SignalCore™

PRESERVING SIGNAL INTEGRITY

Datasheet

SC5405A & SC5406B

1 MHz to 3.9 GHz RF Upconverter

support@signalcore.com

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)	Characterizes expected product performance by means of measurement results gained from individual samples. 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 [1] .... 1 MHz to 3.9 GHz

IF input center frequency .... 70 MHz

IF input polarity [2] .... Non inverted/Inverted

IF bandwidth

3 dB .... > 18 MHz

6 dB .... 20 MHz

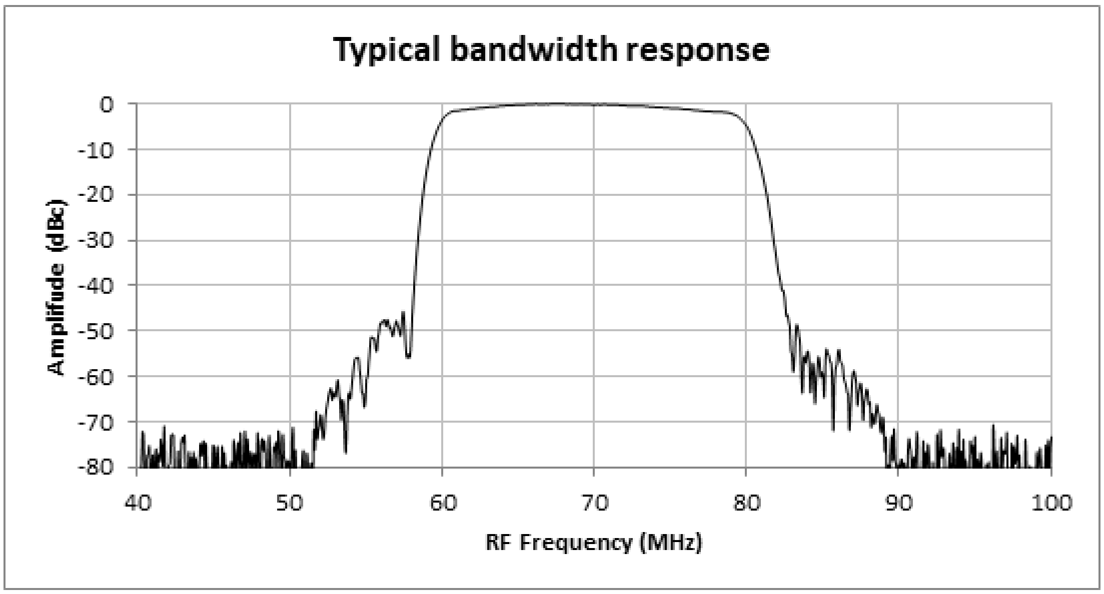

Figure 1. Typical conversion bandwidth response measured at RF = IF.

[1] RF input below 3 MHz suffers from amplitude roll-off and calibration is not valid below this lower-end frequency. In the frequency range below the specified IF bandwidth (< ~15 MHz), the first LO leakage appears inside the IF band. When the LO appears inside the IF band, it will intermodulate with the input RF signal to produce higher order in-band spurious signals that may degrade signal integrity. The spurious content will increase due to intermodulation when the RF is set below the IF bandwidth frequency. Increasing IF attenuation will help to suppress the intermodulation spurs, but at the expense of signal-to-noise degradation.

[2] The IF input polarity refers to the conversion polarity of the upconverter. 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 example, if the generated IF spectrum is inverted, then inverting it in the upconverter will produce a correctly polarized RF spectrum.

