

SG9000 RF Signal Generator



The SG9000 RF Signal Generator delivers bench-top performance in a light-weight portable package. Best in class phase noise, spectral fidelity, and dynamic RF level control makes it the perfect choice for evaluating SSB, AM, FM, and digital radio equipment in the lab or field environment.

Key Performance Specifications

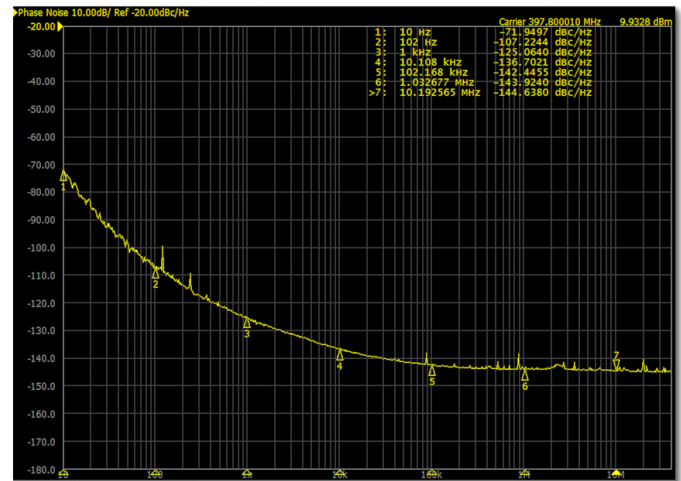
- 400 kHz to 450 MHz, 1 Hz Step Resolution
- CW, AM, DSBSC, FM, APSK-32, BPSK, QPSK & Frequency Sweep
- -135 dBm to +10 dBm RF Power Range, 0.1 dB Step
- Frequency Stability: ± 0.5 ppm (Standard). User CAL Short-Term Accuracy ± 0.2 ppm
- Phase Noise (Standard) -122 dBc/Hz *
- Ultra Low Phase Noise (Option) -139 dBc/Hz *
- Spurious Free Dynamic Range (SFDR): Narrowband: -60 dBc, Wideband: -55 dBc (with TCXO Option 020)
- Reference Level Calibrator: 0 dBm ± 0.1 dB at 50 MHz
- Dynamic RF Level Control Simplifies Receiver AGC Attack/Release Time and Stability Measurements

Key User Features

- Windows-10/11 User Interface (UI)
- SCPI¹ Command Interface Capable
- Small Bench-Top Footprint, Light-Weight, Perfect for Field Service Tasks
- +30 dBm Reverse RF Power Protection/Alarm & 5 VDC Input Block Protection
- External Trigger In/Out: RF Output On/Off, Dynamic RF Level Control, and Frequency Sweep Start
- 10 to 33 VDC Low Power (< 5 Watts typical) Input, Reverse Polarity Protection & 1.5 kVDC Galvanic DC Source Isolation
- Front Panel OLED Status Display

Benchtop Performance at a Fraction of the Cost

The SG9000 is built on Analog Devices' high-performance, [AD9910](#) 14-bit direct digital synthesizer; Microchip MCU; Abracon TCXOs; Mini-Circuits' digital RF attenuators and RF switches. Combined, these technologies deliver comparable performance to expensive benchtop signal generators at a fraction of the cost.



Phase Noise: 139 dBm/Hz, 20 kHz Offset,
Fc = 398.7 MHz, +10 dBm (1 GHz TCXO Option 020)

Windows UI and Open Source Software

Operation is simple and intuitive using the SG9000 Windows remote control application software or chose SCPI¹ command interface in the LabView environment.

Compact, Rugged, and Portable

The SG9000 is packaged in a compact extruded aluminum enclosure, black anodized finished and laser etched lettering for exceptional appearance and durability. The small form-factor conserves valuable lab bench space while the light-weight ruggedized packaging and wide range low-power DC input makes it ideal for field service tasks.



* Phase Noise Levels: Typical, Measured at a 20 kHz Offset, FC = 398.7 MHz

1. SCPI: [Standard Commands for Programmable Instruments](#)

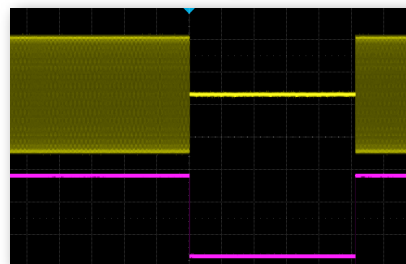
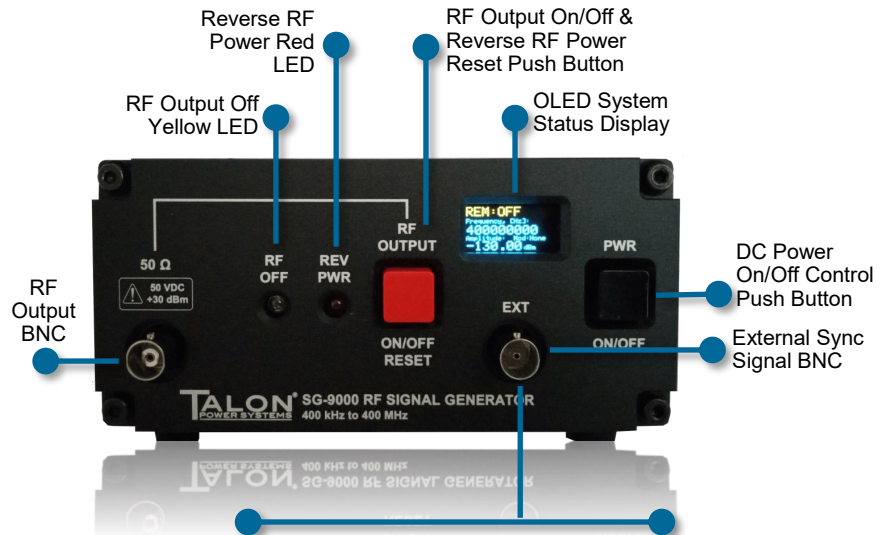
Front Panel Key Operating Features

