RF Signal Generators

SG380 Series — DC to 2 GHz, 4 GHz and 6 GHz analog signal generators

- DC to 2 GHz, 4 GHz or 6 GHz
- 1 µHz resolution
- AM, FM, ΦM, PM and sweeps
- OCXO timebase (std.)
- –116 dBc/Hz SSB phase noise (20 kHz offset, f = 1 GHz)
- Rubidium timebase (opt.)
- Square wave clock outputs (opt.)
- Analog I/Q inputs (opt.)
- Ethernet, GPIB, and RS-232

- SG382 ... $3,900 (U.S. list)
- SG384 ... $5,900 (U.S. list)
- SG386 ... $6,900 (U.S. list)

SG380 Series RF Signal Generators

Introducing the new SG380 Series RF Signal Generators — finally, high performance, affordable RF sources.

The SG380 Series RF Signal Generators use a unique, innovative architecture (Rational Approximation Frequency Synthesis) to deliver ultra-high frequency resolution (1 µHz), excellent phase noise, and versatile modulation capabilities (AM, FM, ΦM, pulse modulation and sweeps) at a fraction of the cost of competing designs.

The standard models produce sine waves from DC to 2.025 GHz (SG382), 4.05 GHz (SG384) and 6.075 GHz (SG386). There is an optional frequency doubler (Opt. 02) that extends the frequency range of the SG384 and SG386 to 8.10 GHz. Low-jitter differential clock outputs (Opt. 01) are available, and an external I/Q modulation input (Opt. 03) is also offered. For demanding applications, the SG380 Series can be ordered with a rubidium timebase (Opt. 04).

On the Front Panel

The SG380 Series Signal Generators have two front-panel outputs with overlapping frequency ranges. A BNC provides outputs from DC to 62.5 MHz with adjustable offsets and amplitudes from 1 mV to 1 Vrms into a 50 Ω load. An N-type output supplies frequencies from 950 kHz to the upper frequency limit of each model, with power from +16.5 dBm to –110 dBm (1 Vrms to 0.707 µVrms) into a 50 Ω load.

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Modulation

The SG380 Signal Generators offer a wide variety of modulation capabilities. Modes include amplitude modulation (AM), frequency modulation (FM), phase modulation (ΦM), and pulse modulation. There is an internal modulation source as well as an external modulation input. The internal modulation source produces sine, ramp, saw, square, and noise waveforms. An external modulation signal may be applied to the rear-panel modulation input. The internal modulation generator is available as an output on the rear panel.

Unlike traditional analog signal generators, the SG380 Series can sweep continuously from DC to 62.5 MHz. And for frequencies above 62.5 MHz, each sweep range covers more than an octave.

OCXO or Rubidium Timebase

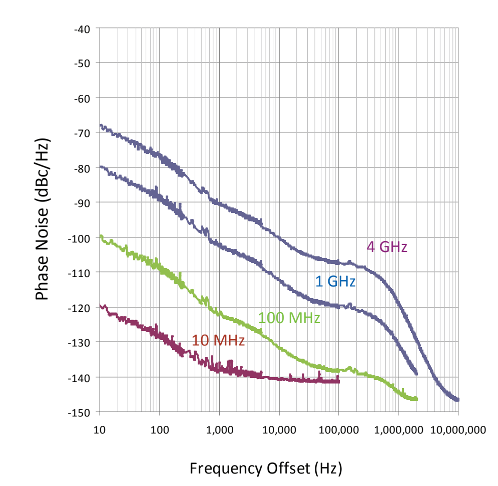
The SG380 Series come with a oven-controlled crystal oscillator (OCXO) timebase. The timebase uses a third-overtone stress-compensated 10 MHz resonator in a thermostatically controlled oven. The timebase provides very low phase noise and very low aging. An optional rubidium oscillator (Opt. 04) may be ordered to substantially reduce frequency aging and improve temperature stability.

The internal 10 MHz timebase (either the standard OCXO or the optional rubidium reference) is available on a rear-panel output. An external 10 MHz timebase reference may be supplied to the rear-panel timebase input.

