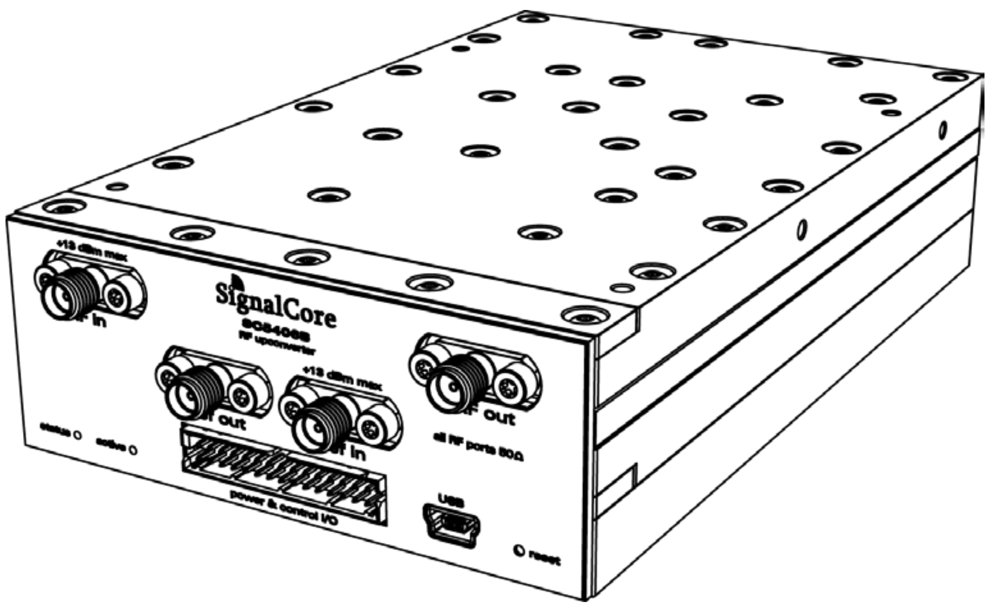

SC5406B
1 MHz to 3.9 GHz RF Upconverter Core Module

Datasheet

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SPECIFICATIONS

Definition of Terms

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

Specification (spec)

Defines guaranteed performance of a calibrated instrument under the following conditions:

- 3 hours storage at room temperature (standardized to 25 °C) followed by thirty minutes minimum warm-up operation.
- Specified environmental conditions are met within the specified operating temperature range of 0 °C to 40 °C unless otherwise noted.
- Recommended calibration intervals are used.

Typical data (typ)

When used with <, > or in a range, defines performance met by approximately 80% of all instruments manufactured. This data is not guaranteed, does not include measurement uncertainty, and is valid only at room temperature (standardized to 25 °C).

Nominal values (nom)

Characterizes product performance by means of average performance of a representative value for the given parameter (e.g. nominal impedance). This data is not guaranteed and is valid only at room temperature (standardized to 25 °C).

Measured values (meas)

Characterizes expected product performance by means of measurement 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

