SignalCore™
PRESERVING SIGNAL INTEGRITY

Datasheet

SC5305A & SC5306B

1 MHz to 3.9 GHz RF Downconverter

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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)	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 input range [1] .... 1 MHz to 3.9 GHz

IF output center frequency .... 70 MHz

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

IF bandwidth (3 dB)

Final IF filter bypassed .... > 20 MHz

Final IF filter enabled (default) .... > 18 MHz

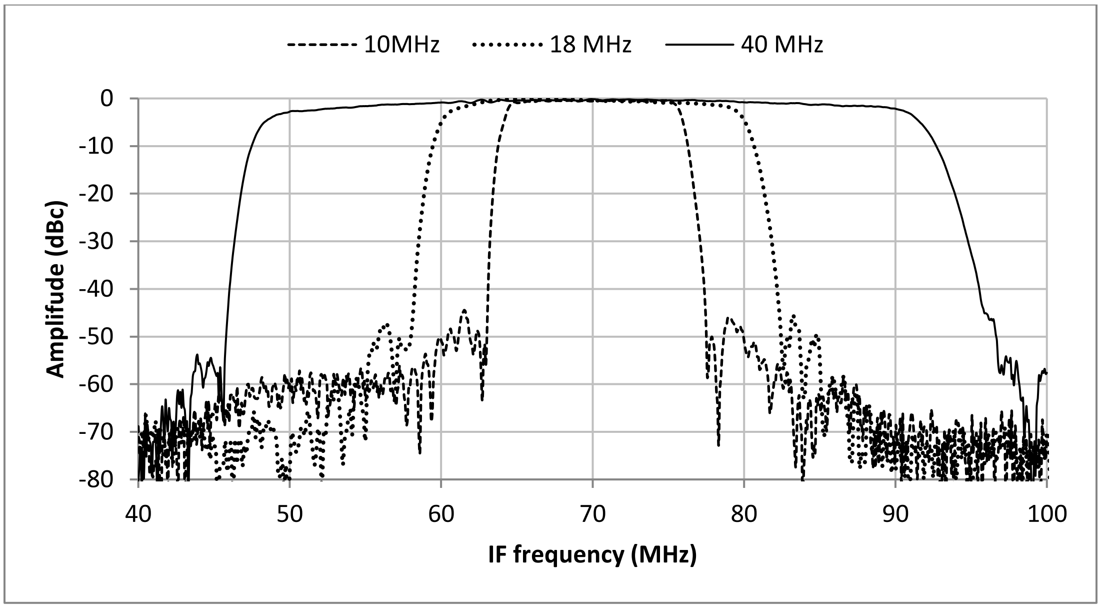

Figure 1. Typical output IF response of filter options. A maximum of two IF filter options are available. Standard IF option is a 20 MHz bandwidth path and a bypass (no filter) path.

[1] RF input below 1 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. This LO leakage will appear as ~DC when the RF is converted to baseband in the final analysis. Furthermore, because the LO appears inside the IF band, it will inter-modulate with the input RF signal to produce higher order in-band spurious signals that may degrade signal integrity. It is recommended to attenuate the RF signal before the first mixer by applying RF attenuation or attenuate after the first mixer by applying IF1 attenuation. Suppressing the RF amplitude in front of the downconversion path will reduce the spurious signal levels.

[2] The IF 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 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.