RF tuning

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

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

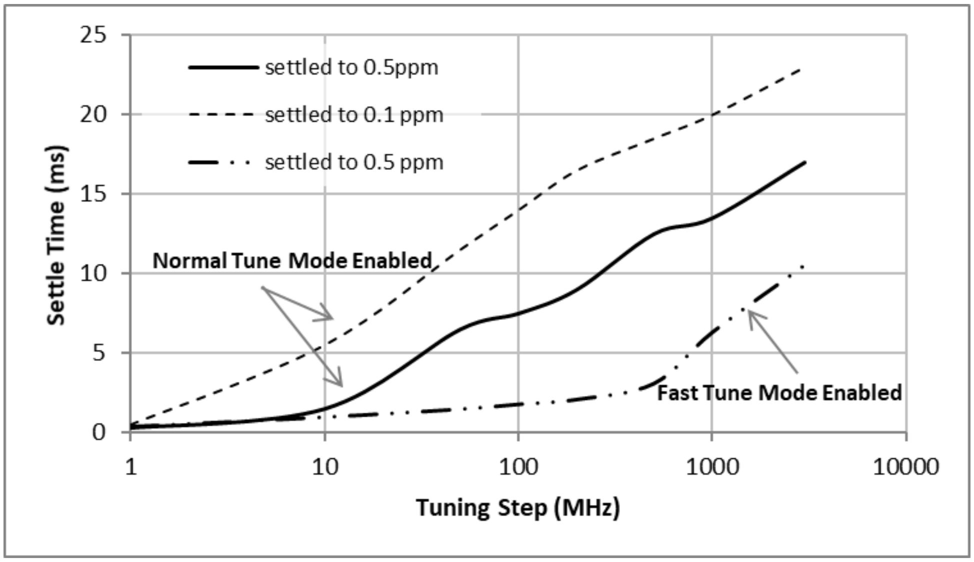

Figure 2. Typical frequency settling time versus tuning step with a 3600 MHz final frequency.

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 input frequency) Hz

---

[3] To give the user flexibility, the device has three resolution modes: two coarse modes and one fine mode. The coarse modes use fractional N PLL to allow 1 MHz and 50 kHz steps. The fine mode uses PLL and DDS to provide < 1 Hz resolution. See the appropriate sections of this manual for further information.

[4] Locked and settled to < 1 ppm of final frequencies of > 500 MHz and step size of < 10 MHz. For final frequencies of < 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. This results in an increase of the rate of current flow through the coil and settles to a steady state quicker. Lock time begins when the full tuning word command is received by the device.

[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 maintain an ambient temperature of 25 °C. This is to keep the unit temperature as read from its internal temperature sensor within 40 °C - 45 °C.

[7] Accuracy of the device for any upconverted output RF signal.

Sideband phase noise (dBc/Hz) [8]

	RF Frequency			
Offset	**100 MHz**	**1000 MHz**	**2000 MHz**	**3500 MHz**
100 Hz	-88	-87	-85	-83
1 kHz	-100	-99	-98	-97
10 kHz	-108	-107	-106	-105
100 kHz	-119	-118	-117	-115
1 MHz	-143	-142	-142	-141
10 MHz	-150	-149	-149	-148