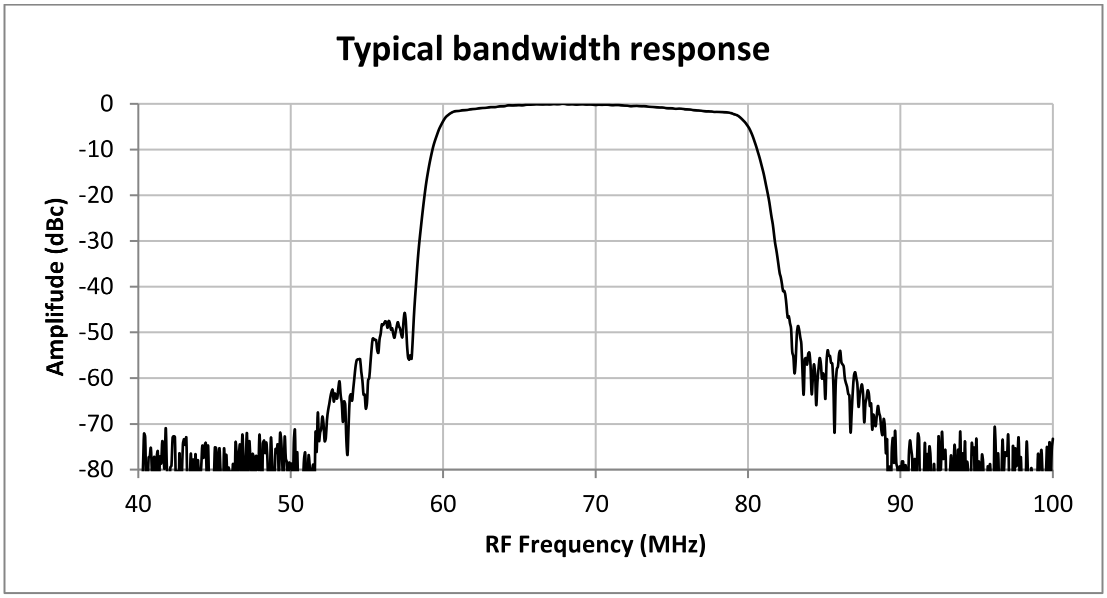


Figure 1. Typical conversion bandwidth response measured at RF = IF.

(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 inter-modulate with the IF 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. To suppress the intermodulation spurs, increasing IF attenuation will help but only 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 choice 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

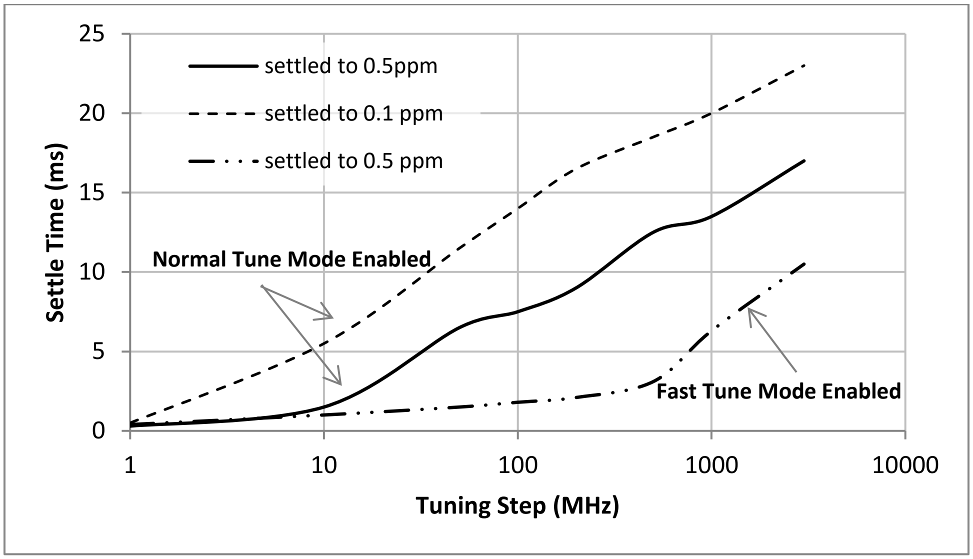


Figure 2. Typical frequency settling time versus tuning step with a 3600 MHz final frequency.

(3) To give users flexibility, the device has 3 resolution modes; two coarse modes and one fine mode. The coarse modes using fractional N PLL's allow 1 MHz and 25 kHz steps, while the fine mode (aided by a DDS) provides 1 Hz resolution. All modes provide exact synthesized frequencies. See the appropriate sections of this manual for further information.

(4) Locked and settled to < 1 ppm of final frequencies of > 500 MHz for step size of < 10 MHz. For final frequencies < 500 MHz the settle time applies to accuracy within 500 Hz of the final frequency for a < 10 MHz step size. 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.

Frequency reference (5)

Source .... Temperature compensated crystal oscillator (TCXO)

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

Initial calibration accuracy .... ±0.05 ppm

Temperature stability (6)

20 ^{0}C to 30 ^{0}C .... ±0.25 ppm

0 ^{0}C to 55 ^{0}C .... ±1.0 ppm

Aging .... ±1 ppm for first year @ 25 ^{0}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 (1x10^{-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 ^{0}C to 46 ^{0}C at an ambient temperature of 25 ^{0}C.

(7) Accuracy of the device for any upconverted output RF signal.

Sideband phase noise (dBc/Hz) (typ) [8][9][11]