RF tuning

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

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

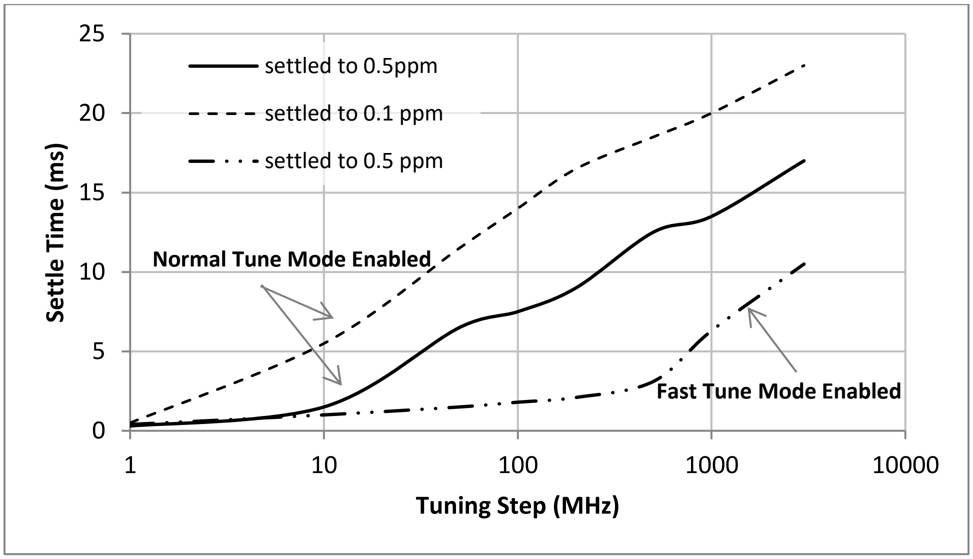

Figure 2. Typical frequency settling time versus tuning step with a 3600 MHz final frequency.

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

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[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 ($1x10^{-6}$).

[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 given input 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	-152	-152	-150	-148

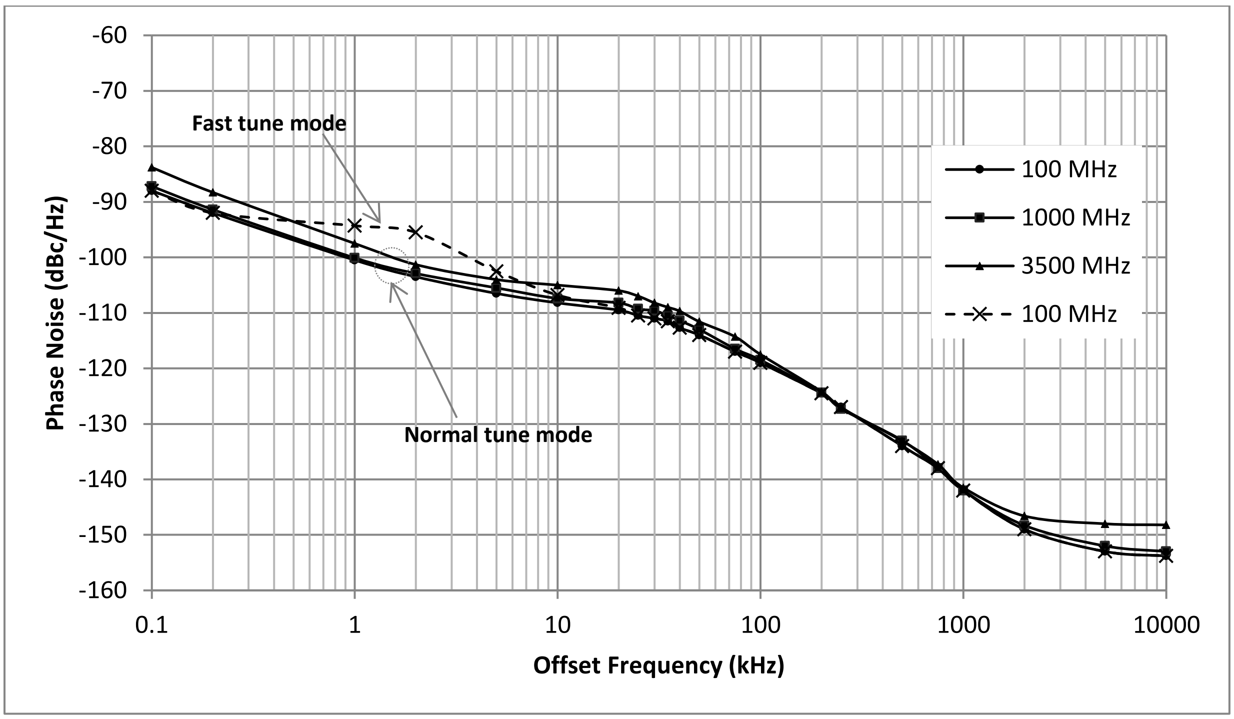


Figure 3. Typical measured sideband noise.[9]

