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5.6 GHz to 8.6 GHz, GaAs, MMIC, I/Q Downconverter

Data Sheet **HMC951A**

FEATURES

- Conversion gain: 13 dB typical
- Image rejection: 32 dBc typical
- Input P1dB compression: −6 dBm typical
- Input IP3: 3 dBm typical, 6.0 GHz to 8.6 GHz
- Noise figure: 2 dB typical
- LO to RF isolation: 48 dBm typical
- LO to IF isolation: 13 dBm typical
- RF to IF isolation: 10 dBm typical
- Amplitude balance: 0.2 dB typical
- Phase balance: −2° typical
- RF return loss: 10 dB typical
- LO return loss: 15 dB typical
- IF return loss: 15 dB typical
- Exposed paddle, 4 mm × 4 mm, 24-lead, LFCSP

APPLICATIONS

- Point to point and point to multipoint radios
- Military radars, electronic warfare, and electronic intelligence
- Satellite communications
- Sensors

FUNCTIONAL BLOCK DIAGRAM

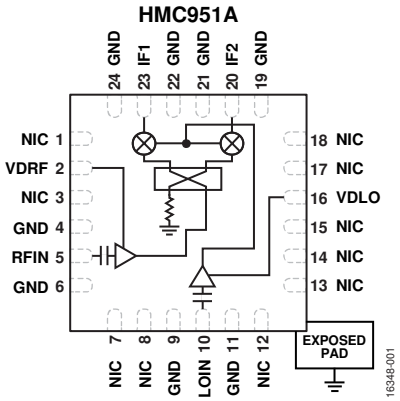

Figure 1.

GENERAL DESCRIPTION

The HMC951A is a compact gallium arsenide (GaAs), monolithic microwave integrated circuit (MMIC), in-phase quadrature (I/Q) downconverter in a RoHS compliant package that operates from 5.6 GHz to 8.6 GHz. This device provides a small signal conversion gain of 13 dB with a noise figure of 2 dB and an image rejection of 32 dBc. The HMC951A uses a low noise amplifier (LNA) followed by an image mixer that is driven by a local oscillator (LO) buffer amplifier. The image reject mixer eliminates the need for a filter following the LNA and removes thermal noise at the image frequency. The IF1 and IF2 mixer outputs 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 unwanted sideband. The HMC951A is a smaller alternative to hybrid style, single sideband (SSB) downconverter assemblies, and it eliminates the need for wire bonding by allowing the use of surface-mount manufacturing techniques.

The HMC951A is available in 4 mm × 4 mm, 24-lead lead frame chip scale package (LFCSP) and operates over the −40°C to +85°C temperature range. An evaluation board for the HMC951A is also available upon request.

Rev. A
Document Feedback

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Technical Support www.analog.com

TABLE OF CONTENTS

REVISION HISTORY

4/2018—Rev. 0 to Rev. A

Changes to Performance at Lower IF Frequencies Section ... 29
Removed Figure 99; Renumbered Sequentially ... 29

3/2018—Revision 0: Initial Version

SPECIFICATIONS

5.6 GHz TO 6.0 GHz

T_A = 25°C, intermediate frequency (IF) = 1000 MHz, VDRF = VDLO = 5 V, local oscillator (LO) power = 0 dBm, unless otherwise noted. Measurements performed with lower sideband selected and an external 90° hybrid at the IF ports, unless otherwise noted.

Table 1.

Parameter	Min	Typ	Max	Unit
OPERATING CONDITIONS				
Frequency Range				
Radio Frequency (RF)	5.6		6.0	GHz
LO	4.5		12.1	GHz
IF	DC		3.5	GHz
LO Drive Range	−4	0	+4	dBm
PERFORMANCE				
Conversion Gain	10	13		dB
Image Rejection	20	32		dBc
Input Power for 1 dB Compression (P1dB)		−6		dBm
Input Third-Order Intercept (IP3)	0	2		dBm
Amplitude Balance		0.2		dB
Phase Balance		−2		Degree
Isolation				
LO to RF	40	48		dB
LO to IF	9	13		dB
RF to IF		10		dB
Noise Figure		2	2.5	dB
Return Loss				
RF		10		dB
LO		15		dB
IF		15		dB
POWER SUPPLY				
Drain Current				
Low Noise Amplifier (I_{DD1})		75	85	mA
LO Amplifier (I_{DD2})		80	95	mA
Total Drain Current (I_{DD})		155		mA

6.0 GHz TO 8.6 GHz

T_A = 25°C, intermediate frequency (IF) = 1000 MHz, VDRF = VDLO = 5 V, local oscillator (LO) power = 0 dBm, unless otherwise noted. Measurements performed with lower sideband selected and an external 90° hybrid at the IF ports, unless otherwise noted.

Table 2.

Parameter	Min	Typ	Max	Unit
OPERATING CONDITIONS				
Frequency Range				
Radio Frequency (RF)	6.0		8.6	GHz
LO	4.5		12.1	GHz
IF	DC		3.5	GHz
LO Drive Range	−4	0	+4	dBm
PERFORMANCE				
Conversion Gain	10	13		dB
Image Rejection	20	32		dBc
Input Power for 1 dB Compression (P1dB)		−6		dBm
Input Third-Order Intercept (IP3)	1	3		dBm
Amplitude Balance		0.2		dB
Phase Balance		−2		Degree
Isolation				
LO to RF	40	48		dB
LO to IF	9	13		dB
RF to IF		10		dB
Noise Figure		2	2.5	dB
Return Loss				
RF		10		dB
LO		15		dB
IF		15		dB
POWER SUPPLY				
Drain Current				
Low Noise Amplifier (I_{DD1})		75	85	mA
LO Amplifier (I_{DD2})		80	95	mA
Total Drain Current (I_{DD})		155		mA

ABSOLUTE MAXIMUM RATINGS

Table 3.

Parameter	Rating
Drain Bias Voltage (VDRF, VDLO)	5.5 V
Input Power	
LO	20 dBm
RF	15 dBm
Moisture Sensitivity Level (MSL) Rating[1]	MSL3
Maximum Junction Temperature	175°C
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−40°C to +85°C
Reflow Temperature	260°C
Electrostatic Discharge Sensitivity	
Human Body Model (HBM)	1000 V
Field Induced Charged Device Model (FICDM)	750 V

[1] See the Ordering Guide.

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.

θ_{JA} is the junction to ambient (or die to ambient) thermal resistance measured in a one cubic foot sealed enclosure, and θ_{JC} is the junction to case (or die to package) thermal resistance.

Table 4. Thermal Resistance

Package Type	θ_{JA}	θ_{JC}	Unit
HCP-24-3[1]	40.9	46.4	°C/W

[1] Thermal impedance simulated values are based on a JEDEC 2S2P test board with 4 × 4 thermal vias. Refer to JEDEC standard JESD51-2 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

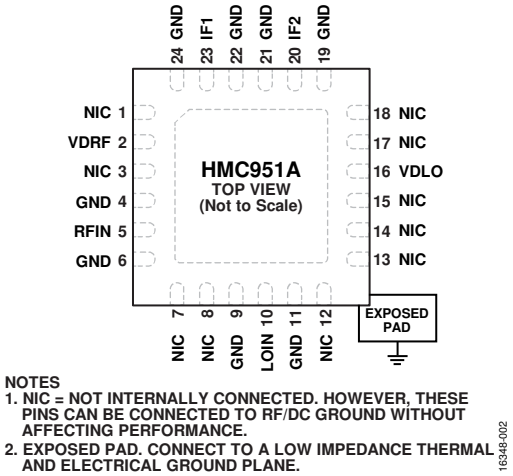

Figure 2. Pin Configuration

Table 5. Pin Function Descriptions

Pin No.	Mnemonic	Description
1, 3, 7, 8, 12 to 15, 17, 18	NIC	Not Internally Connected. However, these pins can be connected to RF/dc ground without affecting performance.
2	VDRF	Power Supply Voltage for the RF Amplifier. See Figure 3 for the interface schematic. Refer to the typical application circuit (see Figure 96) for the required external components.
4, 6, 9, 11, 19, 21, 22, 24	GND	Ground Connect. See Figure 4 for the interface schematic. These pins and package bottom must be connected to RF/dc ground.
5	RFIN	Radio Frequency Input. See Figure 5 for the interface schematic. This pin is ac-coupled and matched to 50 Ω.
10	LOIN	Local Oscillator Input. See Figure 6 for the interface schematic. This pin is ac-coupled and matched to 50 Ω.
16	VDLO	Power Supply Voltage for the LO Amplifier. See Figure 3 for the interface schematic. Refer to the typical application circuit (see Figure 96) for the required external components.
20, 23	IF2, IF1	Quadrature Intermediate Frequency Outputs. See Figure 7 for the interface schematic. For applications not requiring operation to dc, use an off chip dc blocking capacitor. For operation to dc, these pins must not source or sink more than 3 mA of current or device malfunction and failure can result.
	EPAD	Exposed Pad. Connect to a low impedance thermal and electrical ground plane.

INTERFACE SCHEMATICS

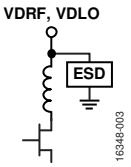

Figure 3. VDRF, VDLO Interface

Figure 4. GND Interface

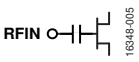

Figure 5. RFIN Interface

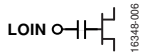

Figure 6. LOIN Interface

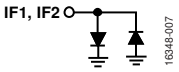

Figure 7. IF2, IF1 Interface

TYPICAL PERFORMANCE CHARACTERISTICS

LOWER SIDEBAND (HIGH-SIDE LO)

IF = 1000 MHz and RF input power = −20 dBm. Data de-embedded for RF trace loss, unless otherwise noted.