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

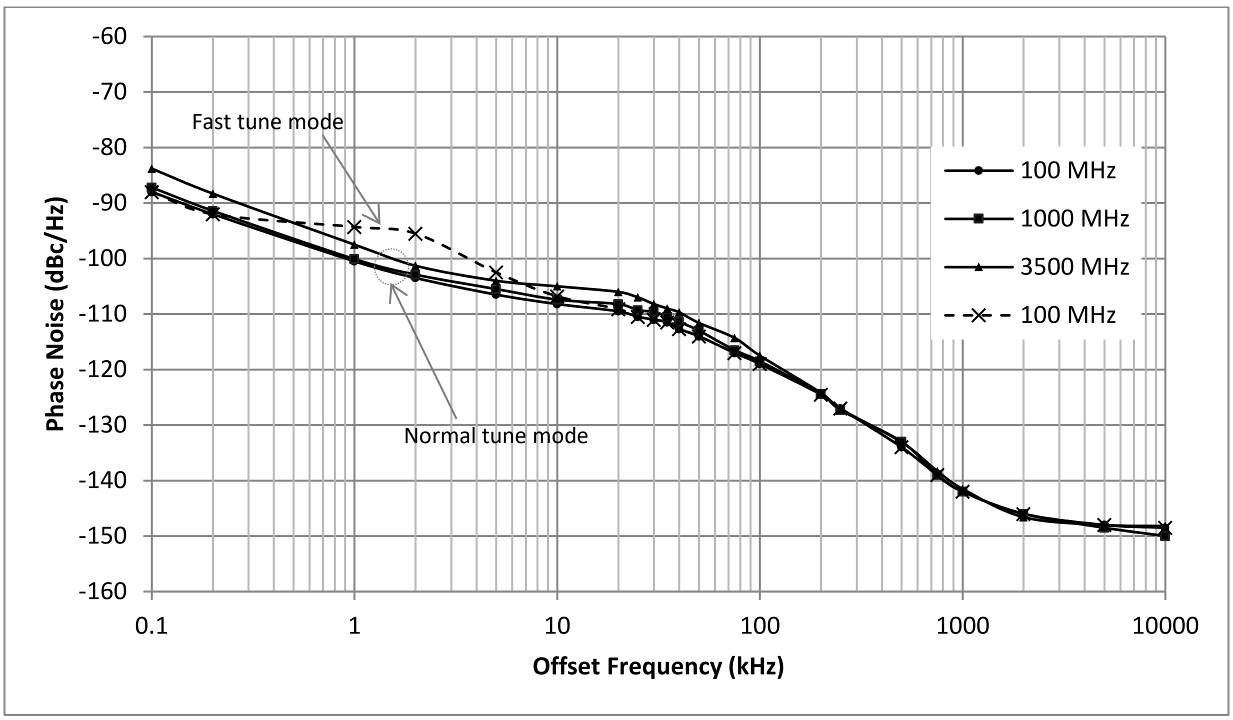


Figure 3. Measured sideband noise.[9]

(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. See 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 was set to > 0 dBm. The sideband phase noise floor is determined by the thermal noise floor.

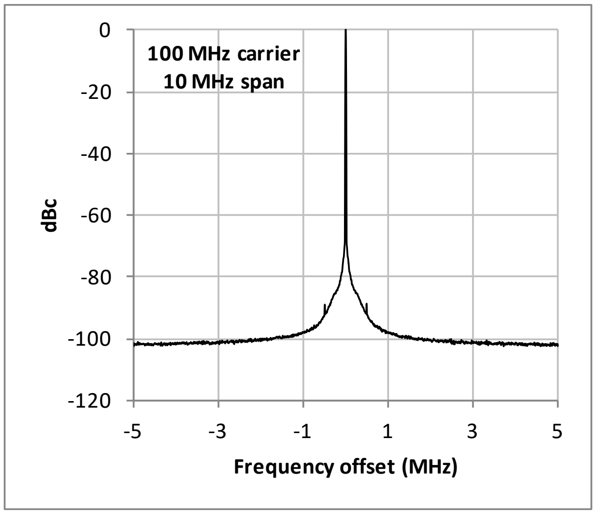
LO related sideband spurious signals (10)(11)

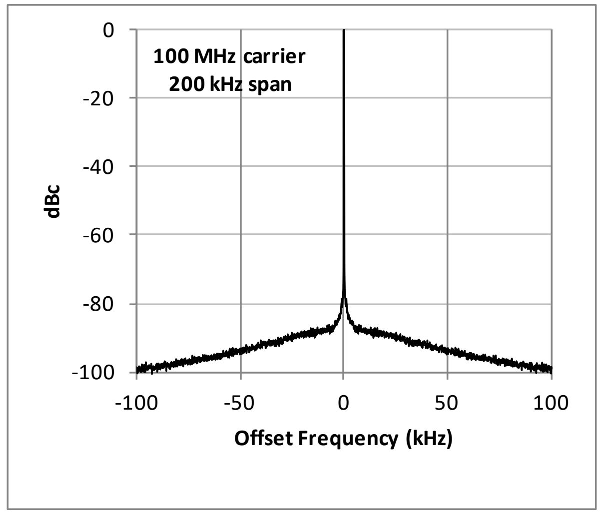
< 200 kHz .... < -75 dBc

> 200 kHz .... < -80 dBc

(10) Sideband spurious signals are usually the result 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 PLL's, DDS noise sources, and intermodulation between oscillators within the multiple-loop PLL synthesizers. Fractional-N and DDS spurious products affect the spectral region below 200 kHz and intermodulation products affect spectral regions out to a couple of MHz. SignalCore uses mathematical algorithms to properly select the synthesizer parameters used in the multiple-loop fractional-N PLL to ensure that typical sideband spurious products are better than the specifications.