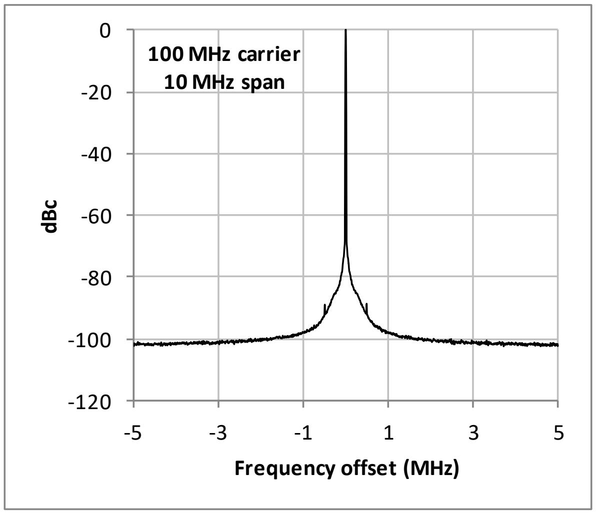
[8] Sideband phase noise as specified is based on measured sideband noise which includes both phase noise and amplitude noise contributions. Sideband noise is specified for the downconverter when tune mode is set to NORMAL. In FAST-TUNE mode, the noise damping capacitor across the YIG tuning coil is 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.

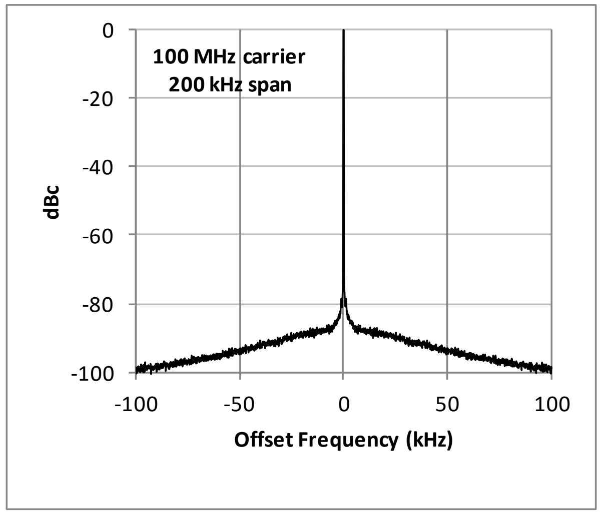
[9] These results are obtained with input signal levels of 0 dBm at the mixer (no RF attenuation) and the output IF level set to 3 dBm.

LO related sideband spurious signals [10]

< 200 kHz .... -75 dBc

> 200 kHz .... -80 dBc





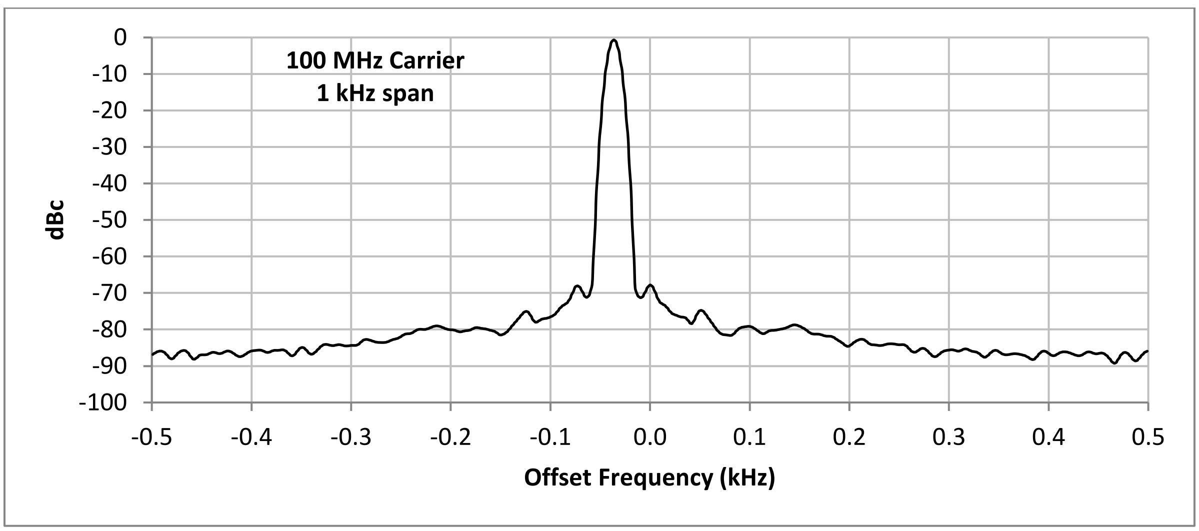


Figure 4. Plots show the raw spectral purity for a 100 MHz input RF signal (LO = 4.775 GHz). Note that the power supply noise of 60 Hz and its harmonics are in the noise. The measurement instrument is not phase-locked to the unit under test.