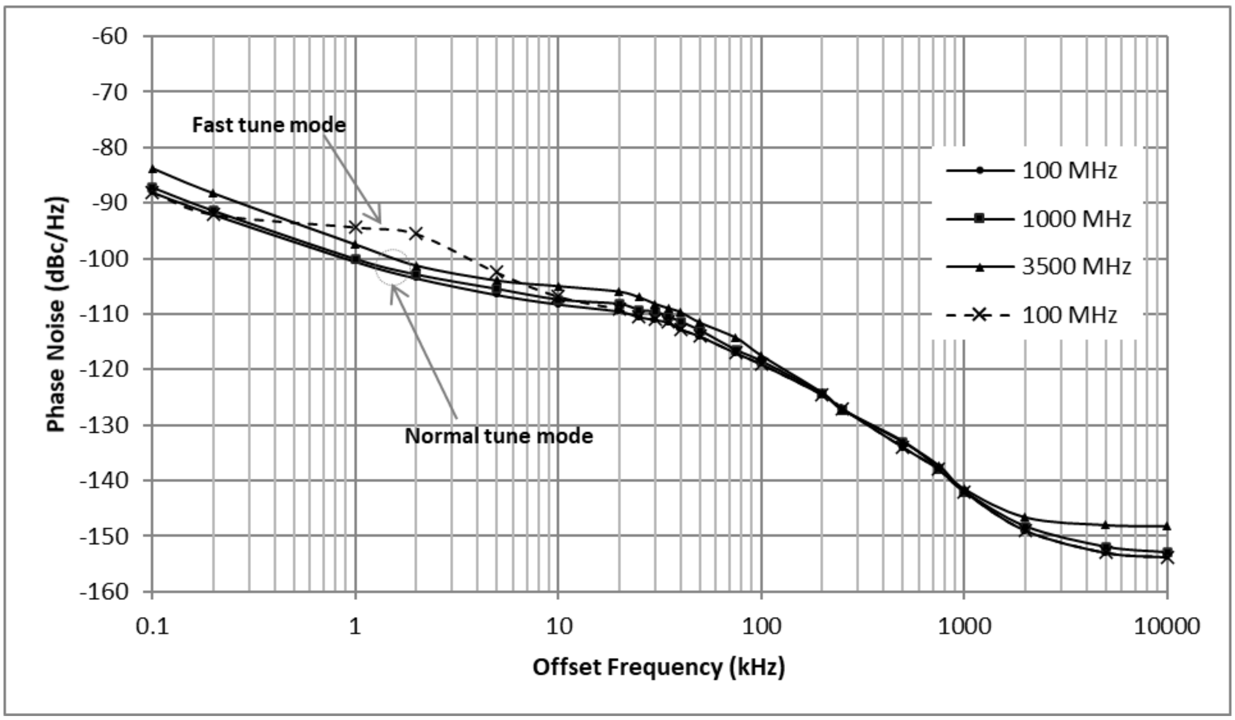

Figure 3. Typical measured sideband noise.[9]

[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 downconverter when tune mode is set to NORMAL. In FAST-TUNE mode, the noise damping capacitor across the YIG tuning coil is disengaged, causing the close-in phase noise to degrade. See the appropriate sections in the User 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 0 dBm at the input IF mixer (no IF attenuation for 0 dBm input signal) and the output RF level set to > 0 dBm. The sideband phase noise floor is determined by the thermal noise floor.

LO related sideband spurious signals [10]