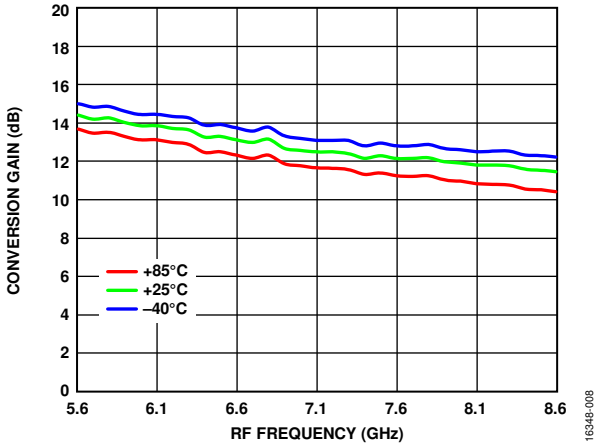

Figure 8. Conversion Gain vs. RF Frequency over Temperatures, LO Power = 0 dBm

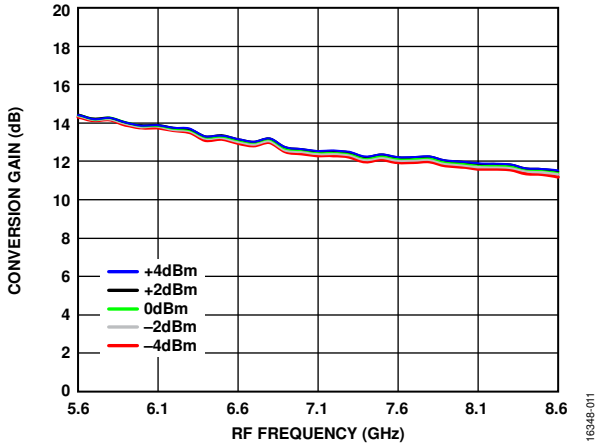

Figure 11. Conversion Gain vs. RF Frequency over LO Powers, T_A = 25°C

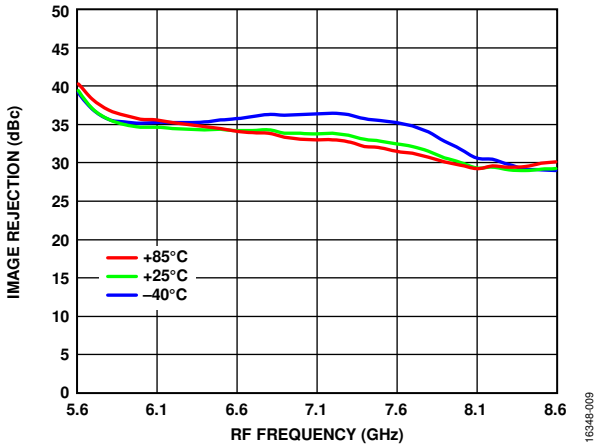

Figure 9. Image Rejection vs. RF Frequency over Temperatures, LO Power = 0 dBm

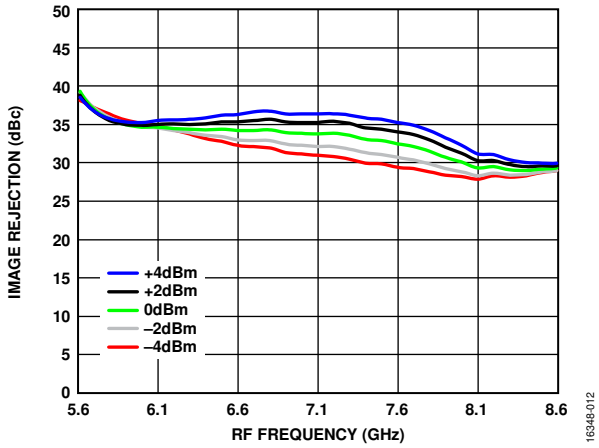

Figure 12. Image Rejection vs. RF Frequency over LO Powers, T_A = 25°C

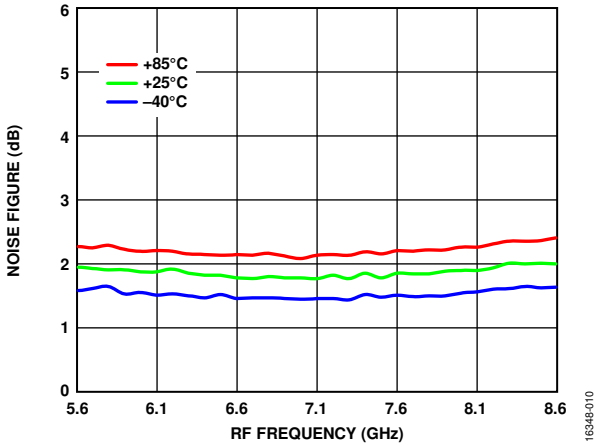

Figure 10. Noise Figure vs. RF Frequency over Temperatures, LO Power = 0 dBm

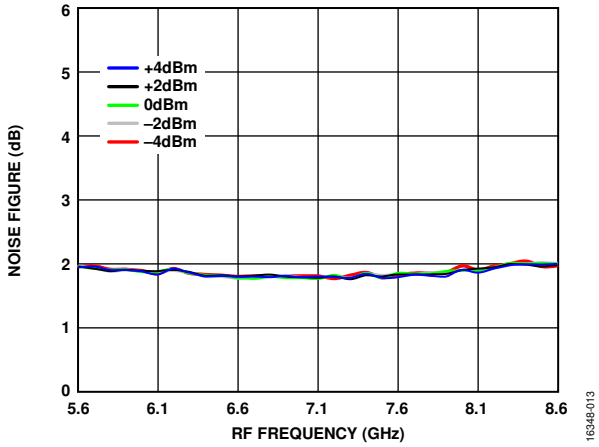

Figure 13. Noise Figure vs. RF Frequency over LO Powers, T_A = 25°C

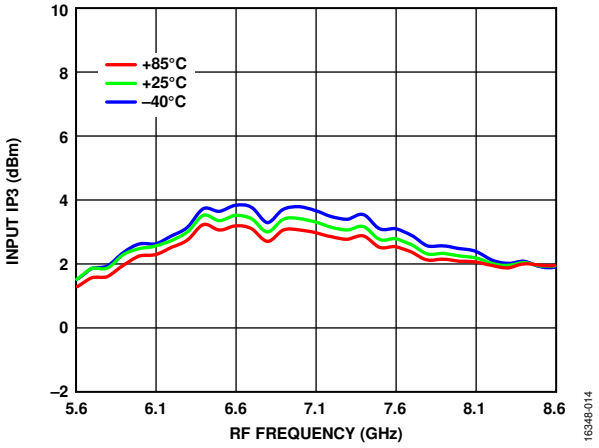

Figure 14. Input IP3 vs. RF Frequency over Temperatures, LO Power = 0 dBm

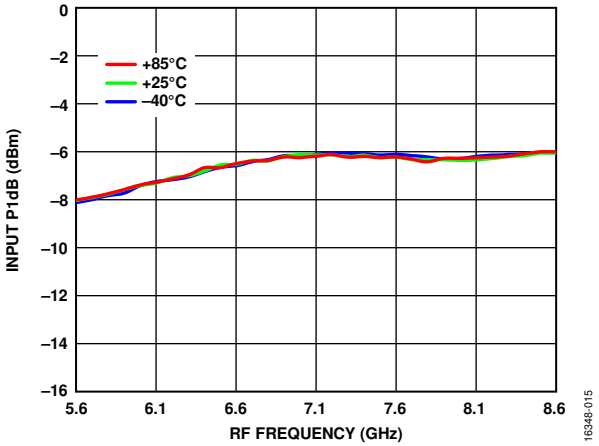

Figure 15. Input P1dB vs. RF Frequency over Temperatures, LO Power = 0 dBm

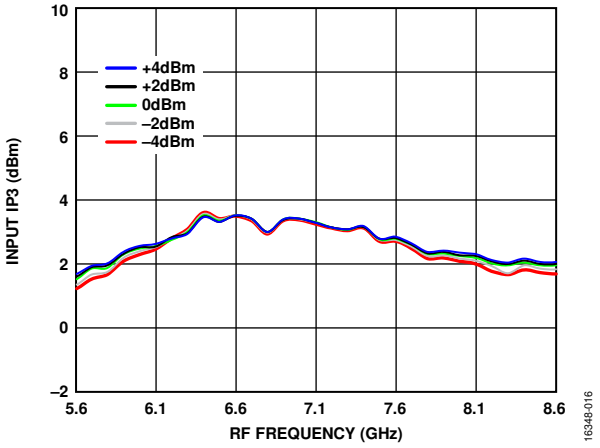

Figure 16. Input IP3 vs. RF Frequency over LO Powers, T_A = 25°C

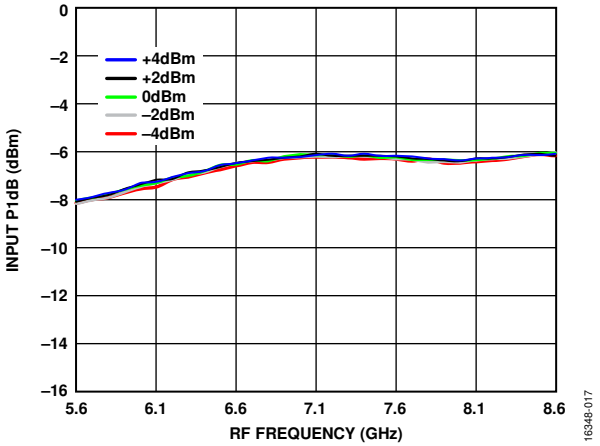

Figure 17. Input P1dB vs. RF Frequency over LO Powers, T_A = 25°C

IF = 150 MHz and RF input power = −20 dBm. Data de-embedded for RF trace loss, unless otherwise noted.

