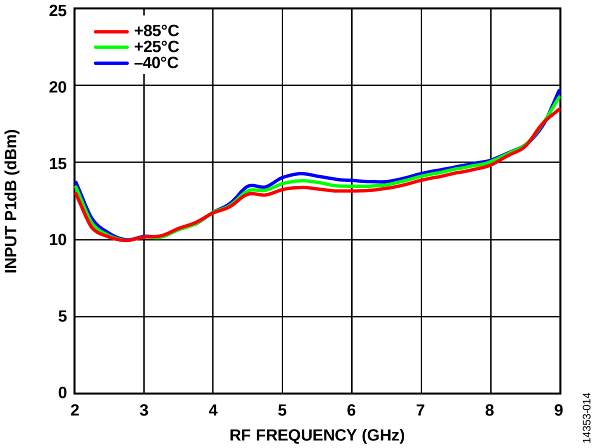


*Figure 14. Input P1dB vs. RF Frequency at Various Temperatures*

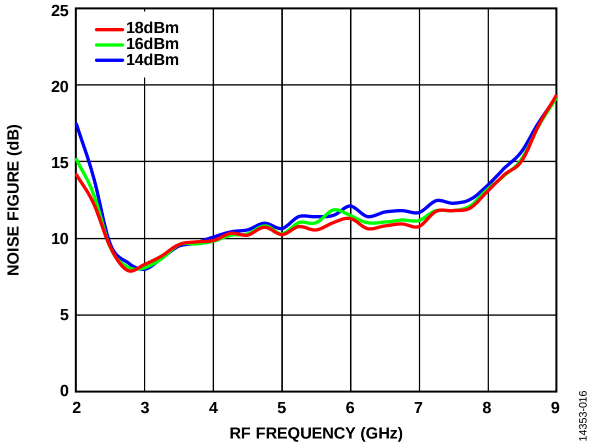


*Figure 16. Noise Figure vs. RF Frequency at Various LO Drives*

### *Downconverter Performance at IF = 1000 MHz, Lower Sideband*

Data taken at LO drive = 18 dBm and $T_A$ = 25°C, unless otherwise noted.

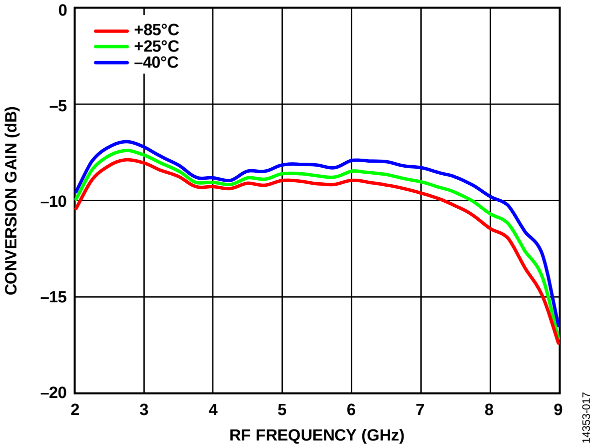


*Figure 17. Conversion Gain vs. RF Frequency at Various Temperatures*

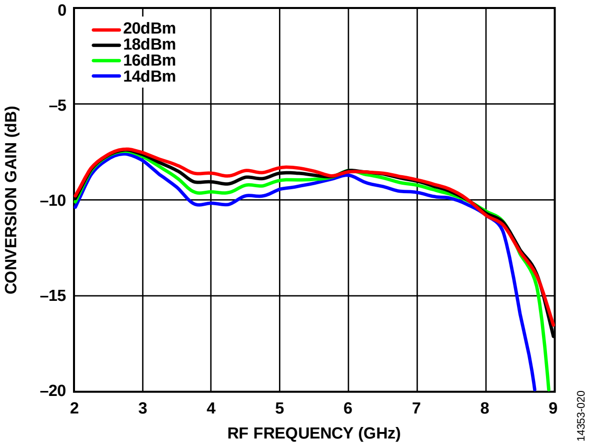


*Figure 20. Conversion Gain vs. RF Frequency at Various LO Drives*

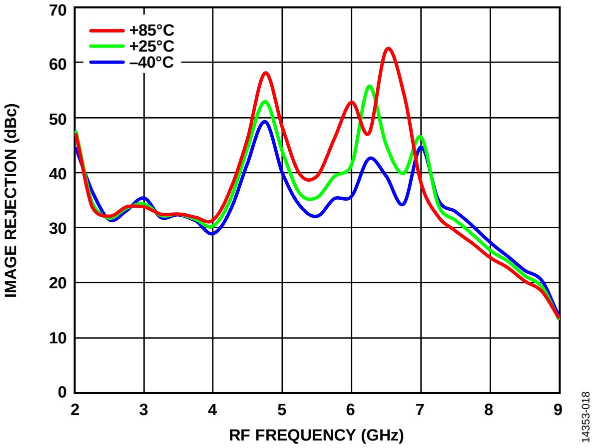


*Figure 18. Image Rejection vs. RF Frequency at Various Temperatures*

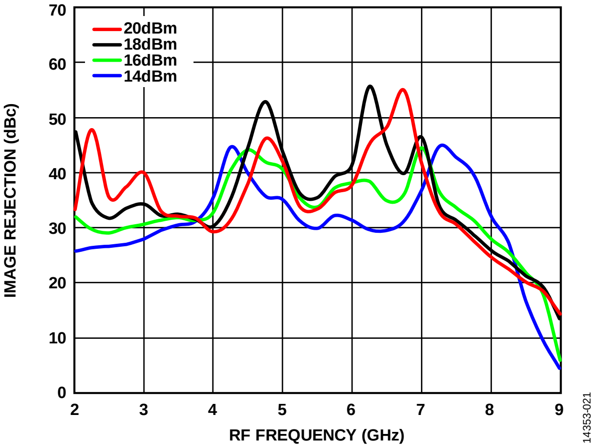


*Figure 21. Image Rejection vs. RF Frequency at Various LO Drives*

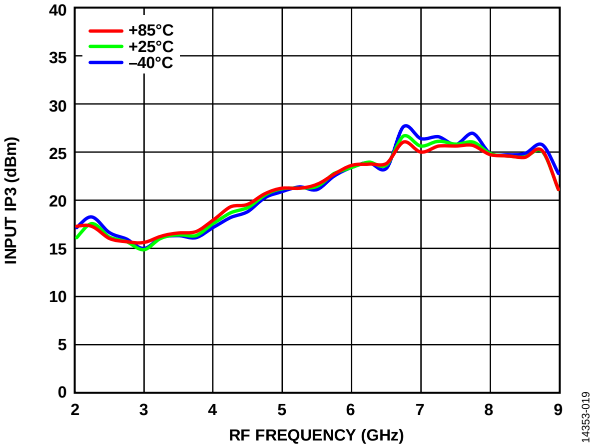


*Figure 19. Input IP3 vs. RF Frequency at Various Temperatures*

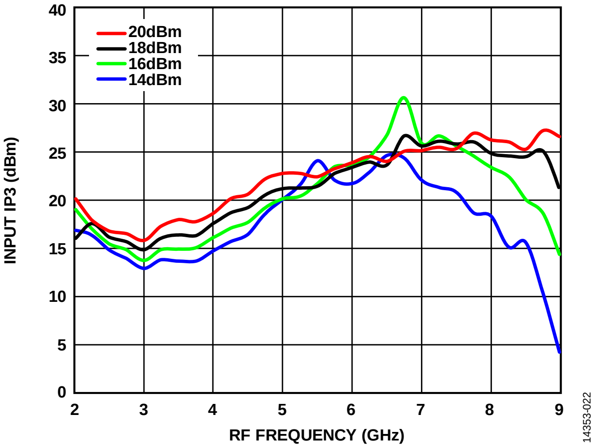


*Figure 22. Input IP3 vs. RF Frequency at Various LO Drives*

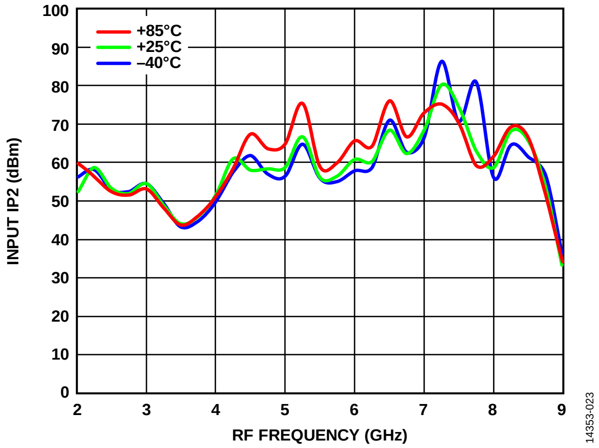


Figure 23. Input IP2 vs. RF Frequency at Various Temperatures

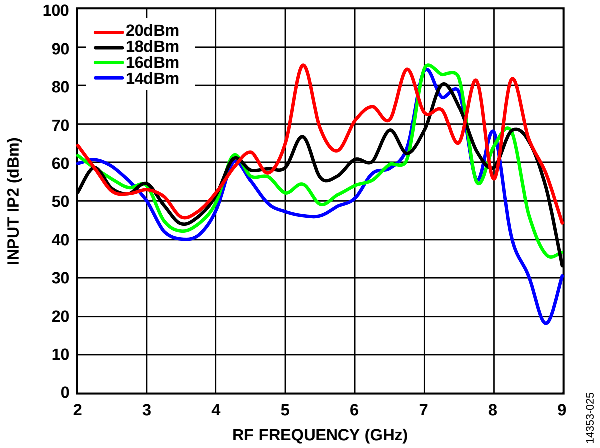


Figure 25. Input IP2 vs. RF Frequency at Various LO Drives

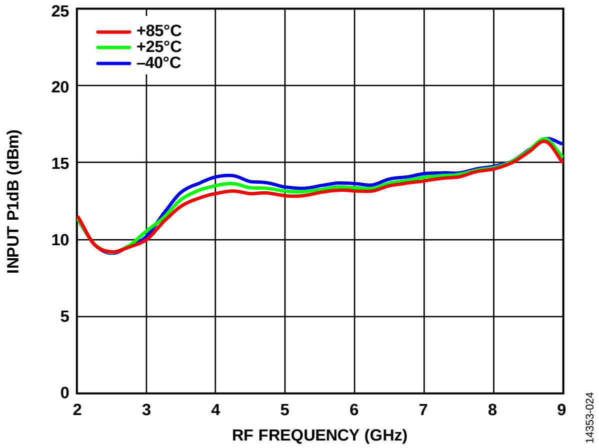


Figure 24. Input P1dB vs. RF Frequency at Various Temperatures

### Downconverter Performance at IF = 3500 MHz, Lower Sideband

Data taken at LO drive = 18 dBm and $T_A$ = 25°C, unless otherwise noted.