< 200 kHz .... < -75 dBc

> 200 kHz .... < -80 dBc

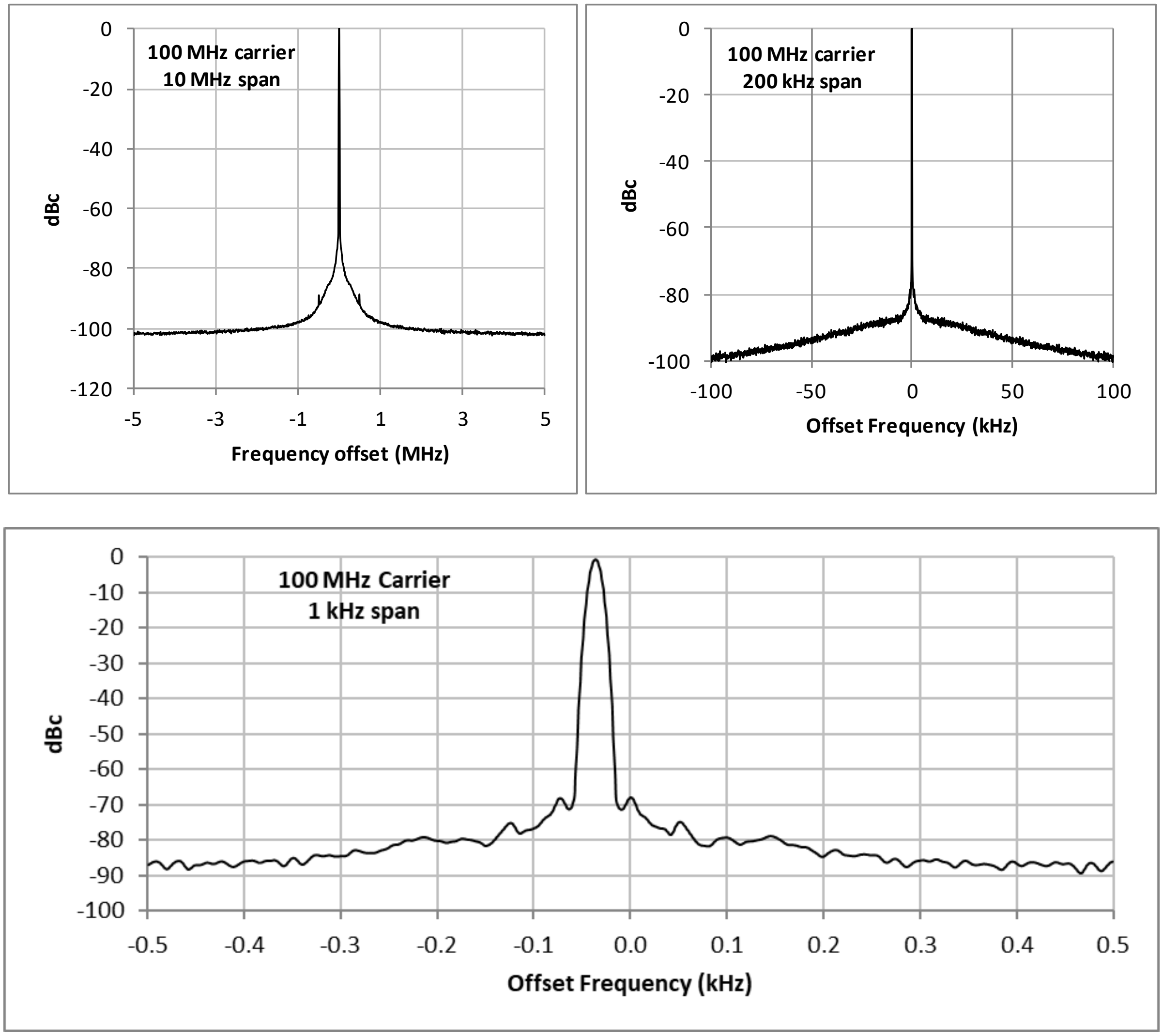

Figure 4. Plots show the raw spectral purity for a 100 MHz input RF signal (LO = 4.775 GHz). Note that the power supply noise of 60 Hz and its harmonics are in the noise. The measurement instrument is not phase-locked to the unit under test.

[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.

The YIG oscillator is sensitive to magnetic fields, magnetic noise due to electrical fans, supply transformers, and other magnetic field-producing devices. Close proximity of these devices to the YIG oscillator may induce sideband noise on the signals. 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

Output range

0 dBm input IF signal [11] .... -110 dBm to +16 dBm typical

Attenuation range

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

IF [12] .... 0 to 90 in 1 dB steps

Output voltage standing wave ratio (VSWR) (3 dB final RF attenuation)

10 MHz to 2.4 GHz .... < 1.8

2.5 GHz to 3.6 GHz .... < 2.5

Conversion gain [13]

< 2000 MHz .... 25 dB typical

> 2000 MHz .... 20 dB typical

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

RF gain response flatness (uncorrected)[14] .... 18 dB typical

RF gain flatness response (corrected[15]) .... ±0.75 dB

Absolute gain accuracy (corrected[15]) .... ±0.8 dB (±0.5 dB typical)

IF Amplitude accuracy (15 °C to 35 °C ambient)

IF in-band response flatness (uncorrected) .... 2 dB peak typical

IF in-band response (corrected[15])[14] .... ±0.2 dB

---

[11] An input IF signal of 0 dBm was used to verify the specifications. Lowering the input power can produce output levels lower than specified. The roll-off at 3.9 GHz is due to the final RF filter.

[12] There are three 30 dB range attenuators with 1 dB step attenuation. There are two attenuators up front at the IF input prior to the first mixer. Another attenuator is located in the second IF stage for optimization of linearity and noise, as well as to increase attenuation when needed to achieve low output signals.

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

[14] Specified for 100 MHz to 3.6 GHz.

[15] 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.

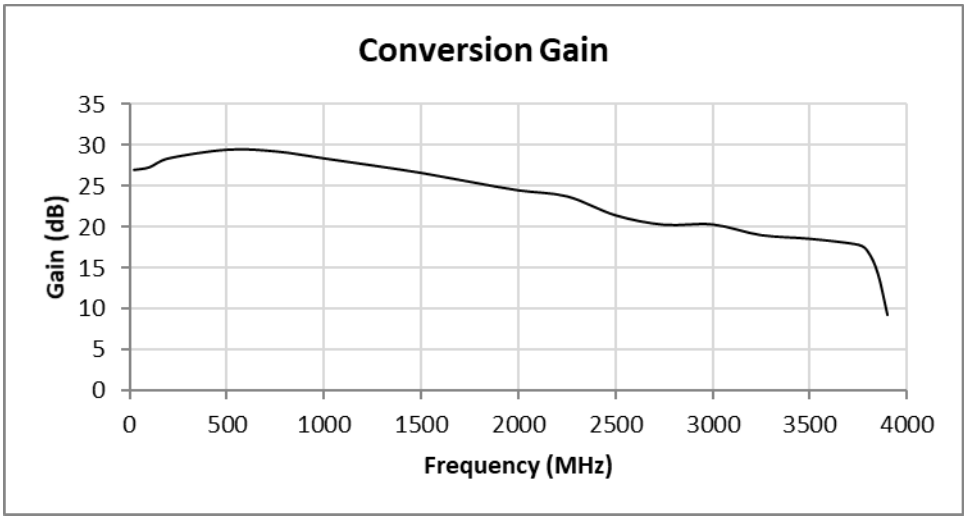

Figure 5. Typical upconverter RF conversion gain response @ 25 °C.