(11) Specifications are valid for all modes of frequency tuning, whether is it PLL only mode or DDS driven mode. As the YIG oscillator is sensitive to magnetic fields, magnetic noise due to electrical fans, supply transformers, and other magnetic producing devices may induce sideband noise on the signals when they are place 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.





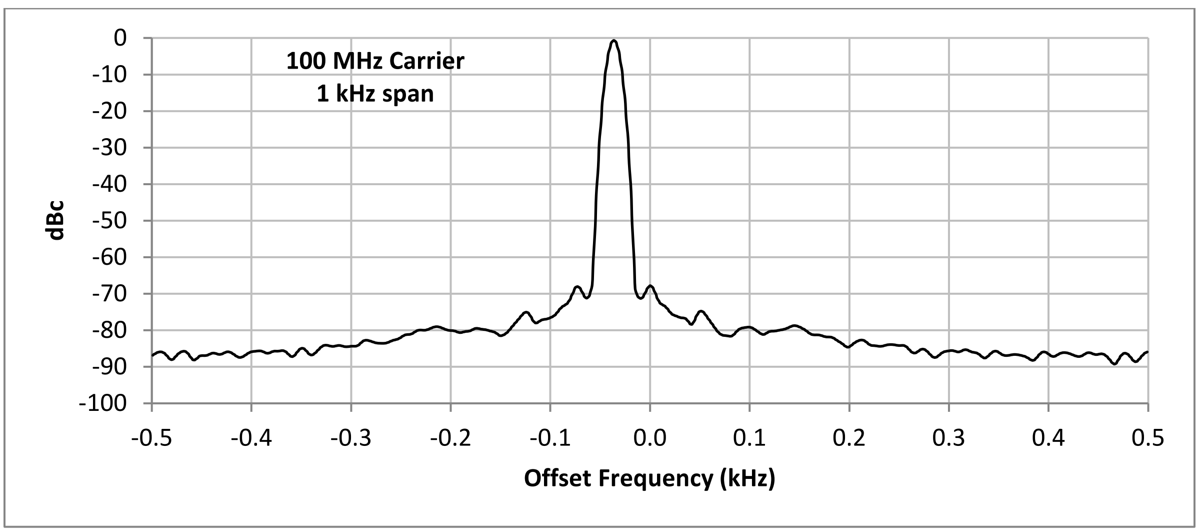


Figure 4. Plots show the raw spectral purity for a 100 MHz input RF signal (LO = 4.775 GHz). Note that the power supply noise of 60 Hz and its harmonics are in the noise. The measurement instrument is not phase locked to the unit under test.

Amplitude Specifications

Output range

0 dBm input IF signal [12] .... -110 dBm to +16 dBm typical

Attenuation range

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

IF [13] .... 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 [14]

< 2000 MHz .... 25 dB typical

> 2000 MHz .... 20 dB typical

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

RF gain response flatness (uncorrected) [15] .... 18 dB typical

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

Absolute gain accuracy (corrected) [16] .... ±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][16] .... ±0.2 dB

