Datasheet

SC5407A & SC5408A

100 kHz to 6 GHz RF Upconverter

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Product Specifications

Definition of Terms

The following terms are used throughout this datasheet to define specific conditions:

Specification (spec)	Defines expected statistical performance within specified parameters which account for measurement uncertainties and changes in performance due to environmental conditions. Protected by warranty.
Typical data (typ)	Defines the expected performance of an average unit without specified parameters. Not protected by warranty.
Nominal values (nom)	Defines the average performance of a representative value for a given parameter. Not protected by warranty.
Measured values (meas)	Defines the expected product performance from the measured results gained from individual samples.

Specifications are subject to change without notice. For the most recent product specifications, visit www.signalcore.com.

Spectral Specifications

RF output range

Direct path .... 100 kHz to 400 MHz

Conversion path .... 20 MHz to 6.0 GHz

IF2 output frequency .... 1.25 GHz

IF input center frequency [1]

First (IF3) stage conversion enabled .... 50 MHz to 500 MHz

Second IF selected (Bypass IF3 conversion) .... 1.25 GHz

RF output polarity [2]

First (IF3) stage conversion enabled .... Non-inverted/Inverted

Second IF selected (Bypass IF3 conversion) .... Inverted

IF bandwidth (3 dB)

First (IF3) stage conversion enabled .... 80/160 MHz

(Contact SignalCore for other IF BW options [1])

IF3 conversion bypassed (2 stage conversion) .... 320 MHz

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[1] The IF may be selected to drive either the output RF, second, or third conversion stages. If the output RF port is selected, the signal to the RF port is directly routed from the IF port, bypassing the conversion process entirely. The frequency range of this path is 100 kHz to 400 MHz. When the second stage is selected, the IF is fixed at 1.25 GHz, and the RF spectrum is inverted with respect to the IF. When the third stage is selected, the IF center frequency is tunable from 1 MHz to 500 MHz in 5 MHz steps. Although the tuning range provides flexibility, the IF bandwidth may practically limit the center frequency. The lowest usable IF frequency for an IF bandwidth of 80 MHz is 90 MHz; for large bandwidths, the IF will need to increase. Lower IF frequencies can be used if a lower bandwidth filter is optionally requested; a 40 MHz BW filter will allow IF as low as 70 MHz.

[2] The RF output polarity refers to the conversion polarity of the downconverter. When the polarity is inverted, the spectral content of the output is inverted with respect to the input; this process is commonly known as “spectral inversion” or “spectral flipping”. The selection depends on the application. For digitizers that are sampling the IF in the even-order Nyquist zones that naturally invert spectra, having the IF polarity inverted will produce non-inverted baseband, and vice-versa. However, this is only a convenience in this application case because inverted spectrum, once digitized, can easily be re-inverted mathematically. This selectable inversion option is only available when the IF3 conversion stage is selected. When the IF3 conversion is bypassed (2 stage conversion), the output spectrum is always inverted.