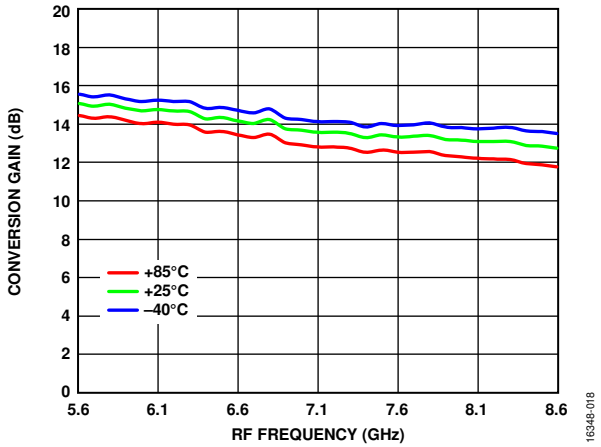

Figure 18. Conversion Gain vs. RF Frequency over Temperatures, LO Power = 0 dBm

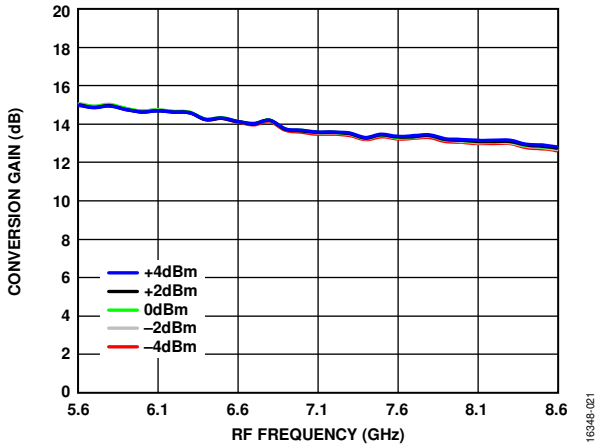

Figure 21. Conversion Gain vs. RF Frequency over LO Powers, T_A = 25°C

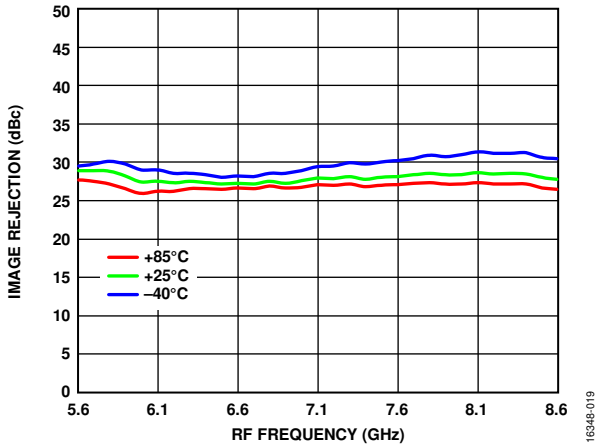

Figure 19. Image Rejection vs. RF Frequency over Temperatures, LO Power = 0 dBm

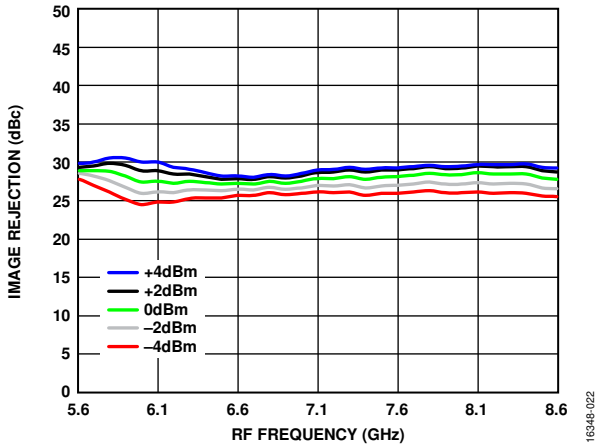

Figure 22. Image Rejection vs. RF Frequency over LO Powers, T_A = 25°C

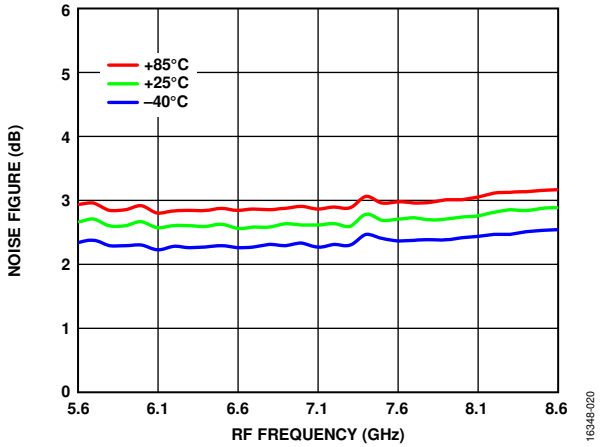

Figure 20. Noise Figure vs. RF Frequency over Temperatures, LO Power = 0 dBm

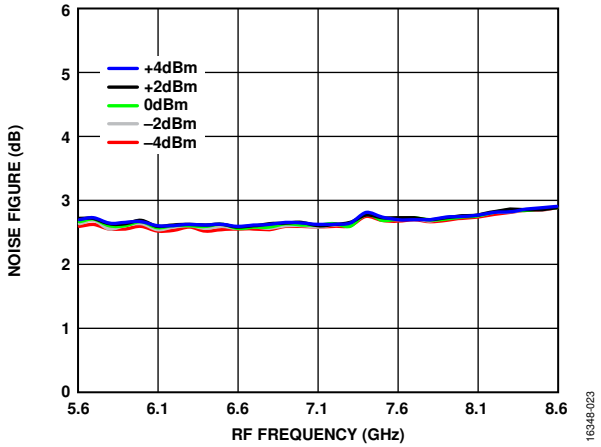

Figure 23. Noise Figure vs. RF Frequency over LO Powers, T_A = 25°C

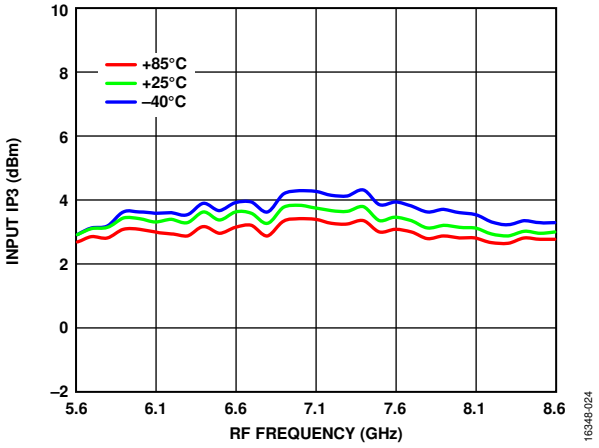

Figure 24. Input IP3 vs. RF Frequency over Temperatures, LO Power = 0 dBm

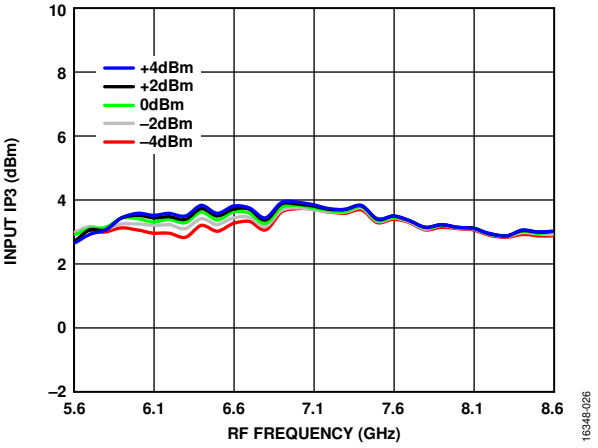

Figure 26. Input IP3 vs. RF Frequency over LO Powers, T_A = 25°C

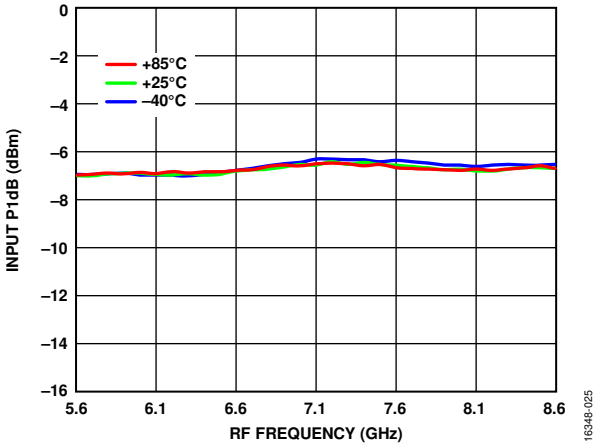

Figure 25. Input P1dB vs. RF Frequency over Temperatures, LO Power = 0 dBm

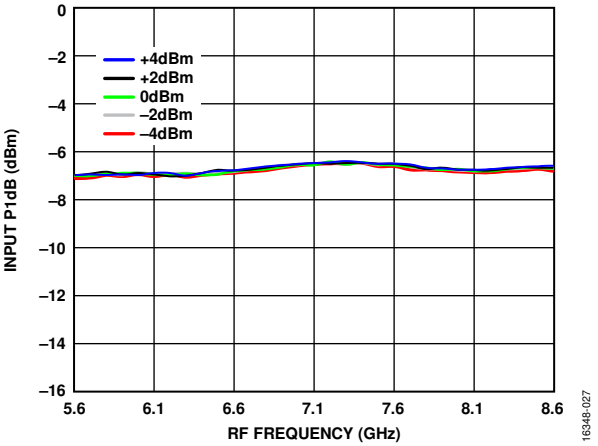

Figure 27. Input P1dB vs. RF Frequency over LO Powers, T_A = 25°C

IF = 3100 MHz and RF input power = −20 dBm. Data de-embedded for RF trace loss, unless otherwise noted.

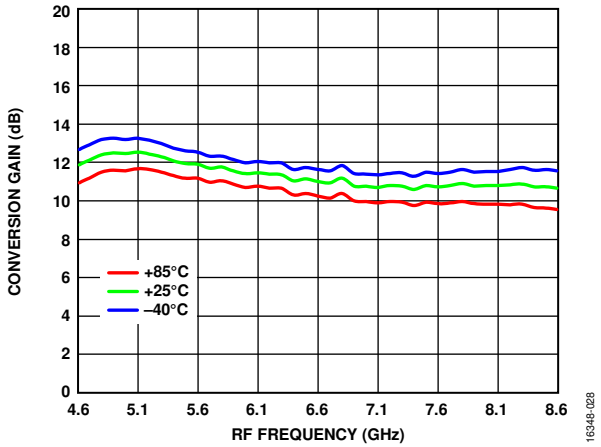

Figure 28. Conversion Gain vs. RF Frequency over Temperatures, LO Power = 0 dBm

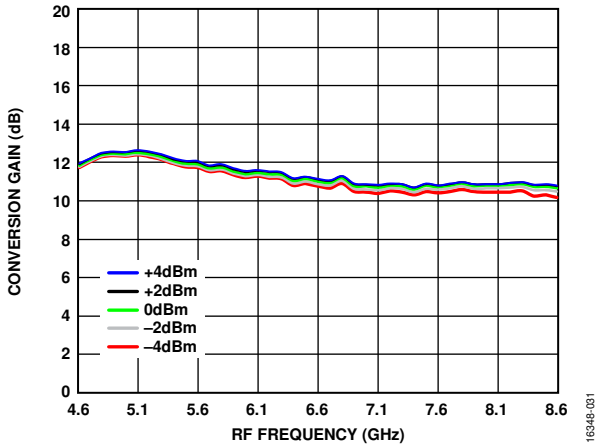

Figure 31. Conversion Gain vs. RF Frequency over LO Powers, T_A = 25°C

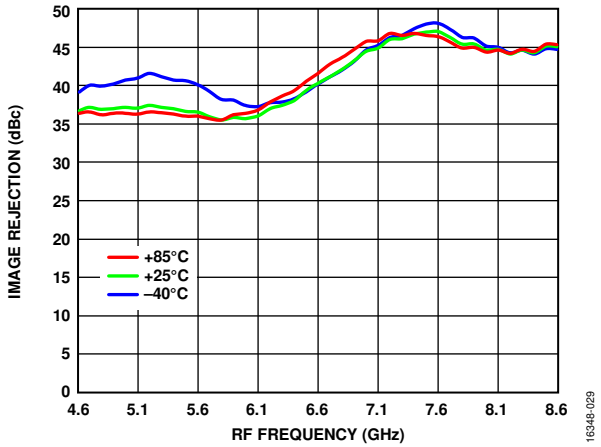

Figure 29. Image Rejection vs. RF Frequency over Temperatures, LO Power = 0 dBm

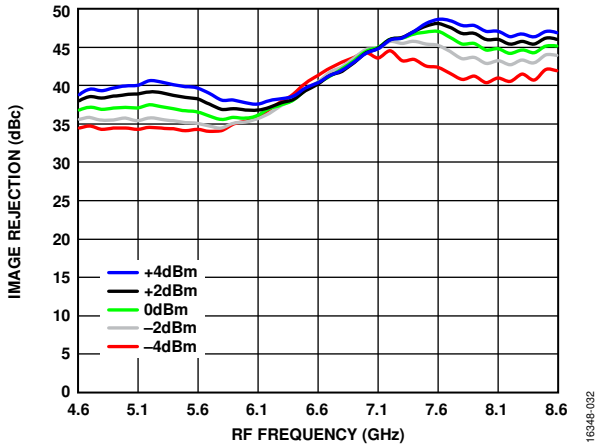

Figure 32. Image Rejection vs. RF Frequency over LO Powers, T_A = 25°C

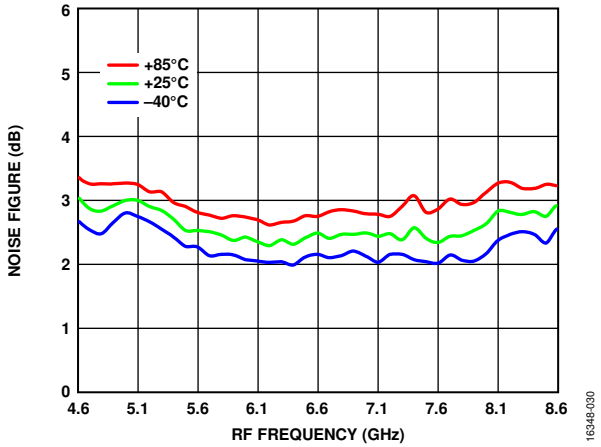

Figure 30. Noise Figure vs. RF Frequency over Temperatures, LO Power = 0 dBm

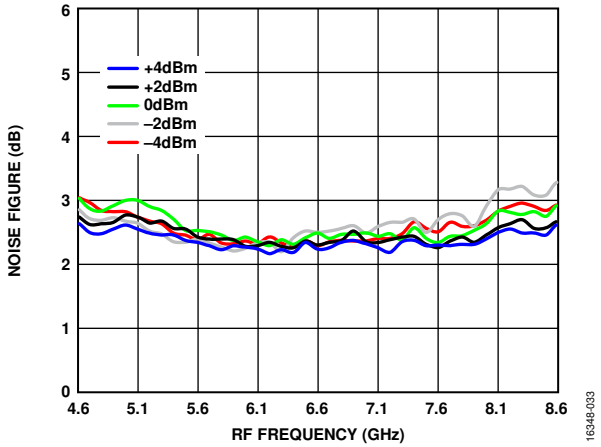

Figure 33. Noise Figure vs. RF Frequency over LO Powers, T_A = 25°C

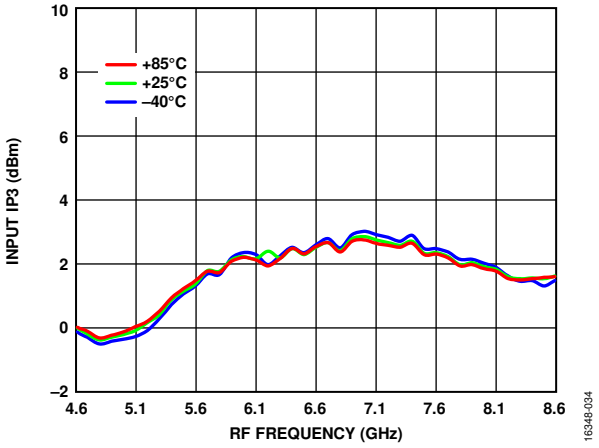

Figure 34. Input IP3 vs. RF Frequency over Temperatures, LO Power = 0 dBm

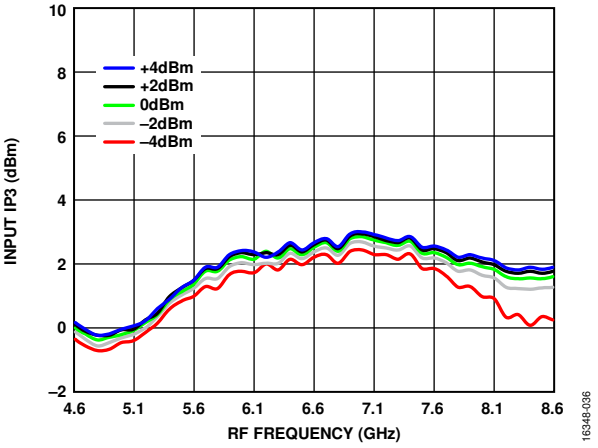

Figure 36. Input IP3 vs. RF Frequency over LO Powers, T_A = 25°C

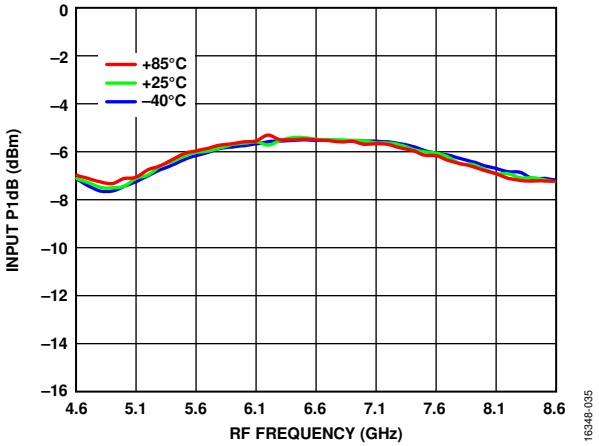

Figure 35. Input P1dB vs. RF Frequency over Temperatures, LO Power = 0 dBm

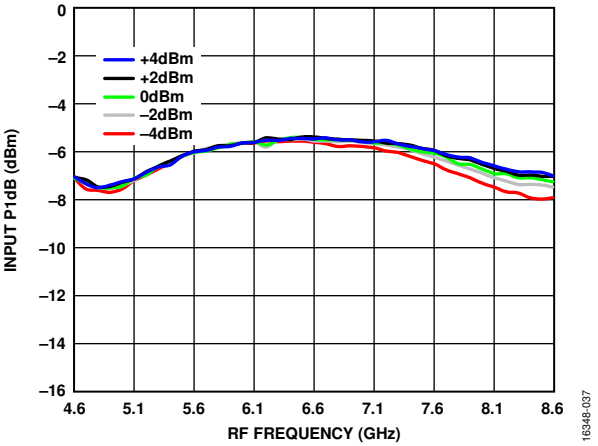

Figure 37. Input P1dB vs. RF Frequency over LO Powers, T_A = 25°C

UPPER SIDEBAND (LOW-SIDE LO)

IF = 150 MHz and RF input power = −20 dBm. Data de-embedded for RF trace loss, unless otherwise noted.