- **RF OFF** LED illuminates yellow when the RF output is off.
- **REV PWR** (reverse RF power) LED flashes red when an external RF power source greater than +20 dBm typical is inadvertently applied to the RF output connector. The RF output remains off until manually reset.
- **RF OUTPUT** push-button switch duplicates the Windows RF on/off output control function and resets the reverse RF power latched off state.
- **Organic LED (OLED)** displays the instruments current operating status
- **EXT OUT Free Run, Sync Signal RF On/Off** a TTL-high when the RF output is enabled, a TTL-low when the RF output is disabled.
- **EXT OUT Free Run, Sync Signal Sweep Start** provides a TTL-high 15 μ s pulse generated at the start of each sweep cycle
- **EXT IN Trigger, RF On/Off** accepts a TTL-high to enable the RF output and a TTL-low to disable the RF output.
- **EXT IN Trigger, Sweep Start** accepts a TTL-high 10 μ s pulse to trigger a sweep cycle.
- **EXT IN Trigger, RF Step Level** accepts a TTL-high to step the RF output from the selected low level to the selected high level for the duration of the of the applied high level.

Radio Receiver Automatic Gain Control (AGC) Evaluation Capability

The SG9000 offers externally triggered dynamic RF level modes, on/off and step level, both with single state or pulse capability, simplifying receiver AGC attack/release timing and stability measurements. RF pulse timing is provided by an external function/arbitrary waveform generator (AWG) with a fast SG9000 minimum input pulse time response of 500 μ s.

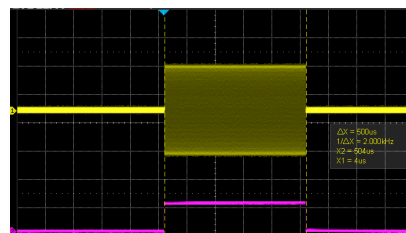
- **EXT IN Trigger RF On/RF Off** evaluates receiver AGC attack timing from an RF Off state (≤ -140 dBm) to an RF On level within the selectable RF power range of -135 dBm to +10 dBm. Conversely, AGC release timing can be measured from the RF On to RF Off state.
- **EXT IN Trigger, RF Step Level** evaluates receiver AGC attack timing from an RF low state, e.g. -120 dBm, to a RF high state, e.g. -73 dBm in ≤ 5 μ s. Conversely, AGC release timing can be measured in the RF high to RF low state.



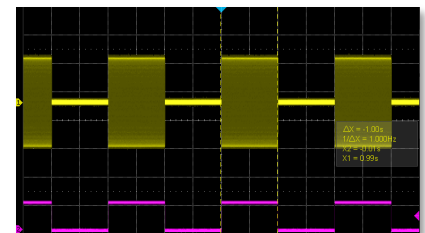
RF Output On/Off Sync, EXT Free Run (Trigger Out)



Sweep-Frequency Start Sync 15 μ s Pulse EXT Free Run (Trigger Out)

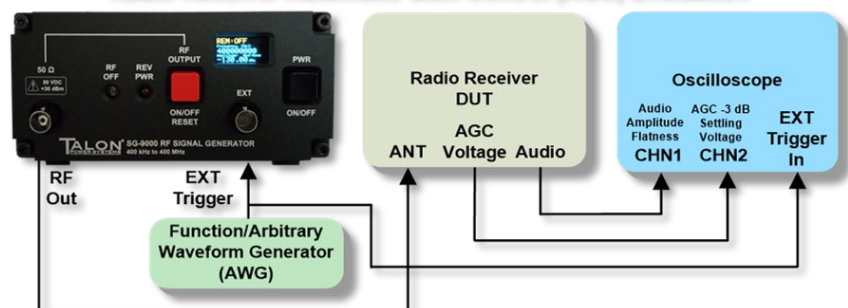


RF Step Level: -50 dBm to -20 dBm 500 μ s Single Pulse, EXT Trigger In



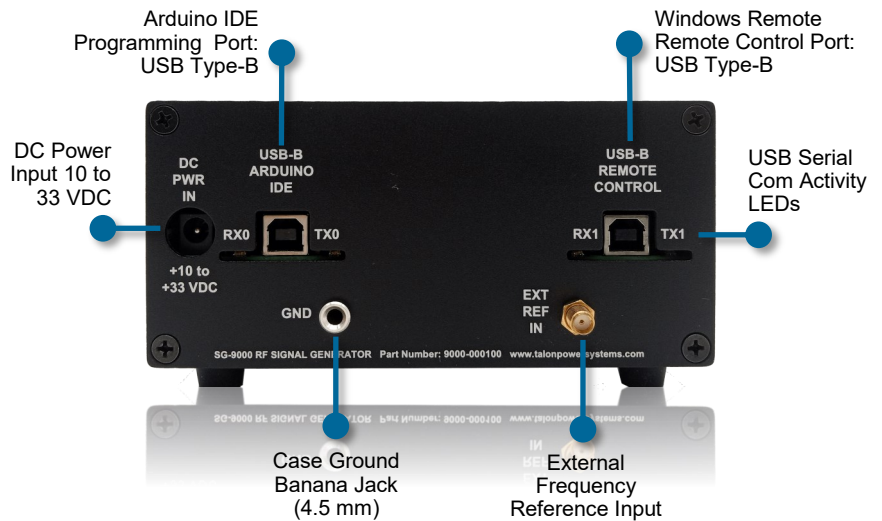
RF Step Level: -50 dBm to -20 dBm 1000 ms Intervals, EXT Trigger In

Radio Receiver Automatic Gain Control (AGC) Evaluation



Rear Panel Key Connectivity Features

- **DC PWR IN** accepts 10 to 33 VDC, reverse polarity/transient protected and galvanically isolated from the input power source.
- **PROGRAMMING PORT (RX0/TX0)** supports Arduino IDE firmware upgrade.
- **REMOTE CONTROL (RX1/TX1)** USB-B port, supports the SG9000 Windows-10/11 remote control application.
- **RX0/TX0 & RX1/TX1 Green/Red LEDs** indicate serial USB Arduino IDE and remote control communications activity.
- **EXT REF IN**, external 50 MHz reference input, 0 dBm typical. Suitable for use with a GPSDO frequency reference source
- **Case Electrical Ground**, Banana Jack, 4.5 mm



Windows Remote Control UI

The SG9000 UI delivers the traditional look and feel of Windows' instrument control with operation organized in three user selectable tabs.