RF tuning

Frequency step resolution [3] .... 1 Hz

Lock and settling times [4] .... 1 ms

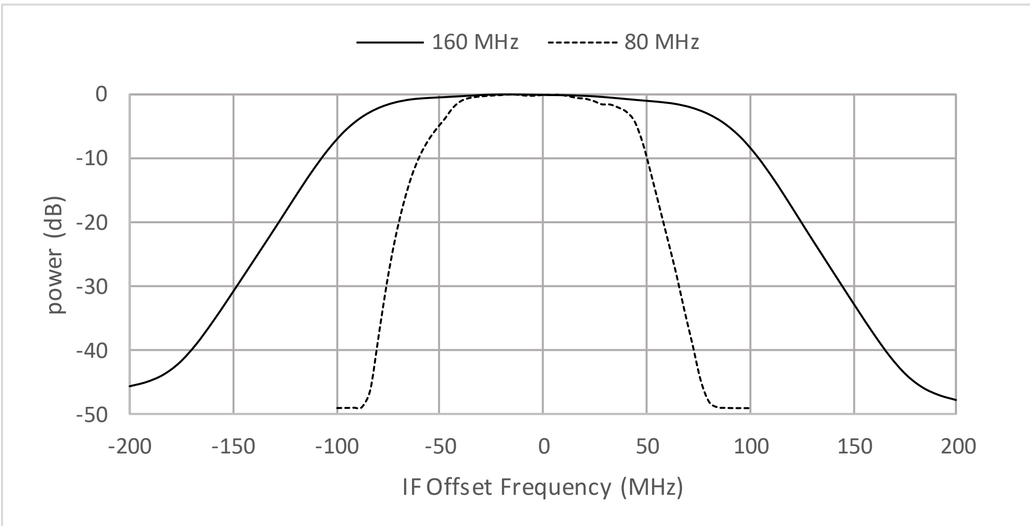

Figure 1. Typical relative output RF responses of bandpass filters measured at 1.5 GHz with center IF of 240 MHz. The noise floor of the power meter limits the out-of-band rejection measurement.

[3] Tuning resolution of 1 mHz is available.

[4] Locked and settled to < 1 ppm of final frequencies of > 500 MHz and step size of < 10 MHz. For final frequencies < 500 MHz, the settle time applies to accuracy with 500 Hz of the final frequency for a 10 MHz step. See Figure 2 for examples of other tuning step settling times. When fast-tune mode is enabled, the noise damping capacitor across the main YIG tuning coil is disengaged, resulting in an increase of the rate of current flow through the coil and settling to a steady state quicker. Lock time begins when the full tuning word command is received by the device.

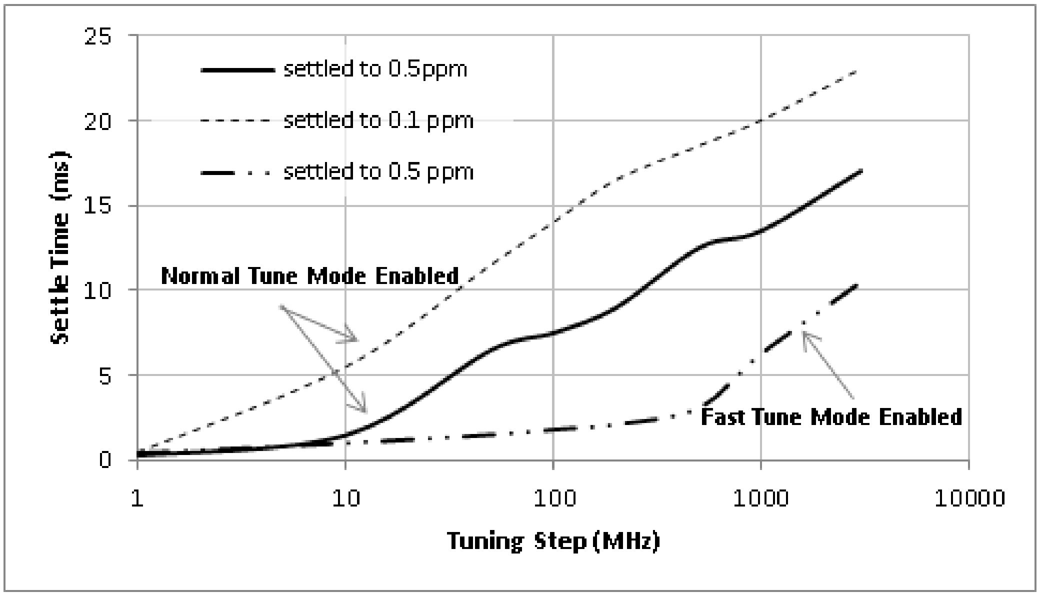

Figure 2. Typical frequency settling time versus tuning step frequency.