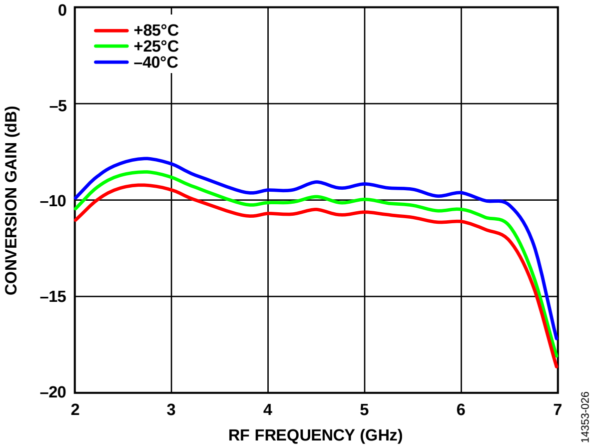


Figure 26. Conversion Gain vs. RF Frequency at Various Temperatures

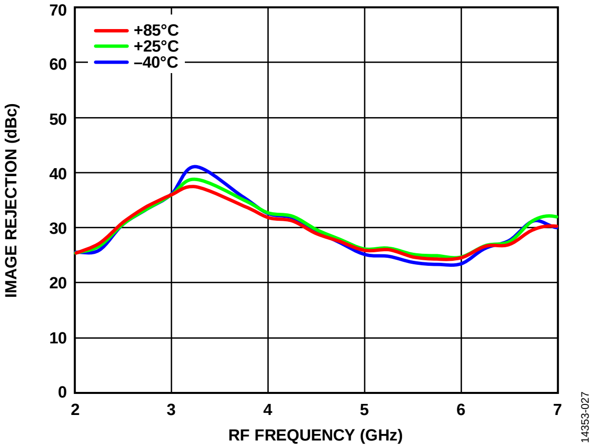


Figure 27. Image Rejection vs. RF Frequency at Various Temperatures

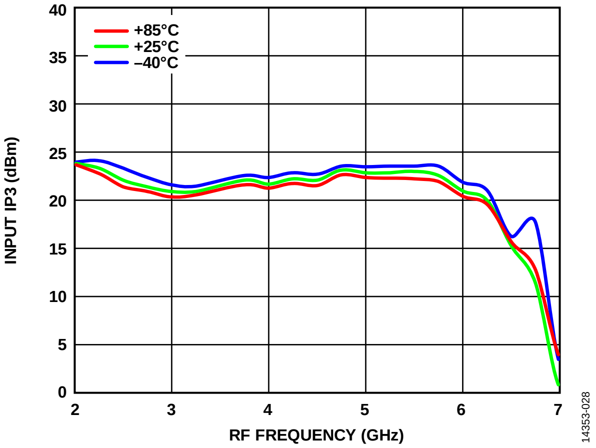


Figure 28. Input IP3 vs. RF Frequency at Various Temperatures

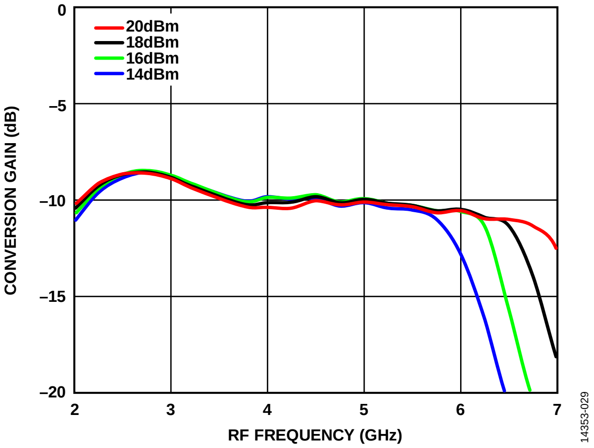


Figure 29. Conversion Gain vs. RF Frequency at Various LO Drives

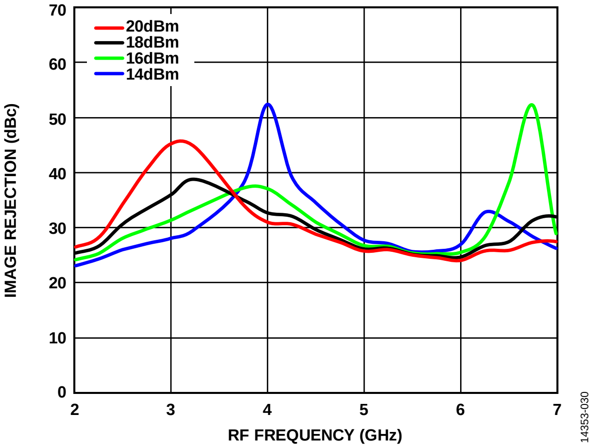


Figure 30. Image Rejection vs. RF Frequency at Various LO Drives

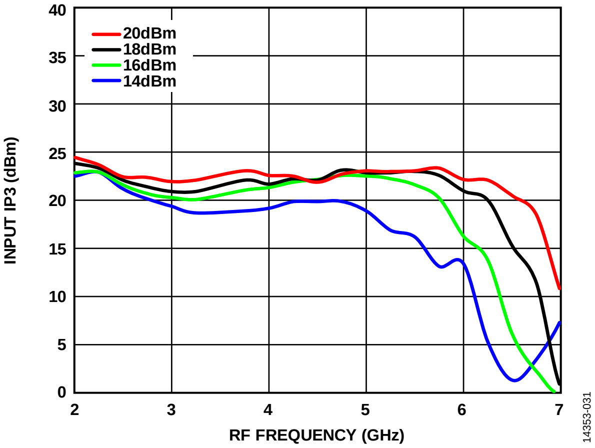


Figure 31. Input IP3 vs. RF Frequency at Various LO Drives

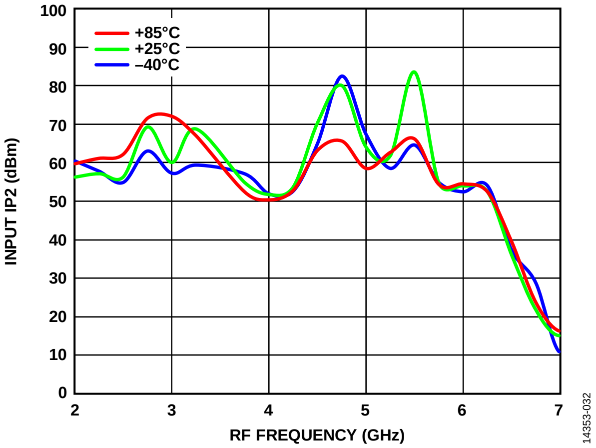


*Figure 32. Input IP2 vs. RF Frequency at Various Temperatures*

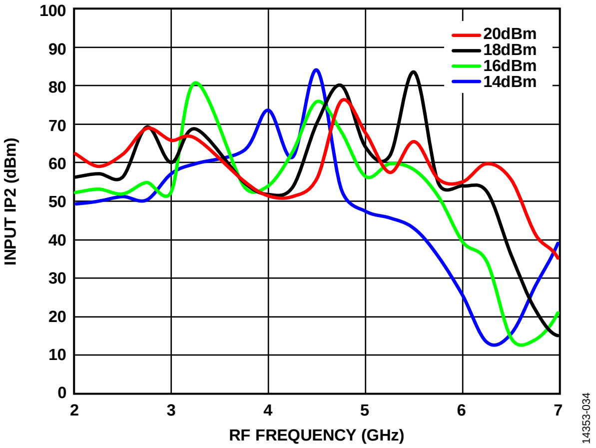


*Figure 34. Input IP2 vs. RF Frequency at Various LO Drives*

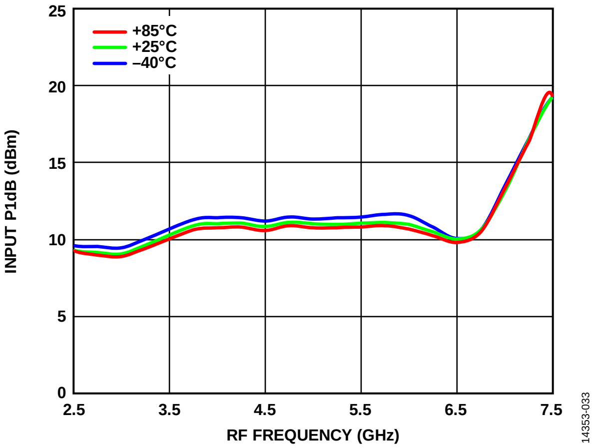


*Figure 33. Input P1dB vs. RF Frequency at Various Temperatures*

### *Downconverter Performance at IF = 100 MHz, Upper Sideband*

Data taken at LO drive = 18 dBm and $T_A$ = 25°C, unless otherwise noted.

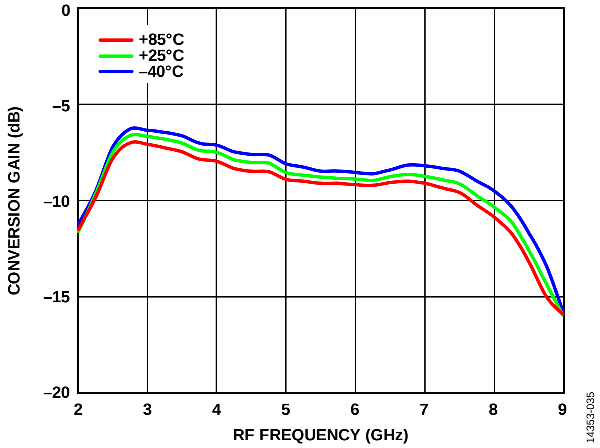


*Figure 35. Conversion Gain vs. RF Frequency at Various Temperatures*

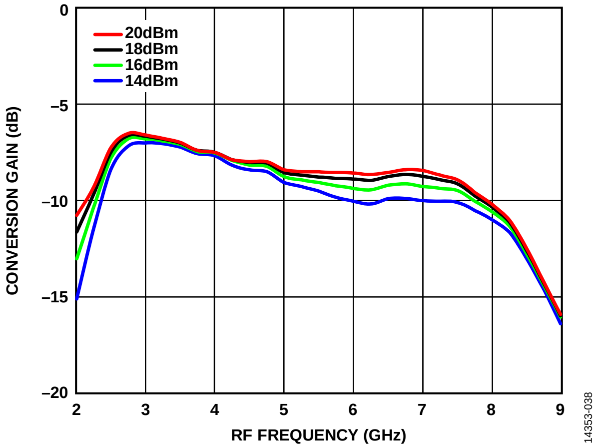


*Figure 38. Conversion Gain vs. RF Frequency at Various LO Drives*

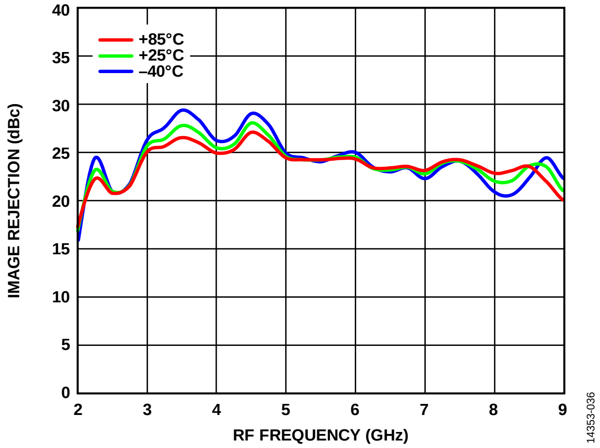


*Figure 36. Image Rejection vs. RF Frequency at Various Temperatures*

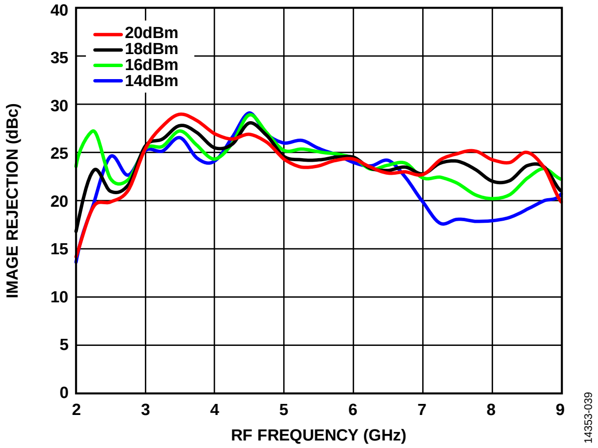


*Figure 39. Image Rejection vs. RF Frequency at Various LO Drives*

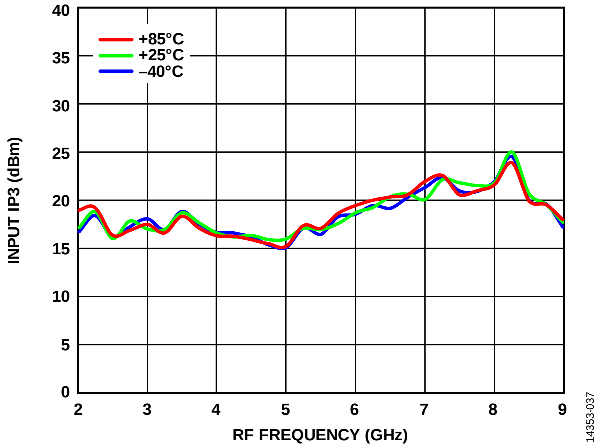


*Figure 37. Input IP3 vs. RF Frequency at Various Temperatures*

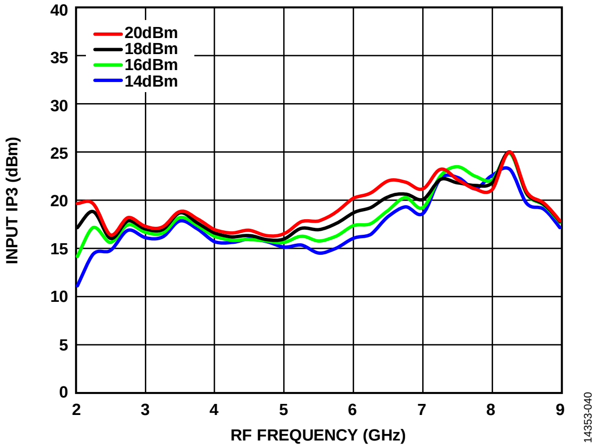


*Figure 40. Input IP3 vs. RF Frequency at Various LO Drives*

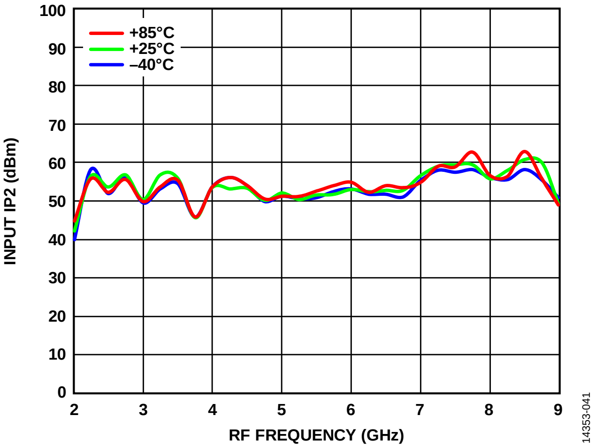


*Figure 41. Input IP2 vs. RF Frequency at Various Temperatures*

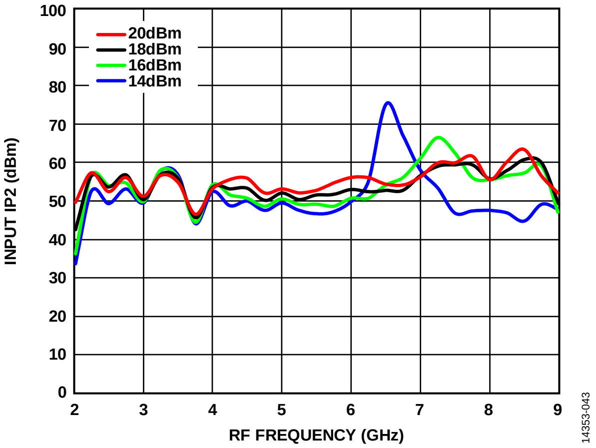


*Figure 43. Input IP2 vs. RF Frequency at Various LO Drives*

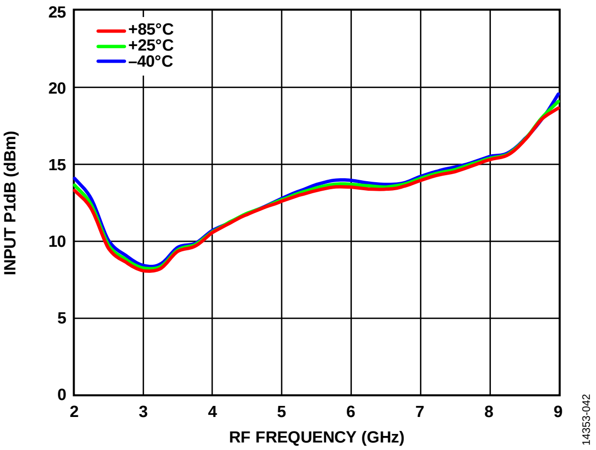


*Figure 42. Input P1dB vs. RF Frequency at Various Temperatures*

### *Downconverter Performance at IF = 1000 MHz, Upper Sideband*

Data taken at LO drive = 18 dBm and $T_A$ = 25°C, unless otherwise noted.