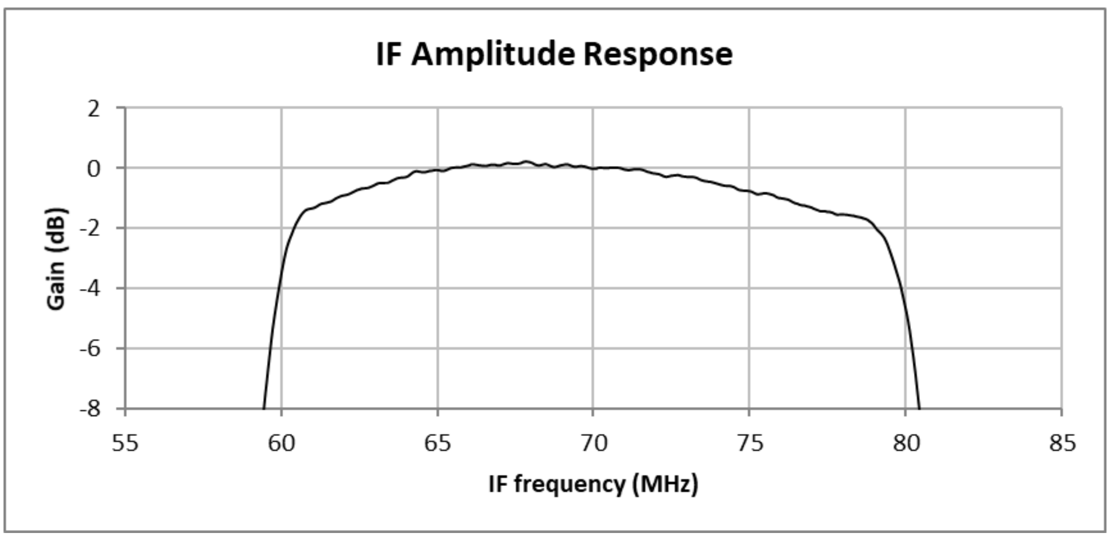

Figure 6. Typical IF amplitude response with respect to IF center @ 25 °C.

RF to IF group delay (80% of IF bandwidth)[16] .... 960 ns typical

IF phase linearity (80% of IF bandwidth) .... +/- 8 degrees

IF phase linearity deviation rate..< 2 degrees/MHz

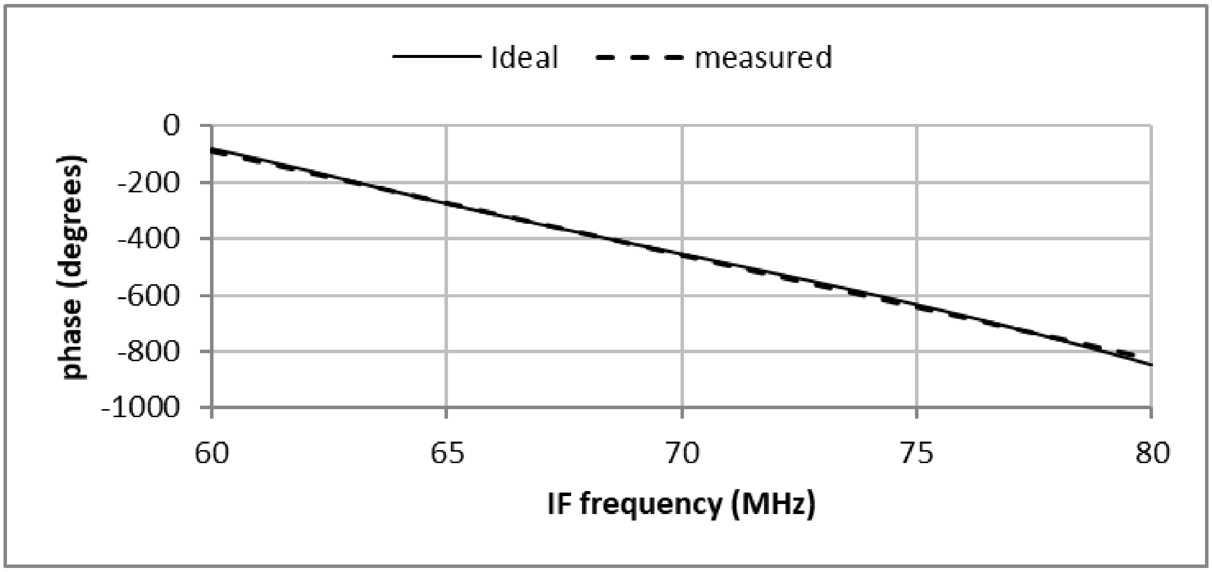

Figure 7. Typical plot showing the deviation from linear phase over the IF band.