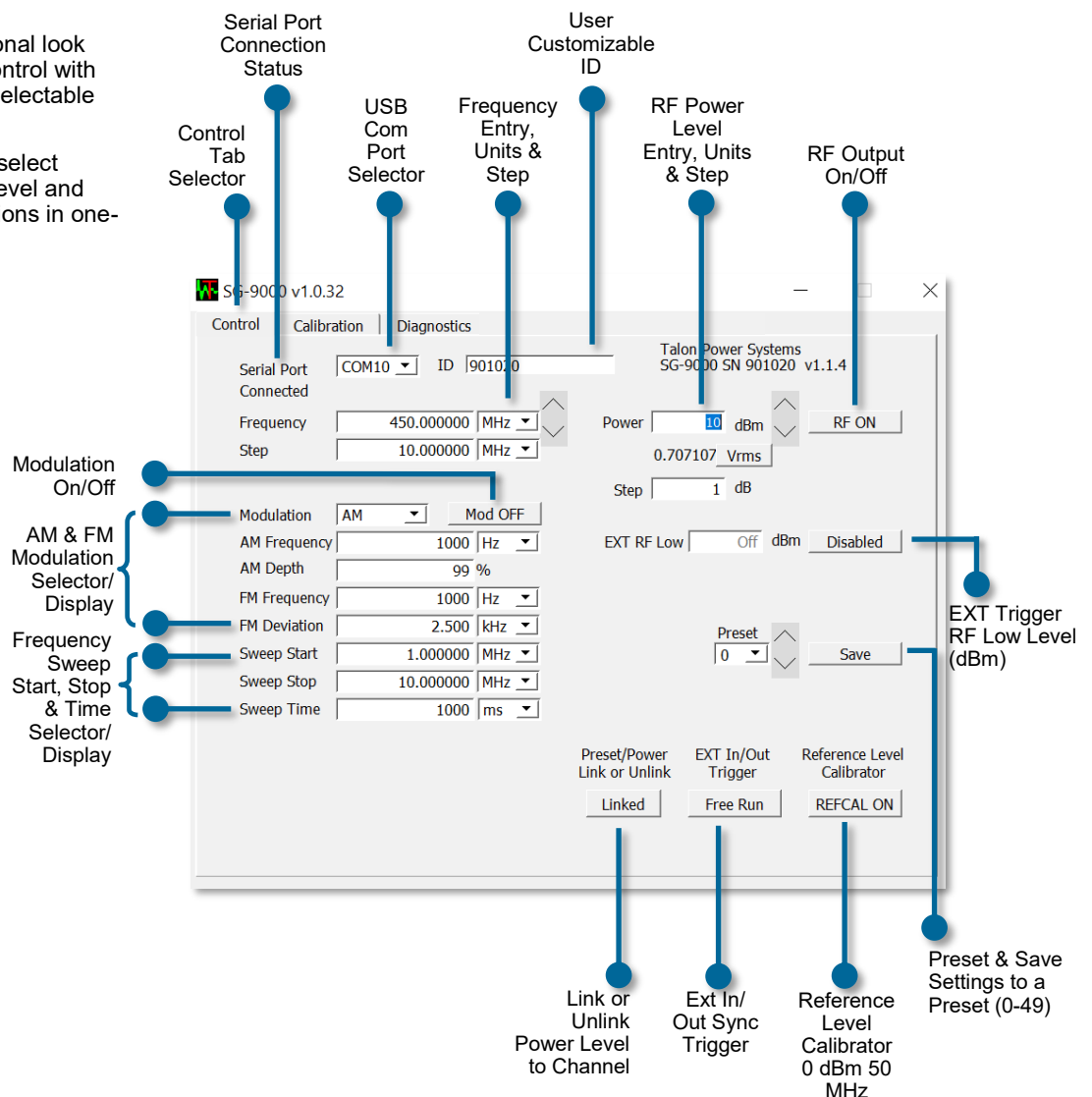
From the Control tab you can easily select frequency, modulation, RF power level and store those the selected configurations in one-of-fifty channel locations.

Simplify Measurement Tasks

EXT RF Low external trigger RF step level. A convenient utility for evaluating receiver AGC attack/release timing and stability performance.

REFCAL (Reference Level Calibrator) sets the frequency to 50 MHz and the RF power level to 0 dBm with an accuracy of $\pm 0.1 \text{ dB}^1$. A convenient utility for confidence testing RF power meters, Oscilloscopes, and Spectrum Analyzers.

1. Calibrated using an Agilent E4418B RF Power Meter's 50 MHz 0 dBm NIST traceable standard.



Windows Remote Control UI

The **Calibration Tab** allows you to inspect or change the calibration levels, in 0.1 dB steps, as well as the calibration frequencies. The calibration levels/frequency are stored in the SG9000 non-volatile memory and can be recalled by pressing the *Load Calibration from SG9000* or new values can be stored by pressing the *Save Calibration to SG9000*.