Square Wave Clock Outputs

Optional differential clock outputs (Opt. 01) are available on the rear panel which makes your SG380 a precision clock

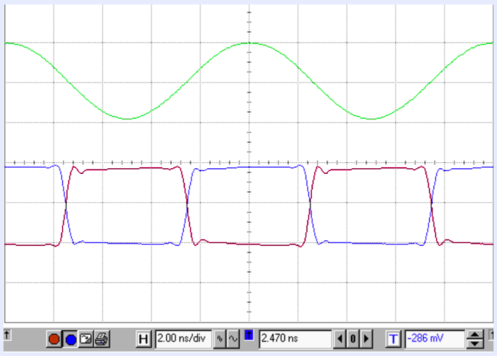
SG380 Series Phase Noise vs. Offset Frequency



The SG380 Series always synthesizes a frequency in the top octave and digitally divides to generate outputs at lower frequencies. Doing so creates phase noise characteristics which scale with output frequency by 6 dB/octave or 20 dB/decade.

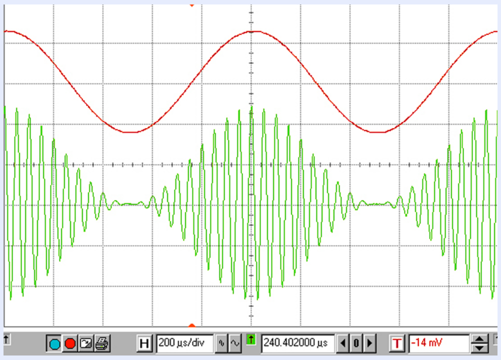
The low phase noise at small offsets (for example, –80 dBc/Hz at 10 Hz offset from 1 GHz) is attributable to the low phase noise OCXO timebase reference oscillator. An important figure of merit for communications applications is the phase noise at 20 kHz offset, which is about –116 dBc/Hz at 1 GHz.

Differential Clock Outputs



Option 01 provides differential clock outputs in addition to sine outputs. The clocks have transition times of about 35 ps. Both the offset and amplitude of the clock outputs can be adjusted for compliance with standard logic levels. Shown here at 2 ns/division: 100 MHz front-panel sine wave output (top trace) and differential clock outputs (bottom traces). The displayed transition times are limited by the 1.5 GHz bandwidth of the oscilloscope.

Amplitude Modulation (100 %)



The frequency range of the SG380 Series extends from DC to 2 GHz, 4 GHz or 6 GHz (depending on model). All of the analog modulation modes also extend to DC allowing your SG380 to perform function generator tasks. Shown here is a 20 kHz carrier being amplitude modulated by a 1 kHz sine.

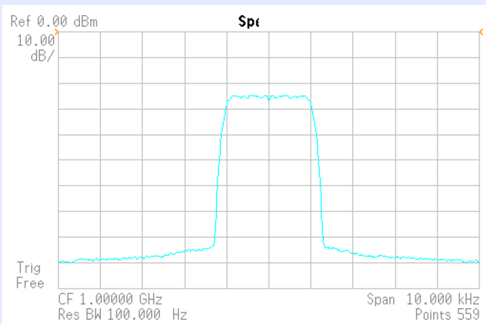
Top trace: Modulation output
Bottom trace: Front-panel BNC output

generator in addition to a signal generator. Transition times are typically 35 ps, and both the offset and amplitude of the clock outputs can be adjusted for compliance with PECL, ECL, RSECL, LVDS, CML, and NIM levels.

I/Q Inputs

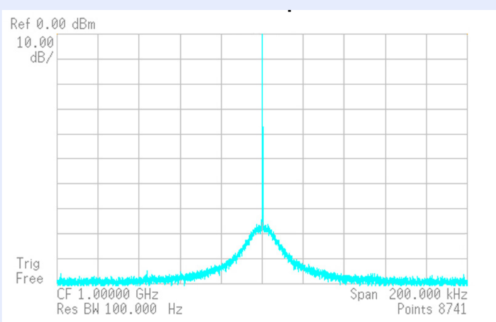
Optional I/Q inputs (Opt. 03) allow I & Q baseband signals to modulate carriers from 400 MHz to the upper frequency limit of your instrument. This option also allows the I/Q modulator to be driven by an internal noise generator with adjustable bandwidth. Rear-panel outputs allow the noise source to be viewed or used for other purposes.