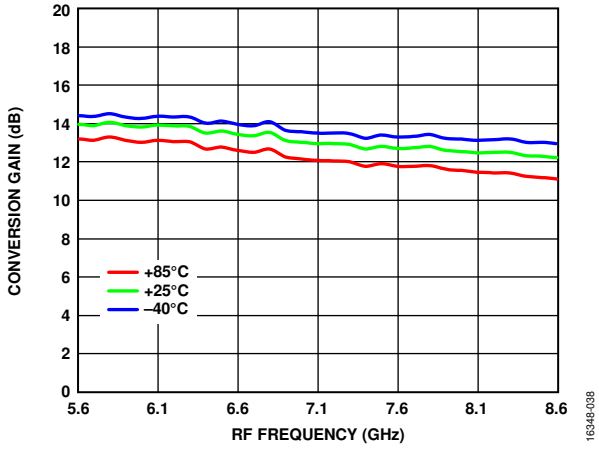

Figure 38. Conversion Gain vs. RF Frequency over Temperatures, LO Power = 0 dBm

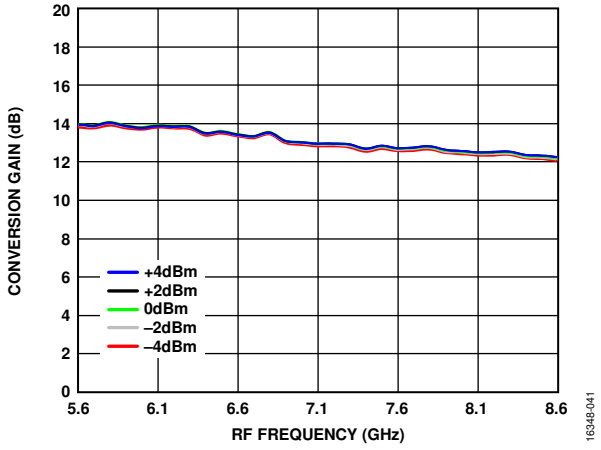

Figure 41. Conversion Gain vs. RF Frequency over LO Powers, T_A = 25°C

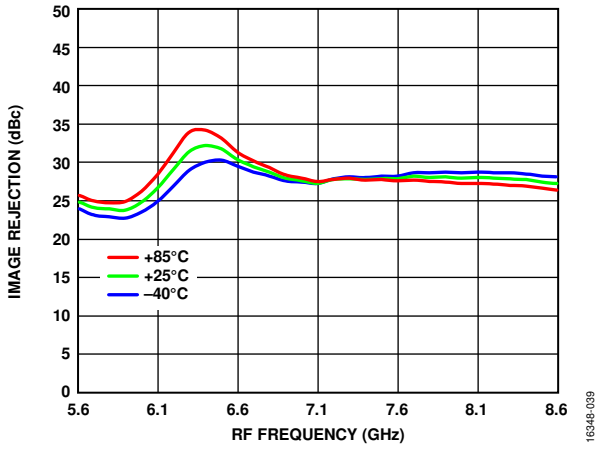

Figure 39. Image Rejection vs. RF Frequency over Temperatures, LO Power = 0 dBm

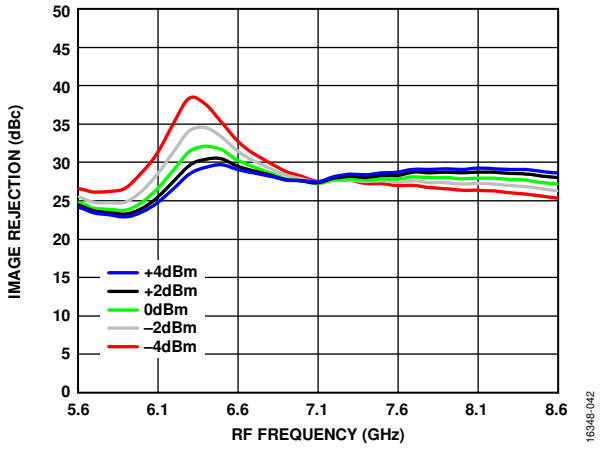

Figure 42. Image Rejection vs. RF Frequency over LO Powers, T_A = 25°C

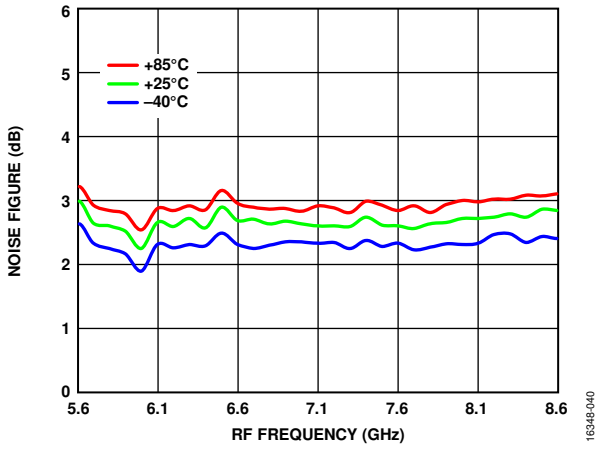

Figure 40. Noise Figure vs. RF Frequency over Temperatures, LO Power = 0 dBm

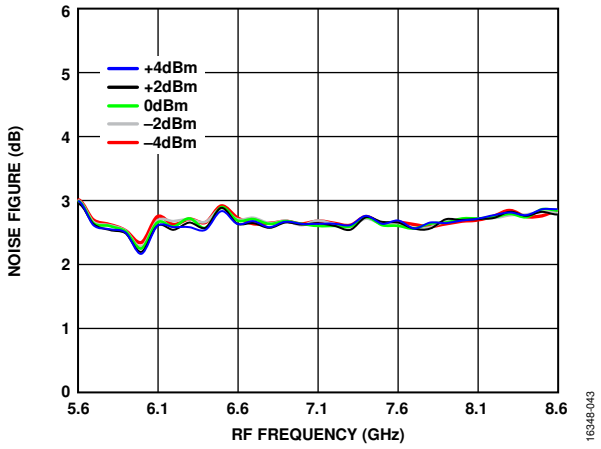

Figure 43. Noise Figure vs. RF Frequency over LO Powers, T_A = 25°C

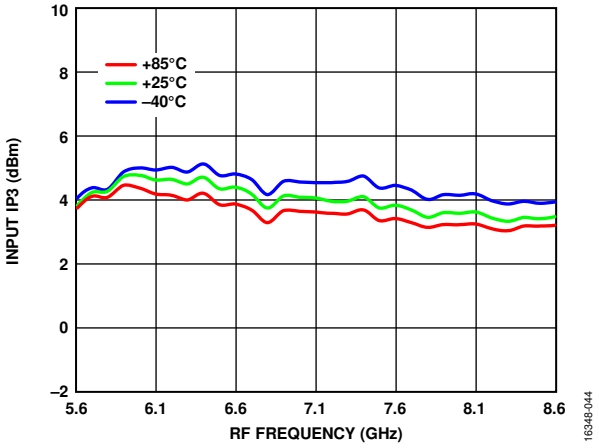

Figure 44. Input IP3 vs. RF Frequency over Temperatures, LO Power = 0 dBm

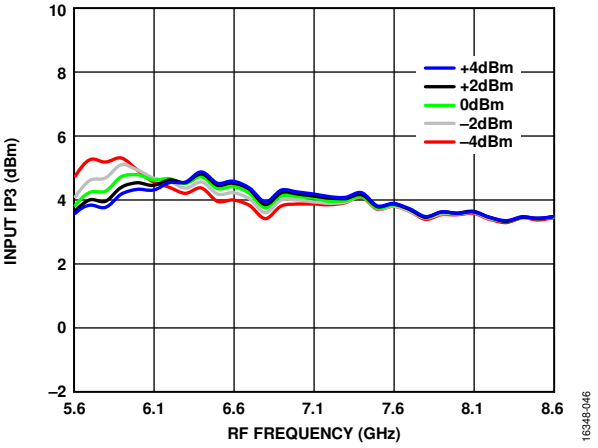

Figure 46. Input IP3 vs. RF Frequency over LO Powers, T_A = 25°C

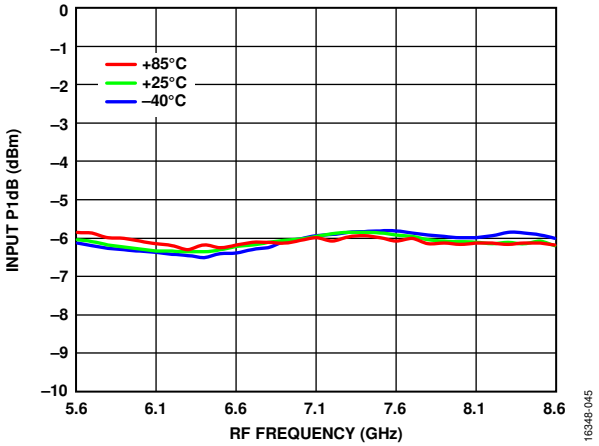

Figure 45. Input P1dB vs. RF Frequency over Temperatures, LO Power = 0 dBm

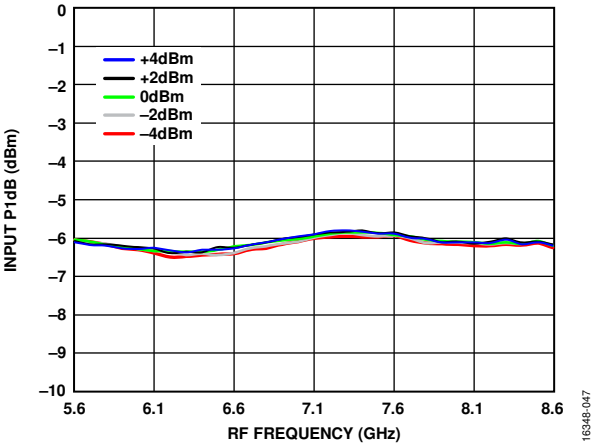

Figure 47. Input P1dB vs. RF Frequency over LO Powers, T_A = 25°C

IF = 1000 MHz and RF input power = −20 dBm. Data de-embedded for RF trace loss, unless otherwise noted.