Calibration Selector Tab

Calibration: Frequencies, Correction Levels & Ranges

Frequency	Below -120dBm	-120 to -70dBm	-70 to -27dBm	Above -27dBm
401500 Hz	-1.06	-1.1	-1.1	-0.54
10101500 Hz	-1.11	-1.09	-1.1	-0.41
20101500 Hz	-1.03	-1.04	-1	-0.27
40101500 Hz	-0.9	-0.92	-0.68	-0.02
50101500 Hz	-0.74	-0.8	-0.53	0.08
60101500 Hz	-0.47	-0.52	-0.39	0.21
80101500 Hz	-0.22	-0.24	-0.2	0.41
100101500 Hz	-0.05	-0.05	0.01	0.48
120101500 Hz	0.13	0.08	0.05	0.4
140101500 Hz	0.18	0.15	0.03	0.32
160101500 Hz	0.14	0.12	0.03	0.19
180101500 Hz	0.11	0.11	0.01	0.07
200101500 Hz	0.24	0.27	0.12	0.11
220101500 Hz	0.49	0.48	0.28	0.25
240101500 Hz	0.64	0.6	0.41	0.44
260101500 Hz	0.71	0.68	0.56	0.64
280101500 Hz	0.84	0.79	0.68	0.85
300101500 Hz	1	1.01	0.86	1.1
320101500 Hz	1.08	1.08	1.08	1.42
340101500 Hz	1.39	1.39	1.42	1.84
360101500 Hz	1.86	1.81	1.73	2.27
380101500 Hz	2.08	2.07	1.97	2.65
400101500 Hz	2.2	2.14	2.11	2.94
420101500 Hz	2.17	2.28	2.27	3.22
440101500 Hz	2.55	2.55	2.62	3.68
450101500 Hz	2.7	2.9	2.93	4.05

Load Cal from SG-9000 Save Cal to SG-9000 Load Cal from File Save Cal to File

Load CAL Values From the SG9000 Save Displayed CAL Values to the SG9000 Load CAL Values From a PC File Save CAL Files to a PC

Diagnostics Selector Tab

18_14_57_127 OUTP?
18_14_57_127 1
18_14_58_126 OUTP?
18_14_58_137 1
18_14_59_148 OUTP?
18_14_59_160 1
18_15_00_158 OUTP?
18_15_00_171 1
18_15_01_161 OUTP?
18_15_01_171 1
18_15_02_171 OUTP?
18_15_02_181 1
18_15_03_193 OUTP?
18_15_03_203 1
18_15_04_201 OUTP?
18_15_04_201 1
18_15_05_225 OUTP?
18_15_05_225 1
18_15_06_224 OUTP?
18_15_06_234 1
18_15_07_239 OUTP?
18_15_07_239 1
18_15_08_239 OUTP?
18_15_08_249 1

PLL Internal Reference

Frequency Offset Correction

Frequency Offset
0 ppm

Save Logs

Save Diagnostic Log to User File

Selects External/Internal 50 MHz Reference Clock Source

Windows Remote Control UI

The **Diagnostics Tab** allows you to:

- Inspect the standard commands for programmable instruments (SCPI) communications between the Windows control application and the SG9000.
- User selectable internal 50 MHz TCXO (standard) reference clock or external 50 MHz reference clock operation.
- Apply user frequency correction capability (TCXO offset) yielding short-term frequency accuracy of up to 0.2 ppm.

SCPI Command Support

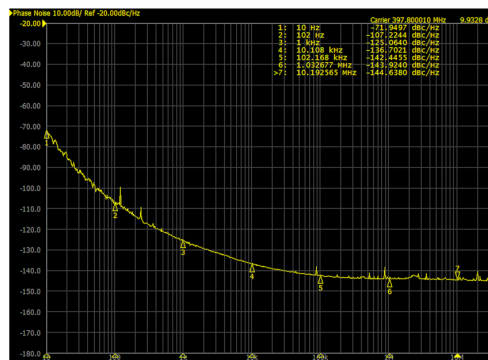
- SCPI commands support all available functions and operating conditions, such as: FREQUENCY, POWER, AM:STATE, AM:FREQUENCY, etc.

AD9910 DDS Reference Clock Frequency

The AD9910 DDS uses a 1 GHz reference clock (REFCLK) frequency, achieved directly by a 1 GHz TCXO or indirectly using the built-in PLL (20X multiplier) and a 50 MHz TCXO. PLL operation also supports the use of an external GPS discipline oscillator (GPSDO) capable of generating a 50 MHz signal. The frequency reference key features table below compares the features and benefits of each type.

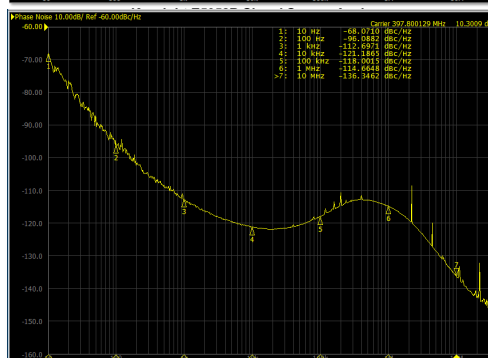
Frequency Reference Key Features Table				
TYPE	INITIAL	STABILITY (over temperature)	PHASE NOISE (398.7 MHz, 20 kHz Offset)	COST
50 MHz TCXO	1± ppm	±0.5 ppm	122 dBc/Hz	Standard (Lowest cost)
1 GHz Ultra Low Phase Noise TCXO	± 0.5 ppm ±1 ppm max	±1 ppm	139 dBc/Hz	Option 020
GPSDO (external)	GPS SV Cesium Frequency Reference: 1x10 ⁻¹² Typical		Good	Option 030

Recommended GPSDO:
Mini Precision GPS Reference Clock
Source: [Leo Bodnar Electronics](#)



Phase Noise Performance
(REFCLK: 1 GHz TCXO)