I/Q Modulation of 1 GHz Carrier by Internal Noise Generator



Option 03 allows I/Q modulation of carriers from 400 MHz to the upper frequency limit of your instrument. Two signal sources may be used for I/Q modulation: external I & Q inputs or an internal noise generator. The external I & Q BNC inputs are on the rear panel. The internal noise generator has adjustable noise bandwidth. Shown here is a 1 GHz carrier being modulated by the internal noise generator with 1 kHz noise bandwidth.

Unmodulated Spectrum of a 1 GHz Output



The SG380 Series outputs exhibit low phase noise and low spurious content. In this direct measurement taken with 100 Hz RBW, the noise floor of the spectrum analyzer dominates over most of the 200 kHz span.

Output Frequency Doubler

The SG384 and SG386 can be ordered with a frequency doubler (Opt. 02) that extends the frequency range to 8.10 GHz. The amplitude of the rear-panel RF output can be adjusted from –10 dBm to +13 dBm. This option also comes with a bias source output which can be set with 5 mV resolution over ±10 VDC.

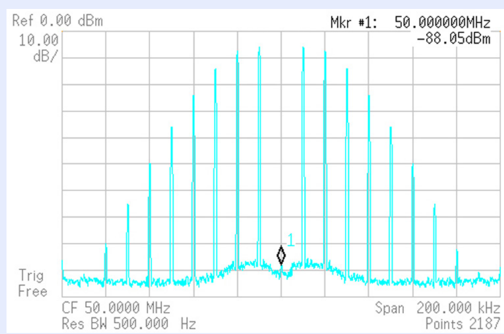
Easy Communication

Remote operation is supported with GPIB, RS-232 and Ethernet interfaces. All instrument functions can be controlled and read over any of the interfaces. Up to nine instrument configurations can be saved in non-volatile memory.

A New Frequency Synthesis Technique

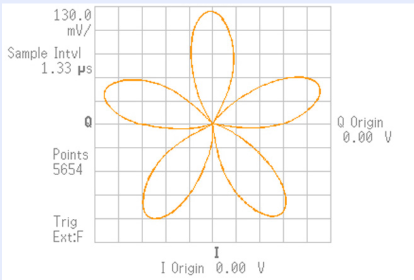
The SG380 Series Signal Generators are based on a new frequency synthesis technique called Rational Approximation Frequency Synthesis (RAFS). RAFS uses small integer divisors in a conventional phase-locked loop (PLL) to synthesize a frequency that would be close to the desired frequency (typically within ±100 ppm) using the nominal PLL reference frequency. The PLL reference frequency, which is sourced by a voltage controlled crystal oscillator that is phase locked to a dithered direct digital synthesizer, is adjusted so that the PLL generates the exact frequency. Doing so provides a high phase comparison frequency (typically 25 MHz) yielding low phase noise while moving the PLL reference spurs far from the carrier where they can be easily removed. The end result is an agile RF source with low phase noise, essentially infinite frequency resolution, without the spurs of fractional-N synthesis or the cost of a YIG oscillator.

Spectrum of Frequency Modulated 50 MHz Carrier



Outputs below 62.5 MHz are generated by direct-digital synthesis with a sample frequency of 1 GHz. In this example, a 50 MHz carrier is frequency modulated at a rate of 10 kHz and a deviation of 24.0477 kHz, for a modulation index β = 2.40477. The carrier amplitude is proportional to the Bessel function $J_0(\beta)$, which has its first zero at 2.40477.