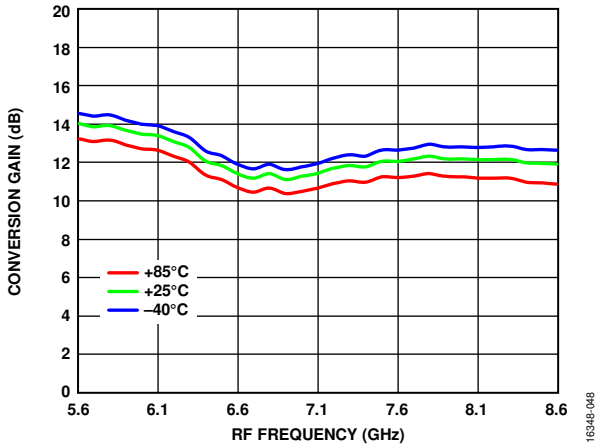

Figure 48. Conversion Gain vs. RF Frequency over Temperatures, LO Power = 0 dBm

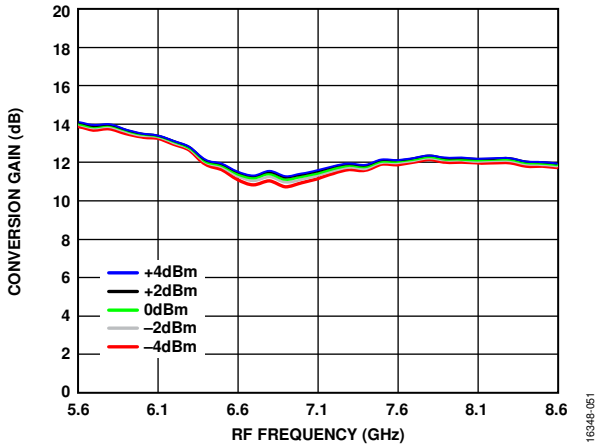

Figure 51. Conversion Gain vs. RF Frequency over LO Powers, T_A = 25°C

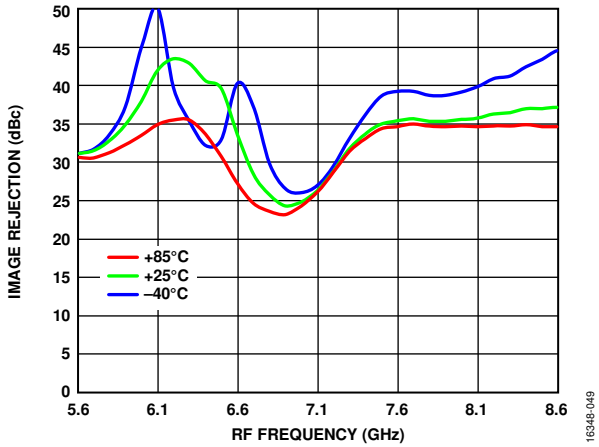

Figure 49. Image Rejection vs. RF Frequency over Temperatures, LO Power = 0 dBm

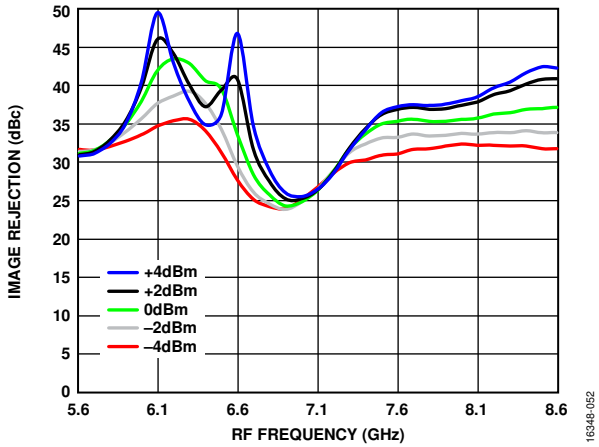

Figure 52. Image Rejection vs. RF Frequency over LO Powers, T_A = 25°C

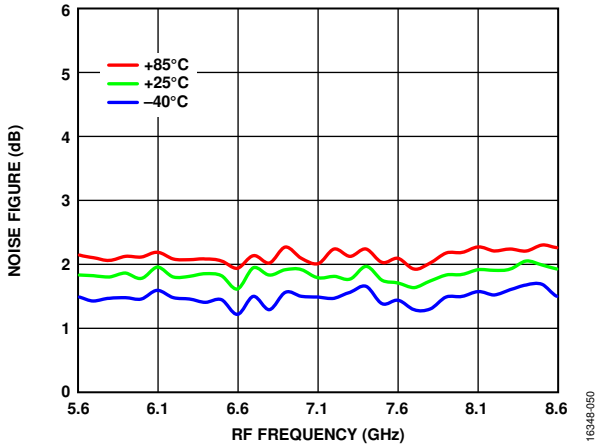

Figure 50. Noise Figure vs. RF Frequency over Temperatures, LO Power = 0 dBm

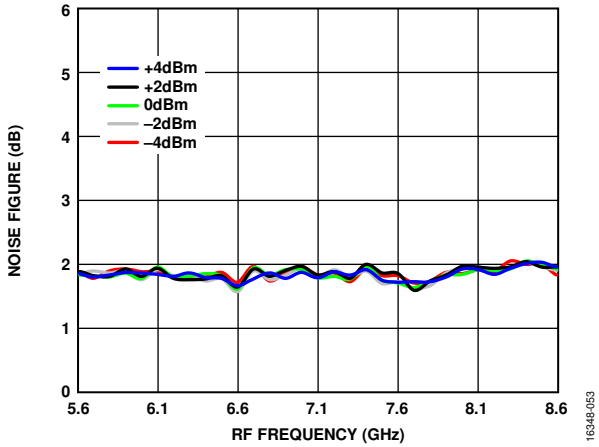

Figure 53. Noise Figure vs. RF Frequency over LO Powers, T_A = 25°C

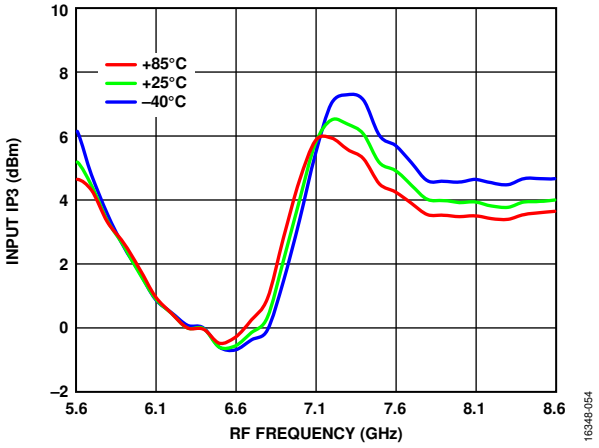

Figure 54. Input IP3 vs. RF Frequency over Temperatures, LO Power = 0 dBm

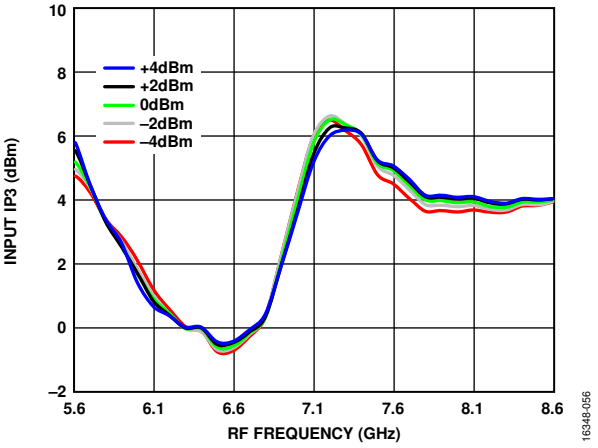

Figure 56. Input IP3 vs. RF Frequency over LO Powers, T_A = 25°C

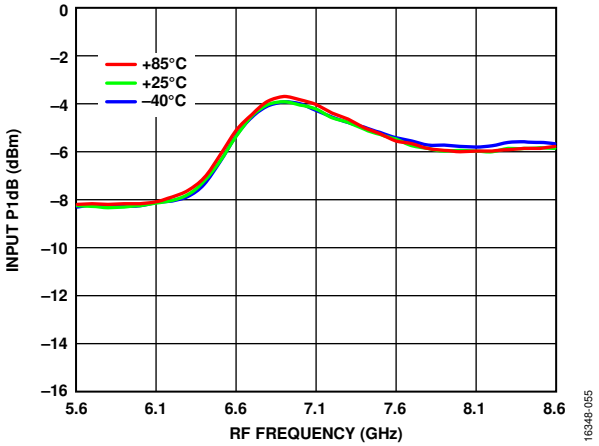

Figure 55. Input P1dB vs. RF Frequency over Temperatures, LO Power = 0 dBm

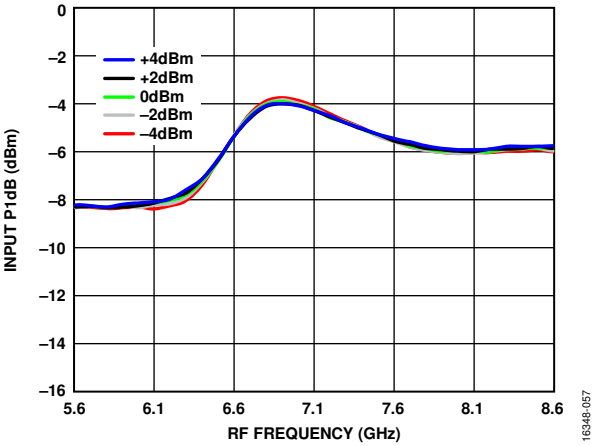

Figure 57. Input P1dB vs. RF Frequency over LO Powers, T_A = 25°C

IF = 3100 MHz and RF input power = −20 dBm. Data de-embedded for RF trace loss, unless otherwise noted.