[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

Input range

AC (preamplifier disabled) .... +27 dBm max

AC (preamplifier enabled) .... +23 dBm max

DC [11] .... 0 V

Attenuation range

RF .... 0 to 30 in 1 dB steps

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

Input voltage standing wave ratio (VSWR)

Preamp off, 0 dB input attenuation

10 MHz to 2.4 GHz .... < 1.5

2.5 GHz to 3.6 GHz .... < 1.8

Preamp on, 0 dB input attenuation

10 MHz to 2.4 GHz .... < 1.5

2.5 GHz to 3.6 GHz .... < 1.9

Gain range (@ 1GHz) [13]

Minimum [14] .... -60 dB typical

Maximum (preamplifier disabled) [15] .... 30 dB typical

Maximum (preamplifier enabled) [15] .... 50 dB typical

Preamplifier gain .... 20 dB typical

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[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. There are two attenuators in the final stage and one attenuator in the first IF stage after the first mixer.

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

[14] Minimum conversion gain is specified when all attenuators are set to their maximum values and the RF pre-amplifier is disabled.

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

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

RF gain response flatness (uncorrected) .... 8 dB typical

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

Absolute gain accuracy (corrected[16]) .... ±0.9 dB (±0.5 dB typical)

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

IF in-band response flatness (uncorrected) .... 3 dB typical

IF in-band response (corrected[16]) .... ±0.5 dB

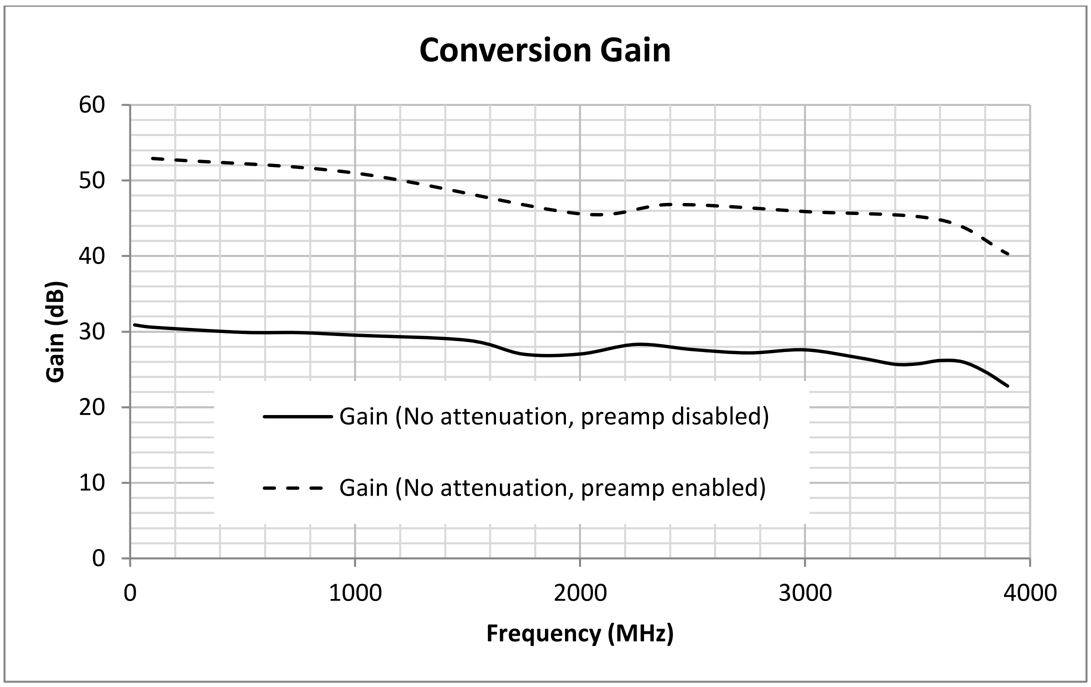

Figure 5. Typical RF conversion gain response @ 25 °C.

[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.

