

## SG-9000 RF Signal Generator



The SG-9000 RF Signal Generator delivers bench-top performance in a light-weight portable package. Its excellent spectral fidelity and phase noise performance makes it the perfect choice for measuring SSB, AM, and, FM communication equipment performance in the lab or field environment.

### Key Performance Specifications

- 400 kHz to 400 MHz, 1 Hz Step Resolution
- CW, AM, FM & Frequency Sweep (1 ms min dwell time)
- -130 dBm to +10 dBm RF Power Range
- 0.1 dB RF Attenuator Step Resolution
- Spurious Free Dynamic Range: Wide Band: -55 dBc, Narrow Band: -60 dBc (with TCXO Options 020)
- TCXO  $\pm 0.5$  ppb (0.5 ppm) (Standard)
- TCXO  $\pm 1$  ppm Ultra Low Phase Noise (Option 020) -139 dBc/Hz 10 kHz Offset @ 100 MHz, Typical\*
- TCXO CAL: Short-Term Accuracy 0.2 ppm, User Cal
- External GPS Disciplined Oscillator (Option 030)
- External RF On/Off & Sweep Start Triggers

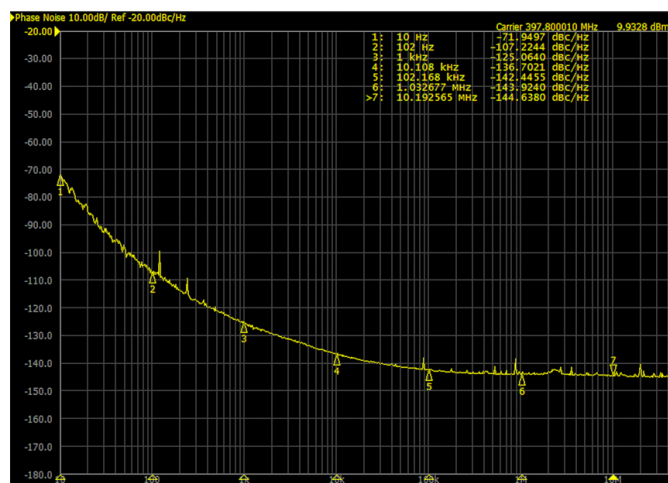
### Key User Features

- Windows-10 User Interface (UI)
- SCPI<sup>1</sup> Command Interface
- Small Bench-Top Footprint, Light-Weight, Perfect for Field Service Tasks
- Open-Source Software, Program in the Arduino Integrated Development Environment (IDE) System
- +30 dBm Reverse RF Power Protection/Alarm & 50 VDC Input Block Protection
- External Sync Output for RF Output On/Off and Frequency Sweep Start
- 10 to 33 Volt DC Power Input, Reverse Polarity Protection & 1.5 kVDC Galvanic DC Source Isolation
- OLED Status Display

\* Design Objective, Pending Measurement Validation

### Benchtop Performance at a Fraction of the Cost

The SG-9000 is built on Analog Devices' high-performance, [AD9910](#) 14-bit direct digital synthesizer; Microchip's ATmega-2560 microcontroller; Abracon TCXOs; Mini-Circuits' digital-step RF attenuators and RF switches. Combined, these technologies deliver comparable performance to expensive benchtop signal generators at a fraction of the cost.



Phase Noise: 136 dBm/Hz 10 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 SG-9000 Windows remote control application or chose SCPI<sup>1</sup> command interface in the LabView environment.

Open source ATmega2560 MCU software developed in the Arduino integrated development environment (IDE) allows you to customize code for your specific test application.

### Compact, Rugged, and Portable

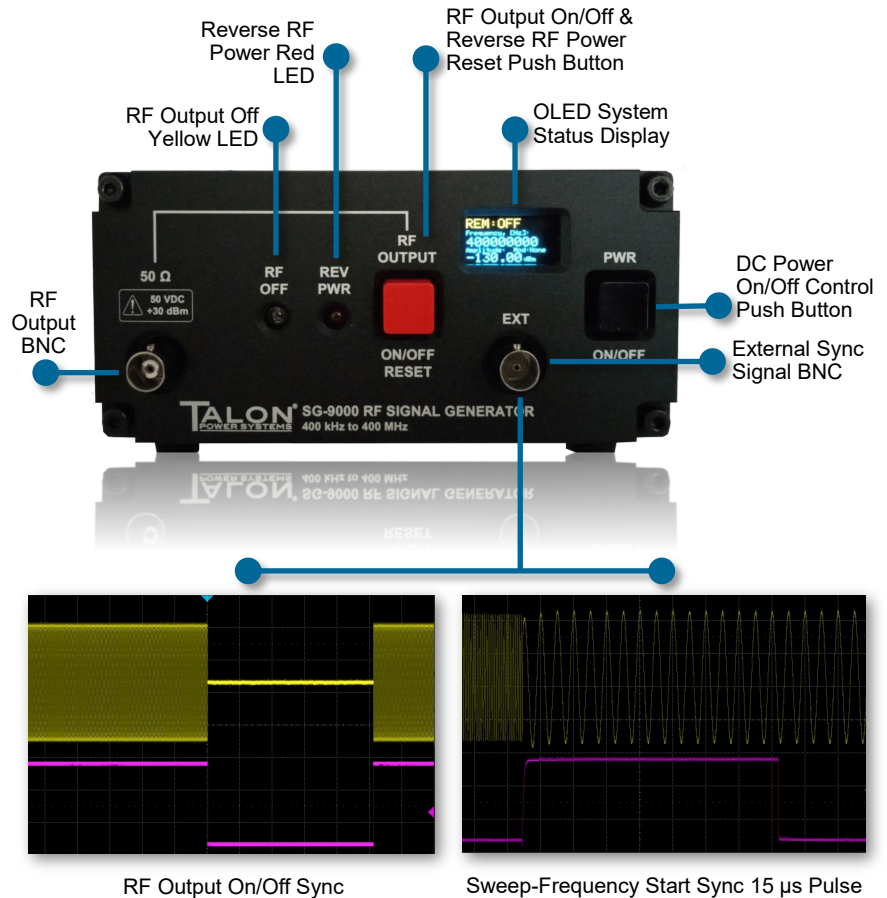
The SG-9000 is packaged in a compact extruded aluminum enclosure, black anodized finished and laser etched lettering for exceptional appearance and durability. The small form-factor conserves valuable lab bench space while the light-weight ruggedized packaging makes it ideal for field service tasks.