Frequency reference [5]

Technology .... Temperature compensated crystal oscillator

Accuracy .... ± [(aging x last adjustment time lapse) + temp stability + cal accuracy]

Initial calibration accuracy .... ±0.05 ppm

Temperature stability [6]

20 °C to 30 °C .... ±0.25 ppm

0 °C to 55 °C .... ±1.0 ppm

Aging .... ±1 ppm for first year @ 25 °C

Frequency accuracy [7] .... ± (frequency reference accuracy * RF output frequency) Hz

[5] The frequency reference refers to the device's internal 10 MHz TCXO time-base. Accuracy is in parts-per-million or ppm (1×10^{-6}).

[6] Users must apply sufficient cooling to the device to keep the unit temperature as read from its internal temperature sensor within the range of 40 °C to 45 °C at an ambient temperature of 25 °C.

[7] Accuracy of the device for any given input RF signal.

Sideband noise (dBc/Hz) [8]

RF Frequency

Offset	100 MHz	2000 MHz	4000 MHz	5500 MHz
100 Hz	-80	-78	-76	-74
1 kHz	-95	-93	-91	-89
10 kHz	-100	-97	-95	-93
100 kHz	-112	-110	-110	-109
1 MHz	-139	-138	-138	-137
10 MHz	-148	-147	-144	-143

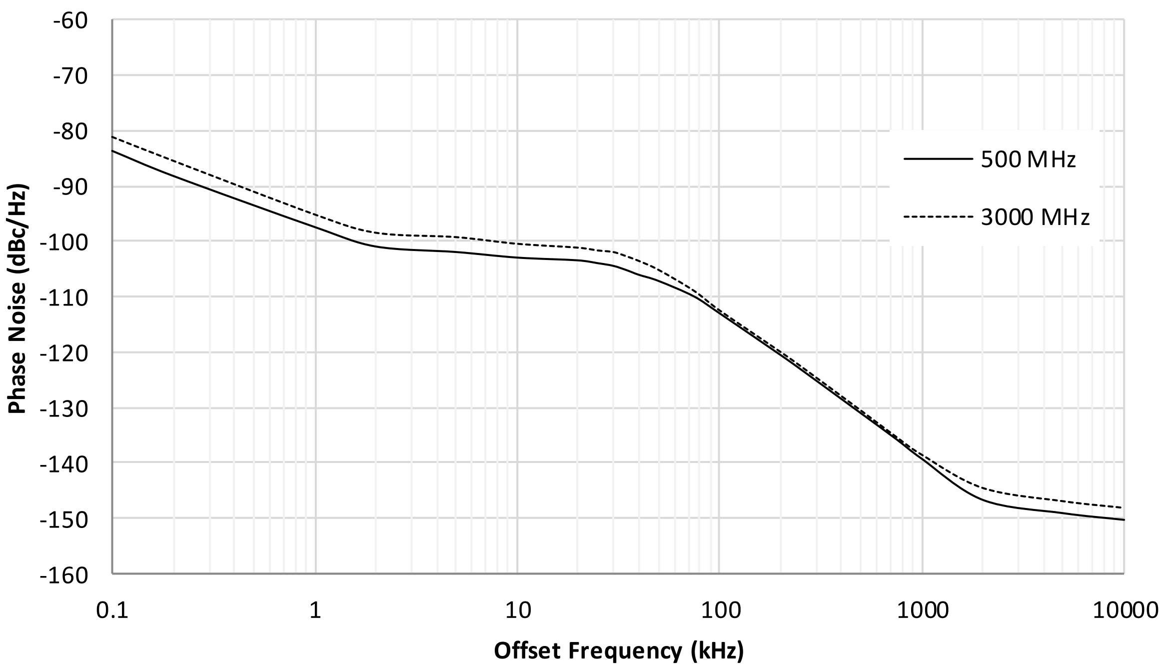

Figure 3. Typical measured sideband noise. [9]

[8] Sideband phase noise as specified is based on measured sideband noise which includes both phase noise and amplitude noise contributions. Sideband noise is specified for the upconverter when tune mode is set to NORMAL. In FAST-TUNE mode, the noise damping capacitor across the YIG tuning coil is disengaged, and thus the close-in phase noise degrades. See the appropriate sections in the programming manual for further information on how to set the device to NORMAL or FAST-TUNE modes.