-139 dBc/Hz, 20 kHz Offset
397.8 MHz +10 dBm



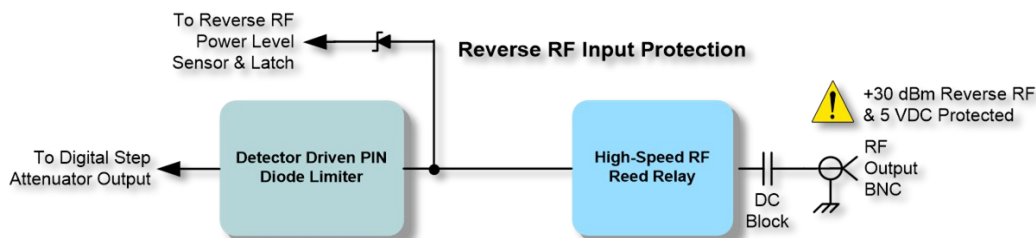
Phase Noise Performance
(REFCLK: 50 MHz TCXO)

-122 dBc/Hz, 20 kHz Offset
397.8 MHz +10 dBm

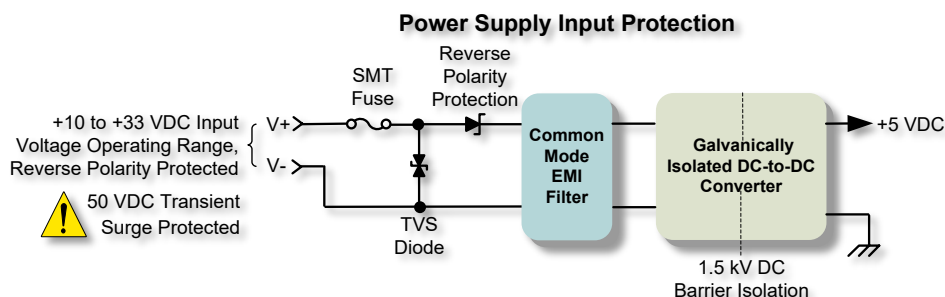
Keysight E5052B Signal Source Analyzer

Key Protection Features

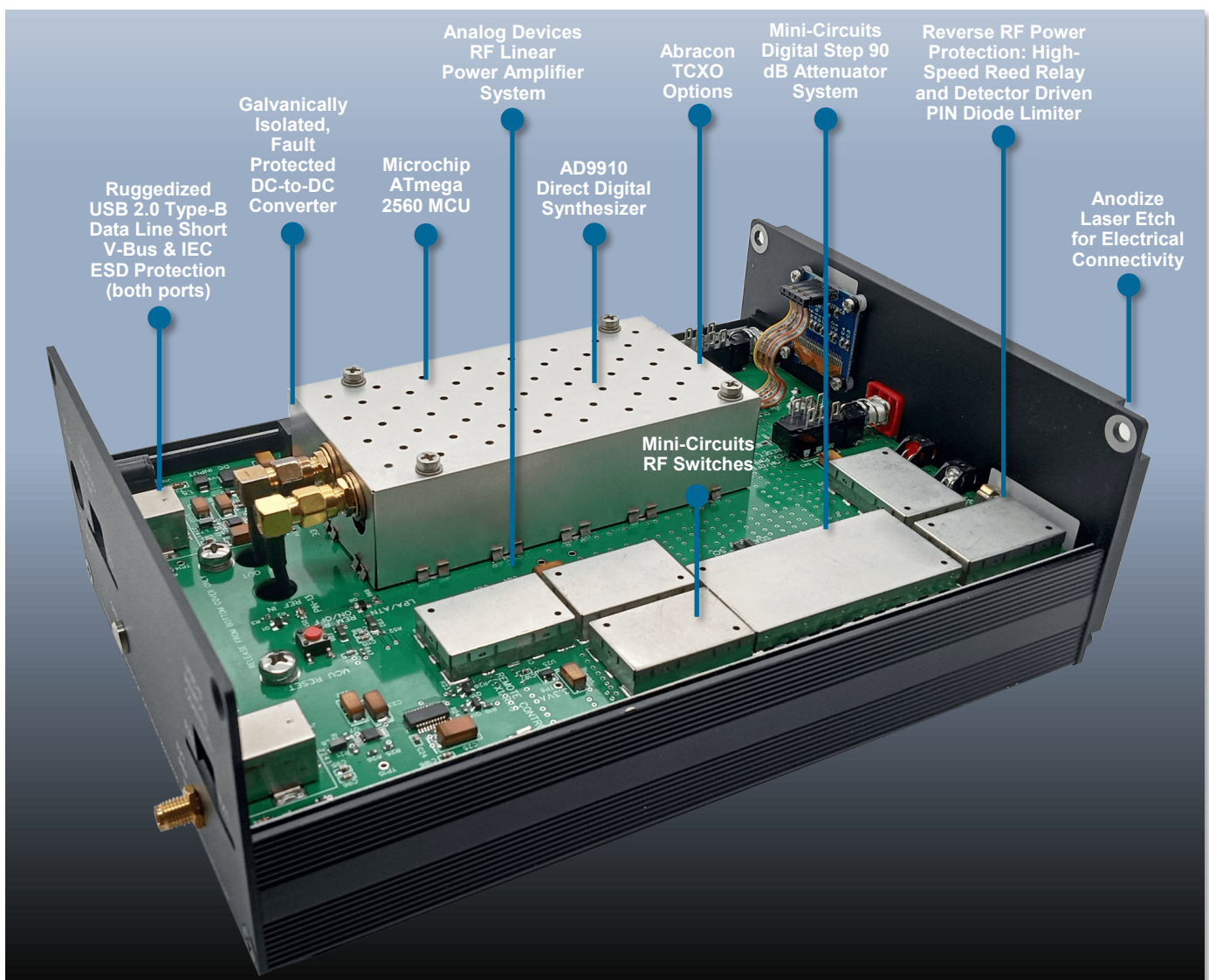
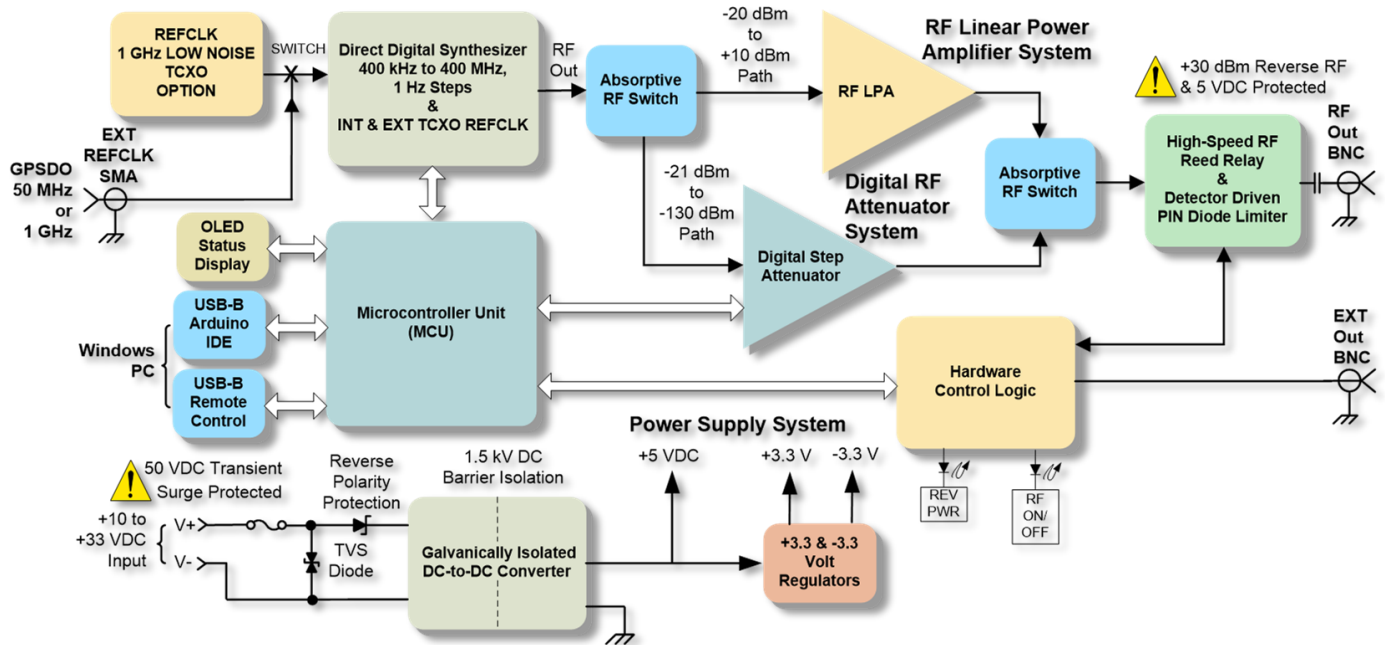
- RF Input Protection** for the inadvertent application of reverse RF up to +30 dBm is achieved through a high-speed RF reed relay and a detector-driven PIN diode limiter. In operation, levels above +20 dBm will latch the RF output reed-relay open. During the relay's 0.05 ms transition time, reverse power is clamped to a safe-level by the PIN diode limiter. A series output capacitor blocks DC voltages up to 5 VDC.