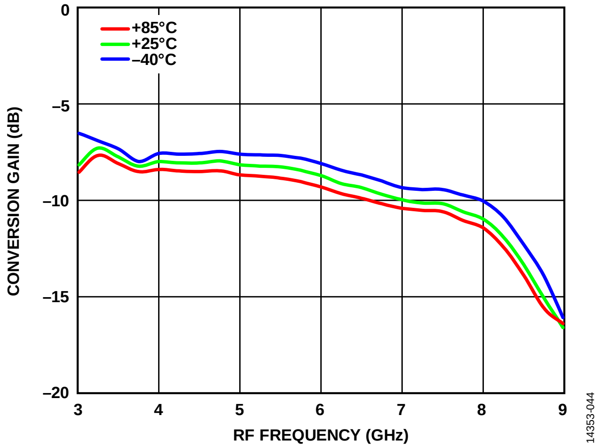


*Figure 44. Conversion Gain vs. RF Frequency at Various Temperatures*

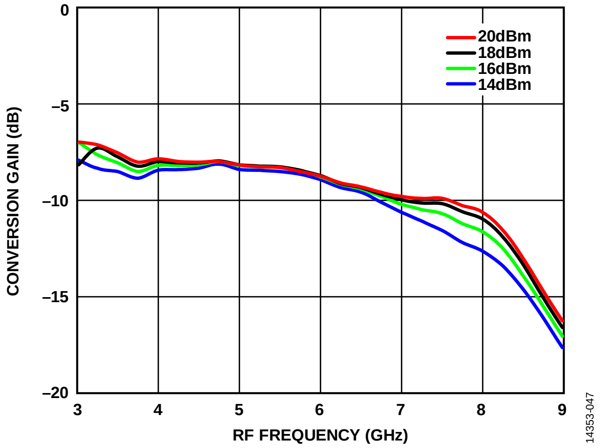


*Figure 47. Conversion Gain vs. RF Frequency at Various LO Drives*

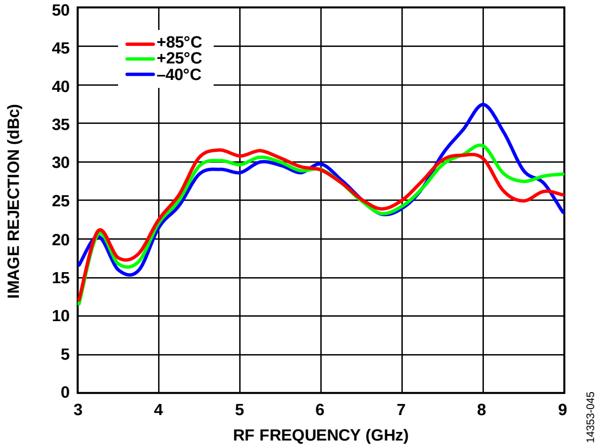


*Figure 45. Image Rejection vs. RF Frequency at Various Temperatures*

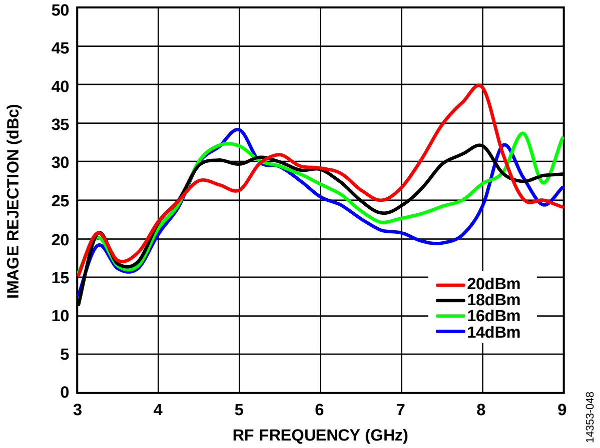


*Figure 48. Image Rejection vs. RF Frequency at Various LO Drives*

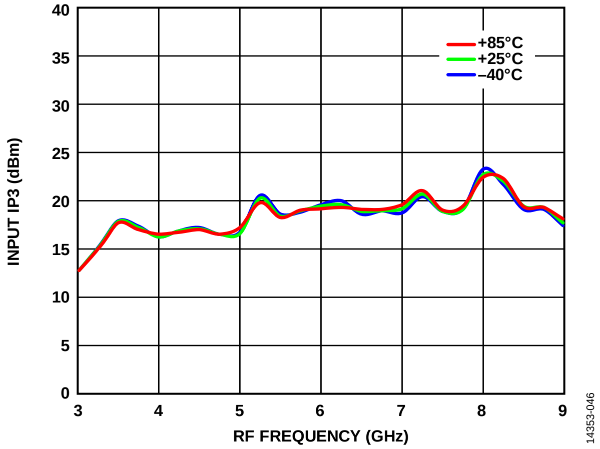


*Figure 46. Input IP3 vs. RF Frequency at Various Temperatures*

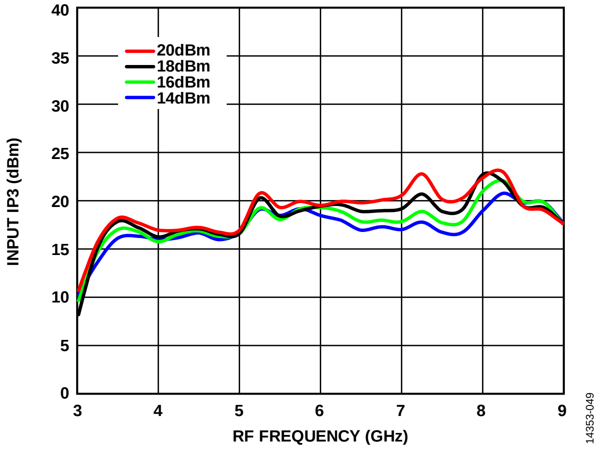


*Figure 49. Input IP3 vs. RF Frequency at Various LO Drives*

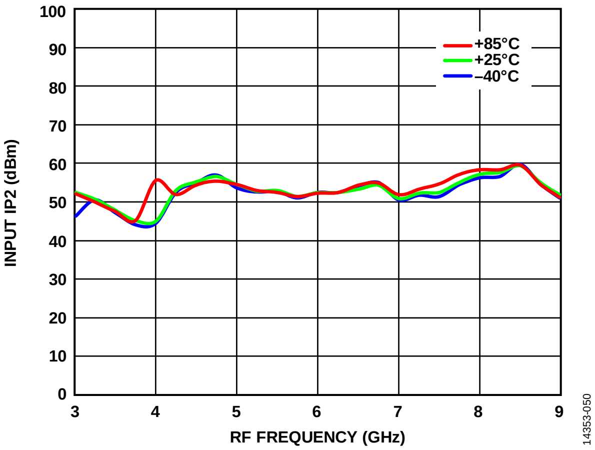


*Figure 50. Input IP2 vs. RF Frequency at Various Temperatures*

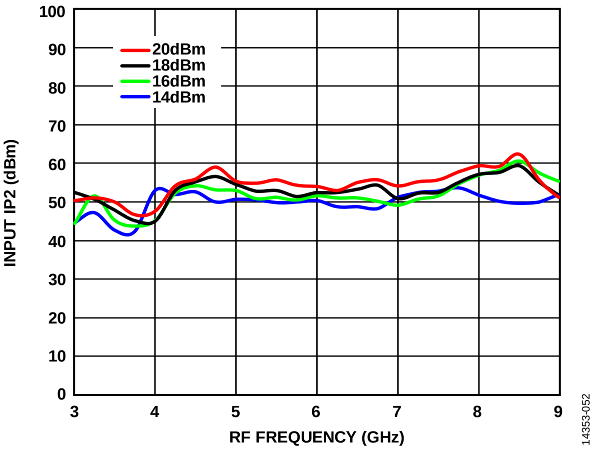


*Figure 52. Input IP2 vs. RF Frequency at Various LO Drives*

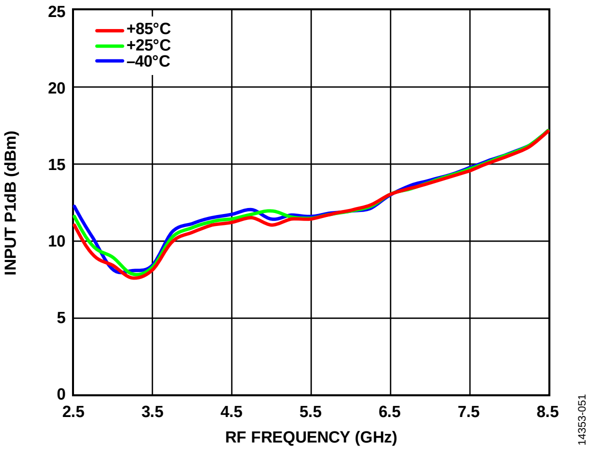


*Figure 51. Input P1dB vs. RF Frequency at Various Temperatures*

### *Downconverter Performance at IF = 3500 MHz, Upper Sideband*

Data taken at LO drive = 18 dBm and $T_A$ = 25°C, unless otherwise noted.

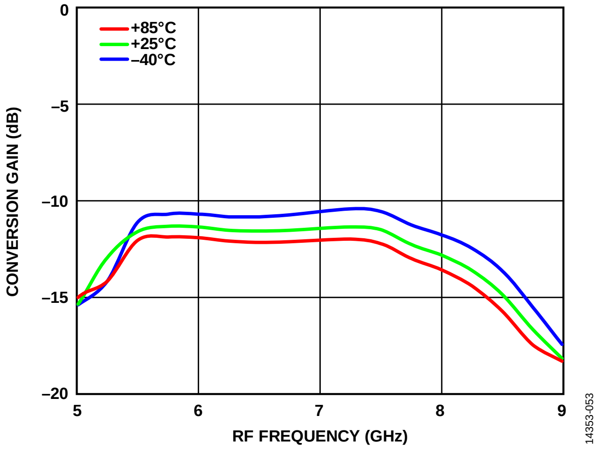


*Figure 53. Conversion Gain vs. RF Frequency at Various Temperatures*

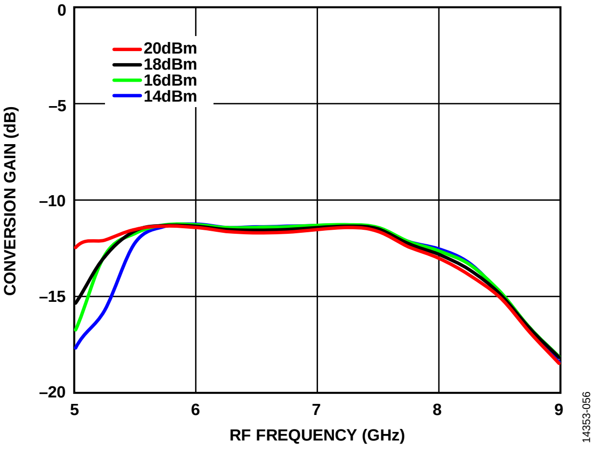


*Figure 55. Conversion Gain vs. RF Frequency at Various LO Drives*

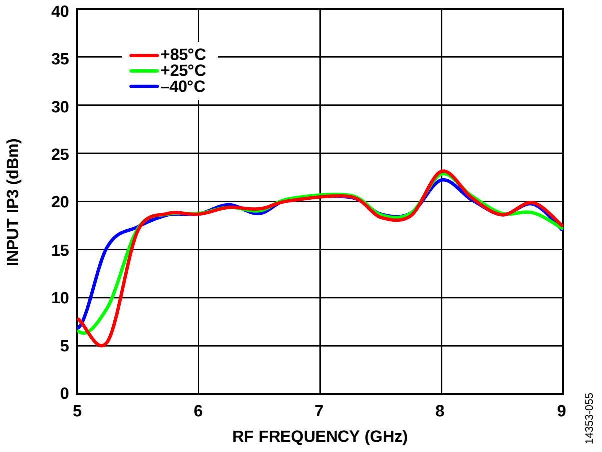


*Figure 54. Input IP3 vs. RF Frequency at Various Temperatures*

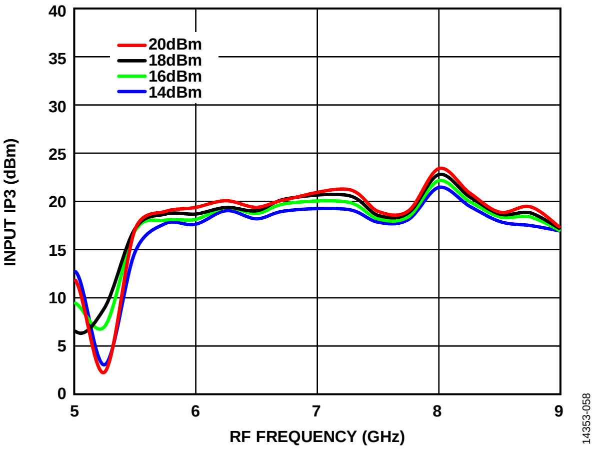


*Figure 56. Input IP3 vs. RF Frequency at Various LO Drives*

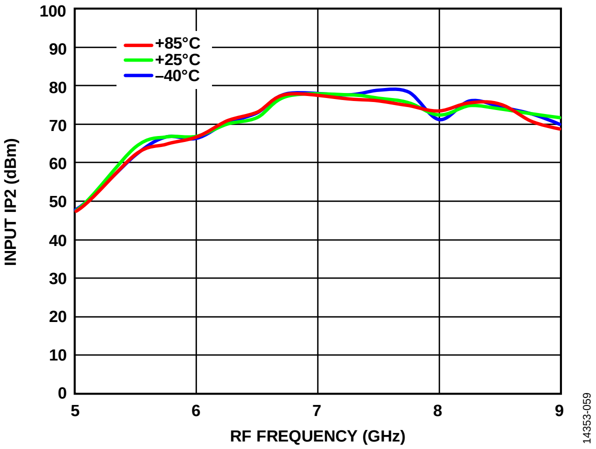


*Figure 57. Input IP2 vs. RF Frequency at Various Temperatures*

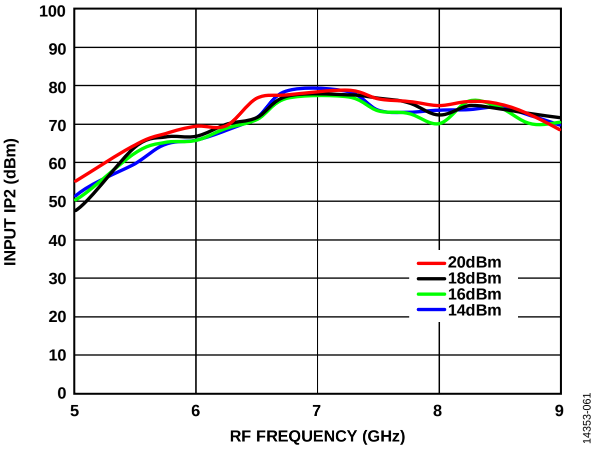


*Figure 59. Input IP2 vs. RF Frequency at Various LO Drives*

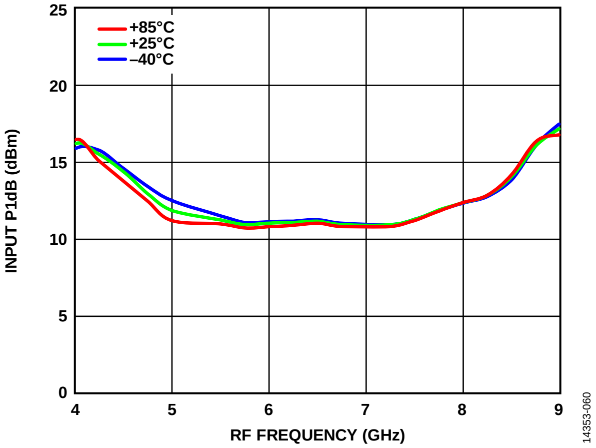


*Figure 58. Input P1dB vs. RF Frequency at Various Temperatures*

## UPCONVERTER PERFORMANCE

### *Upconverter Performance at IF = 100 MHz, Lower Sideband*

Data taken at LO drive = 18 dBm and $T_A$ = 25°C, unless otherwise noted.