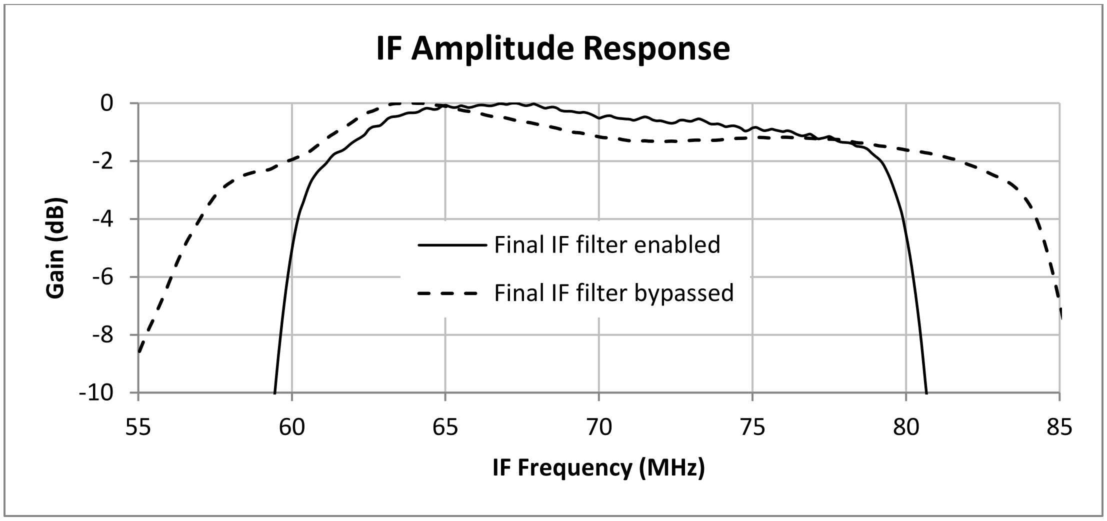

Figure 6. Typical IF amplitude response @ 25 °C for standard 20 MHz IF filter.

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

Final IF filter enabled .... 1 μs typical

Final IF filter bypassed .... 100 ns typical

IF phase linearity (80% of IF bandwidth) [17]

Final IF filter enabled .... +/- 8 degrees

Final IF filter bypassed .... +/- 8 degrees

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

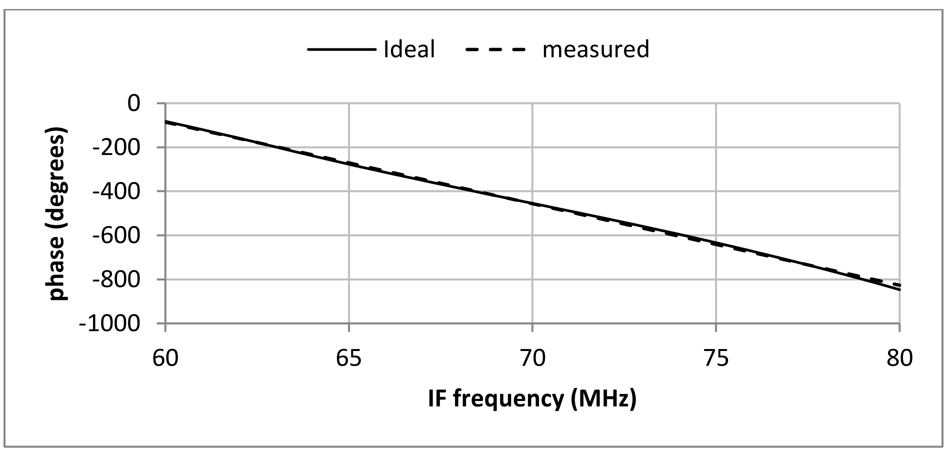

Figure 7. Phase deviation over 20 MHz.

[17] For broadband signal operation, it is recommended for users to apply in situ amplitude and phase equalization to the received 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 [18]