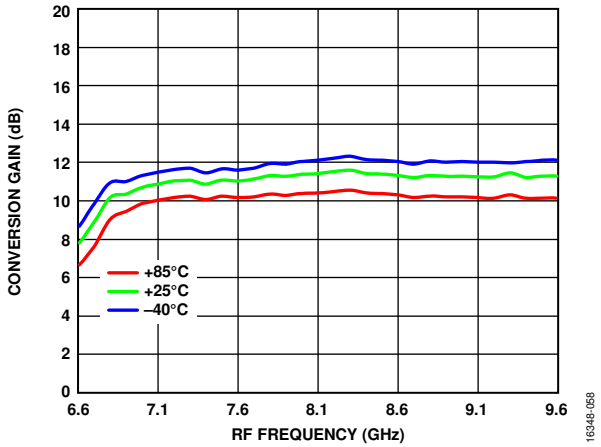

Figure 58. Conversion Gain vs. RF Frequency over Temperatures, LO Power = 0 dBm

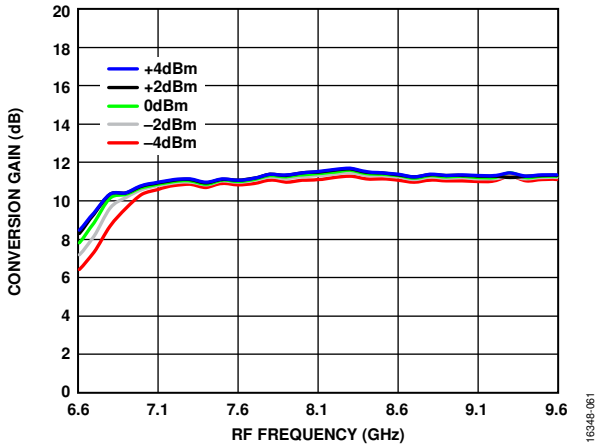

Figure 61. Conversion Gain vs. RF Frequency over LO Powers, T_A = 25°C

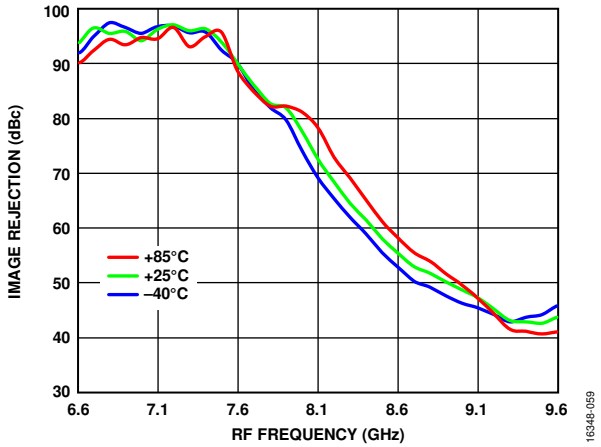

Figure 59. Image Rejection vs. RF Frequency over Temperatures, LO Power = 0 dBm

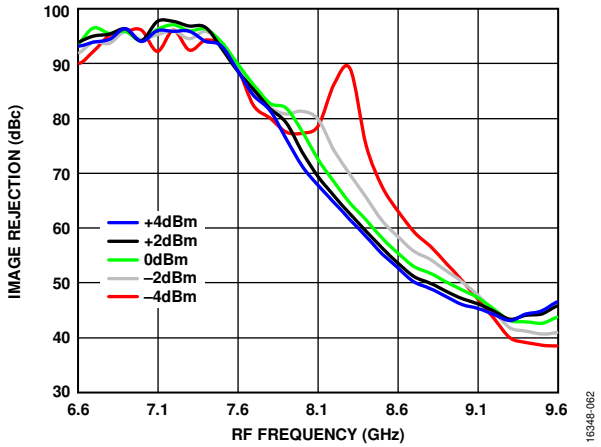

Figure 62. Image Rejection vs. RF Frequency over LO Powers, T_A = 25°C

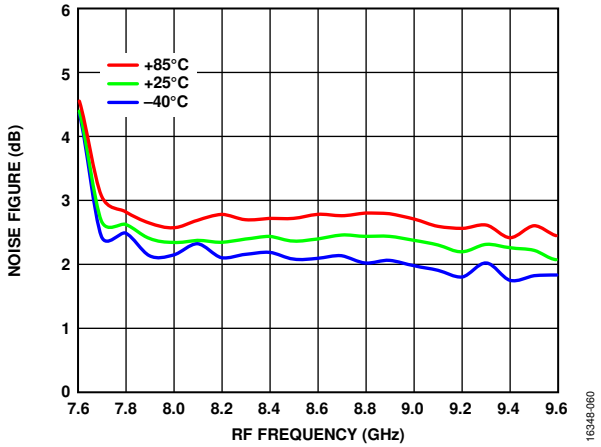

Figure 60. Noise Figure vs. RF Frequency over Temperatures, LO Power = 0 dBm

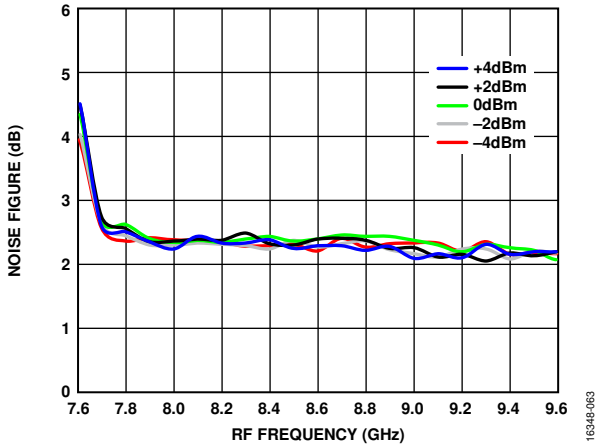

Figure 63. Noise Figure vs. RF Frequency over LO Powers, T_A = 25°C

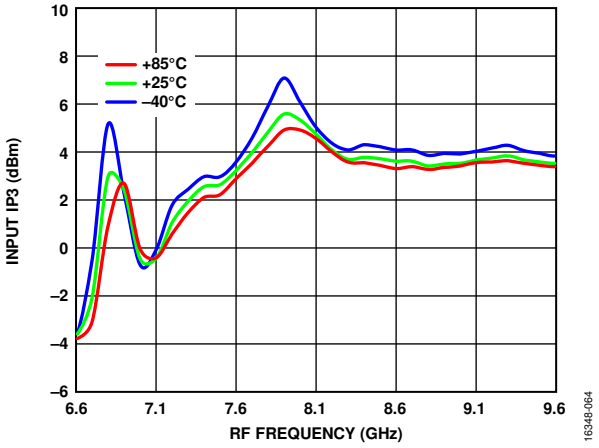

Figure 64. Input IP3 vs. RF Frequency over Temperatures, LO Power = 0 dBm

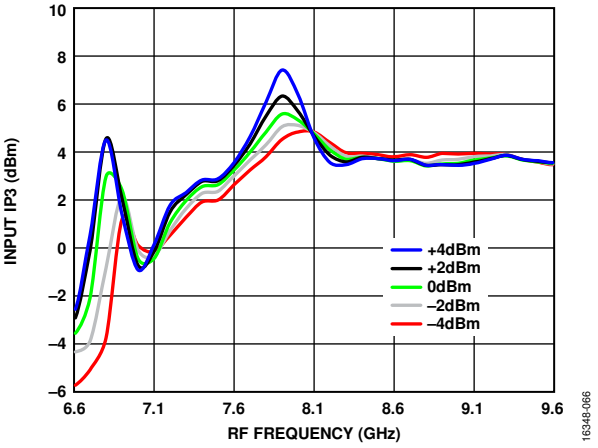

Figure 66. Input IP3 vs. RF Frequency over LO Powers, T_A = 25°C

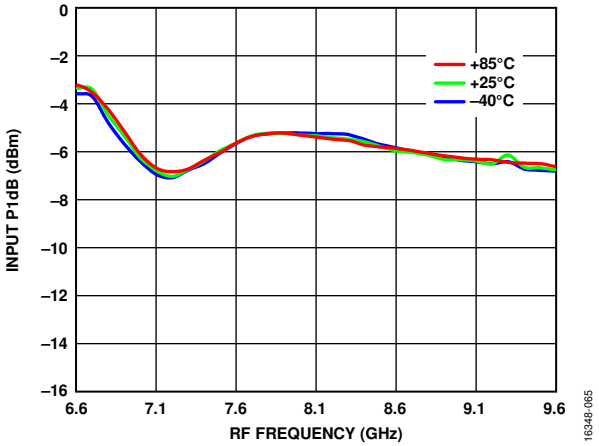

Figure 65. Input P1dB vs. RF Frequency over Temperatures, LO Power = 0 dBm

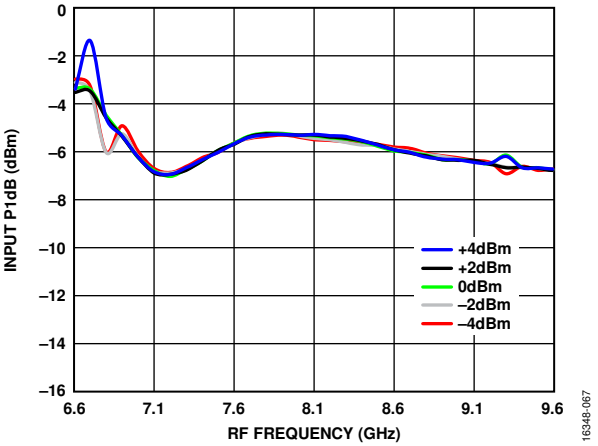

Figure 67. Input P1dB vs. RF Frequency over LO Powers, T_A = 25°C

ISOLATION AND RETURN LOSS

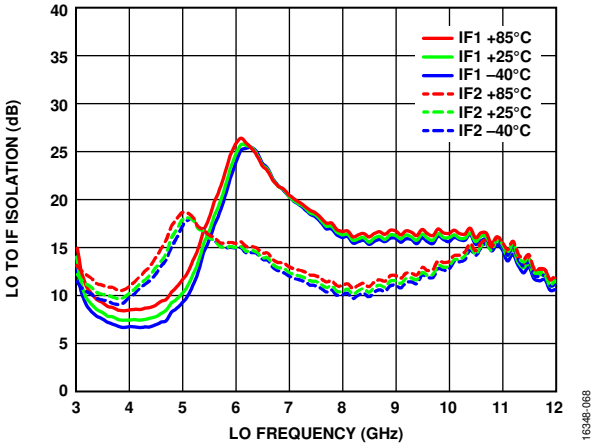

Figure 68. LO to IF Isolation vs. LO Frequency over Temperatures, LO Power = 0 dBm

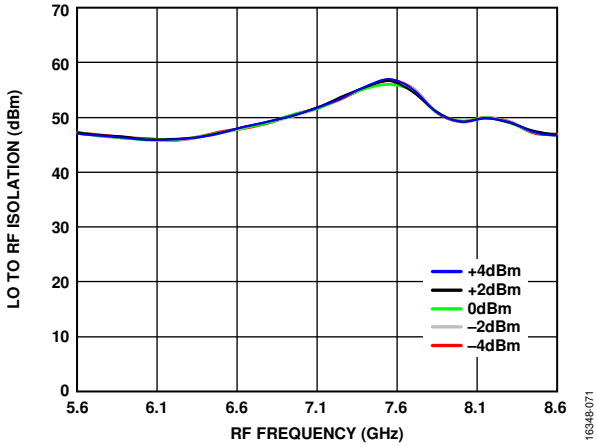

Figure 71. LO to RF Isolation vs. RF Frequency over LO Powers, T_A = 25°C

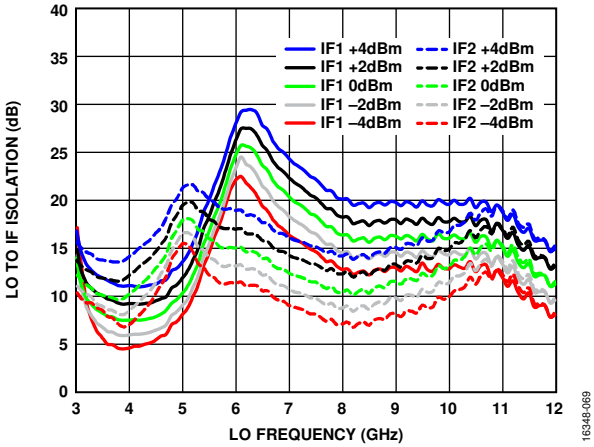

Figure 69. LO to IF Isolation vs. LO Frequency over LO Powers, T_A = 25°C

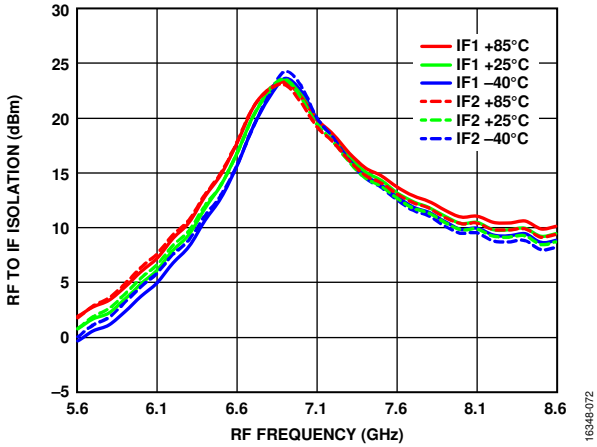

Figure 72. RF to IF Isolation vs. RF Frequency over Temperatures, LO Power = 0 dBm

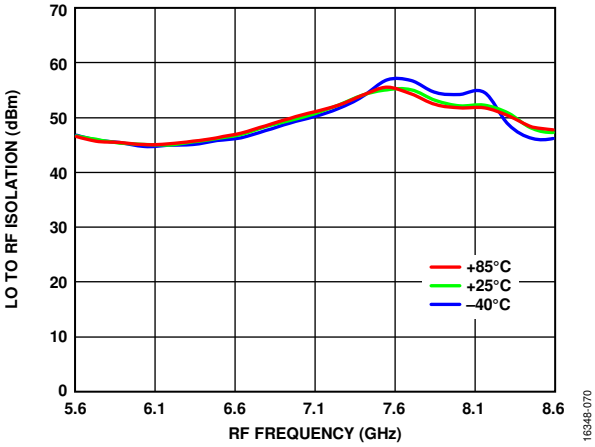

Figure 70. LO to RF Isolation vs. RF Frequency over Temperatures, LO Power = 0 dBm