[9] These results are obtained with input signal levels of 5 dBm at the IF3 mixer (no IF3 attenuation), and the output RF level set to > 3 dBm. The upconverter is set for best SNR, a setting suitable for generating single tone CW signals.

LO related sideband spurious signals [10]

< 200 kHz .... -70 dBc

> 200 kHz .... -75 dBc

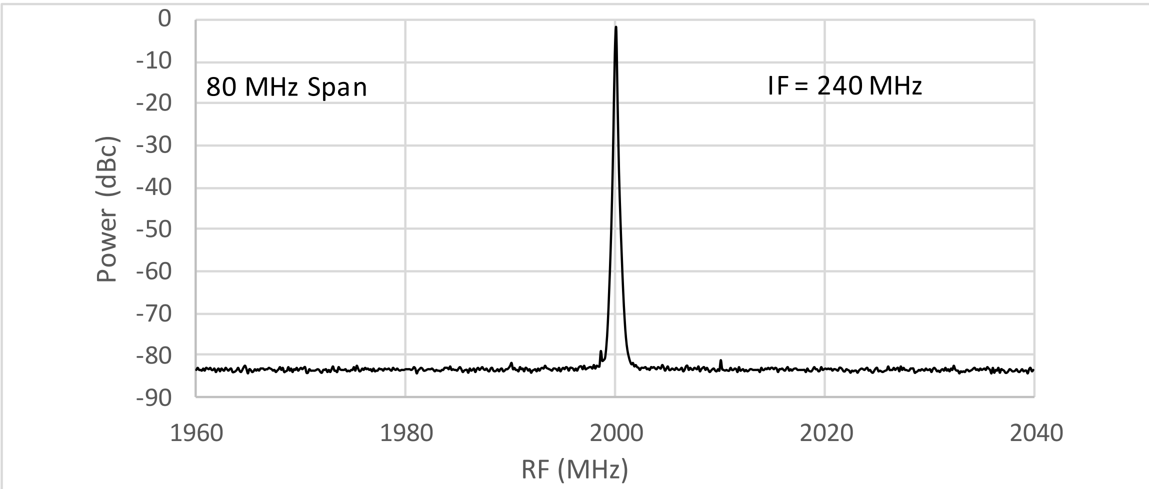

Figure 4 Spectrum of 2 GHz up converted RF signal from 240 MHz; spanned out to 80 MHz