Polar Plot of 1.000001 GHz Referenced to 1 GHz with 100 % AM at 5 kHz

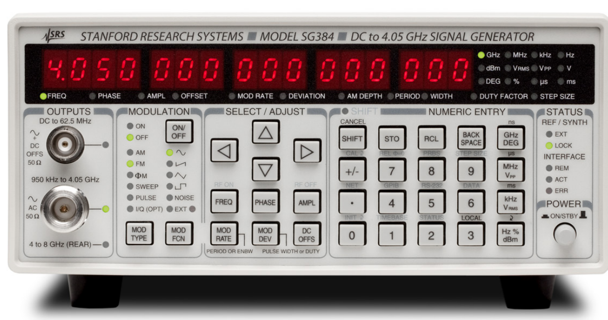


The polar plot shows the trajectory of a signal in the I/Q plane. An unmodulated carrier at the analyzer's reference frequency (1 GHz in this case) appears as a single dot in the I/Q plane. When the carrier frequency is offset, the single dot moves in a circle about the center of the I/Q plane. The pattern shown occurs when the carrier amplitude is modulated with 100 % depth at a rate of five times the carrier offset frequency (creating five lobes). The symmetry of the lobes indicates that there is no residual phase distortion (AM to ΦM conversion) in the amplitude modulator. The narrow line of the trajectory is indicative of low phase and amplitude noise.

Ordering Information

SG382	2 GHz signal generator	$3,900
SG384	4 GHz signal generator	$5,900
SG386	6 GHz signal generator	$6,900
Option 01	Rear-panel clock outputs	$750
Option 02	8 GHz doubler & DC bias (SG384 and SG386 only)	$750
Option 03	External I/Q modulation	$750
Option 04	Rubidium timebase	$1750
RM2U-S	Single rack mount kit	$100
RM2U-D	Dual rack mount kit	$100

SG384 rear panel



SG384 front panel

SG380 Series Specifications

Frequency Setting

Frequency ranges	*DC to 62.5 MHz (BNC output, all models)*
SG382	950 kHz to 2.025 GHz (N-type output)
SG384	950 kHz to 4.05 GHz (N-type output)
	4.05 GHz to 8.1 GHz (w/ Opt. 02)
SG386	950 kHz to 6.075 GHz (N-type output)
	6.075 GHz to 8.1 GHz (w/ Opt. 02)
Frequency resolution	1 μHz at any frequency
Switching speed	<8 ms (to within 1 ppm)
Frequency error	$<(10^{-18} + \text{timebase error}) \times f_C$
Frequency stability	1×10^{-11} (1 s Allan variance)

Front-Panel BNC Output

Frequency range	DC to 62.5 MHz
Amplitude	1.00 Vrms to 0.001 Vrms
Offset	±1.5 VDC
Offset resolution	5 mV
Max. excursion	1.817 V (amplitude + offset)
Amplitude resolution	<1 %
Amplitude accuracy	±5 %
Harmonics	<–40 dBc
Spurious	<–75 dBc
Output coupling	DC, 50 Ω ±2 %
User load	50 Ω
Reverse protection	±5 VDC

Front-Panel N-Type Output

Frequency range	
SG382	950 kHz to 2.025 GHz
SG384	950 kHz to 4.050 GHz
SG386	950 kHz to 6.075 GHz
Power output	
SG382	+16.5 dBm to –110 dBm
SG384	+16.5 dBm to –110 dBm (<3 GHz)
SG386	+16.5 dBm to –110 dBm (<4 GHz)
Voltage output	
SG382	1.5 Vrms to 0.7 μVrms
SG384	1.5 Vrms to 0.7 μVrms (<3 GHz)
SG386	1.5 Vrms to 0.7 μVrms (<4 GHz)
Power resolution	0.01 dBm
Power accuracy	±1 dB
Output coupling	AC, 50 Ω
User load	50 Ω
VSWR	<1.6
Reverse protection	30 VDC, +25 dBm RF

