RF Signal Generators

SG380 Series — DC to 2 GHz, 4 GHz and 6 GHz analog 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 +13 dBm to −110 dBm (1 Vrms to 0.707 µVrms) into a 50 Ω load.
Modulation

The SG380 Signal Generators offer a wide variety of modulation capabilities. Modes include amplitude modulation (AM), frequency modulation (FM), phase modulation (PM), 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.
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.

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.

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.
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
- **SG384** 4 GHz signal generator
- **SG386** 6 GHz signal generator
- Option 01 Rear-panel clock outputs
- Option 02 8 GHz doubler & DC bias (SG384 and SG386 only)
- Option 03 External I/Q modulation
- Option 04 Rubidium timebase
- **RM2U-S** Single rack mount kit
- **RM2U-D** Dual rack mount kit
SG380 Series Specifications

Frequency Setting

<table>
<thead>
<tr>
<th>Frequency setting</th>
<th>DC to 62.5 MHz (BNC output, all models)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG382</td>
<td>950 kHz to 2.025 GHz (N-type output)</td>
</tr>
<tr>
<td>SG384</td>
<td>950 kHz to 4.050 GHz (N-type output)</td>
</tr>
<tr>
<td>SG386</td>
<td>4.05 GHz to 8.1 GHz (w/ Opt. 02)</td>
</tr>
<tr>
<td>Frequency resolution</td>
<td>1 µHz at any frequency</td>
</tr>
<tr>
<td>Switching speed</td>
<td>&lt;8 ms (to within 1 ppm)</td>
</tr>
<tr>
<td>Frequency error</td>
<td>&lt;10^-18 + timebase error x f_c</td>
</tr>
<tr>
<td>Frequency stability</td>
<td>1 x 10^-11 (1 s Allan variance)</td>
</tr>
</tbody>
</table>

Front-Panel BNC Output

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>DC to 62.5 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplitude</td>
<td>1.00 Vrms to 0.001 Vrms</td>
</tr>
<tr>
<td>Offset</td>
<td>±1.5 VDC</td>
</tr>
<tr>
<td>Offset resolution</td>
<td>5 mV</td>
</tr>
<tr>
<td>Max. excursion</td>
<td>1.817 V (amplitude + offset)</td>
</tr>
<tr>
<td>Amplitude accuracy</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Harmonics</td>
<td>&lt;40 dBc</td>
</tr>
<tr>
<td>Spurious</td>
<td>&lt;75 dBc</td>
</tr>
<tr>
<td>Output coupling</td>
<td>DC, 50 Ω ±2%</td>
</tr>
<tr>
<td>User load</td>
<td>50 Ω</td>
</tr>
<tr>
<td>Reverse protection</td>
<td>±5 VDC</td>
</tr>
</tbody>
</table>

Front-Panel N-Type Output

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

Spectral Purity of the RF Output Referenced to 1 GHz

<table>
<thead>
<tr>
<th>Sub harmonics</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harmonics</td>
<td>–25 dBc (&lt;+7 dBm, N-type output)</td>
</tr>
<tr>
<td>Spurious</td>
<td>–10 kHz offset: –65 dBc</td>
</tr>
<tr>
<td></td>
<td>&gt;10 kHz offset: –75 dBc</td>
</tr>
<tr>
<td>Phase noise (typ.)</td>
<td>10 Hz offset: –80 dBc</td>
</tr>
<tr>
<td></td>
<td>1 kHz offset: –102 dBc</td>
</tr>
</tbody>
</table>

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         | Rubidium 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 = 62.5 MHz (SG382 & SG384))             |
|                        | (f_c = 93.75 MHz (SG386))                    |
| Rate resolution         | 1 µHz                                        |
| Rate error              | 1.2^1/2 + 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     |
### SG380 Series Specifications

#### Modulation Waveform Output
- **Output impedance**: 50Ω (for reverse termination)
- **User load**: Unterminated 50Ω 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**: >100kHz
- **Modulation distortion**: <−60 dB
- **Input impedance**: 100kΩ
- **Input offset**: <500 μV
- **Pulse/Blank threshold**: +1 V DDC

#### Amplitude Modulation
- **Range**: 0 to 100% (decreases above +7 dBm)
- **Resolution**: 0.1%
- **Modulation source**: Internal or external
- **Modulation distortion** 
  - **BNC output**: <1% (f<sub>c</sub> < 62.5 MHz, f<sub>m</sub> = 1 kHz)
  - **N-type output**: <3% (f<sub>c</sub> > 62.5 MHz, f<sub>m</sub> = 1 kHz)
- **Modulation bandwidth**: >100kHz