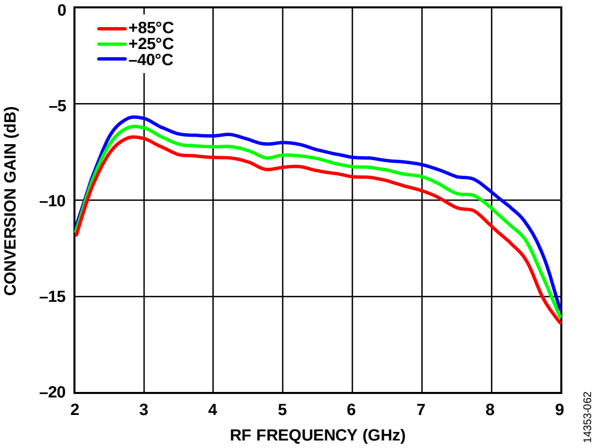


*Figure 60. Conversion Gain vs. RF Frequency at Various Temperatures*

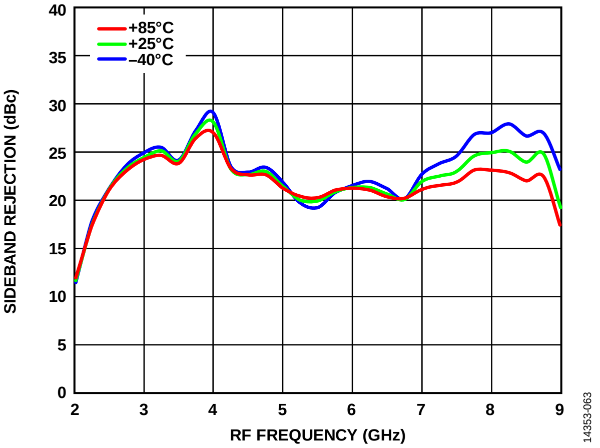


*Figure 61. Sideband Rejection vs. RF Frequency at Various Temperatures*

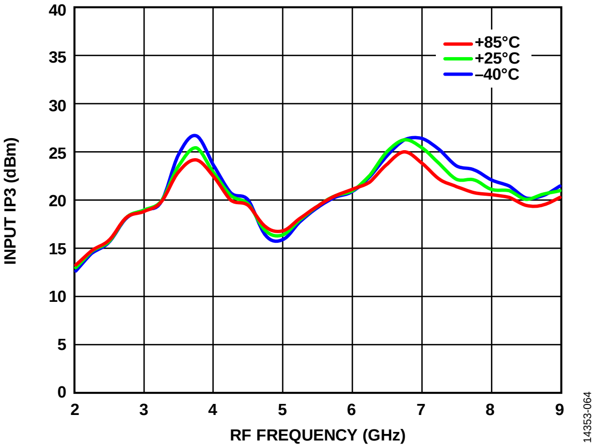


*Figure 62. Input IP3 vs. RF Frequency at Various Temperatures*

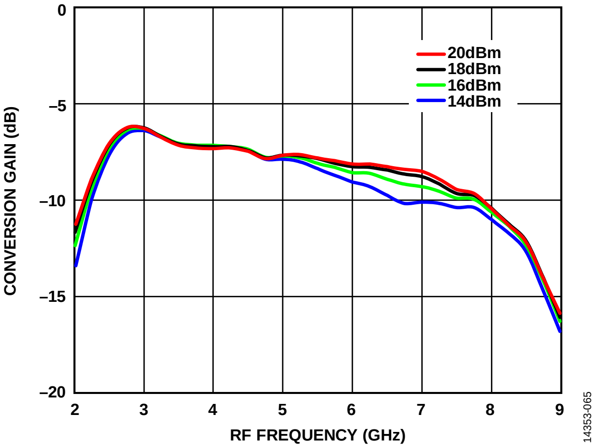


*Figure 63. Conversion Gain vs. RF Frequency at Various LO Drives*

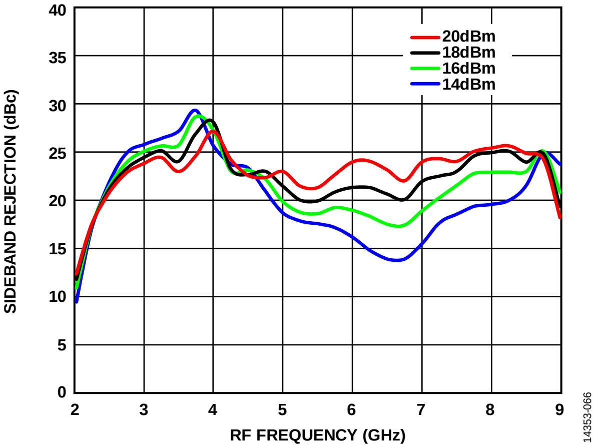


*Figure 64. Sideband Rejection vs. RF Frequency at Various LO Drives*

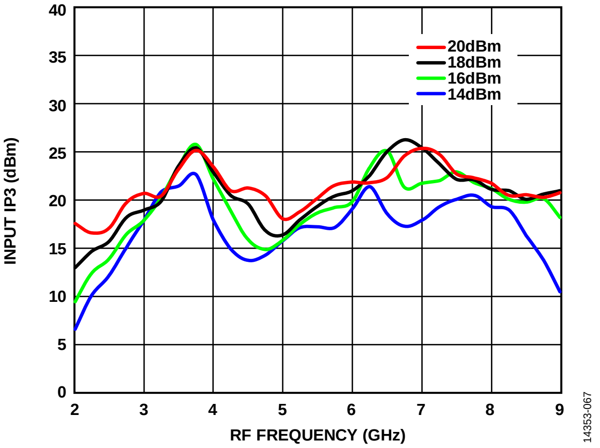


*Figure 65. Input IP3 vs. RF Frequency at Various LO Drives*

### *Upconverter Performance at IF = 1000 MHz, Lower Sideband*

Data taken at LO drive = 18 dBm and $T_A$ = 25°C, unless otherwise noted.

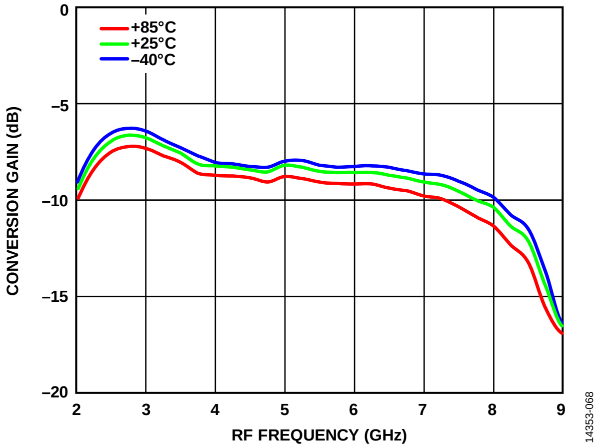


*Figure 66. Conversion Gain vs. RF Frequency at Various Temperatures*

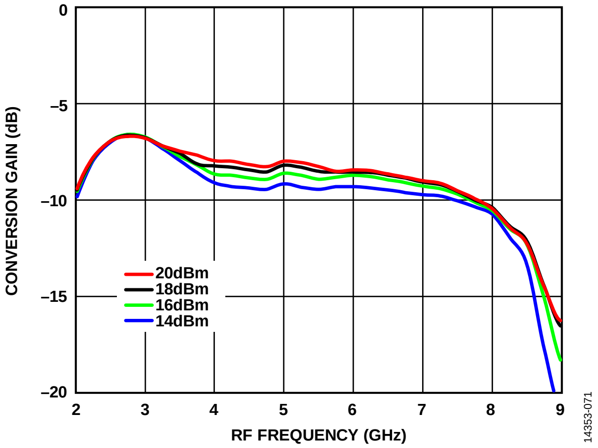


*Figure 69. Conversion Gain vs. RF Frequency at Various LO Drives*

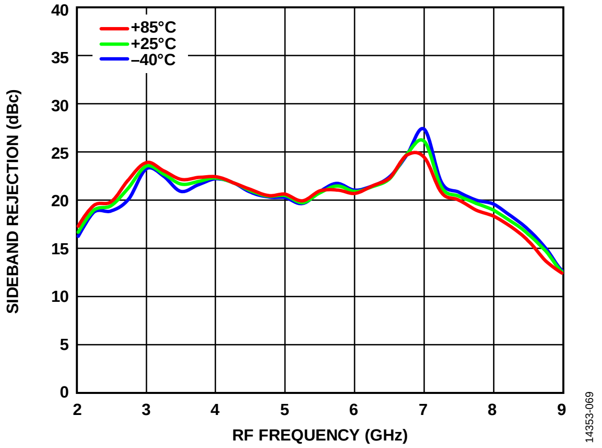


*Figure 67. Sideband Rejection vs. RF Frequency at Various Temperatures*

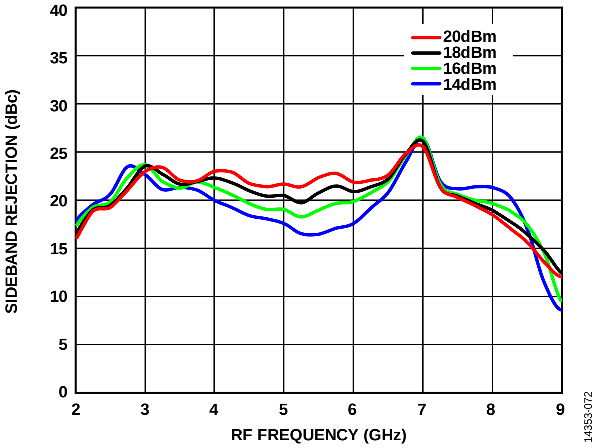


*Figure 70. Sideband Rejection vs. RF Frequency at Various LO Drives*

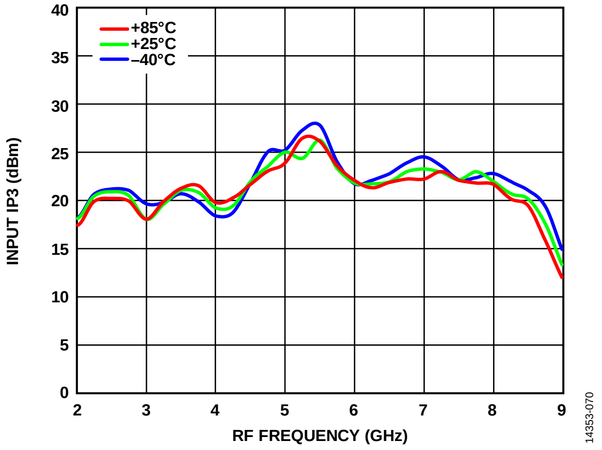


*Figure 68. Input IP3 vs. RF Frequency at Various Temperatures*

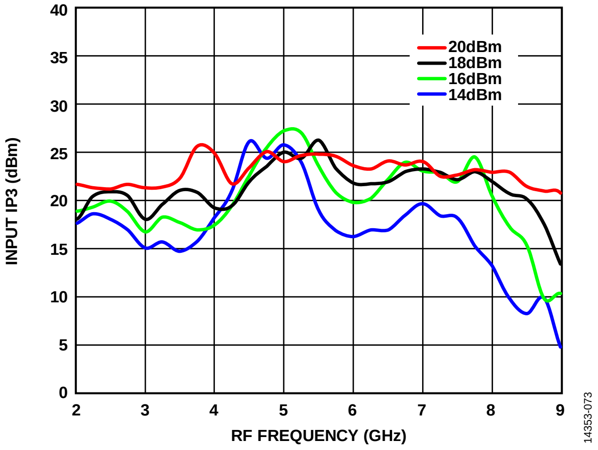


*Figure 71. Input IP3 vs. RF Frequency at Various LO Drives*

### Upconverter Performance at IF = 3500 MHz, Lower Sideband

Data taken at LO drive = 18 dBm and $T_A$ = 25°C, unless otherwise noted.

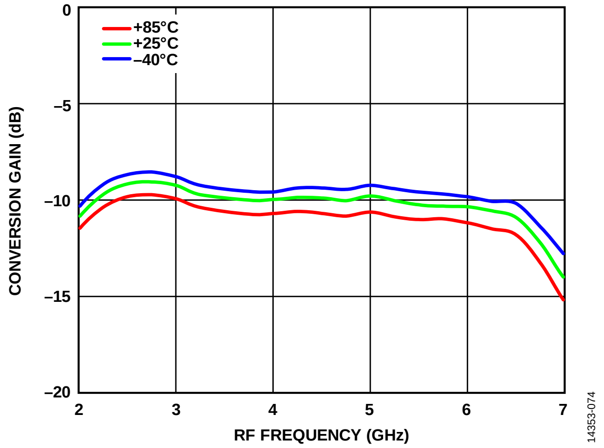


Figure 72. Conversion Gain vs. RF Frequency at Various Temperatures

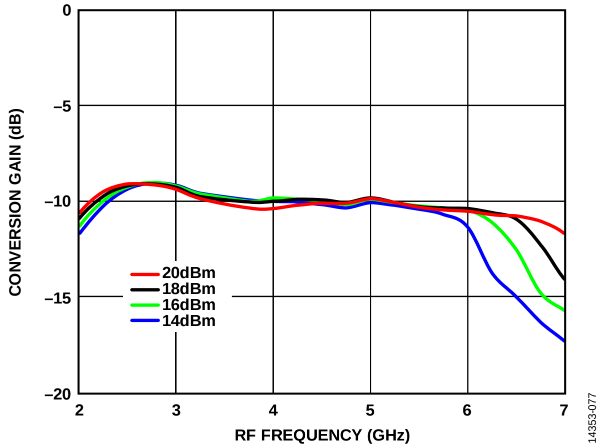


Figure 75. Conversion Gain vs. RF Frequency at Various LO Drives

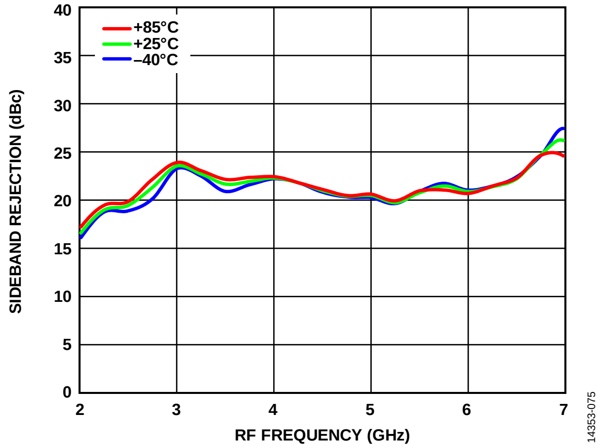


Figure 73. Sideband Rejection vs. RF Frequency at Various Temperatures

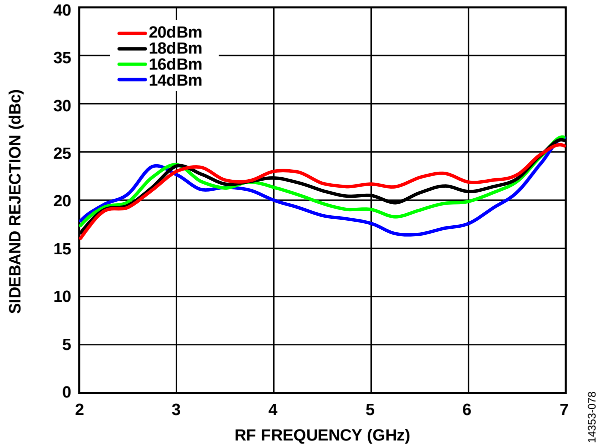


Figure 76. Sideband Rejection vs. RF Frequency at Various LO Drives

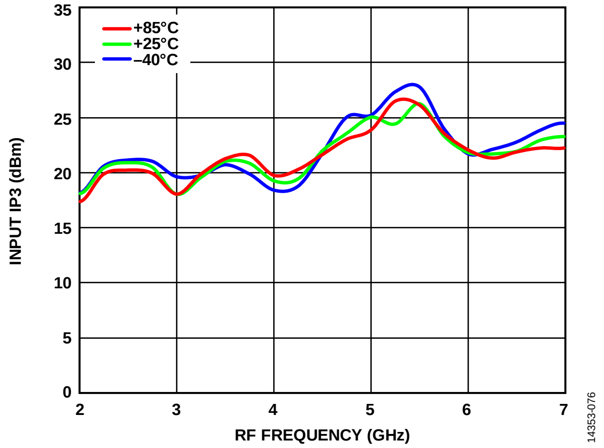


Figure 74. Input IP3 vs. RF Frequency at Various Temperatures

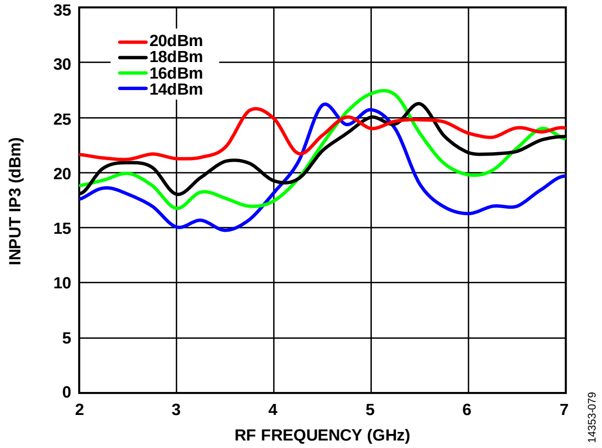


Figure 77. Input IP3 vs. RF Frequency at Various LO Drives

### *Upconverter Performance at IF = 100 MHz, Upper Sideband*

Data taken at LO drive = 18 dBm and $T_A$ = 25°C, unless otherwise noted.