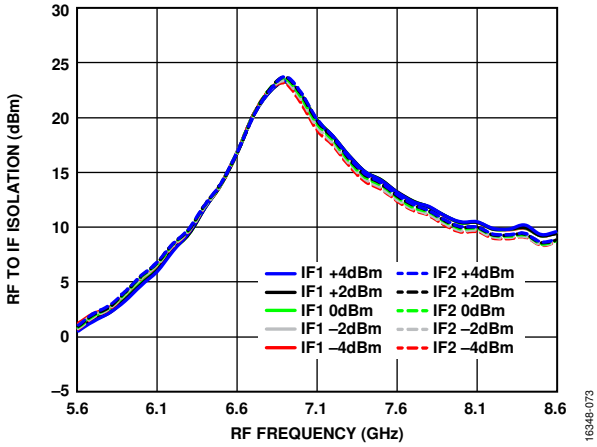

Figure 73. RF to IF Isolation vs. RF Frequency over LO Powers, T_A = 25°C

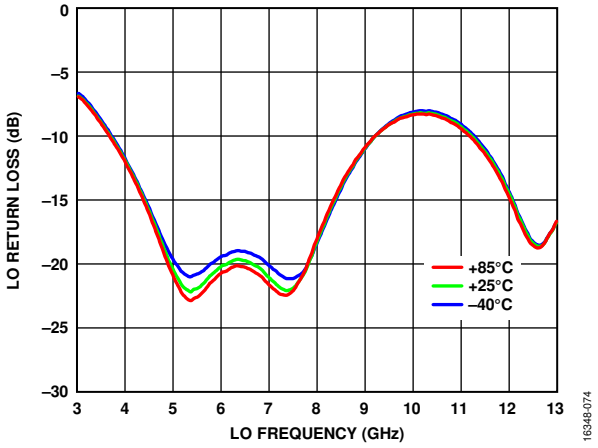

Figure 74. LO Return Loss vs. LO Frequency over Temperatures, LO Power = 0 dBm

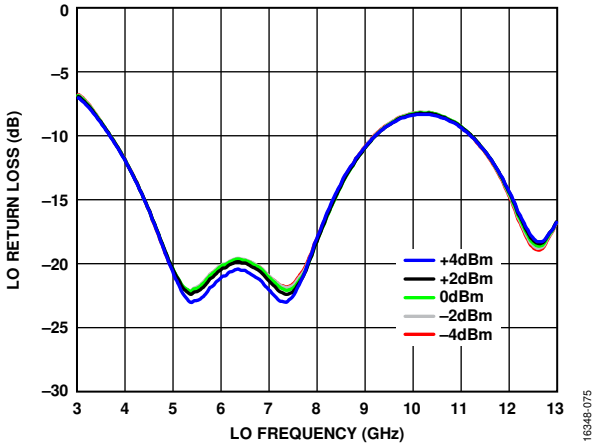

Figure 75. LO Return Loss vs. LO Frequency over LO Powers, T_A = 25°C

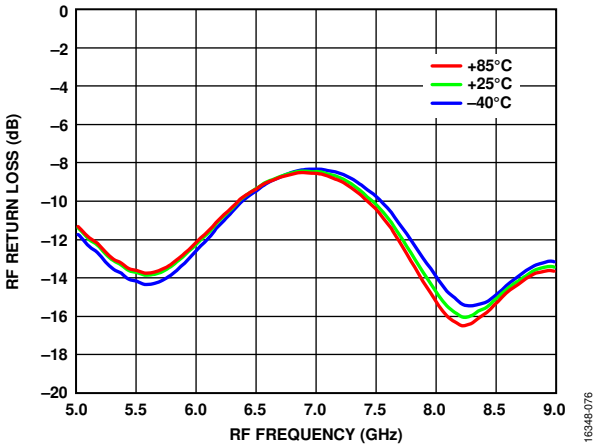

Figure 76. RF Return Loss vs. RF Frequency over Temperatures, LO Frequency = 7 GHz, LO Power = 0 dBm

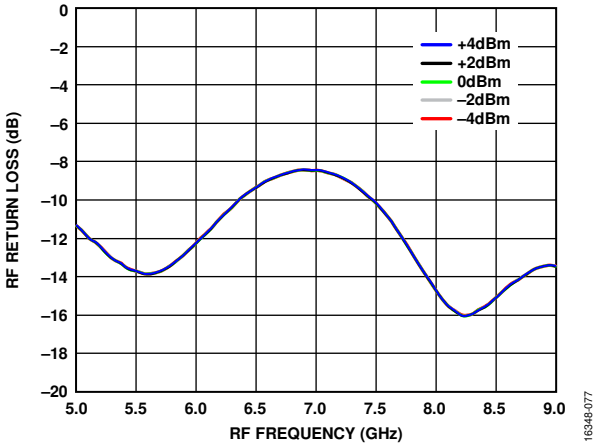

Figure 77. RF Return Loss vs. RF Frequency over LO Powers, LO Frequency = 7 GHz, T_A = 25°C

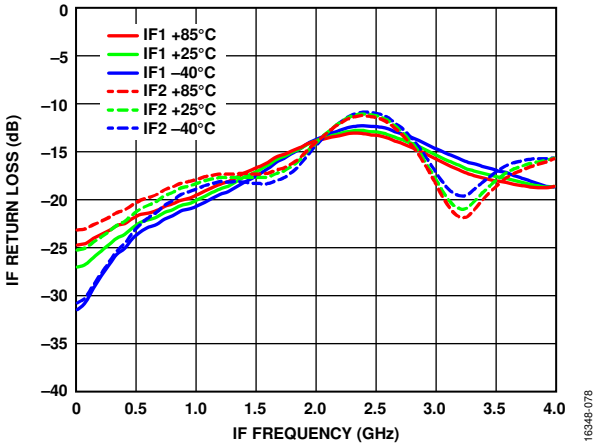

Figure 78. IF Return Loss vs. IF Frequency over Temperatures, LO Frequency = 7 GHz, LO Power = 0 dBm

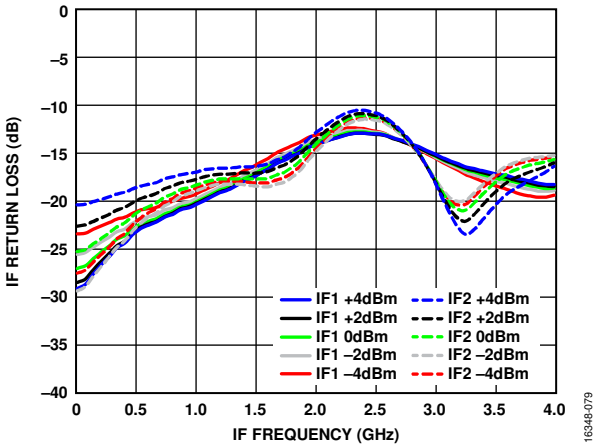

Figure 79. IF Return Loss vs. IF Frequency over LO Powers, LO Frequency = 7 GHz, T_A = 25°C

IF BANDWIDTH PERFORMANCE

Lower Sideband (High-Side LO)

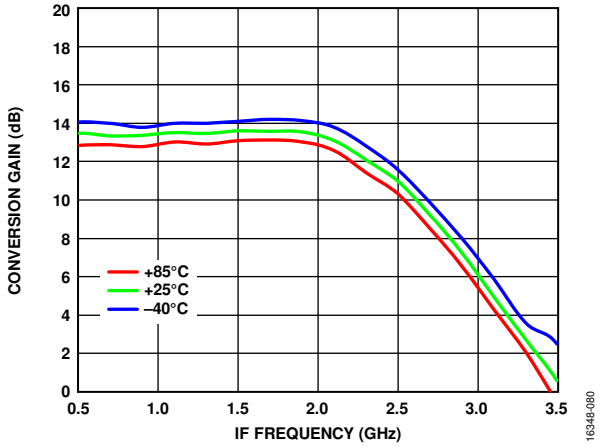

Figure 80. Conversion Gain vs. IF Frequency over Temperatures, LO Frequency = 7 GHz, LO Power = 0 dBm

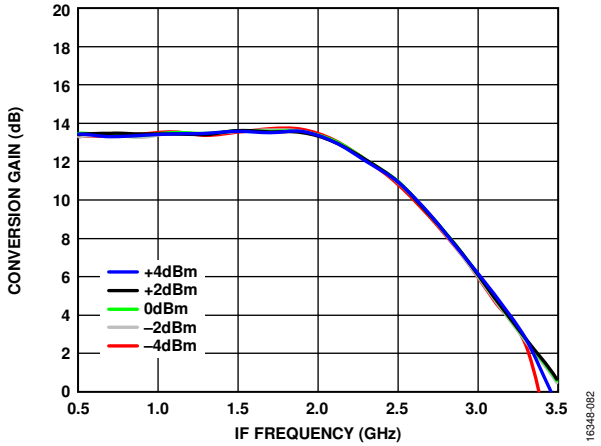

Figure 82. Conversion Gain vs. IF Frequency over LO Powers, LO Frequency = 7 GHz, T_A = 25°C

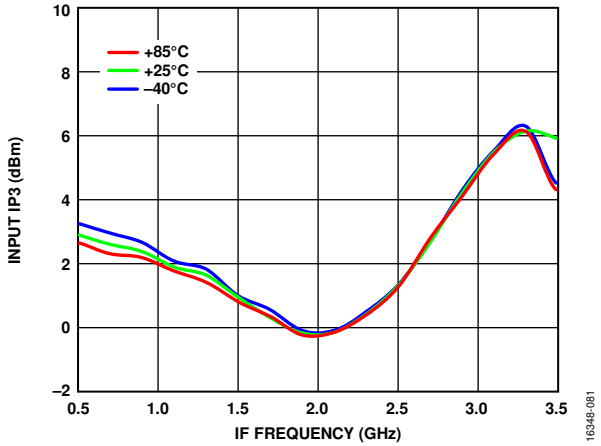

Figure 81. Input IP3 vs. IF Frequency over Temperatures, LO Frequency = 7 GHz, LO Power = 0 dBm

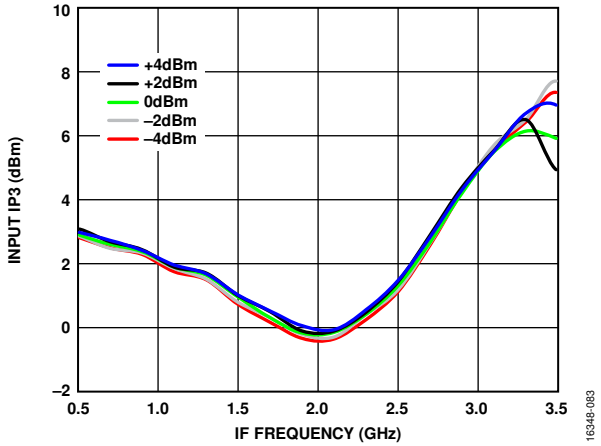

Figure 83. Input IP3 vs. IF Frequency over LO Powers, LO Frequency = 7 GHz, T_A = 25°C

Upper Sideband (Low-Side LO)

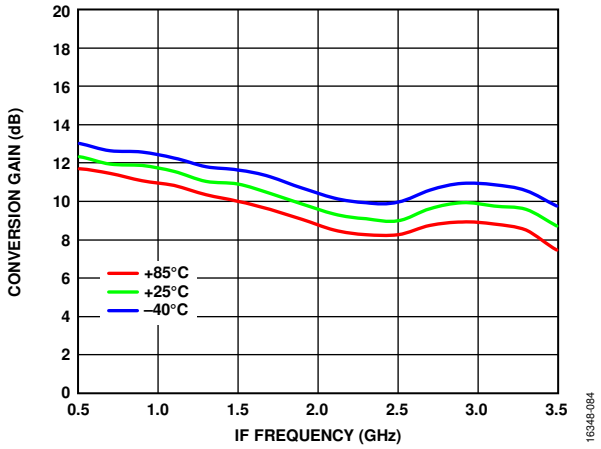

Figure 84. Conversion Gain vs. IF Frequency over Temperatures, LO Frequency = 7 GHz, LO Power = 0 dBm

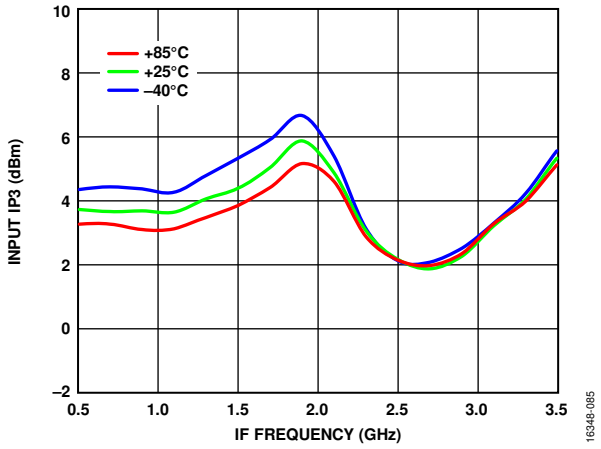

Figure 85. Input IP3 vs. IF Frequency over Temperatures, LO Frequency = 7 GHz, LO Power = 0 dBm