Spectral Purity of the RF Output Referenced to 1 GHz*

Sub harmonics	None
Harmonics	<–25 dBc (<+7 dBm, N-type output)
Spurious	
<10 kHz offset	<–65 dBc
>10 kHz offset	<–75 dBc
Phase noise (typ.)	
10 Hz offset	–80 dBc/Hz
1 kHz offset	–102 dBc/Hz
20 kHz offset	–116 dBc/Hz (SG382 & SG384)
	–114 dBc/Hz (SG386)
1 MHz offset	–130 dBc/Hz (SG382 & SG384)
	–124 dBc/Hz (SG386)
Residual FM (typ.)	1 Hz rms (300 Hz to 3 kHz BW)
Residual AM (typ.)	0.006 % rms (300 Hz to 3 kHz BW)

** Spurs, phase noise and residual FM scale by 6 dB/octave to other carrier frequencies*

Phase Setting on Front-Panel Outputs

Max. phase step	±360°
Phase resolution	0.01° (DC to 100 MHz)
	0.1° (100 MHz to 1 GHz)
	1.0° (1 GHz to 8.1 GHz)

Standard OCXO Timebase

Oscillator type	Oven controlled, 3rd OT, SC-cut crystal
Stability (0 to 45 °C)	<±0.002 ppm
Aging	<±0.05 ppm/year

Rubidium Timebase (Opt. 04)

Oscillator type	Oven controlled, 3rd OT, SC-cut crystal
Physics package	Rb vapor frequency discriminator
Stability (0 to 45 °C)	<±0.0001 ppm
Aging	<±0.001 ppm/year

Timebase Input

Frequency	10 MHz, ±2 ppm
Amplitude	0.5 to 4 Vpp (–2 dBm to +16 dBm)
Input impedance	50 Ω, AC coupled

Timebase Output

Frequency	10 MHz, sine
Source	50 Ω, DC transformer coupled
Amplitude	1.75 Vpp ±10 % (8.8 dBm ± 1 dBm)

Internal Modulation Source

Waveforms	Sine, ramp, saw, square, pulse, noise
Sine THD	–80 dBc (typ. at 20 kHz)
Ramp linearity	<0.05 % (1 kHz)
Rate	1 μHz to 500 kHz
	($f_C \leq 62.5$ MHz (SG382 & SG384))
	($f_C \leq 93.75$ MHz (SG386))
	1 μHz to 50 kHz
	($f_C > 62.5$ MHz (SG382 & SG384))
	($f_C > 93.75$ MHz (SG386))
Rate resolution	1 μHz
Rate error	$1:2^{31}$ + timebase error
Noise function	White Gaussian noise (rms = dev / 5)
Noise bandwidth	1 μHz < ENBW < 50 kHz
Pulse generator period	1 μs to 10 s

Pulse generator width	100 ns to 9999.9999 ms
Pulse timing resolution	5 ns
Pulse noise function	PRBS $2^5 – 2^{19}$. Bit period (100 + 5N) ns

Modulation Waveform Output

Output impedance	50 Ω (for reverse termination)
User load	Unterminated 50 Ω coax
AM, FM, ΦM	±1 V for ± full deviation
Pulse/Blank	"Low" = 0 V, "High" = 3.3 VDC

External Modulation Input

Modes	AM, FM, ΦM, Pulse, Blank
Unmodulated level	0 V input for unmodulated carrier
AM, FM, ΦM	±1 V input for ± full deviation
Modulation bandwidth	>100 kHz
Modulation distortion	<–60 dB
Input impedance	100 kΩ
Input offset	<500 µV
Pulse/Blank threshold	+1 VDC

Amplitude Modulation

Range	0 to 100 % (decreases above +7 dBm)
Resolution	0.1 %
Modulation source	Internal or external
Modulation distortion	
BNC output	<1 % (f_C < 62.5 MHz, f_M = 1 kHz)
N-type output	<3 % (f_C > 62.5 MHz, f_M = 1 kHz)
Modulation bandwidth	>100 kHz