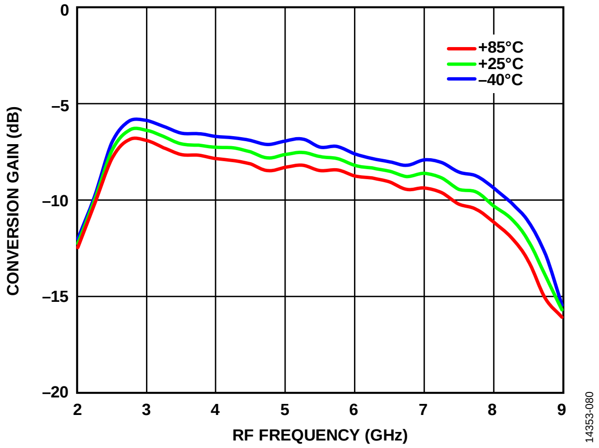


*Figure 78. Conversion Gain vs. RF Frequency at Various Temperatures*

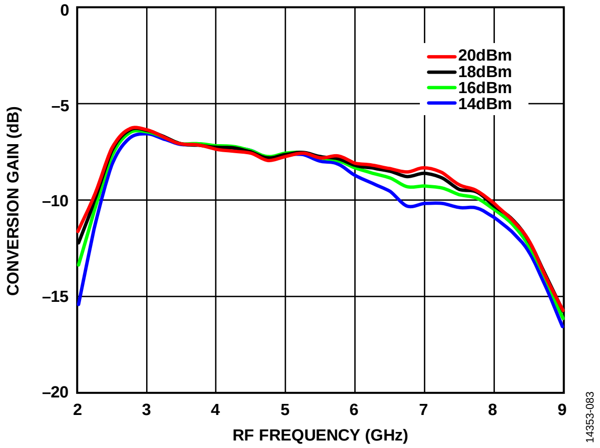


*Figure 81. Conversion Gain vs. RF Frequency at Various LO Drives*

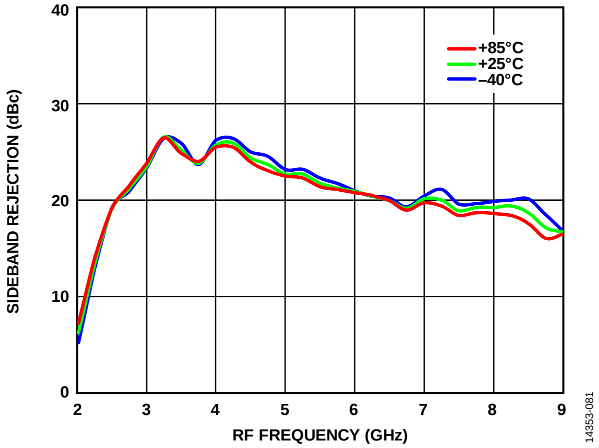


*Figure 79. Sideband Rejection vs. RF Frequency at Various Temperatures*

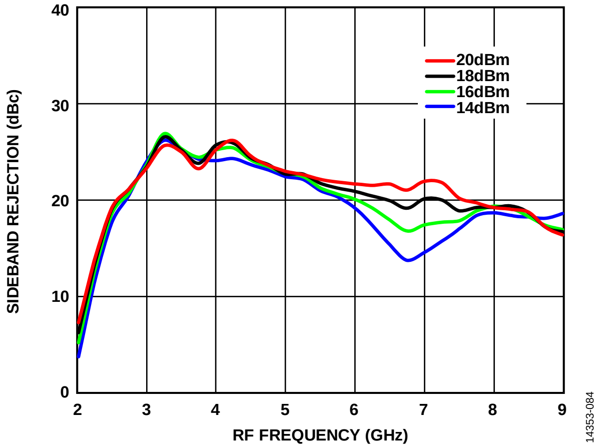


*Figure 82. Sideband Rejection vs. RF Frequency at Various LO Drives*

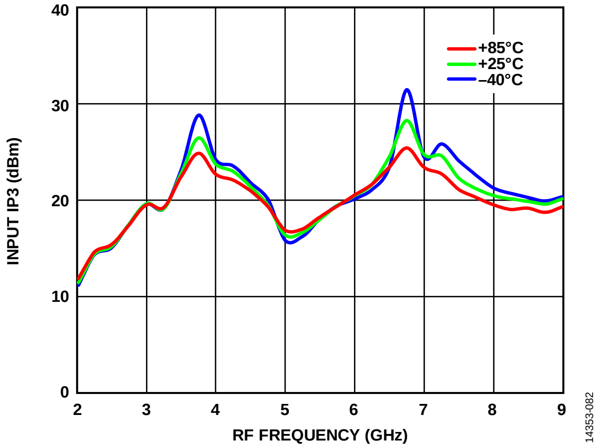


*Figure 80. Input IP3 vs. RF Frequency at Various Temperatures*

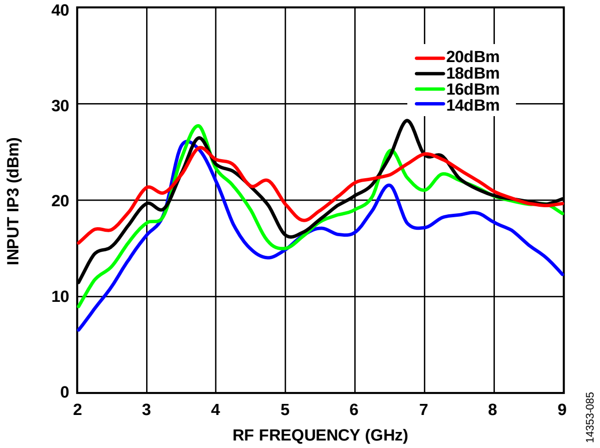


*Figure 83. Input IP3 vs. RF Frequency at Various LO Drives*

### *Upconverter Performance at IF = 1000 MHz, Upper Sideband*

Data taken at LO drive = 18 dBm and $T_A$ = 25°C, unless otherwise noted.

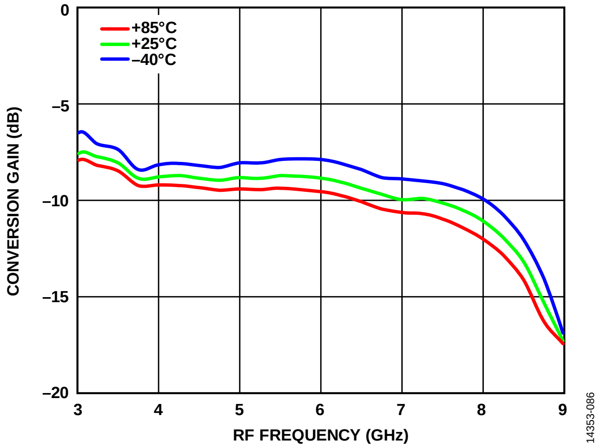


*Figure 84. Conversion Gain vs. RF Frequency at Various Temperatures*

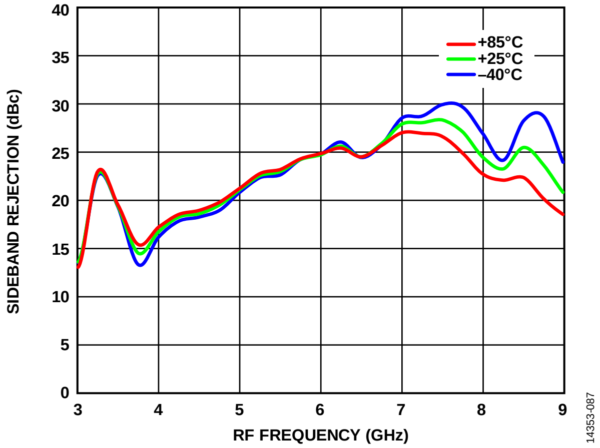


*Figure 85. Sideband Rejection vs. RF Frequency at Various Temperatures*

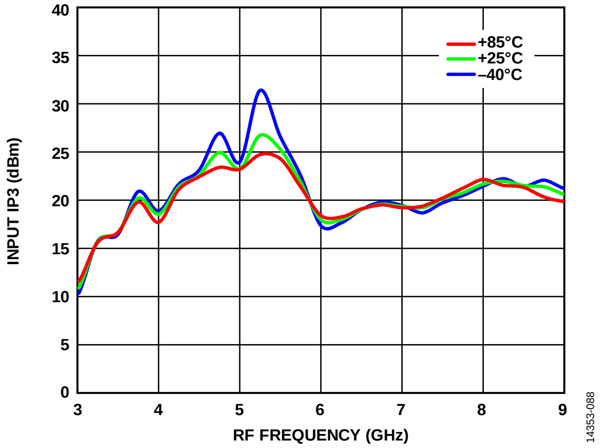


*Figure 86. Input IP3 vs. RF Frequency at Various Temperatures*

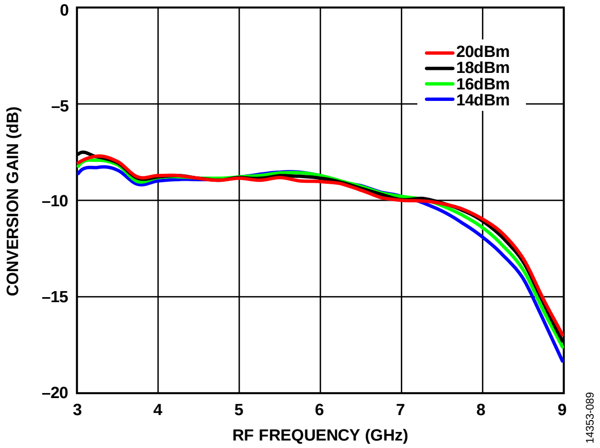


*Figure 87. Conversion Gain vs. RF Frequency at Various LO Drives*

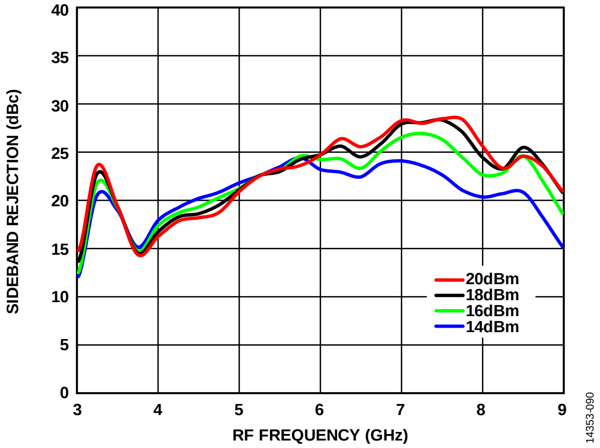


*Figure 88. Sideband Rejection vs. RF Frequency at Various LO Drives*

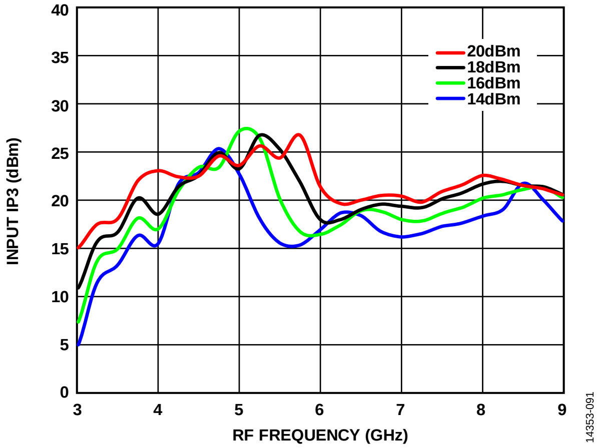


*Figure 89. Input IP3 vs. RF Frequency at Various LO Drives*

### Upconverter Performance at IF = 3500 MHz, Upper Sideband

Data taken at LO drive = 18 dBm and $T_A$ = 25°C, unless otherwise noted.

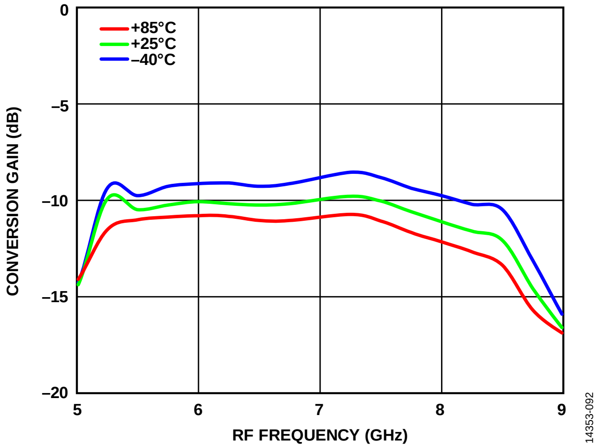


*Figure 90. Conversion Gain vs. RF Frequency at Various Temperatures*

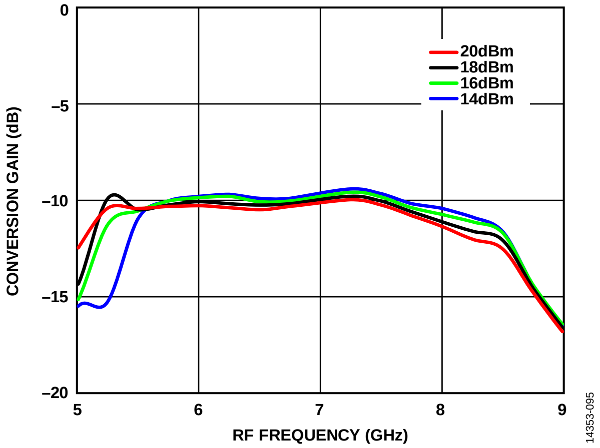


*Figure 92. Conversion Gain vs. RF Frequency at Various LO Drives*

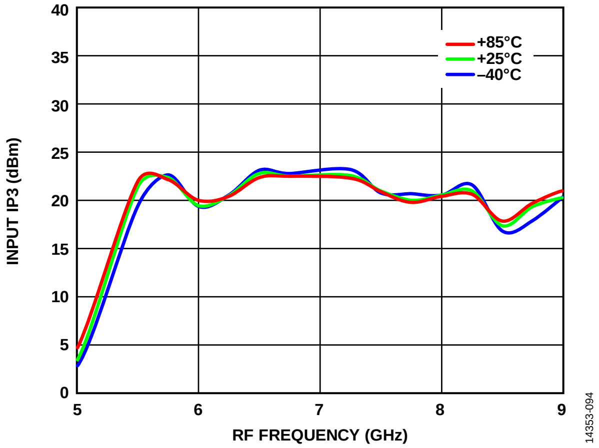


*Figure 91. Input IP3 vs. RF Frequency at Various Temperatures*

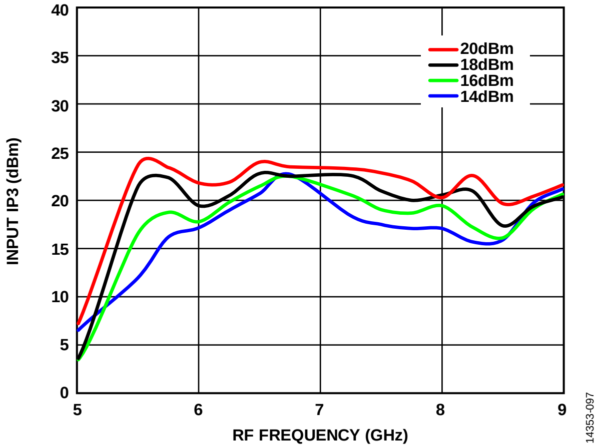


*Figure 93. Input IP3 vs. RF Frequency at Various LO Drives*

## ISOLATION AND RETURN LOSS

Data taken at LO drive = 18 dBm, $T_A$ = 25°C, unless otherwise noted.