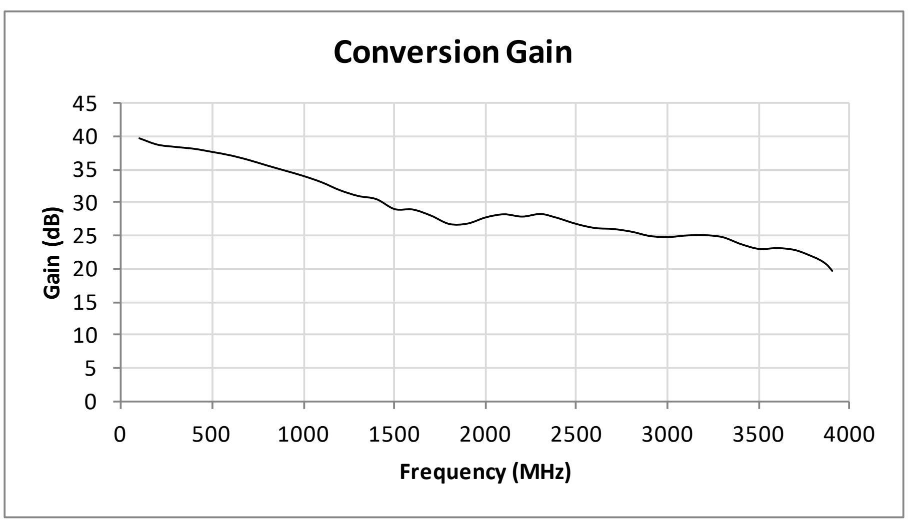


Figure 5. Typical upconverter RF conversion gain response @ 25 ^{O}C

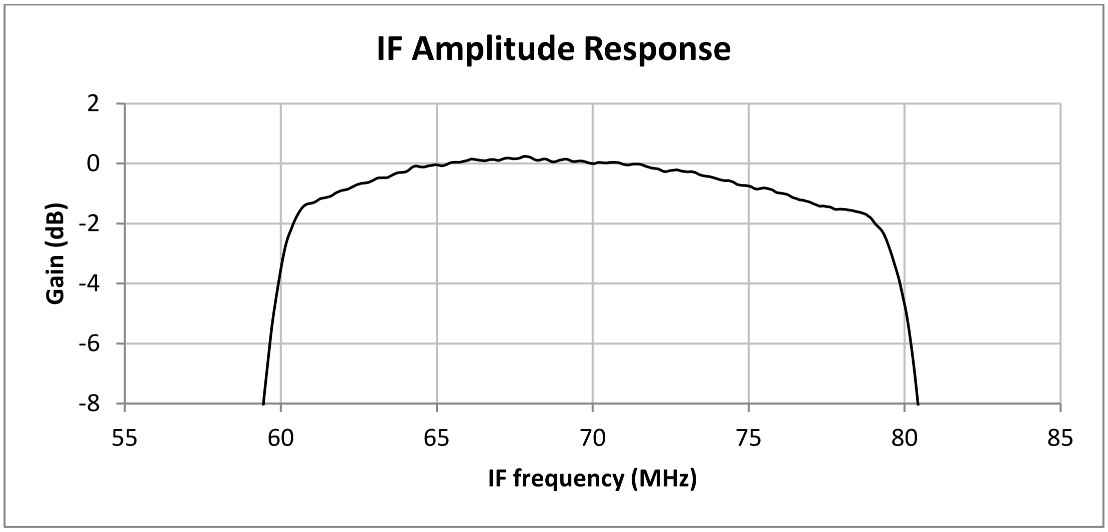


Figure 6. Typical IF amplitude response with respect to IF center @ 25 ^{O}C.

RF to IF group delay (80% of IF bandwidth) (18) .... 960 ns typical

IF phase linearity (80% of IF bandwidth) (18) .... +/- 8 degrees

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

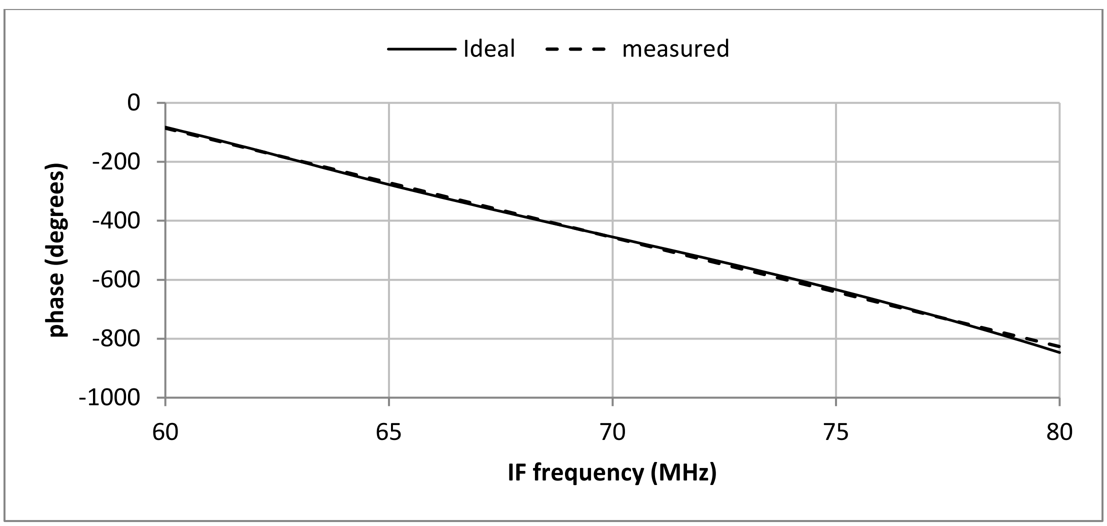


Figure 7 Typical plot showing the deviation from linear phase over the IF band.