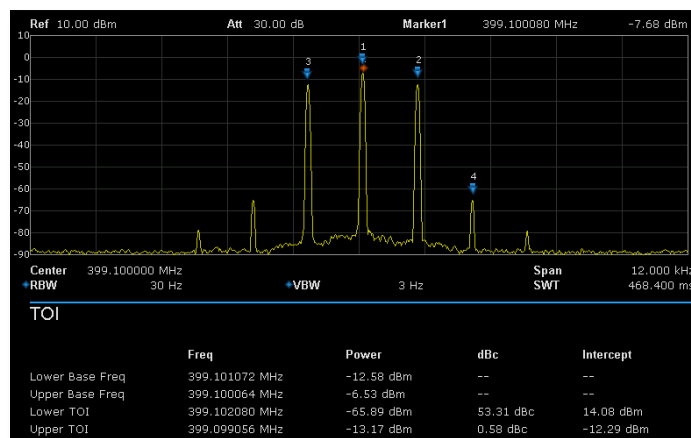
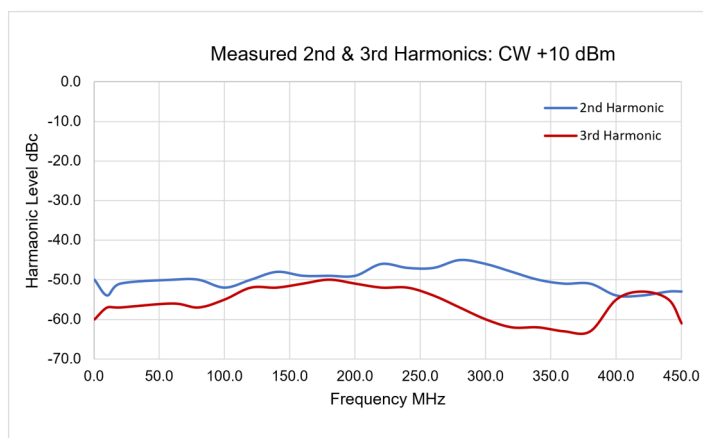
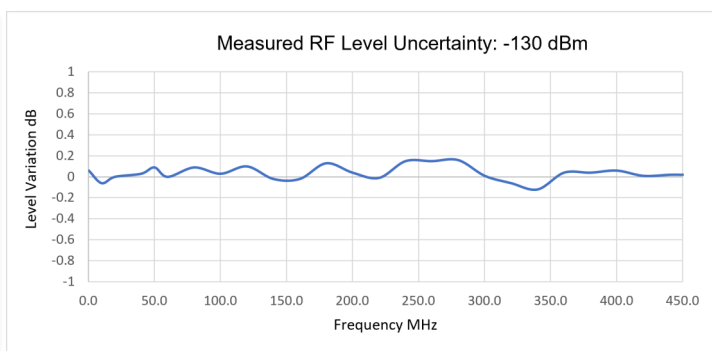
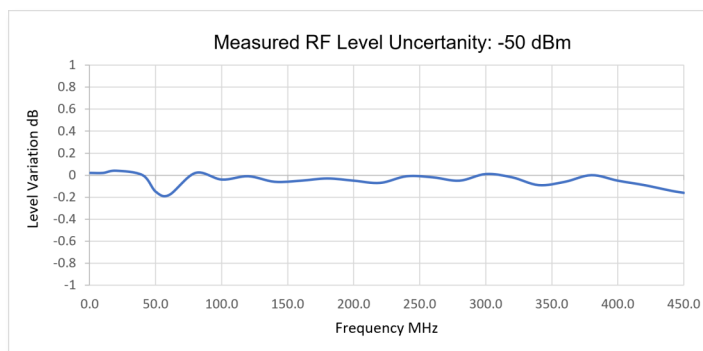
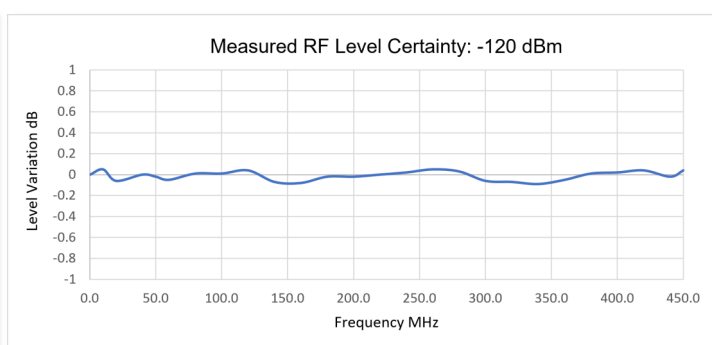
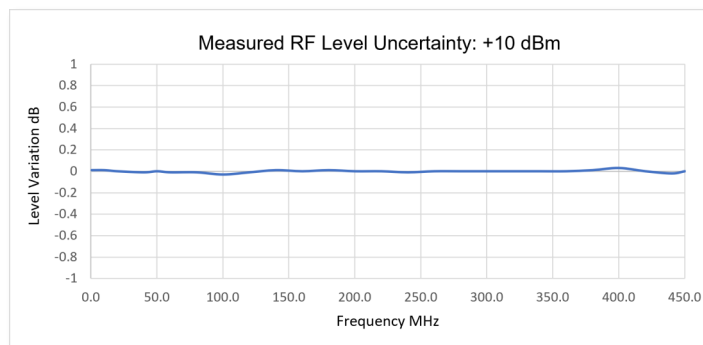
- DC Power Input Protection** is provided by a slow-blow fuse, 600-Wpk transient voltage suppressor (TVS) diode, line-to-line and line-to-ground bypass capacitors, a series reverse-polarity Schottky power diode, and common mode EMI filter. In addition, the dc-to-dc converter galvanically isolates the input DC power from the 5-volt system through a 1.5 kVDC rated physical isolation barrier. This rugged input power architecture makes the SG9000 ideal for field service sites where transient voltage events and ground-loops can materially interfere with and degrade measurement performance.