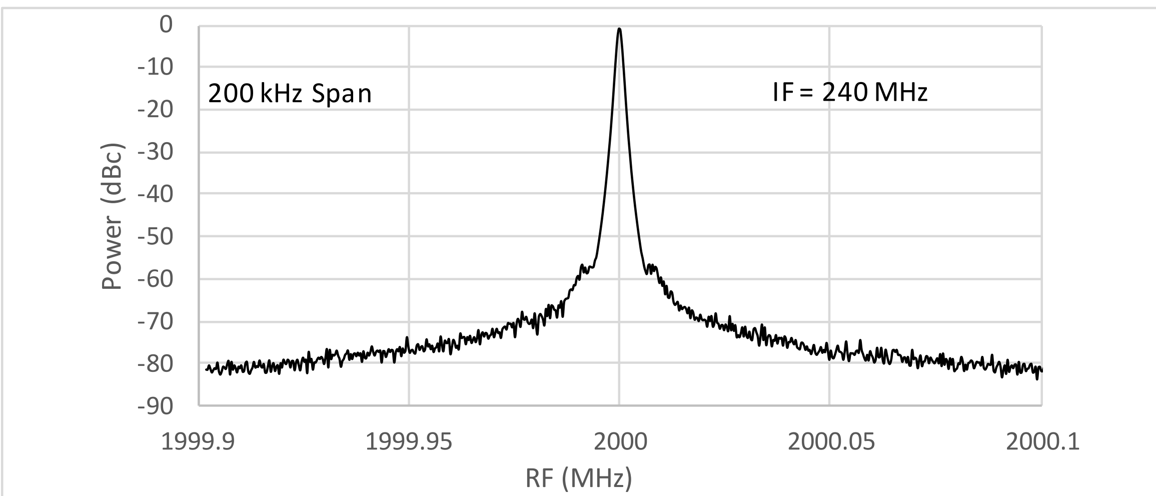

Figure 5 Narrow span RF signal centered at 2.0 GHz

[10] Sideband spurious signals are those that fall within 2 MHz of the carrier that are direct results of the local oscillators in the device. Sources of sideband spurious signals in the synthesized local oscillators are primarily due to fractional-N spurious products in the PLLs, DDS noise sources, and intermodulation between oscillators within the multiple-loop PLL synthesizers. Fractional-N and DDS spurious products affect spectral regions below 200 kHz and intermodulation products affect spectral regions out to a couple MHz.
As the YIG oscillator is sensitive to magnetic fields, magnetic noise due to electrical fans, supply transformers, and other magnetic field-producing devices may induce sideband noise on the signals when they are placed in close proximity. It is recommended that users exercise good technical judgment when such accessories are needed (e.g., mounting a cooling fan directly onto the RF enclosure of the device).

Amplitude Specifications

IF Input range

AC .... +17 dBm max

DC [11] .... 0 V

Attenuation range

RF .... 0 to 60 in 1 dB steps

IF [12] .... 0 to 60 in 1 dB steps

Output voltage standing wave ratio (VSWR)

10 MHz to 3.0 GHz .... < 2.0

3.0 GHz to 6.0 GHz .... < 2.8

Gain (@ 1GHz) [13]

Minimum [14] .... -90 dB typical

Maximum [15] .... 30 dB typical

RF amplitude response (15 °C to 35 °C ambient)

RF gain flatness response (uncorrected) .... 14 dB typical

RF gain flatness response (corrected[16]) .... ±0.75 dB

Absolute gain accuracy (corrected[16]) .... ±1.0 dB (±0.75 dB typical)

IF flatness (15 °C to 35 °C ambient)

IF in-band response flatness .... 3 dB typical

[11] Large and fast DC transients could damage the input solid state devices. A slow ramp up of DC to 10 V is sustainable.

[12] There are two IF attenuators in total, each having 30 dB of attenuation.

[13] These are typical gain specifications. The gain of the device is calibrated and stored in the device calibration EEPROM.

[14] Minimal gain is specified when all the attenuators are set to their maximum values.

[15] Maximum conversion gain is specified when all the attenuators are set to 0 dB attenuation.

[16] Correction stored in the calibration EEPROM must be applied properly. Users are not obligated to use the calibration provided; they may devise their own method of calibration and correction. User methods of calibration and application may improve on the accuracies specified.