[16] For broadband signal operation, it is recommended that users apply in situ amplitude and phase equalization to the generated IF signal in order to minimize amplitude and phase errors caused by the device. Phase deviation at offset frequencies from the center frequency of 70 MHz is stored in the calibration EEPROM. The calibration may be applied as a first order correction.

Dynamic Range Specifications

Spurious response [17]

Final IF - RF output frequency [18] .... < -65 dBc typical

IF leakage .... < -100 dBc typical

LO leakage........ < -100 dBc typical

Other intermodulated spurs .... < -75 dBc typical

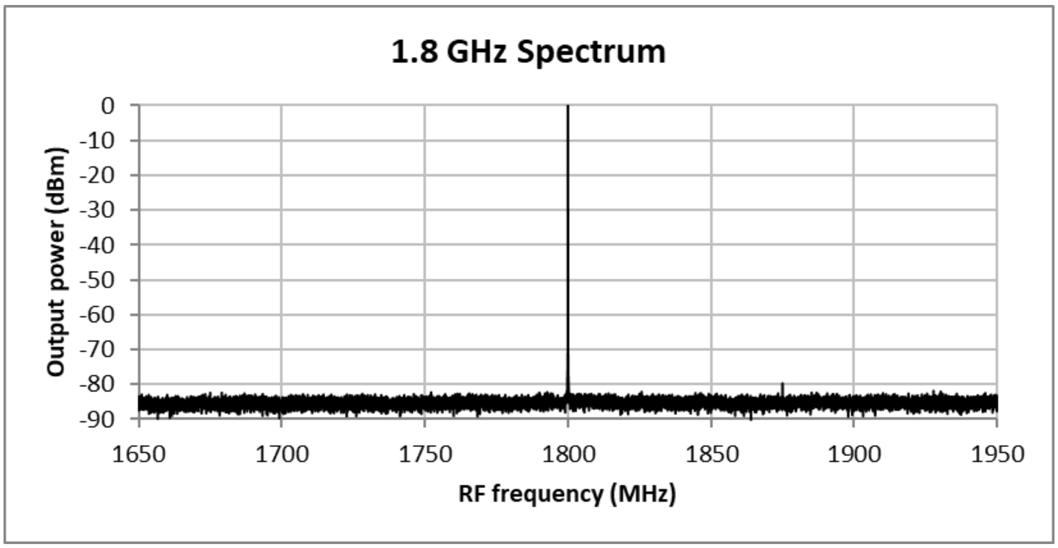

Figure 8. Spectrum showing low LO related spurious signals for 1.8 GHz tone generation.

[17] Spurious responses are unwanted signals appearing at the RF output that are not due to harmonics. The specifications are valid for 0 dBm RF output power and 0 dBm IF input power.

[18] The final IF frequency is 4675 MHz. Due to low isolation between the IF and RF ports of the mixer, the IF signal at the mixer output intermodulates with the RF signal to produce products that exist inside the RF band. To improve on this leakage and improve the signal-to-spur ratio, the IF signal needs to be attenuated further and the RF attenuation needs to be decreased to obtain the original output signal level.

Output noise (dBm/Hz) (15 °C to 35 °C ambient) [19]