Residual spurious signals [19] .... < -100 dBm

LO related spurious signals [20] .... < -80 dBc

Image rejection [21] .... < -100 dBc

IF rejection [22] .... < -115 dBc

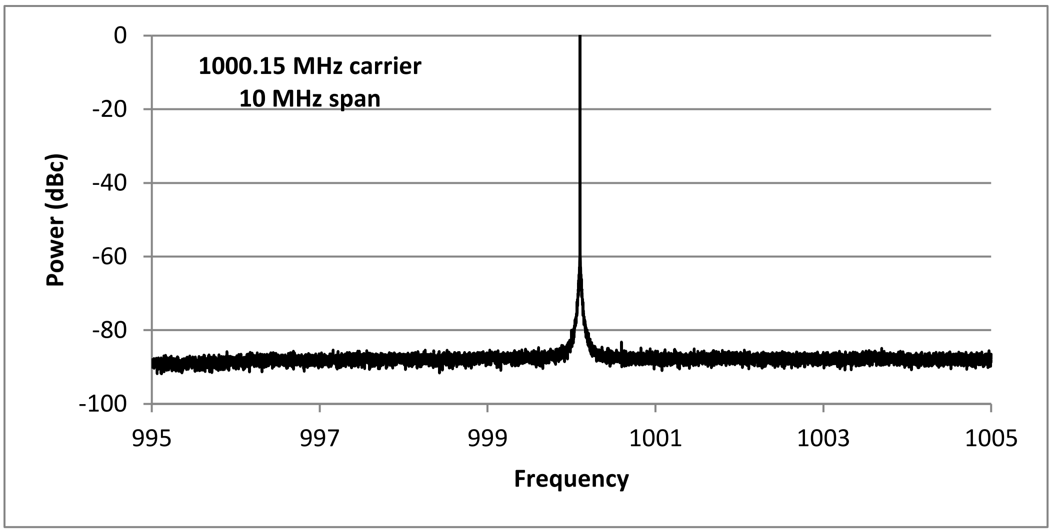

Figure 8. Spectrum showing low LO related spurious signals for an input signal of 1000.15 MHz.

[18] Spurious responses are unwanted signals appearing at the IF output. All spurious products are referenced to the RF input, meaning they are treated as if they originate at the input port of the device.

[19] Residual spurious signals are observed and referenced to the RF input of the device when the RF input is terminated with a matched load. The RF and first IF (IF1) attenuators are set to 0 dB attenuation and the final IF attenuators were adjusted to obtain an overall device gain of 20 dB. The preamplifier is disabled.

[20] LO related spurious signals are unwanted signals produced at the IF output due to intermodulation of the local oscillators. These spurious signals are measured relative to an RF signal present at the input. The specification referenced here is for a device configuration of -20 dBm at the mixer, 0 dBm at the IF output, and a total gain of 20 dB.

[21] Image rejection is the ability of the device to reject an image signal of the RF frequency that would otherwise produce the same result as the desired RF signal. The image of the desired RF signal is calculated as: $RF_{image} = RF + 2IF_1$, where $IF_1 = 4.675$ GHz.

[22] IF rejection is the ability of the device to reject RF signals at any of the IF frequencies while the device is tuned elsewhere. The signal level at the mixer is -20 dBm and the total gain is 20 dB.

Input noise (15 °C to 35 °C ambient) [23]

Preamplifier disabled [24]

	100 MHz	1000 MHz	3600 MHz
Noise floor (dBm/Hz)	-153	-152	-148
Noise figure (dB)	21	22	26

Preamplifier enabled [24]