(12) 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.

(13) 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, and one in the second IF stage for optimization of linearity and noise, as well as to increase attenuation when needed to achieve low output signals.

(14) Maximum conversion gain is specified when all attenuators are set to 0 dB attenuation.

(15) Specified for 100 MHz to 3.6 GHz.

(16) Applies for the entire RF range after calibration is applied. Calibration data is stored in the on-board calibration EEPROM.

(17) IF group delay, amplitude response, and phase linearity are measured using a VNA when the RF is tuned to the same center frequency as the IF. Extrapolating this result for other RF frequencies does not affect the specifications of the amplitude and phase variations as the RF band changes are negligible compared to the IF band.

(18) For broadband signal operation it is recommended that users apply in situ amplitude and phase equalization to the generated IF signal 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 signals (19)

Final IF - RF output frequency (20) .... < -65 dBc typical

IF leakage .... < -100 dBc typical

LO leakage .... < -100 dBc typical

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

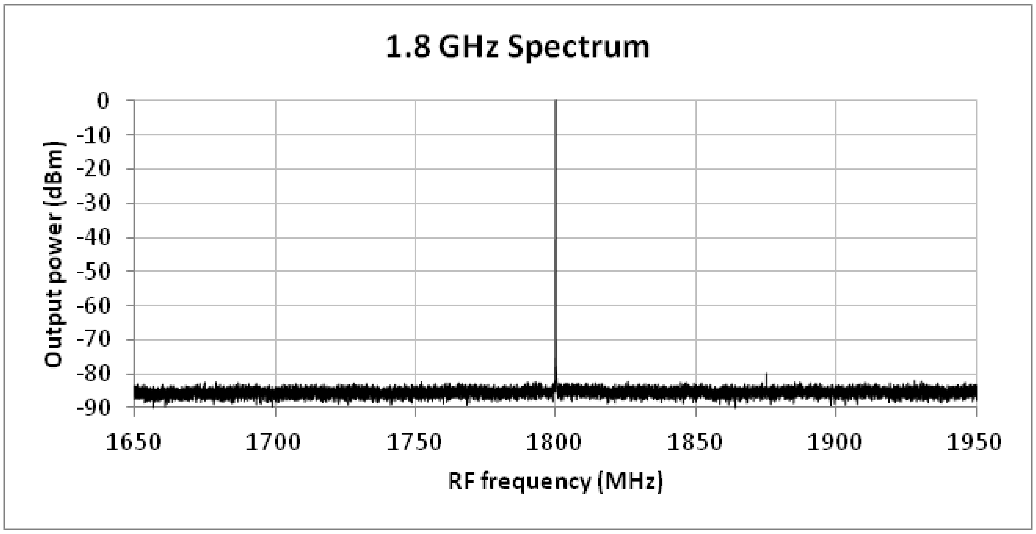


Figure 8. Spectrum showing low spurious signals for 1.8 GHz tone generation.

(19) 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.

(20) 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) (21)