#### Frequency Modulation
- **Frequency deviation**
  - **Minimum**: 0.1 Hz
  - **Maximum (SG382 & SG384)**:
    - Smaller of f<sub>c</sub> or 64 MHz−f<sub>c</sub>
    - 62.5 MHz < f<sub>c</sub> ≤ 126.5625 MHz: 1 MHz
    - 126.5625 MHz < f<sub>c</sub> ≤ 253.125 MHz: 2 MHz
    - 253.125 MHz < f<sub>c</sub> < 506.25 MHz: 4 MHz
    - 506.25 MHz < f<sub>c</sub> ≤ 1.0125 MHz: 8 MHz
    - 1.0125 GHz < f<sub>c</sub> ≤ 2.025 GHz: 16 MHz
    - 2.025 GHz < f<sub>c</sub> ≤ 4.050 GHz (SG384): 32 MHz
    - 4.050 GHz < f<sub>c</sub> ≤ 8.100 GHz (opt. 2): 64 MHz
- **Maximum (SG386)**:
  - Smaller of f<sub>c</sub> or 96 MHz−f<sub>c</sub>
  - 93.75 MHz < f<sub>c</sub> ≤ 189.84375 MHz: 1 MHz
  - 189.8437 MHz < f<sub>c</sub> ≤ 379.6875 MHz: 2 MHz
  - 379.6875 MHz < f<sub>c</sub> ≤ 759.375 MHz: 4 MHz
  - 759.375 MHz < f<sub>c</sub> ≤ 1.51875 GHz: 8 MHz
  - 1.51875 GHz < f<sub>c</sub> ≤ 3.0375 GHz: 16 MHz
  - 3.0375 GHz < f<sub>c</sub> ≤ 6.075 GHz: 32 MHz
  - 6.075 GHz < f<sub>c</sub> ≤ 8.100 GHz (opt. 2): 64 MHz
- **Deviation resolution**: 0.1 Hz
- **Deviation accuracy**: <0.1%
  - Smaller of f<sub>c</sub> or 64 MHz−f<sub>c</sub>

#### 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**: 0.1° to 100 MHz, 0.1° to 1 GHz, 1° above 1 GHz
- **Deviation accuracy**: <0.1%
  - Smaller of f<sub>c</sub> or 64 MHz−f<sub>c</sub>
  - 62.5 MHz < f<sub>c</sub> ≤ 126.5625 MHz: 1 MHz
  - 126.5625 MHz < f<sub>c</sub> ≤ 253.125 MHz: 2 MHz
  - 253.125 MHz < f<sub>c</sub> < 506.25 MHz: 4 MHz
  - 506.25 MHz < f<sub>c</sub> ≤ 1.0125 MHz: 8 MHz
  - 1.0125 GHz < f<sub>c</sub> ≤ 2.025 GHz: 16 MHz
  - 2.025 GHz < f<sub>c</sub> ≤ 4.050 GHz (SG384): 32 MHz
  - 4.050 GHz < f<sub>c</sub> ≤ 8.100 GHz (opt. 2): 64 MHz
- **Deviation resolution**: 0.1 Hz
- **Deviation accuracy**: <0.1%
  - (f<sub>c</sub> ≤ 62.5 MHz (SG382 & SG384))
  - (f<sub>c</sub> ≤ 93.75 MHz (SG386))
  - (f<sub>c</sub> > 62.5 MHz (SG382 & SG384))
  - (f<sub>c</sub> > 93.75 MHz (SG386))
- **Modulation source**: Internal or external
- **Modulation distortion**: ≤70 dB (f<sub>c</sub> = 1 GHz, f<sub>m</sub> = f<sub>D</sub> = 20 kHz)

#### Pulse/Blank Modulation
- **Pulse mode**: Logic “High” turns RF “on”
- **Blank mode**: Logic “High” turns RF “off”
SG380 Series Specifications

On/Off ratio
- BNC output: 70 dB (f_c ≤ 1 GHz)
- Type-N output: 57 dB (f_c ≤ 1 GHz), 40 dB (1 GHz ≤ f_c < 4 GHz), 35 dB (f_c ≥ 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
- 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 (1 kHz to 5 MHz BW)
  - f_c < 62.5 MHz: <10^{-7} U.I. rms (1 kHz to 5 MHz 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 (4.05 GHz to 7 GHz)
  - –10 dBm to +7 dBm (7 GHz to 8.10 GHz)
  - +13 to +16.5 dBm (spec. not guaranteed)
- 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 x 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 w/ PFC
- Dimensions, weight: 8.5" × 3.5" × 13" (WHD)
- Weight: 10 lbs.
- Warranty: One year parts and labor on defects in materials and workmanship