	100 MHz	1000 MHz	3600 MHz
Noise floor (dBm/Hz)	-167	-166	-164
Noise figure (dB)	7	8	10

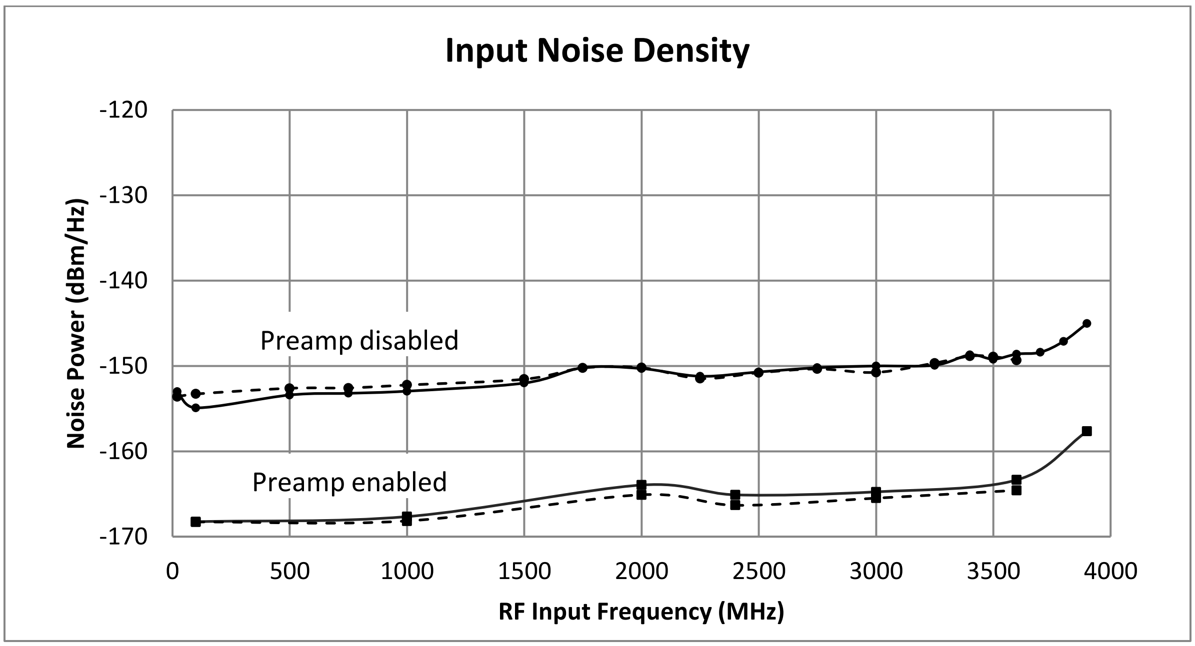

Figure 9. Measured noise density of the average of two lots.[25]

[23] Noise (thermal) is referred to the input of the device.
[24] The device is configured with 0 dB RF attenuation, 0 dB IF1 attenuation, and IF attenuators adjusted to set the gain to 20 dB. This setting is made to be consistent with the configuration for other specifications such as linearity and spurious responses so that the user may obtain a clearer picture of the specified performance of the device. The RF input is terminated with a matching 50 Ω load.
[25] In spectrum analyzer and signal analyzer applications, this is also commonly referred to as the Displayed Average Noise Level (DANL). This assumes that the digitizer used does not limit the performance of the device.

Input third-order intermodulation (IIP3, dBm) [26]

	100 MHz – 1 GHz	1 GHz – 2.5 GHz	2.5 GHz – 3.9 GHz
Preamplifier disabled [27]	16 [17]	17.5 [20]	18.5 [20]
Preamplifier enabled [28]	-5.0 [-2]	-3.0 [-1]	-2.0 [0]

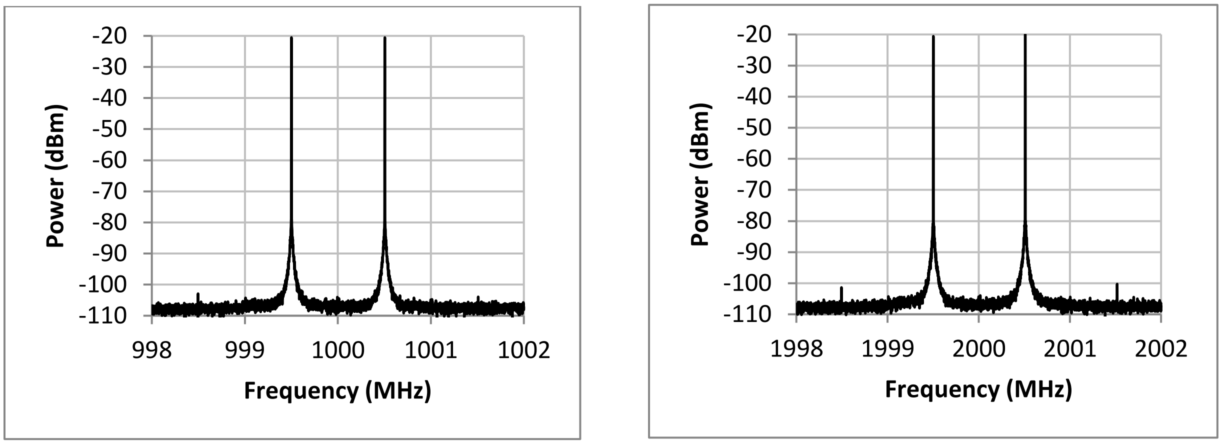

Figure 10. Plots show the typical IMD performance with two -20 dBm signals at the input, 0 dB RF attenuation, preamp disabled, and conversion gain of 20 dB.

Input second harmonic distortion (SHI, dBm)

Input second harmonic intercept point (dBm)	400 MHz	1000 MHz	1.8 GHz
Preamplifier disabled	62	62	58
Preamplifier enabled	32	33	30

[26] 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.
[27] Specifications are based on 0 dB RF attenuation, 0 dB IF1 attenuation, two -20 dBm tones with 1 MHz separation at the mixer, and final IF attenuators set to maintain 0 dBm at the IF output. The IF frequency is set at 240 MHz.
[28] Specifications are based on 0 dB RF attenuation, 0 dB IF1 attenuation, two -30 dBm tones with 1 MHz separation at the mixer, and final IF attenuators set to maintain 0 dBm at the IF output. The IF frequency is set at 240 MHz.