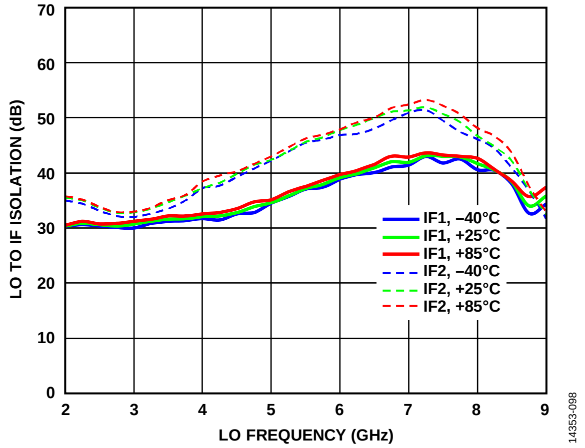


*Figure 94. LO to IF Isolation vs. LO Frequency at Various Temperatures*

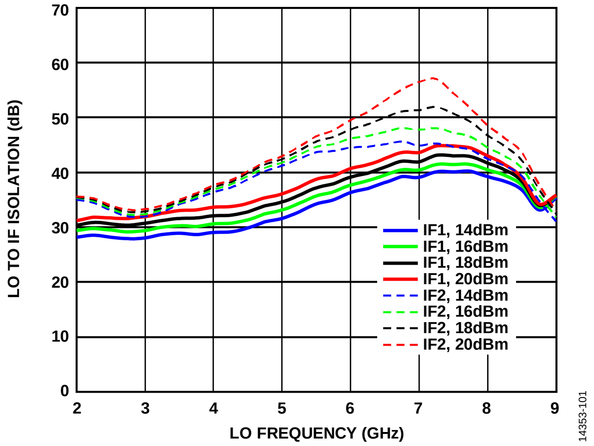


*Figure 97. LO to IF Isolation vs. LO Frequency at Various LO Drives*

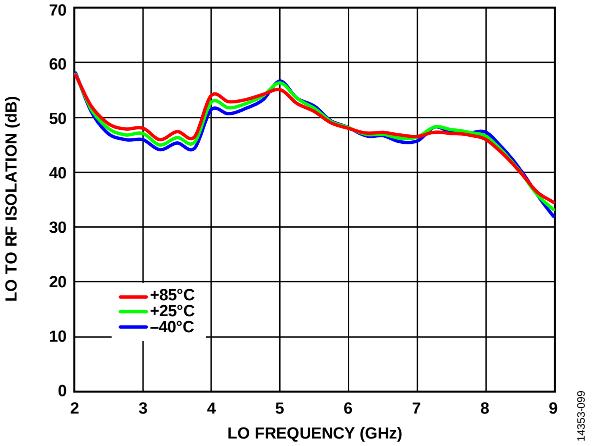


*Figure 95. LO to RF Isolation vs. LO Frequency at Various Temperatures*

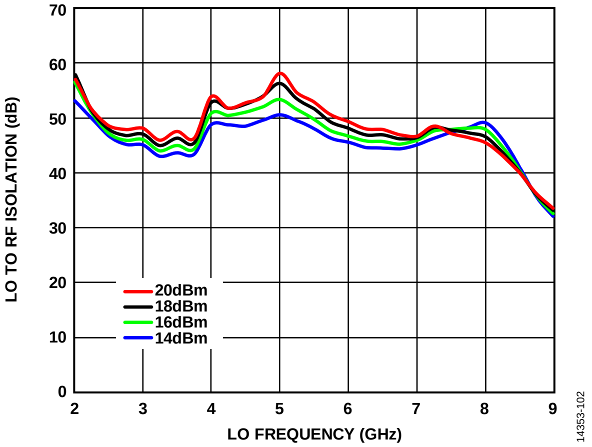


*Figure 98. LO to RF Isolation vs. LO Frequency at Various LO Drives*

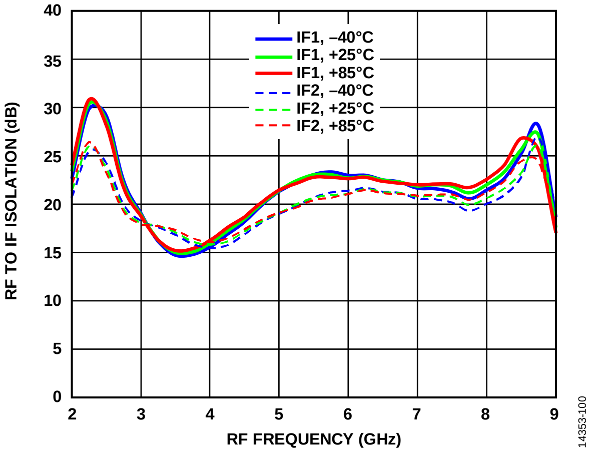


*Figure 96. RF to IF Isolation vs. RF Frequency at Various Temperatures*

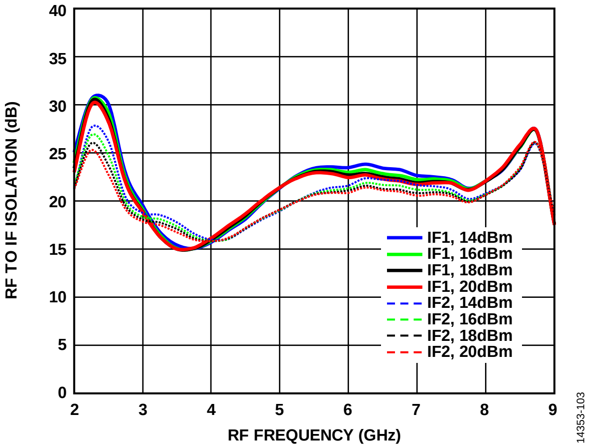


*Figure 99. RF to IF Isolation vs. RF Frequency at Various LO Drives*

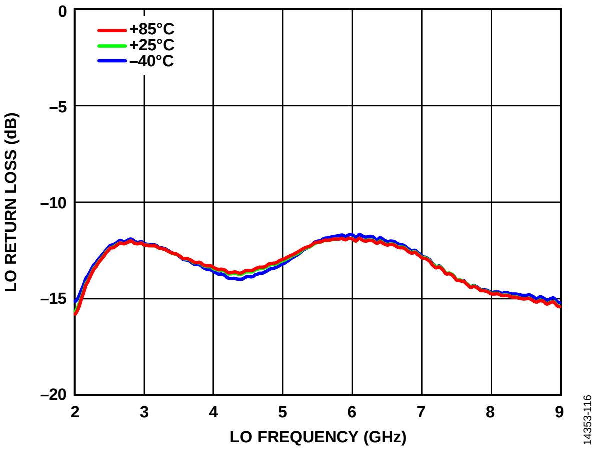


*Figure 100. LO Return Loss vs. LO Frequency at Various Temperatures*

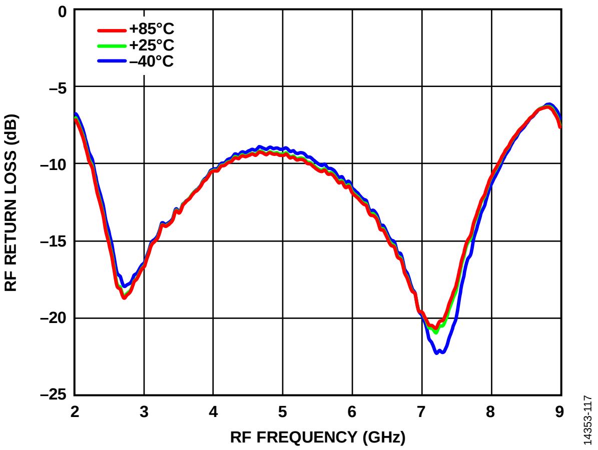


*Figure 101. RF Return Loss vs. RF Frequency at Various Temperatures LO Frequency = 5.5 GHz*

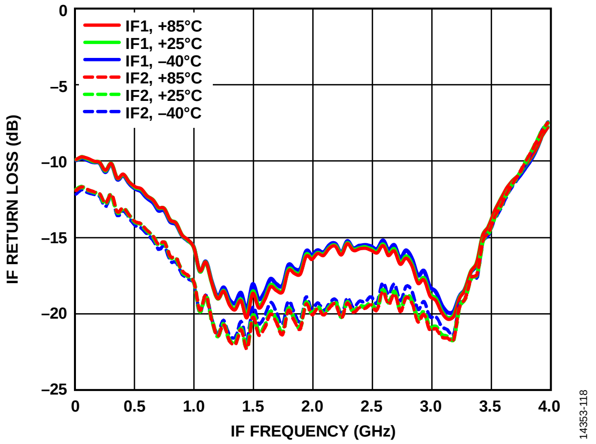


*Figure 102. IF Return Loss vs. IF Frequency at Various Temperatures LO Frequency = 5.5 GHz*

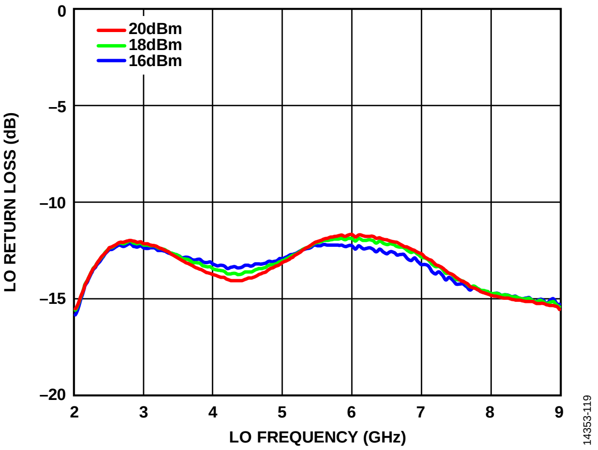


*Figure 103. LO Return Loss vs. LO Frequency at Various LO Drives*

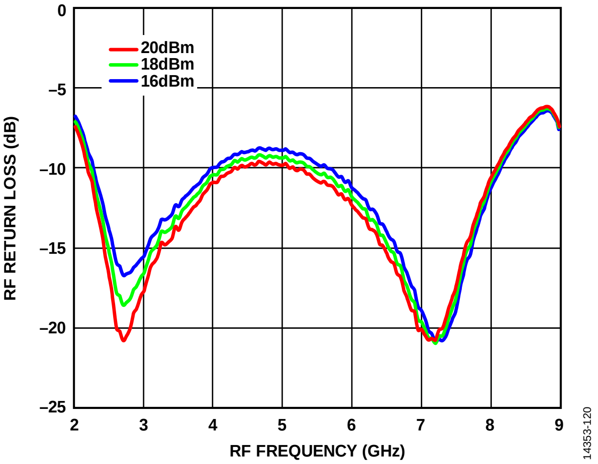


*Figure 104. RF Return Loss vs. RF Frequency at Various LO Drives LO Frequency = 5.5 GHz*

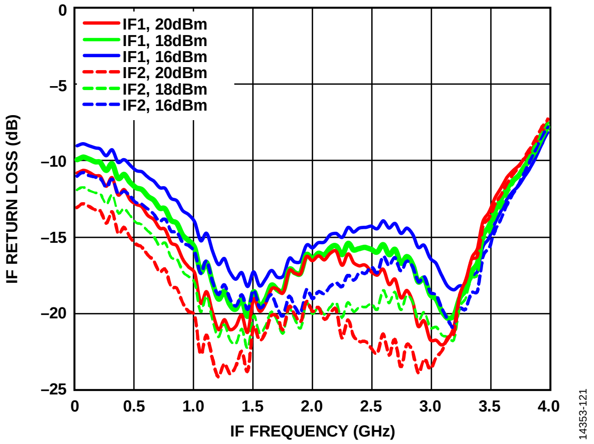


*Figure 105. IF Return Loss vs. IF Frequency at Various Temperatures LO Frequency = 5.5 GHz*

## IF BANDWIDTH

Data taken as a downconverter, lower sideband, at LO drive = 18 dBm, $T_A$ = 25°C, unless otherwise noted.