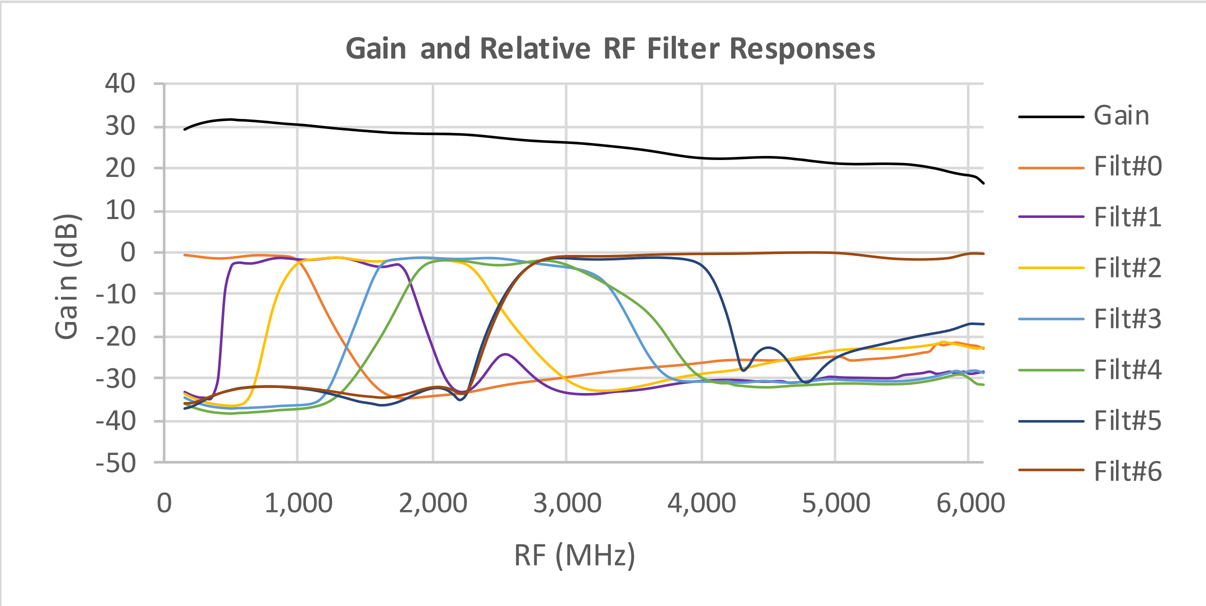

Figure 6. Typical RF conversion gain response @ 25 °C. IF set to 240 MHz, attenuation set to zero. Filter responses are measured relative to the gain.

IF to RF group delay (80% of IF bandwidth)

3 stage conversion .... 100 ns typical

2 stage conversion .... 100 ns typical

Dynamic Range Specifications

Spurious response [17]

Spurious signals [18] .... < -65 dBc

LO leakage [19] .... < -65 dBc

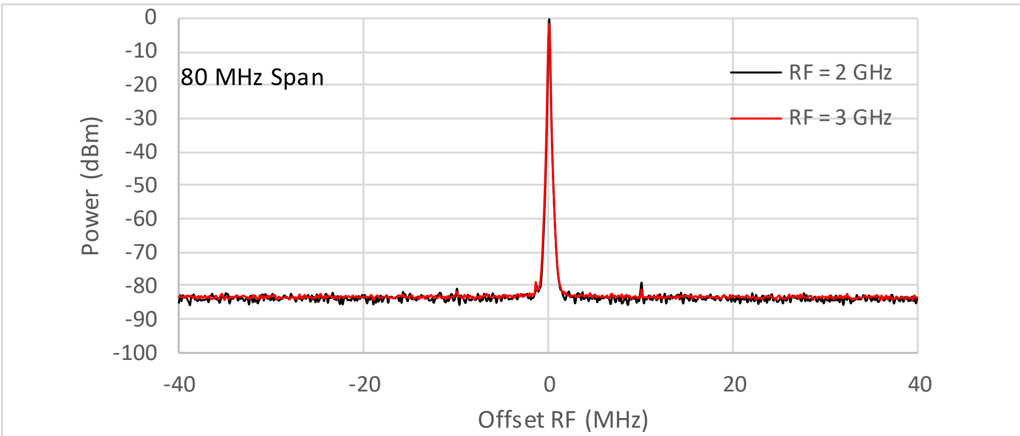

Figure 7. Spectrum showing low in-band spurs for RF converted frequencies from 240 MHz IF.

Output Signal-to-Noise (15 °C to 30 °C ambient) [20]

	100 MHz	3000 MHz	5500 MHz
Best SNR setting [21]	148 dB/Hz	147 dB/Hz	140 dB/Hz
Best linearity setting [22]	126 dB/Hz	124 dB/Hz	120 dB/Hz

Output third-order intermodulation (OIP3, dBm) [23]