Frequency Modulation

Frequency deviation	
Minimum	0.1 Hz
Maximum (SG382 & SG384)	
$f_C \le$ 62.5 MHz	Smaller of f_C or 64 MHz – f_C
62.5 MHz < $f_C \le$ 126.5625 MHz	1 MHz
126.5625 MHz < $f_C \le$ 253.125 MHz	2 MHz
253.125 MHz < $f_C \le$ 506.25 MHz	4 MHz
506.25 MHz < $f_C \le$ 1.0125 GHz	8 MHz
1.0125 GHz < $f_C \le$ 2.025 GHz	16 MHz
2.025 GHz < $f_C \le$ 4.050 GHz (SG384)	32 MHz
4.050 GHz < $f_C \le$ 8.100 GHz (opt. 2)	64 MHz
Maximum (SG386)	
$f_C \le$ 93.75 MHz	Smaller of f_C or 96 MHz – f_C
93.75 MHz < $f_C \le$ 189.84375 MHz	1 MHz
189.8437 MHz < $f_C \le$ 379.6875 MHz	2 MHz
379.6875 MHz < $f_C \le$ 759.375 MHz	4 MHz
759.375 MHz < $f_C \le$ 1.51875 GHz	8 MHz
1.51875 GHz < $f_C \le$ 3.0375 GHz	16 MHz
3.0375 GHz < $f_C \le$ 6.075 GHz	32 MHz
6.075 GHz < $f_C \le$ 8.100 GHz (opt. 2)	64 MHz
Deviation resolution	0.1 Hz

Deviation accuracy	<0.1 % ($f_C \le$ 62.5 MHz (SG382 & SG384)) ($f_C \le$ 93.75 MHz (SG386)) <3 % (f_C > 62.5 MHz (SG382 & SG384)) (f_C > 93.75 MHz (SG386))
Modulation source	Internal or external
Modulation distortion	<–60 dB (f_C = 100 MHz, $f_M = f_D$ = 1 kHz)
Ext. FM carrier offset	<1:1,000 of deviation
Modulation bandwidth	500 kHz ($f_C \le$ 62.5 MHz (SG382 & SG384)) ($f_C \le$ 93.75 MHz (SG386)) 100 kHz (f_C > 62.5 MHz (SG382 & SG384)) (f_C > 93.75 MHz (SG386))

Frequency Sweeps (Phase Continuous)

Frequency span	10 Hz to entire sweep range
Sweep ranges	
SG382 & SG384	DC to 64 MHz 59.375 MHz to 128.125 MHz 118.75 MHz to 256.25 MHz 237.5 MHz to 512.5 MHz 475 MHz to 1025 MHz 950 MHz to 2050 MHz 1900 MHz to 4100 MHz (SG384) 3800 MHz to 8200 MHz (Opt. 02)
SG386	DC to 96 MHz 89.0625 MHz to 192.188 MHz 178.125 MHz to 384.375 MHz 356.25 MHz to 768.75 MHz 712.5 MHz to 1537.5 MHz 1425 MHz to 3075 MHz 2850 MHz to 6150 MHz 5950 MHz to 8150 MHz (Opt. 02)
Deviation resolution	0.1 Hz
Sweep source	Internal or external
Sweep distortion	<0.1 Hz + (deviation / 1,000)
Sweep offset	<1:1,000 of deviation
Sweep function	Triangle, ramp or sine up to 120 Hz

Phase Modulation

Deviation	0 to 360°
Deviation resolution	0.01° to 100 MHz, 0.1° to 1 GHz, 1° above 1 GHz
Deviation accuracy	<0.1 % ($f_C \le$ 62.5 MHz (SG382 & SG384)) ($f_C \le$ 93.75 MHz (SG386)) <3 % (f_C > 62.5 MHz (SG382 & SG384)) (f_C > 93.75 MHz (SG386))
Modulation source	Internal or external
Modulation distortion	<–60 dB (f_C = 100 MHz, f_M = 1 kHz, Φ_D = 50°)
Modulation bandwidth	500 kHz (f_C > 62.5 MHz (SG382 & SG384)) (f_C > 93.75 MHz (SG386)) 100 kHz (f_C > 62.5 MHz (SG382 & SG384)) (f_C > 93.75 MHz (SG386))