Block Diagram & Interior View



Measured Performance: RF Level Uncertainty, Harmonic Content & Linearity



Linearity Performance
399.1 MHz, 0 dBm PEP; AM: 1 kHz, 99%
3rd Order IMD Products: 59 dB below PEP (53 dB Below a Tone)
 (Standard 50 MHz TCXO)

Specifications

Frequency Range

Range: 400 kHz to 450.0 MHz

Frequency Step Resolution: 1 Hz

Channel Storage: 50 channels

Reference Clock (REFCLK) TCXO

Standard: [50.0 MHz TCXO](#)

Initial Calibration: ± 1 ppm

Over Temperature Range: ± 0.5 ppm

Aging/Year: ± 1 ppm, Max: ± 6 ppm over 10-years

Option 020: [1 GHz Ultra Low Phase Noise TCXO](#)

Initial Calibration: $\leq \pm 1$ ppm typical, ± 1.5 ppm max

Over Temperature Range: ± 1 ppm

Aging/Year: ± 1 ppm after 1-year

Option 030: [GPSDO](#)

RF Power Level & Control

Power Range: -135 dBm to +10 dBm (AM 99 % Modulation +4 dBm Carrier = +10 dBm PEP max), 50-Ohm

Step Resolution: 0.1 dB

Level Uncertainty: +10 dBm to -120 dBm: ≤ 1.1 dB,
< -120 dBm: ≤ 1.8 dB.

Level Stability: $\leq \pm 0.1$ dB over 8-hours

VSWR: < 1.8:1 nominal (RF output BNC connector)

RF Output-Off Residual Level: ≤ -140 dBm

Reference Level Calibrator: 0 dBm ± 0.1 dB at 50 MHz. Calibrated using an Agilent E4418B RF Power Meter's 50 MHz 0 dBm NIST traceable standard.