	100 MHz	1000 MHz	3600 MHz
Optimized lineary setting [20]	-130	-130	-132
Optimized noise setting [21]	-148	-150	-148

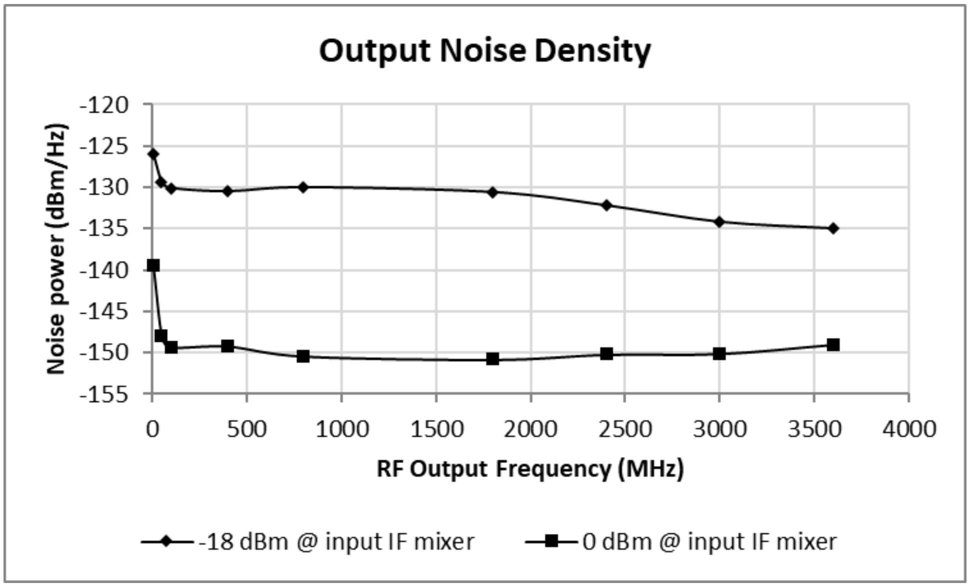

Figure 9. Typical measured output noise density at 0 dBm RF output power.

[19] Noise (thermal) is referred to the output of the device when the output level is at 0 dBm. Noise floor density is specified from 5 MHz away from the carrier and out to 100 MHz away from the carrier. Close to the carrier, noise is dominated by phase noise.

[20] When the upconverter is set for optimized linearity and SNR, the IF1 attenuator is set to 18 dB (mixer level is -18 dBm), and the IF3 attenuator is set to 3 dB for 0 dBm IF input. The IF1 attenuation ensures that the signal at the input IF mixer is -18 dBm. The RF attenuators are set appropriately to obtain the required RF output level, which in this case is 0 dBm.

[21] When the upconverter is set for optimal SNR, the signal at the input IF mixer is set to 0 dBm, the IF3 attenuator is set to 3 dB, and the RF attenuators are adjusted to the required output level, which in this case is 0 dBm. When the upconverter is set for optimal SNR the non-linear products increase in magnitude and the output spurious contents increase with respect to the output signal.

Output third-order intermodulation (OIP3, dBm) [22]

	100 MHz – 1 GHz	1 GHz – 2.5 GHz	2.5 GHz – 3.9 GHz
Optimized for linearity and noise setting	36 [39]	32 [36]	31 [34]

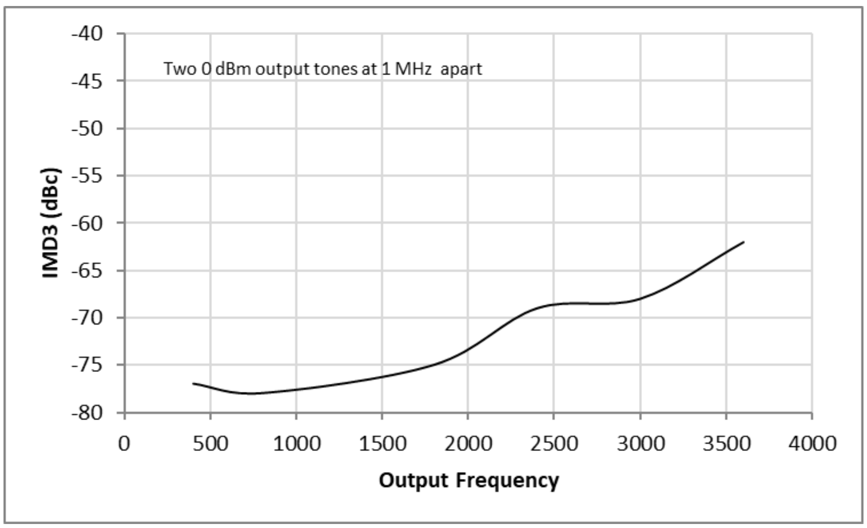

Figure 10. Typical IMD3 products with respect to two output 0 dBm signals at 1 MHz apart.

Output second harmonic (dBc)

Frequency	< 1500 MHz	1.5 GHz – 3.2 GHz	> 3.2 GHz
Optimized linearity and noise setting	< -45	< -40	< -50

[22] These are in-band measurements and not out-of-band measurements. Out-of-band signal tones exist outside the IF filter bandwidth of the device, and thus may provide better IP3 measurements. However, using in-band signal tones provides a better estimation of the device's non-linear effects on broadband signals.