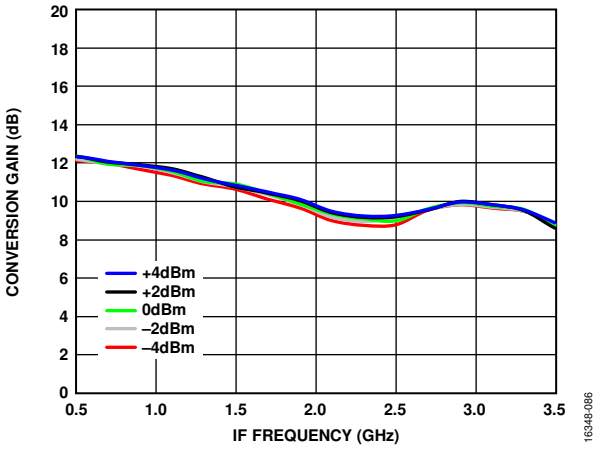

Figure 86. Conversion Gain vs. IF Frequency over LO Powers, LO Frequency = 7 GHz, T_A = 25°C

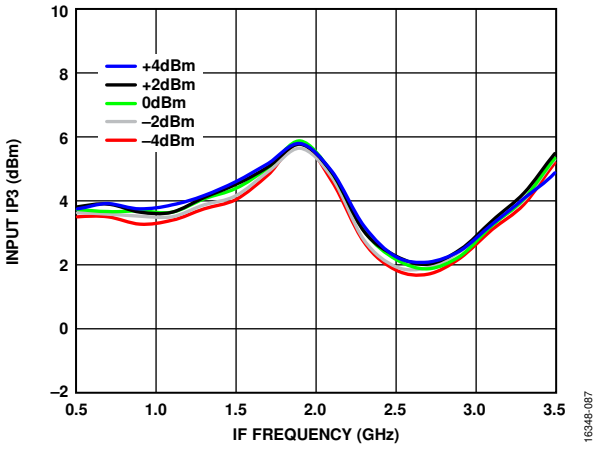

Figure 87. Input IP3 vs. IF Frequency over LO Powers, LO Frequency = 7 GHz, T_A = 25°C

AMPLITUDE AND PHASE IMBALANCE PERFORMANCE

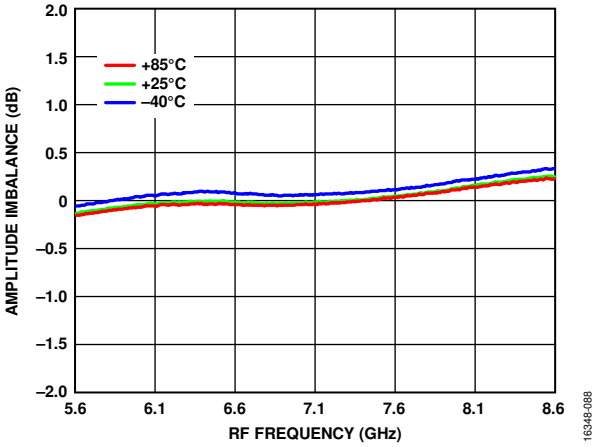

Figure 88. Amplitude Imbalance vs. RF Frequency over Temperatures, LO Power = 0 dBm, IF = 1000 MHz, Lower Sideband

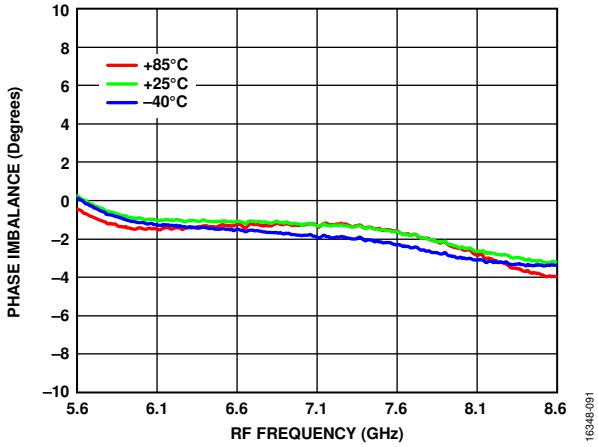

Figure 91. Phase Imbalance vs. RF Frequency over Temperatures, LO Power = 0 dBm, IF = 1000 MHz, Lower Sideband

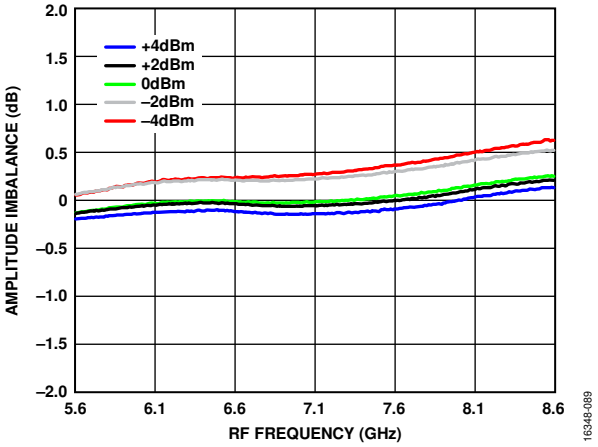

Figure 89. Amplitude Imbalance vs. RF Frequency over LO Powers, IF = 1000 MHz, T_A = 25°C, Lower Sideband

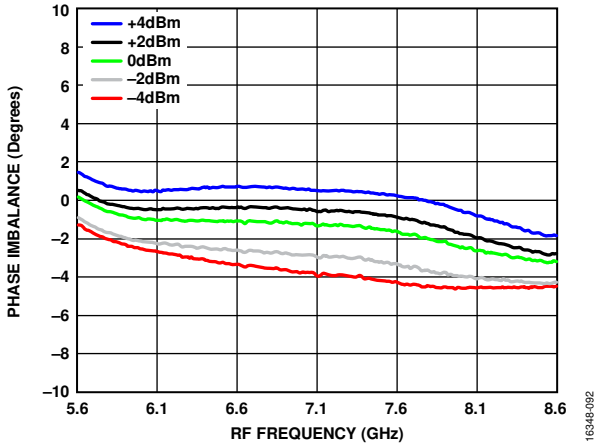

Figure 92. Phase Imbalance vs. RF Frequency over LO Powers, IF = 1000 MHz, T_A = 25°C, Lower Sideband

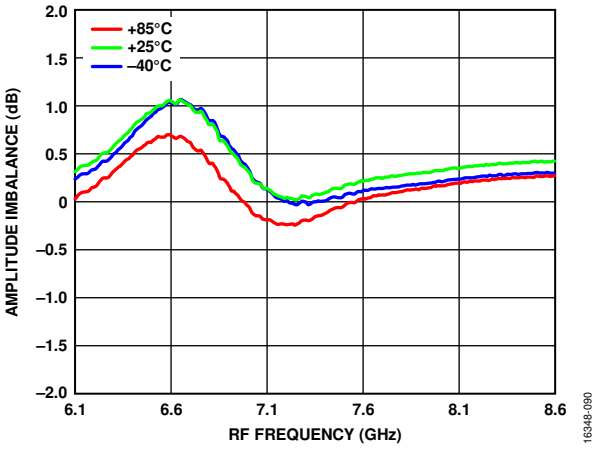

Figure 90. Amplitude Imbalance vs. RF Frequency over Temperatures, LO Power = 0 dBm, IF = 1000 MHz, Upper Sideband

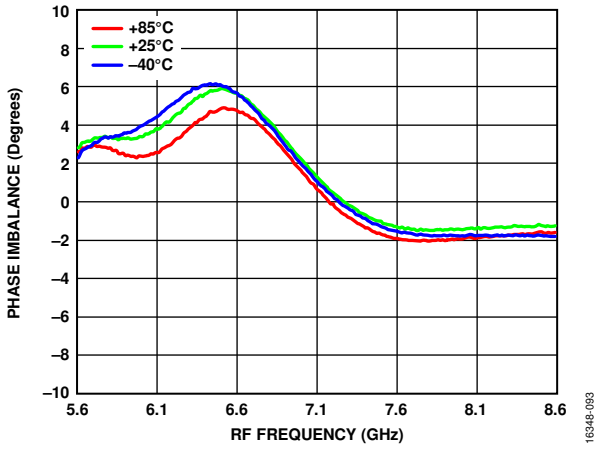

Figure 93. Phase Imbalance vs. RF Frequency over Temperatures, LO Power = 0 dBm, IF = 1000 MHz, Upper Sideband

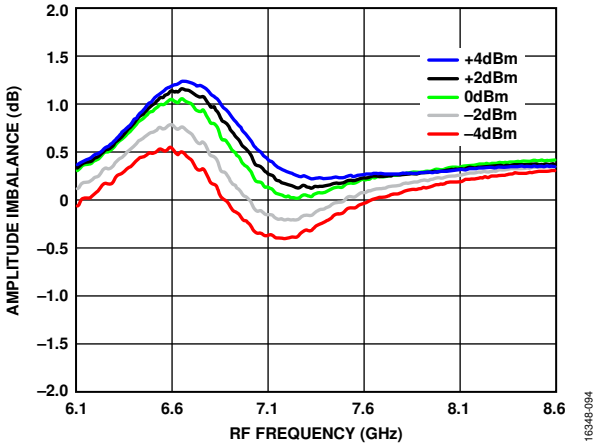

Figure 94. Amplitude Imbalance vs. RF Frequency over LO Powers, IF = 1000 MHz, T_A = 25°C, Upper Sideband

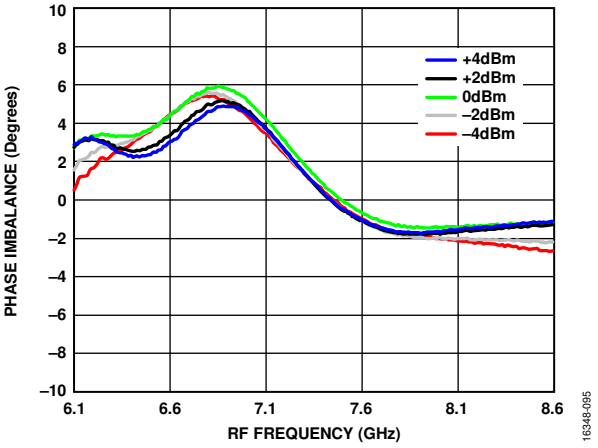

Figure 95. Phase Imbalance vs. RF Frequency over LO Powers, IF = 1000 MHz, T_A = 25°C, Upper Sideband

SPURIOUS PERFORMANCE

Mixer spurious products are measured in dBc from the RF output power level. Spur values are (M × RF) − (N × LO). N/A means not applicable.

M × N Spurious Outputs, IF = 150 MHz

RF = 5600 MHz, LO frequency = 5750 MHz at LO input power = 0 dBm, RF input power = −20 dBm.

		N × LO				
		0	**1**	**2**	**3**	**4**
M × RF	**0**	N/A	15	33	18	34
	1	17	0	30	37	43
	2	57	60	60	57	71
	3	70	78	59	59	68
	4	84	87	88	70	81

RF = 6100 MHz, LO frequency = 6250 MHz at LO input power = 0 dBm, IF input power = −20 dBm.

		N × LO				
		0	**1**	**2**	**3**	**4**
M × RF	**0**	N/A	18	26	27	29
	1	22	0	39	38	41
	2	58	72	68	68	73
	3	71	80	70	62	82
	4	83	87	88	77	81

RF = 8500 MHz, LO frequency = 8650 MHz at LO input power = 0 dBm, IF input power = −20 dBm.

		N × LO				
		0	**1**	**2**	**3**	**4**
M × RF	**0**	N/A	16	13	23	28
	1	28	0	46	53	59
	2	53	78	63	69	64
	3	79	82	85	68	86
	4	79	79	86	84	82

M × N Spurious Output, IF = 1000 MHz

RF = 5600 MHz, LO frequency = 6600 MHz at LO input power = 0 dBm, IF input power = −20 dBm.

		N × LO				
		0	**1**	**2**	**3**	**4**
M × RF	**0**	N/A	16	24	26	42
	1	17	0	47	43	50
	2	55	61	55	61	63
	3	75	88	61	76	86
	4	86	89	90	76	77

RF = 6100 MHz, LO frequency = 7100 MHz at LO input power = 0 dBm, IF input power = −20 dBm.

		N × LO				
		0	**1**	**2**	**3**	**4**
M × RF	**0**	N/A	17	14	21	32
	1	23	0	49	41	59
	2	57	54	54	68	68
	3	72	83	65	68	87
	4	82	89	91	83	77

RF = 8500 MHz, LO frequency = 9500 MHz at LO input power = 0 dBm, IF input power = −20 dBm.

		N × LO				
		0	**1**	**2**	**3**	**4**
M × RF	**0**	N/A	13	19	13	39
	1	28	0	39	44	57
	2	52	78	55	68	82
	3	78	81	88	76	84
	4	77	82	86	87	81