Input compression point (dBm)

	100 MHz – 1 GHz	1 GHz – 2.5 GHz	2.5 GHz – 3.9 GHz
Preamplifier disabled	1	1.5	2
Preamplifier enabled	-23	-20	-19

Dynamic range

Measurement dynamic range [29] .... > 185 dB

Instantaneous dynamic range [30] .... > 150 dB

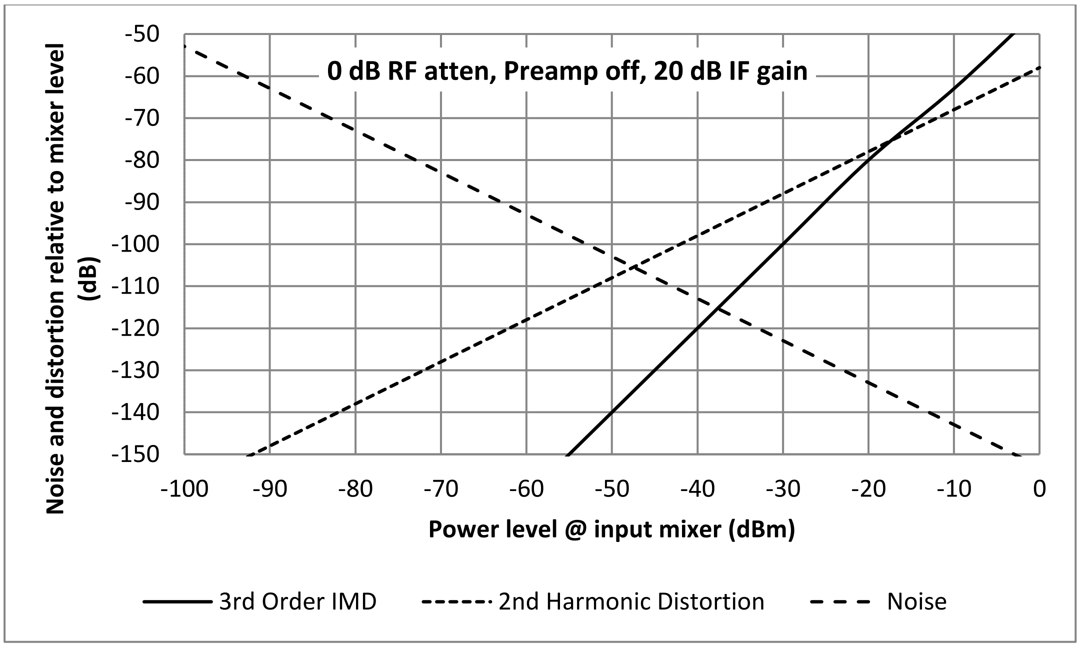

Figure 11. Instantaneous dynamic ranges plotted with preamplifier disabled for 1000 MHz measured data. Mixer level is at input level.

[29] Measurement dynamic range refers to the device SNR measurement capability using two or more configuration settings. For example, the user could set sufficient RF attenuation to capture the high level signals and then turn on the preamplifier to measure low level noise.

[30] Instantaneous dynamic range refers to the instantaneous device SNR measurement using a single configuration setting. For example, the user could set the downconverter to receive a 0 dBm signal at the mixer, while at the same setting be able to measure the signal noise floor to -150 dB below its peak.

Reference Input and Output Specifications

Reference output specifications

Center frequency [31] .... 10 MHz/100 MHz
Amplitude .... 6 dBm min 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 .... -10 dBm min/ +13 dBm max
Phase-lock range .... ± 10 ppm (typ)
Impedance .... 50 Ω nominal
Coupling .... AC
Connector type .... SMA female

Port Specifications

RF input

Input impedance .... 50 Ω
Coupling .... AC
Connector type .... SMA female
LO leakage .... < -120 dBm

IF output

Output impedance .... 50 Ω
VSWR 1.6
Coupling .... AC
Connector type .... SMA female
Output amplitude .... 20 dBm max

[31] 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 [32] .... 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) (SC5306B) .... 3.7” x 1.4” x 6.1”
Dimensions (W x H x D, max envelope) (SC5305A) .... 2x3U slots
Weight .... 2.6 lbs
Input voltage (SC5306B) .... 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

[32] 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	8/10/2020	Combined SC5305A and SC5306B datasheets into one document.