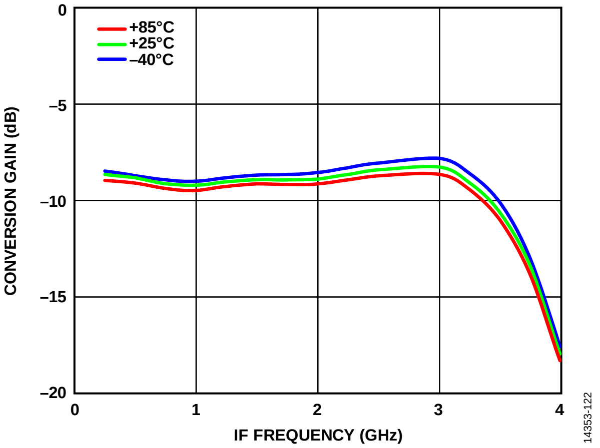


*Figure 106. Conversion Gain vs. IF Frequency at Various Temperatures LO Frequency = 5.5 GHz*

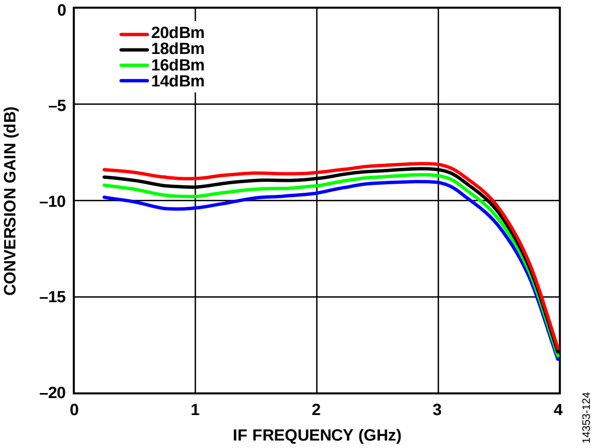


*Figure 108. Conversion Gain vs. IF Frequency at Various LO Drives LO Frequency = 5.5 GHz*

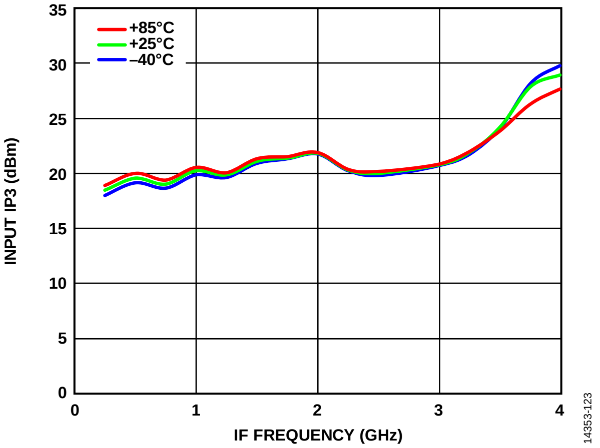


*Figure 107. Input IP3 vs. IF Frequency at Various Temperatures LO Frequency = 5.5 GHz*

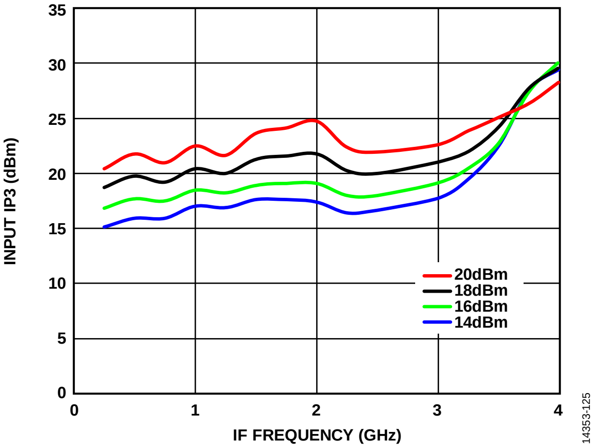


*Figure 109. Input IP3 vs. IF Frequency at Various LO Drives LO Frequency = 5.5 GHz*

## AMPLITUDE AND PHASE IMBALANCE

### *Downconverter Performance, Lower Sideband*

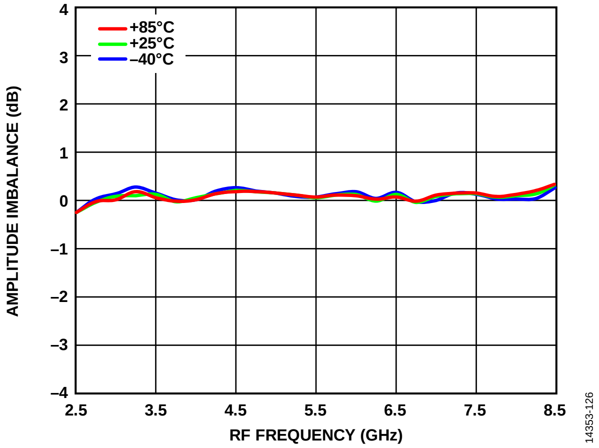


*Figure 110. Amplitude Imbalance vs. RF Frequency at Various Temperatures, LO Drive = 18 dBm, IF = 100 MHz*

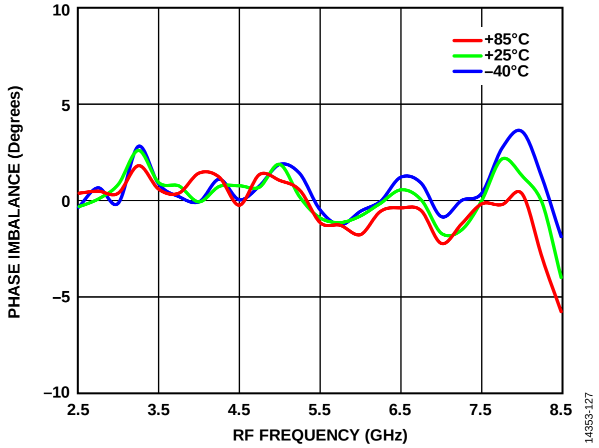


*Figure 111. Phase Imbalance vs. RF Frequency at Various Temperatures, LO Drive = 18 dBm, IF = 100 MHz*

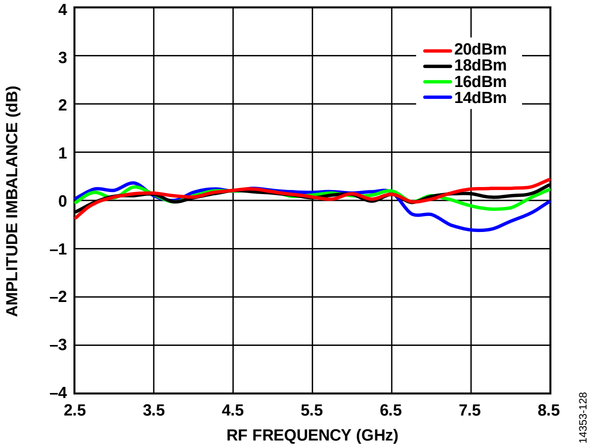


*Figure 112. Amplitude Imbalance vs. RF Frequency at Various LO Drives, IF = 100 MHz, $T_A$ = 25°C*

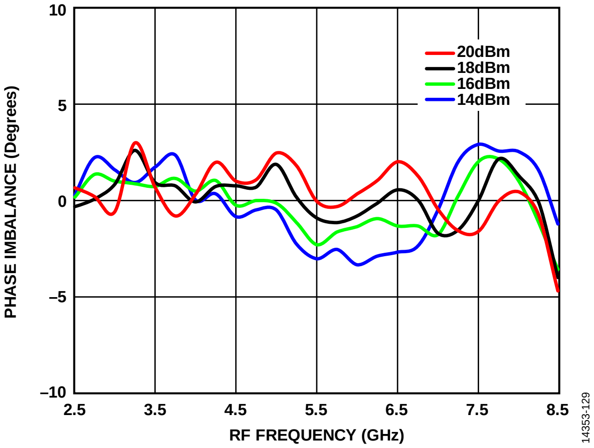


*Figure 113. Phase Imbalance vs. RF Frequency at Various LO Drives, IF = 100 MHz, $T_A$ = 25°C*

### Downconverter Performance, Upper Sideband

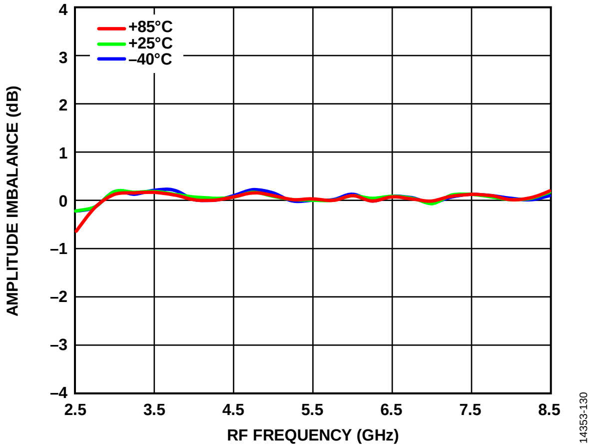


Figure 114. Amplitude Imbalance vs. RF Frequency at Various Temperatures, LO Drive = 18 dBm, IF = 100 MHz

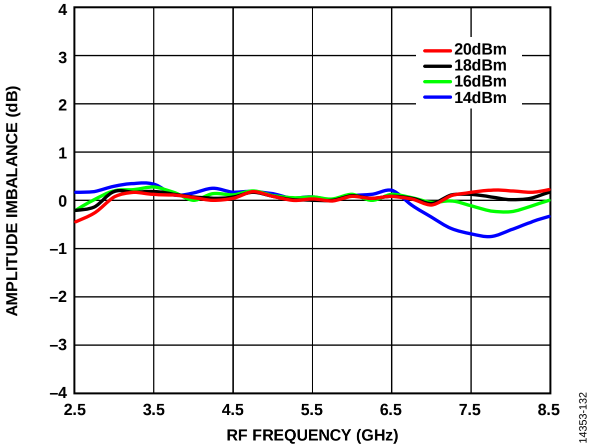


Figure 116. Amplitude Imbalance vs. RF Frequency at Various LO Drives, IF = 100 MHz, $T_A$ = 25°C

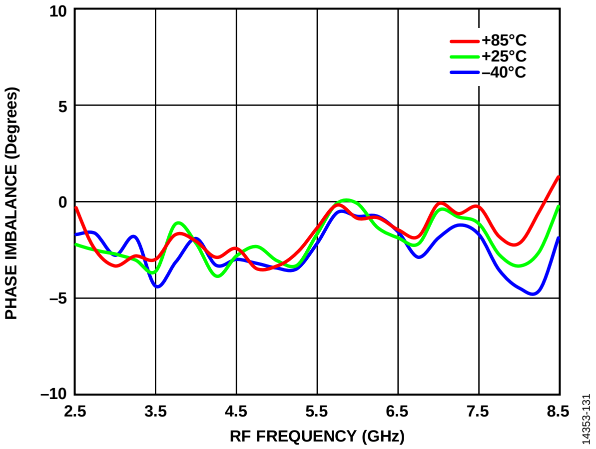


Figure 115. Phase Imbalance vs. RF Frequency at Various Temperatures, LO Drive = 18 dBm, IF = 100 MHz

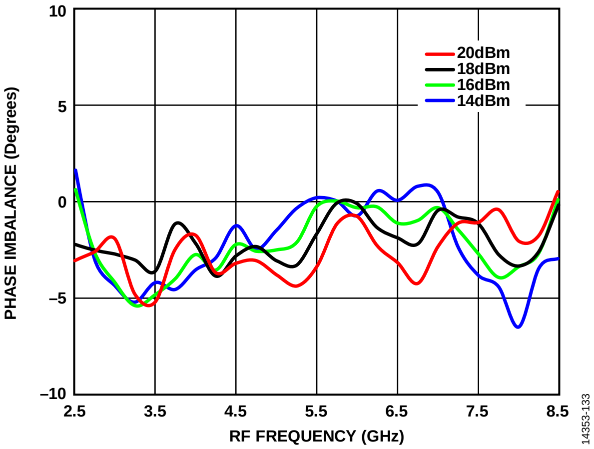


Figure 117. Phase Imbalance vs. RF Frequency at Various LO Drives, IF = 100 MHz, $T_A$ = 25°C

## SPURIOUS AND HARMONICS PERFORMANCE

All M × N spur data captured with the 90° hybrid attached.

### *Downconverter M × N Spurious Outputs*

Mixer spurious products are measured in dBc from the IF output power level, unless otherwise specified. Spur values are (M × RF) − (N × LO).

IF = 100 MHz, RF = 2500 MHz, LO = 2600 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | **N × LO** | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × RF** | **0** | Not applicable | 0 | 34 | 33 | 47 |
| | **1** | 22 | 0 | 29 | 41 | 46 |
| | **2** | 84 | 69 | 73 | 70 | 85 |
| | **3** | 84 | 82 | 89 | 69 | 87 |
| | **4** | 82 | 83 | 79 | 89 | 92 |

IF = 100 MHz, RF = 5500 MHz, LO = 5600 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | **N × LO** | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × RF** | **0** | Not applicable | 9 | 35 | 29 | 48 |
| | **1** | 23 | 0 | 53 | 47 | 52 |
| | **2** | 81 | 68 | 69 | 70 | 81 |
| | **3** | 80 | 82 | 84 | 67 | 80 |
| | **4** | 77 | 80 | 79 | 83 | 91 |

IF = 100 MHz, RF = 8500 MHz, LO = 8600 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | **N × LO** | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × RF** | **0** | Not applicable | 1 | 30 | 35 | 48 |
| | **1** | 15 | 0 | 53 | 69 | 57 |
| | **2** | 76 | 76 | 72 | 78 | 76 |
| | **3** | 70 | 77 | 79 | 89 | 77 |
| | **4** | 67 | 72 | 76 | 80 | 87 |

IF = 1000 MHz, RF = 2500 MHz, LO = 3500 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | **N × LO** | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × RF** | **0** | Not applicable | −6 | +22 | +19 | +33 |
| | **1** | +11 | +0 | +32 | +36 | +43 |
| | **2** | +74 | +55 | +77 | +69 | +72 |
| | **3** | +73 | +68 | +65 | +59 | +76 |
| | **4** | +71 | +74 | +59 | +65 | +68 |

IF = 1000 MHz, RF = 5500 MHz, LO = 6500 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | **N × LO** | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × RF** | **0** | Not applicable | 2 | 19 | 13 | 35 |
| | **1** | 12 | 0 | 31 | 38 | 40 |
| | **2** | 71 | 61 | 65 | 64 | 70 |
| | **3** | 68 | 70 | 76 | 67 | 71 |
| | **4** | 64 | 68 | 69 | 77 | 73 |

IF = 1000 MHz, RF = 8500 MHz, LO = 9500 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | **N × LO** | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × RF** | **0** | Not applicable | −3 | +19 | +12 | +32 |
| | **1** | +6 | +0 | +35 | +63 | +51 |
| | **2** | +66 | +69 | +62 | +67 | +63 |
| | **3** | +59 | +66 | +70 | +67 | +66 |
| | **4** | +59 | +60 | +66 | +70 | +68 |

IF = 3500 MHz, RF = 2500 MHz, LO = 6000 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | **N × LO** | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × RF** | **0** | Not applicable | 4 | 36 | 13 | 52 |
| | **1** | 20 | 0 | 49 | 60 | 44 |
| | **2** | 74 | 61 | 80 | 87 | 81 |
| | **3** | 87 | 78 | 87 | 91 | 88 |
| | **4** | 92 | 94 | 97 | 92 | 88 |

IF = 3500 MHz, RF = 5500 MHz, LO = 9000 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | **N × LO** | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × RF** | **0** | Not applicable | 7 | 23 | 28 | 41 |
| | **1** | 14 | 0 | 37 | 55 | 56 |
| | **2** | 85 | 91 | 88 | 81 | 83 |
| | **3** | 88 | 90 | 89 | 93 | 87 |
| | **4** | 87 | 88 | 93 | 93 | 85 |

IF = 3500 MHz, RF = 8500 MHz, LO = 12,000 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | **N × LO** | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × RF** | **0** | Not applicable | −20 | +5 | +7 | +20 |
| | **1** | −10 | +0 | +38 | +61 | +54 |
| | **2** | +60 | +69 | +64 | +64 | +61 |
| | **3** | +61 | +61 | +70 | +64 | +63 |
| | **4** | +54 | +63 | +53 | +34 | +62 |

### *Upconverter M × N Spurious Outputs*

Mixer spurious products are measured in dBc from the RF output power level, unless otherwise specified. Spur values are (M × IF) − (N × LO).