	100 MHz – 1.5 GHz	1.5 GHz – 4 GHz	4 GHz – 6 GHz
Best SNR setting [21]	17	17	15
Best linearity setting [22]	32	31	29

[17] Spurious responses are unwanted signals appearing at the RF output. All spurious products are referenced to the RF output.
[18] Spurious signals are observed at the RF port that result from higher order mixed products.
[19] LO leakages are unwanted signals from the internal oscillators.
[20] This is the output signal level measured with respect to output noise density within the passband range.
[21] Requires +5 dBm level at the IF input mixer, and RF output set to ≥ 0 dBm.
[22] Requires -10 dBm level at the IF input mixer, and RF output set to ≤ 0 dBm.
[23] Specifications are based on two 0 dBm tones with 1 MHz separation at the RF output. The IF frequencies were set at 240 ± 0.5 MHz.

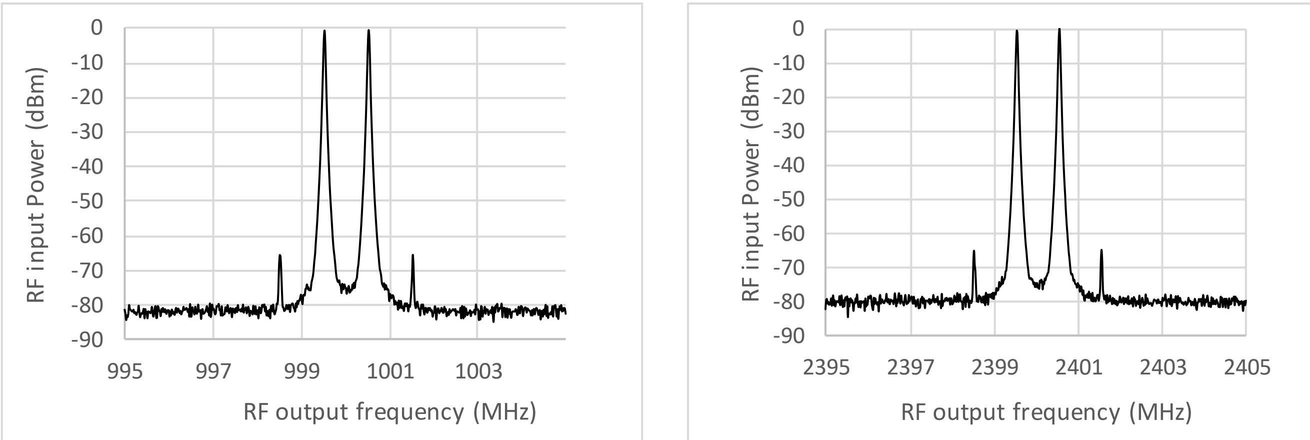

Figure 8. Plots show the typical IMD performance with two 0 dBm signals at the output, -10 dB IF3 mixer level, IF2_Atten = 6 dB, and IF frequency of 240 MHz.

Output second harmonic (dBm @ 0 dBm Output)

	500 MHz	1000 MHz	2700 MHz
Harmonic level	-60	-55	-52

Output compression point (dBm)