RF Output Control: Front panel switch and remote control with yellow LED RF off annunciator

EXT Out Free Run Trigger (TTL): high RF output on, low RF output off; Trigger high RF-on delay: ± 10 μ s, Trigger low RF-off delay: ± 10 μ s

Ext In Trigger (TTL): high RF output on, low RF output off; Step Level Mode: high RF level high, low RF level low. Minimum trigger pulse width 500 μ s

Reverse RF Power & DC Voltage Protection

Maximum Reverse RF Input Power: +30 dBm, trip threshold +20 dBm typical, RF output open-circuit when tripped with reverse power annunciator red LED, front panel resettable

Maximum DC Input Voltage: 5 VDC

Power Off, RF Output Circuit Condition: Open circuit

Spectral Purity

Narrowband (25 kHz) Spurious Free Dynamic Range (SFDR): -50 dBc, -60 dBc with 1 GHz TCXO 020 option

Wideband (400 kHz to 500 MHz) Spurious Free Dynamic Range (SFDR): -45 dBc (-30 dBc >390 MHz), -55 dBc with 1 GHz TCXO 020 option

Harmonics: 2nd: ≤ -40 dBc, 3rd: ≤ -45 dBc

PLL 50 MHz Reference Oscillator Feed-Thru, Fundamental & Harmonics Products: < -130 dBm

SSB Phase Noise

50 MHz TCXO (Standard): -122 dBc/Hz typical, $F_c = 398.7$ MHz, 20 kHz offset

1 GHz TCXO (Option 020): -139 dBc/Hz typical, $F_c = 398.7$ MHz, 20 kHz offset

Amplitude Modulation (AM)

Frequency Range: 10 Hz to 100 kHz in 1 Hz steps

Modulation Depth: 0% to 99% in 1% steps

Max Linear AM Power: 99 % Modulation & +4 dBm Carrier = +10 dBm PEP max), 50-Ohm

Double Sideband Suppressed Carrier (DSBSC)

Frequency Spacing: 10 Hz to 100 kHz, 1 HZ Steps

Frequency Modulation (FM)

Frequency Range: 10 Hz to 100 kHz in 1 Hz steps

Frequency Deviation Range: 0 Hz to 100 kHz in 1 Hz steps

Digital Modulation

APSK-32, BPSK & QPSK

Frequency Sweep

Sweep Type: Linear

Sweep Range: Full frequency range, Start Frequency Error: As Calibrated, Stop Frequency Error: 5 ppm Typical

Sweep Mode: Continuous

Dwell Time Range: 1 ms to 10s, $\pm 3.5\%$

Dwell Time Resolution: 1 ms

EXT Out Free Run Trigger Output: 15 μ s TTL-high pulse at the low -frequency sweep start

EXT In Trigger: Single shot 15 μ s TTL-high pulse low-frequency sweep start

Sweep On/Off Control: Windows remote control UI Sweep On/Off button or SCPI control

Remote Control Protocol & Software

Remote Control Protocol: Standard Commands for Programmable Instruments (SCPI)

Windows SG9000 remote controlled software supplied

USB Communications

USB Arduino IDE Port & USB Remote Control Port: Ruggedized USB 2.0 Type-B with data line short to V-bus protection & IEC ESD protection (IEC 61000-4-2 & ISO 10605 for ± 8 kV contact discharge ± 15 kV air gap, TX & RX LED communications activity indicators. Com, bps: 9600; bits: 8; parity: none; stop bit: 1

Power Supply System

DC Power Converter: Switching DC-to-DC power converter

DC Input Voltage Operating Range: 10 to 33 VDC

DC Input Current Consumption (12 VDC @ 0 dBm): 315 mA typical, power-off: 25 mA typical

Converter Protection: 1.5 kVDC galvanic input/output isolation; under voltage, overload, short-circuit protection, and input transient voltage protection; internal PCB SMT DC fuse

DC Power Jack: 2-Pin, 5.5 mm outer, 2-mm center-pin + polarity

AC Wall Mount Power Supply: AC transformer/bridge rectifier, 18 VDC 9 W output, 120 VAC $\pm 20\%$, 50-60 Hz Input, 72" cable length with mating 5.5 mm DC power plug

Front Panel Connectors, Switches & Indicators

RF Output Connector: BNC female, 50-Ohm, unbalanced

RF Output/Reverse Power Reset Switch: Alternate push-on/push-off

RF Off Indicator: LED illuminated yellow (RF on: extinguished)

Reverse Power Fault Indicator: Flashing red LED

DC Power Switch: Alternate push-on/push-off

EXT Output Connector: BNC female, RF output on TTL high, or 15 μ s TTL pulse at sweep low frequency start

Rear Panel Connectors

USB Arduino IDE: USB Type-B

USB Windows Remote Control: USB Type-B

EXT REF IN: SMA female, external reference clock input

DC Power In: 2-Pin, 5.5 mm with 2-mm center pin

General Specifications

Dimensions: 8.19" L x 5.73" W x 2.68" H (208 mm L x 145.5 mm W x 68 mm H)

Weight: 2.3 lb. (1.1 kg)

Temperature, Operating: 5°C to 45°C; Storage: -20°C to 70°C

Humidity: 0°C to 30°C <95% relative humidity

Warranty: Three year warranty parts and labor excluding transportation fees.

Supplied Items

Description	Part Number
SG9000 RF Signal Generator, TCXO 50 MHz	9000-000100
AC-to-DC Wall-Mount Linear Power Supply, Input: 120 VAC $\pm 20\%$, 50-60 Hz, Output: 18 VDC, 9W	1010-124773
Connector Kit, SG9000 USB-A to USB-B 2M-cable assembly & DC power connector 2-pin 5.5 mm	9000-005001
Operating Manual, on-line pdf	9000-000203

Options

Description	Part Number
Option 020: TCXO, 1 GHz, ± 1 ppm, Ultra Low Phase Noise	9000-000165
Option 030: GPSDO 50.0 MHz Input Kit	9000-000262

All specifications are warranted performance specifications with guaranteed tolerance limits using the standard supplied 50 MHz TCXO frequency reference unless otherwise noted.

Specifications are valid if the instrument is within the calibration period, has been powered-on for at least 45-minutes, and the operating environment ambient temperature is between 18°C and 28°C unless otherwise noted.

Nominal refers to the features or characteristics of the design.

Typical indicates that 80% of units will meet the published typical performance with 80% confidence, unless otherwise noted. Typical performance is not warranted.



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