	100 MHz	1000 MHz	3600 MHz
Optimized linearity setting (22)	-130	-130	-132
Optimized noise setting (23)	-148	-150	-148

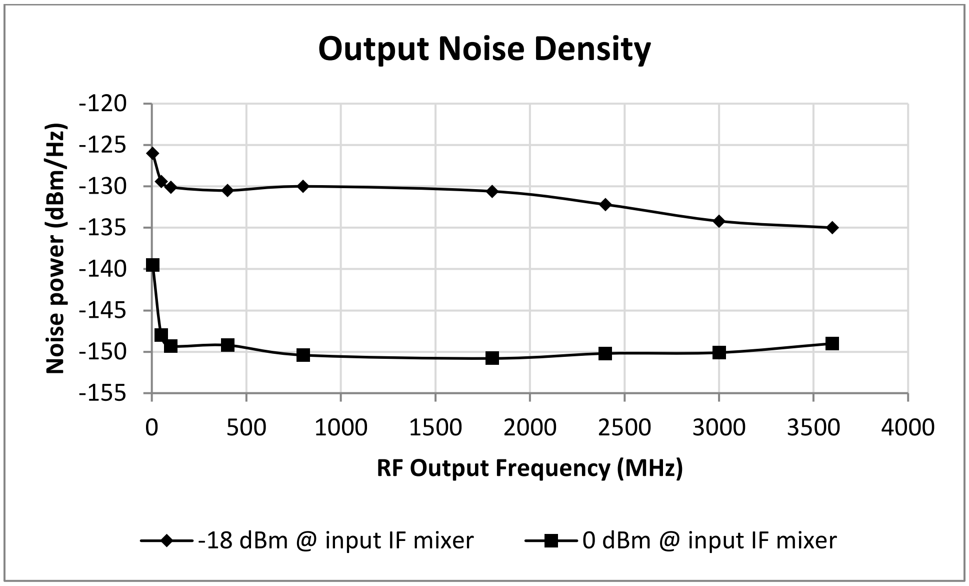


Figure 9. Typical measured output noise density at 0 dBm RF output power

(21) 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. See "**Sideband phase noise**" specification.

(22) 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.

(23) When the upconverter is set for optimal SNR the signal at the input IF mixer is 0 dBm and the IF3 attenuator is set to 3 dB, while 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) (24)

	100 MHz – 1 GHz	1 GHz – 2.5 GHz	2.5 GHz – 3.6 GHz
Optimized for linearity and noise setting	36 [39]	32 [36]	31 [34]

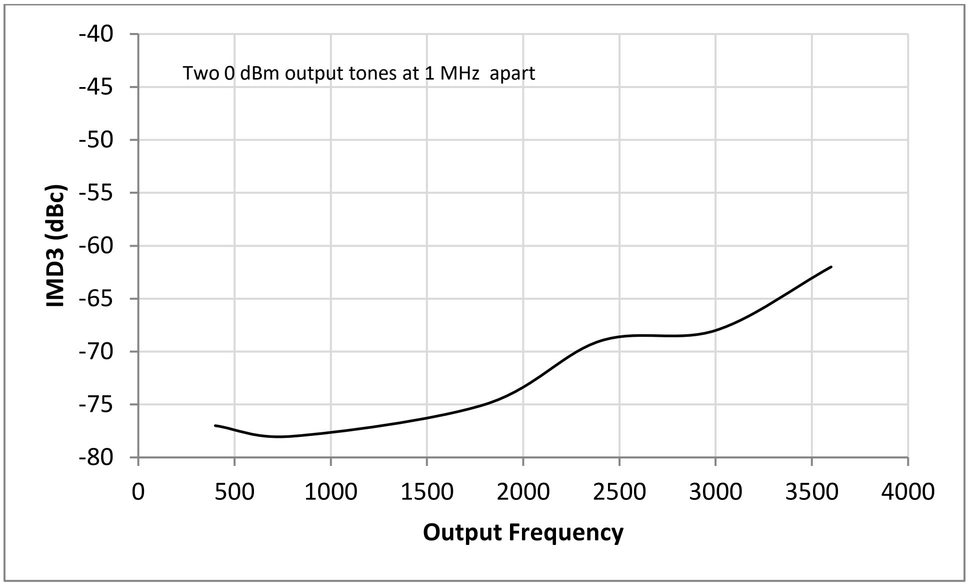


Figure 10. Typical IMD3 products with respect to two output 0 dBm signals at 1 MHz apart.

Output second harmonic (dBc)

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

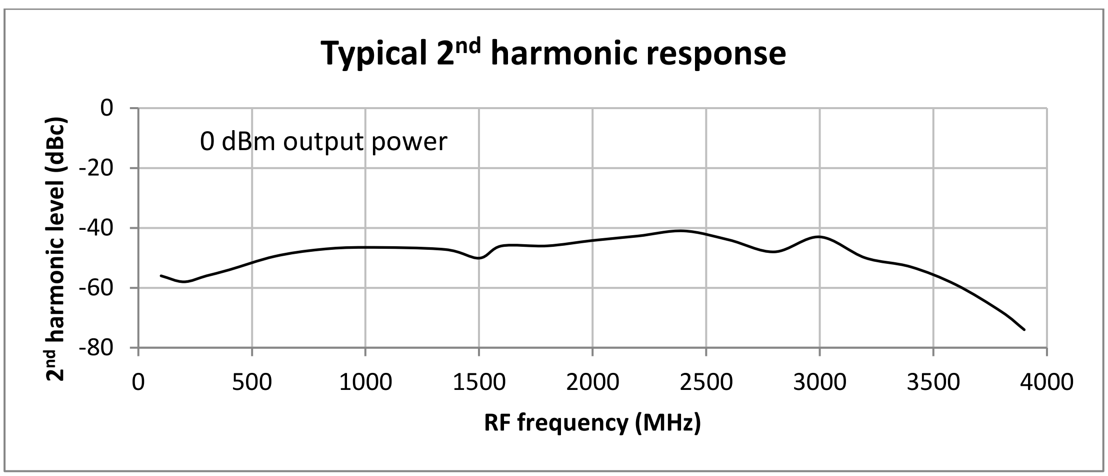


Figure 11. Harmonic levels measured at 0 dBm output power.