IF = 100 MHz, RF = 2500 MHz, LO = 2600 MHz, RF power = −10 dBm, and LO power = +18 dBm..

| | | N × LO | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × IF** | **0** | Not applicable | 10 | 9 | 24 | 20 |
| | **1** | 27 | 0 | 15 | 10 | 29 |
| | **2** | 75 | 53 | 47 | 61 | 61 |
| | **3** | 79 | 59 | 72 | 57 | 76 |
| | **4** | 93 | 90 | 92 | 89 | 92 |

IF = 100 MHz, RF = 5500 MHz, LO = 5600 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | N × LO | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × IF** | **0** | Not applicable | 19 | 20 | 23 | 40 |
| | **1** | 25 | 0 | 50 | 26 | 44 |
| | **2** | 75 | 54 | 70 | 81 | 78 |
| | **3** | 89 | 69 | 85 | 84 | 85 |
| | **4** | 94 | 94 | 89 | 87 | 86 |

IF = 100 MHz, RF = 8500 MHz, LO = 8600 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | N × LO | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × IF** | **0** | Not applicable | −2 | +16 | +18 | +19 |
| | **1** | 20 | +0 | +31 | +35 | +46 |
| | **2** | 67 | +50 | +55 | +67 | +75 |
| | **3** | 77 | +70 | +81 | +79 | +78 |
| | **4** | 92 | +86 | +81 | +80 | +74 |

IF = 1000 MHz, RF = 2500 MHz, LO = 3500 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | N × LO | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × IF** | **0** | Not applicable | 12 | 11 | 23 | 34 |
| | **1** | 13 | 0 | 25 | 35 | 46 |
| | **2** | 57 | 48 | 63 | 70 | 80 |
| | **3** | 83 | 91 | 79 | 65 | 82 |
| | **4** | 77 | 91 | 84 | 67 | 83 |

IF = 1000 MHz, RF = 5500 MHz, LO = 6500 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | N × LO | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × IF** | **0** | Not applicable | 13 | 25 | 33 | 41 |
| | **1** | 11 | 0 | 44 | 31 | 39 |
| | **2** | 63 | 40 | 69 | 64 | 75 |
| | **3** | 84 | 68 | 80 | 78 | 75 |
| | **4** | 84 | 89 | 82 | 79 | 76 |

IF = 1000 MHz, RF = 8500 MHz, LO = 9500 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | N × LO | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × IF** | **0** | Not applicable | −3 | +24 | +21 | +34 |
| | **1** | +8 | 0 | +45 | +36 | +36 |
| | **2** | +58 | +37 | +59 | +63 | +66 |
| | **3** | +70 | +70 | +75 | +69 | +65 |
| | **4** | +80 | +80 | +75 | +70 | +68 |

IF = 3500 MHz, RF = 2500 MHz, LO = 6000 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | N × LO | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × IF** | **0** | Not applicable | 20 | 25 | 22 | 29 |
| | **1** | 8 | 0 | 33 | 43 | 41 |
| | **2** | 67 | 71 | 62 | 75 | 70 |
| | **3** | 87 | 79 | 80 | 79 | 88 |
| | **4** | 85 | 91 | 95 | 97 | 92 |

IF = 3500 MHz, RF = 5500 MHz, LO = 9000 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | N × LO | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × IF** | **0** | Not applicable | −5 | +17 | +42 | +19 |
| | **1** | +6 | 0 | +40 | +37 | +49 |
| | **2** | +62 | +67 | +67 | +88 | +73 |
| | **3** | +91 | +82 | +80 | +79 | +84 |
| | **4** | +86 | +94 | +94 | +89 | +88 |

IF = 3500 MHz, RF = 8500 MHz, LO = 12,000 MHz, RF power = −10 dBm, and LO power = +18 dBm.

| | | N × LO | | | | |
|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** |
| **M × IF** | **0** | Not applicable | −1 | +12 | +5 | +7 |
| | **1** | −4 | 0 | +29 | +58 | +59 |
| | **2** | +37 | +44 | +62 | +71 | +60 |
| | **3** | +53 | +69 | +72 | +70 | +58 |
| | **4** | +70 | +79 | +74 | +72 | +65 |

### *LO Harmonics*

LO drive = 18 dBm and all values in are in dBc below the input LO level measured at the RF port.

**Table 5. Harmonics of LO**

| | N × LO Spur at RF Port | | | |
|---|---|---|---|---|
| **LO Frequency (GHz)** | **1** | **2** | **3** | **4** |
| 2.5 | 50 | 45 | 61 | 66 |
| 3.5 | 47 | 46 | 56 | 71 |
| 4.5 | 50 | 63 | 65 | 60 |
| 5.5 | 52 | 68 | 61 | 69 |
| 6.5 | 50 | 66 | 66 | 73 |
| 7.5 | 49 | 63 | 69 | 62 |
| 8.5 | 40 | 59 | 59 | 81 |

# THEORY OF OPERATION

The HMC8193 is a passive, wideband, I/Q, MMIC mixer that can be used as an image rejection mixer or as a single-sideband upconverter for transmitter operations. With an RF and LO range of 2.5 GHz to 8.5 GHz, as well as an IF bandwidth of dc to 4 GHz, the HMC8193 is ideal for applications requiring wide frequency range, excellent RF performance, and a simple design that includes a few components and a small PCB footprint. A single HMC8193 can replace multiple narrow-band mixers in a design.

The inherent I/Q architecture of the HMC8193 offers excellent image rejection and sideband rejection, thereby eliminating the need for expensive filtering of unwanted sidebands. The double balanced architecture of the mixer also provides excellent LO to RF and LO to IF isolation and reduces the effect of LO leakage to ensure signal integrity.

The HMC8193 does not require any dc power sources because it is a passive mixer. The device offers a lower noise figure than an active mixer, ensuring superior dynamic range for high performance and precision applications.

The HMC8193 is fabricated on a GaAs MESFET process and uses Analog Devices mixer cells and a 90° hybrid. The HMC8193 is available in a compact, 4 mm × 4 mm, 24-terminal LCC package and operates over a −40°C to +85°C temperature range. An evaluation board for the HMC8193 is also available from Analog Devices.

For both upconversion and downconversion, an external 90° hybrid is required. See the Applications Information section for information regarding interfacing with an external 90° hybrid

# APPLICATIONS INFORMATION

Figure 118 shows the typical application circuit for the HMC8193. To select the appropriate sideband, an external 90° hybrid is required. For applications not requiring operation to dc, use an off-chip dc blocking capacitor. For applications that require the LO signal at the output to be suppressed, use a bias tee/RF choke as shown in Figure 118. Ensure that the source/sink current used for LO suppression is less than 6 mA for each IF port; otherwise, device damage may occur. The common-mode voltage for each IF port is 0 V.

To select the upper sideband when using as an upconverter, connect the IF1 pin to the 90° port of the hybrid, and connect the IF2 pin to the 0° port of the hybrid. To select the lower sideband, connect IF1 to the 0° port of the hybrid and IF2 to the 90° port of the hybrid. The input is from the sum port of the hybrid and the difference port is 50 Ω terminated.

To select the upper sideband (low-side LO) when using as a downconverter, connect the IF1 pin to the 0° port of the hybrid, and connect the IF2 pin to the 90° port of the hybrid. To select the lower sideband (high-side LO), connect the IF1 pin to the 90° port of the hybrid and IF2 to the 0° port of the hybrid. The output is from the sum port of the hybrid, and the difference port is 50 Ω terminated.

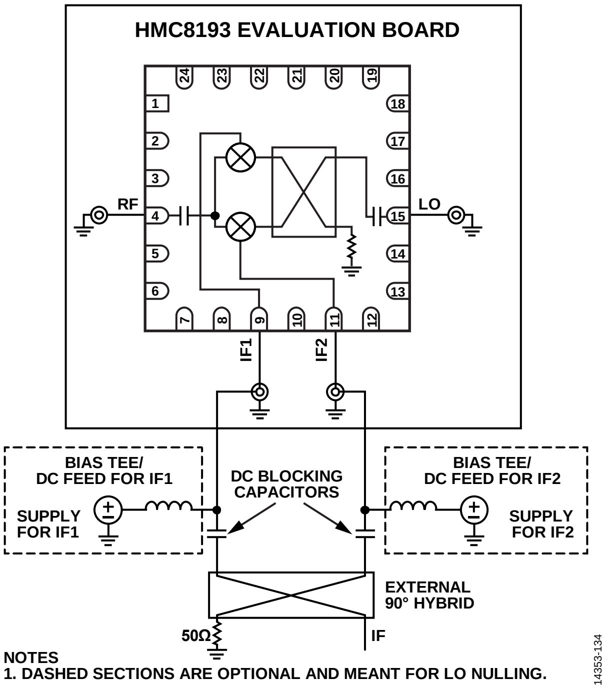


*Figure 118. Typical Application Circuit*

## SOLDERING INFORMATION AND RECOMMENDED LAND PATTERN

Figure 119 and Figure 120 show the recommended land pattern and solder stencil for the HMC8193, respectively. The HMC8193 is contained in a 4 mm × 4 mm, 24-terminal, ceramic, LCC package, which has an exposed ground pad (EP). This pad is internally connected to the ground of the chip. To minimize thermal impedance and ensure electrical performance, solder the pad to the low impedance ground plane on the PCB. To further reduce thermal impedance, it is recommended that the ground planes on all layers under the pad be stitched together with vias.

The land pattern on the HMC8193 evaluation board provides a simulated thermal resistance ($\theta_{JA}$) of 120°C/W

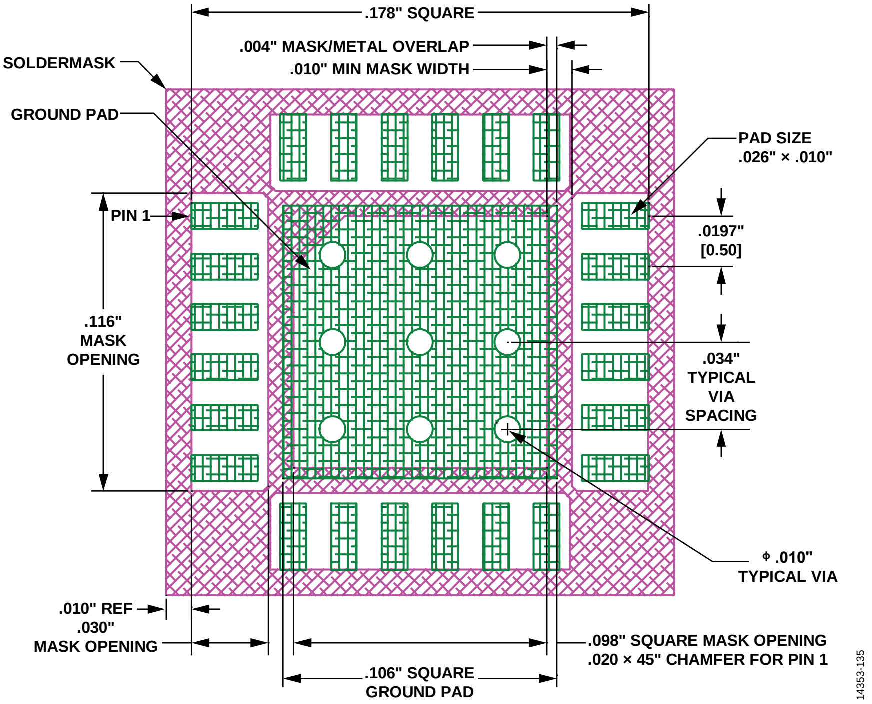


*Figure 119. Evaluation Board Land Pattern for the HMC8193 Package*

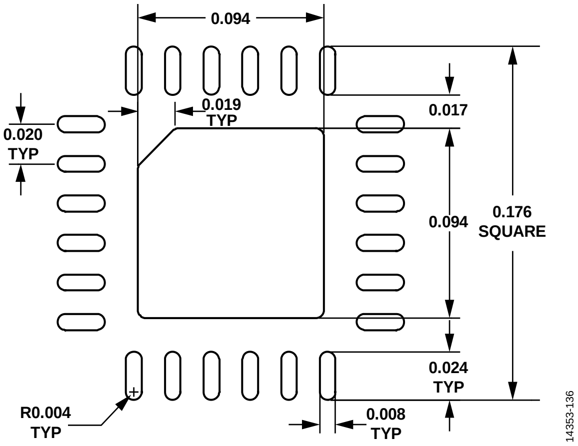


*Figure 120. Solder Stencil for the HMC8193 Package on the HMC8193 Evaluation Board*

## EVALUATION BOARD INFORMATION

The EV1HMC8193LC4 evaluation PCB used in the application must use RF circuit design techniques. Signal lines must have 50 Ω impedance and connect the package ground leads and exposed pad directly to the ground plane, similar to what is shown in Figure 119. Use a sufficient number of via holes to connect the top and bottom ground planes. The evaluation circuit board shown in Figure 121 is available from Analog Devices upon request.

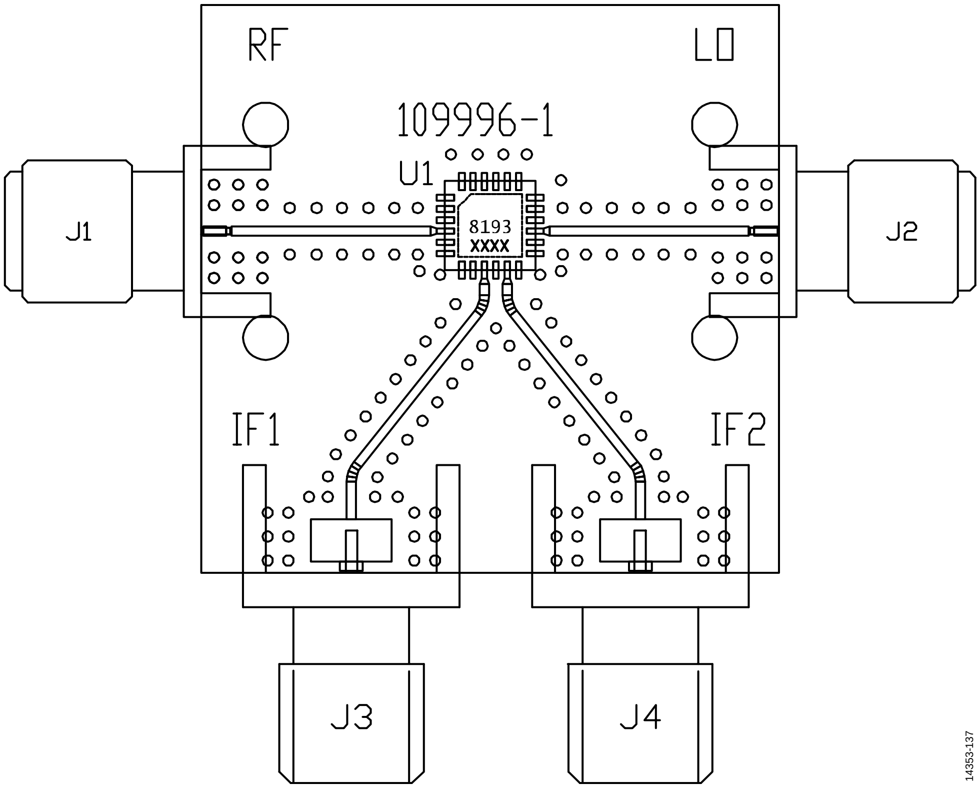


*Figure 121. EV1HMC8193LC4 Evaluation PCB, Top Layer*

**Table 6. Bill of Materials for the EV1HMC8193LC4[1] Evaluation PCB**

| Quantity | Reference Designator | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 1 | Not applicable | PCB, EV1HMC8193LC4[2] | Analog Devices | 109996-1 |
| 2 | J1, J2 | PCB mount SMA RF connector | SRI Connector Gage Co. | 21-146-1000-01 |
| 2 | J3, J4 | PCB mount SMA connector | Johnson SMA Connector | 142-0701-851 |
| 1 | U1 | Device under test (HMC8193) | Analog Devices | HMC8193 |

[1] Reference this number when ordering the evaluation PCB.
[2] The circuit board material is Rogers 4350.