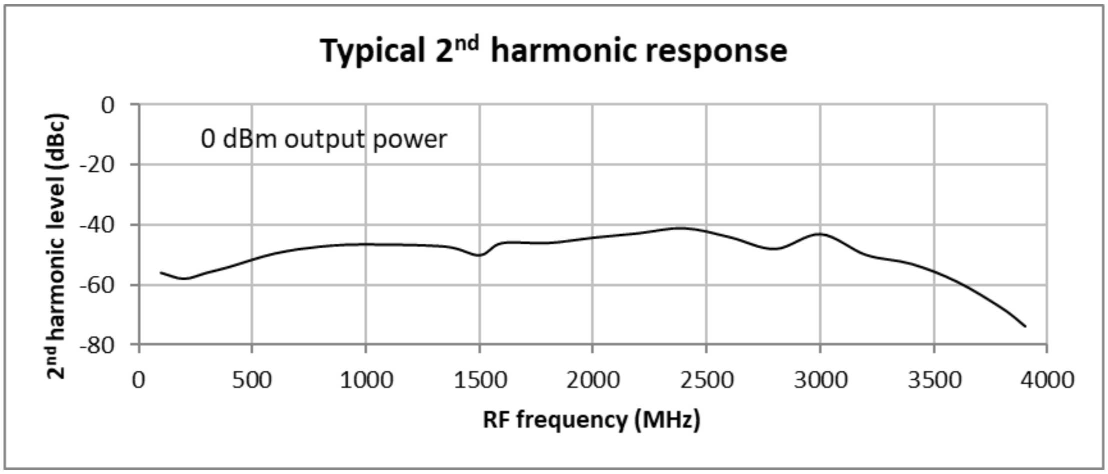

Figure 11. Harmonic levels measured at 0 dBm output power.

Output compression point (dBm) [23]

Frequency	50 MHz – 3.0 GHz	3.0 GHz – 3.8 GHz	3.8 GHz – 3.9 GHz
With 0 dBm at IF input	18	16	9

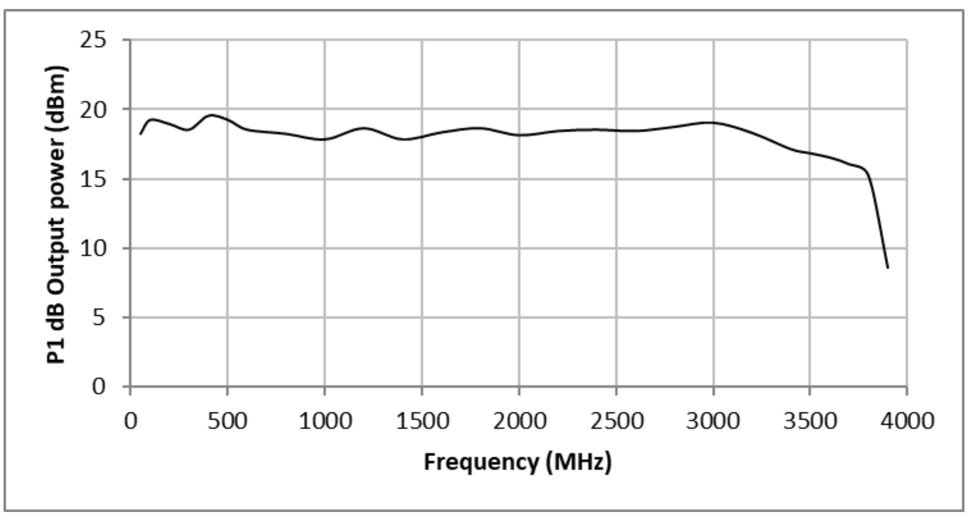

Figure 12. Typical output power at 1 dB compression.

[23] To obtain levels close to the compression requires the final IF3 signal to drive the output mixer at a higher level, which increases the amplitude of intermodulated spurious signals. Suppressing spurious levels requires external filtering of the RF signal.

Reference Input and Output Specifications

Reference output specifications

Center frequency [24] .... 10 MHz/100 MHz
Amplitude .... 3 dBm typical
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 .... -10 dBm min/ +13 dBm max
Phase-lock range .... ± 5 ppm (typical)
Impedance .... 50 Ω nominal
Coupling .... AC
Connector type .... SMA female

Port Specifications

IF input

Input impedance .... 50 Ω
Coupling .... AC
VSWR .... < 1.3
Connector type .... SMA female
Input amplitude .... +23 dBm max

RF output

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

[24] The output reference frequency may be selected programmatically for 10 MHz or 100 MHz. The 100 MHz reference may be used to drive a digitizing ADC directly.

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) (SC5406B) .... 3.7" x 1.4" x 6.1"
Dimensions (W x H x D, max envelope) (SC5405A) .... 2x3U slots
Weight .... 2.6 lbs
Input voltage (SC5406B) .... 12 VDC
Power consumption .... 24 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 parts and labor on defects in materials or workmanship

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

Revision Notes

Revision	Revision Date	Description
1.0	8/11/2020	Combined SC5405A and SC5406B datasheets into one document.