Output compression point (dBm) (25)

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

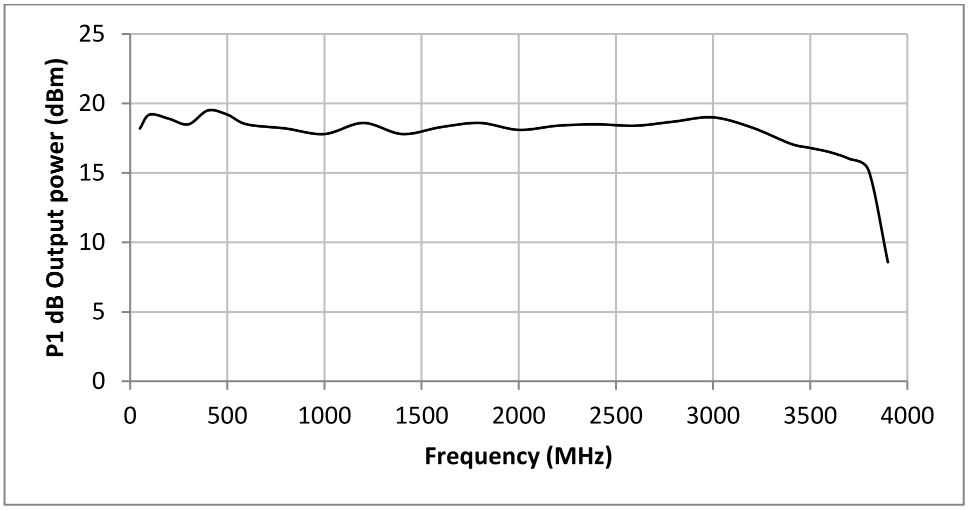


Figure 12. Typical output power at 1 dB compression.

(24) Specifications are based on the following configuration: 18 dB IF1 attenuation, 3 dB IF3 attenuation, two 0 dBm tones with 1 MHz separation at the IF input, and RF attenuation adjusted to maintain 0 dBm at the RF output. Increasing the IF1 attenuation will improve the IMD3 performance but the SNR may degrade as a result.

(25) To obtain levels close to the compression requires that the final IF3 signal to drive the output mixer at a higher level, which will cause an increase in the amplitude of intermodulated spurious signals. To suppress spurious levels requires external filtering of the RF signal.

Reference Input and Output Specifications

Reference output specifications

Center frequency [26] .... 10 MHz/100 MHz
Amplitude .... 3 dBm typical
Waveform .... Sine
Impedance .... 50 Ω nominal
Coupling .... AC
Connector type .... SMA female

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

(26) The output reference frequency may be programmatically selected for 10 MHz or 100 MHz. The 100 MHz may be used to drive a digitizing ADC directly. Refer to the **"Frequency reference**" specifications under "Spectral Specifications" for frequency accuracy.

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

General Specifications

Environmental

Operating temperature (27) .... 0 °C to +50 °C

Storage temperature (28) .... -40 °C to +70 °C

Operating relative humidity (29) .... 10% to 90%, non-condensing

Storage relative humidity (29) .... 5% to 90%, non-condensing

Operating shock (30) .... 30 g, half-sine pulse, 11 ms duration

Storage shock (30) .... 50 g, half-sine pulse, 11 ms duration

Operating vibration (31) .... 5 Hz to 500 Hz, 0.31 g_{rms}

Storage vibration (31) .... 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) .... 3.7” x 1.4” x 6.1”

Weight .... 2.6 lbs

Power consumption .... 34 W typical

Input Voltage .... 12 VDC

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; Low-Voltage Directive (safety), 2004/108/EC; Electromagnetic Compatibility Directive (EMC Directive)

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

(27) Meets requirements of IEC-60068-2-1 and IEC-60068-2-2. Operating temperature may be extended to +55 °C with appropriate user-provided cooling solution. Contact SignalCore for recommended minimum airflow rates.
(28) Meets requirements of IEC-60068-2-1 and IEC-60068-2-2.
(29) Meets requirements of IEC-60068-2-56 and MIL-PRF-28800F, Class 3.
(30) Meets requirements of IEC-60068-2-27 and MIL-PRF-28800F, Class 3.
(31) Meets requirements of IEC-60068-2-64 and MIL-PRF-28800F, Class 3.

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