Pulse/Blank Modulation

Pulse mode	Logic “High” turns RF “on”
Blank mode	Logic “High” turns RF “off”
On/Off ratio	
BNC output	70 dB
Type-N output	57 dB ($f_C \leq 1$ GHz)
	40 dB (1 GHz $\leq f_C < 4$ GHz)
	35 dB ($f_C \geq 4$ GHz)
Pulse feed-through	10 % of carrier for 20 ns at turn on (typ.)
Turn on/off delay	60 ns
RF rise/fall time	20 ns
Modulation source	Internal or external pulse

External I/Q Modulation (Opt. 03)

Carrier frequency range	400 MHz to 2.025 GHz (SG382)
	400 MHz to 4.05 GHz (SG384)
	400 MHz to 6.075 GHz (SG386)
Modulated output	Front-panel N-type only
I/Q inputs	50 Ω, ±0.5 V
I or Q input offset	<500 µV
I/Q full scale	$(I^2 + Q^2)^{1/2} = 0.5$ V
Carrier suppression	>40 dBc (>35 dBc above 4 GHz)
Modulation bandwidth	200 MHz (–3 dB)

Square Wave Clock Outputs (Opt. 01)

Differential clocks	Rear-panel SMAs drive 50 Ω loads
Frequency range	DC to 4.05 GHz
Transition time (typ.)	<35 ps (20 % to 80 %)
Jitter	
$f_C > 62.5$ MHz	<300 fs rms (typ., 1 kHz to 5 MHz BW at 1 GHz)
$f_C \leq 62.5$ MHz	$<10^{-4}$ U.I. (1 kHz to 5 MHz or f_C/2 BW)
Amplitude	0.4 Vpp to 1 Vpp
Offset	±2 VDC
Ampl/offset resolution	5 mV
Ampl/offset accuracy	±5 %
Output coupling	DC, 50 Ω ±2 %
Compliance	ECL, PECL, RSECL, CML, LVDS, NIM

Frequency Doubler Output (Opt. 02)

Output	Rear-panel SMA
Frequency range	4.05 GHz to 8.10 GHz (SG384)
	6.075 GHz to 8.10 GHz (SG386)
RF amplitude	–10 dBm to +13 dBm (4 GHz to 7 GHz)
	–10 dBm to +7 dBm (7 GHz to 8 GHz)
	+13 to +16.5 dBm (typ.)
Sub harmonic (f_C/2)	<–25 dBc ($f_C < 6.5$ GHz)
	<–12 dBc ($f_C < 8.1$ GHz)
Mixing products (3f_C/2)	<–20 dBc
Harmonics ($n \times f_C$)	<–25 dBc
Spurious (8 GHz)	<–55 dBc (>10 kHz offset)
Phase noise (8 GHz)	–98 dBc/Hz at 20 kHz offset (typ.)
Amplitude resolution	0.01 dBm
Amplitude accuracy	±1 dB (4.05 GHz to 6.5 GHz)
	±2 dB (6.5 GHz to 8.1 GHz)
Modulation modes	FM, ΦM, sweeps
Output coupling	AC, 50 Ω
Reverse protection	30 VDC, +25 dBm RF

DC Bias Source (comes with Opt. 02)

Output	Rear-panel SMA
Voltage range	±10 V
Offset voltage	<20 mV
DC accuracy	±0.2 %
DC resolution	5 mV
Output resistance	50 Ω
Current limit	20 mA

General

Ethernet (LAN)	10/100 Base-T.TCP/IP & DHCP default
GPIB	IEEE488.2
RS-232	4800 to 115,200 baud, RTS/CTS flow
Line power	<90 W, 90 to 264 VAC, 47 to 63 Hz (with PFC)
Dimensions, weight	8.5" × 3.5" × 13" (WHD)
Weight	10 lbs.
Warranty	One year parts and labor on defects in materials and workmanship