	100 MHz – 1.5 GHz	1.5 GHz – 4.0 GHz	4.0 GHz – 6.0 GHz
IF3 mixer level = 0 dB	> 18	> 17	> 15

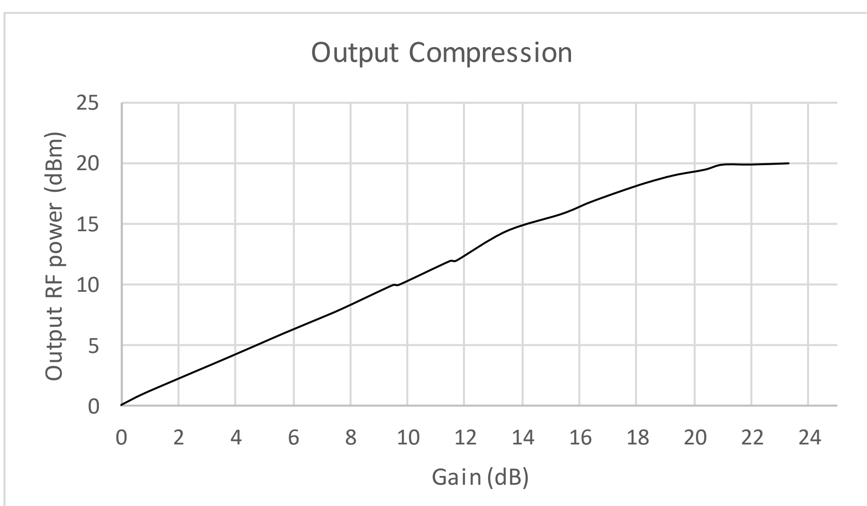

Figure 9. Output RF power vs Gain; RF =2 GHz, IF = 240 MHz, IF level = 0 dBm

Reference Input and Output Specifications

Reference output specifications

Center frequency [24] .... 10 MHz/100 MHz
Amplitude .... 3 dBm typ
Waveform .... Sine
Impedance .... 50 Ω nominal
Coupling .... AC
Connector type .... SMA female
Frequency accuracy .... See "Spectral Specifications" section

Reference input specifications

Center frequency .... 10 MHz
Amplitude .... 0 dBm min/ +10 dBm max
Phase-lock range .... ± 3 ppm (typ)
Impedance .... 50 Ω nominal
Coupling .... AC
Connector type .... SMA female

Port Specifications

RF output

Output impedance .... 50 Ω
Coupling .... AC
Connector type .... SMA female

IF input

Input impedance .... 50 Ω
VSWR 1.8
Coupling .... AC
Connector type .... SMA female
Output amplitude .... 20 dBm max

[24] The output frequency may be selected programmatically for 10 MHz or 100 MHz.

General Specifications

Environmental

Operating temperature [25] .... 0 °C to +55 °C
Storage temperature .... -40 °C to +70 °C
Operating relative humidity .... 10% to 90%, non-condensing
Storage relative humidity .... 5% to 90%, non-condensing
Operating shock .... 30 g, half-sine pulse, 11 ms duration
Storage shock .... 50 g, half-sine pulse, 11 ms duration
Operating vibration .... 5 Hz to 500 Hz, 0.31 g_{rms}
Storage vibration .... 5 Hz to 500 Hz, 2.46 g_{rms}
Altitude .... 2,000 m maximum (maintaining 25 °C maximum ambient temperature)

Physical

Dimensions (W x H x D, max envelope) (SC5408A) .... 3.7” x 1.4” x 6.1”
Dimensions (W x H x D, max envelope) (SC5407A) .... 2x3U slots
Weight .... 2.6 lbs
Input voltage (SC5408A) .... 12 VDC
Power consumption .... 25 W typical
Communication interface .... USB and RS-232 / SPI

Safety .... Designed to meet the requirements of:
IEC 61010-1, EN 61010-1, UL 61010-1, CSA 61010-1

Electromagnetic Compatibility (EMC) .... Designed to meet the requirements of:
EN 61326-1 (IEC 61326-1): Class A emissions; Basic immunity 1, EN 55011 (CISPR 11) Group 1, Class A emissions, AS/NZS CISPR 11: Group 1, Class A emissions, FCC 47 CFR Part 15B: Class A emissions, ICES-001: Class A emissions

CE .... Meets the requirements of:
2006/95/EC; Electromagnetic Compatibility Directive (EMC Directive)

Warranty .... 3 years on parts and labor on defects in materials or workmanship

[25] A user-provided cooling solution is required to keep the device less than 15 °C above the ambient temperature. Recommended operating device temperature is 0 °C to 55 °C, as measured by the internal temperature sensor.

Revision Notes

Revision	Revision Date	Description
1.0	8/15/2016	Original document
1.1	4/23/2017	Updated result graphs
1.2	11/10/2017	Grammar corrections Modified operating temperatures
1.3	2/22/2019	Updated port specifications
2.0	8/7/2020	Update picture Revised Definition of Terms Modified operating temperatures Reformatted footnotes Removed Low Voltage Directive from CE requirements met

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