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

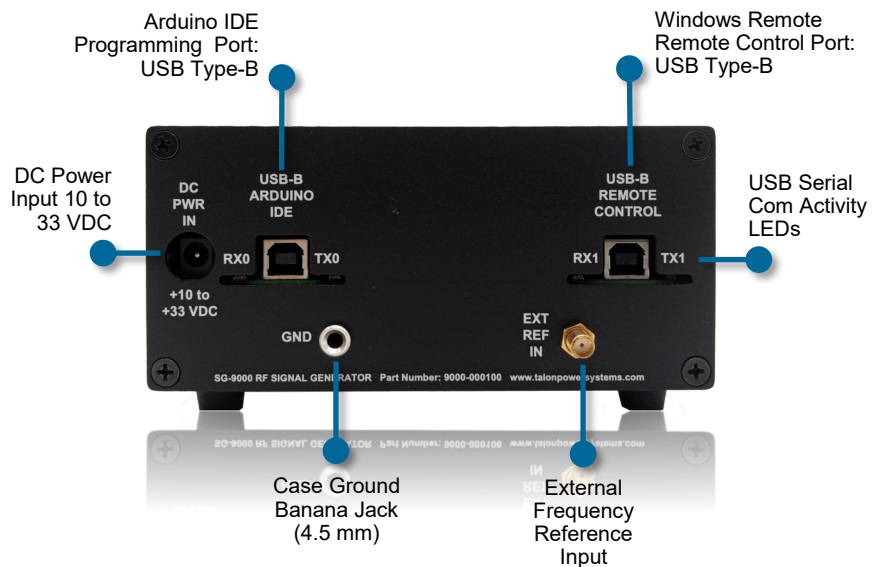
## Front Panel Key Operating Features

- **RF OFF** LED illuminates yellow when the RF output is off
- **REV PWR** (reverse RF power) LED illuminates 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 also resets the reverse power latched off state
- **Organic LED (OLED)** displays the instruments current operating status
- **EXT Sync Signal RF Out** TTL-high when the RF output is enabled, TTL-low when the RF output is disabled—an excellent aid in evaluating radio receiver AGC attack/release time characteristics.
- **EXT Sync Signal Sweep Start** TTL-high 15  $\mu$ s pulse generated at the start of each sweep cycle—perfect for oscilloscope sweep triggering during bode-plot evaluation of filters and networks.



## 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 SG-9000 Windows-10 remote control application
- **RX0/TX0 & RX1/TX1** Red/green LEDs indicate serial USB Arduino IDE and remote control communications activity
- **EXT REF IN**, external 40 MHz reference input, -10 dBm typical. Suitable for use with a GPSDO frequency reference source.
- **Case Electrical Ground**, Banna Jack, 4.5 mm

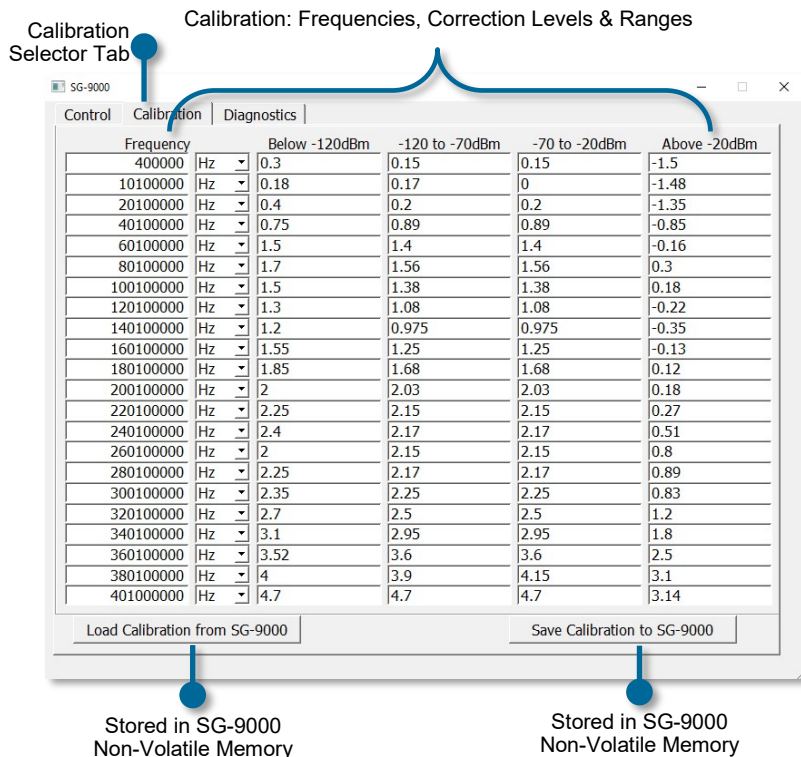
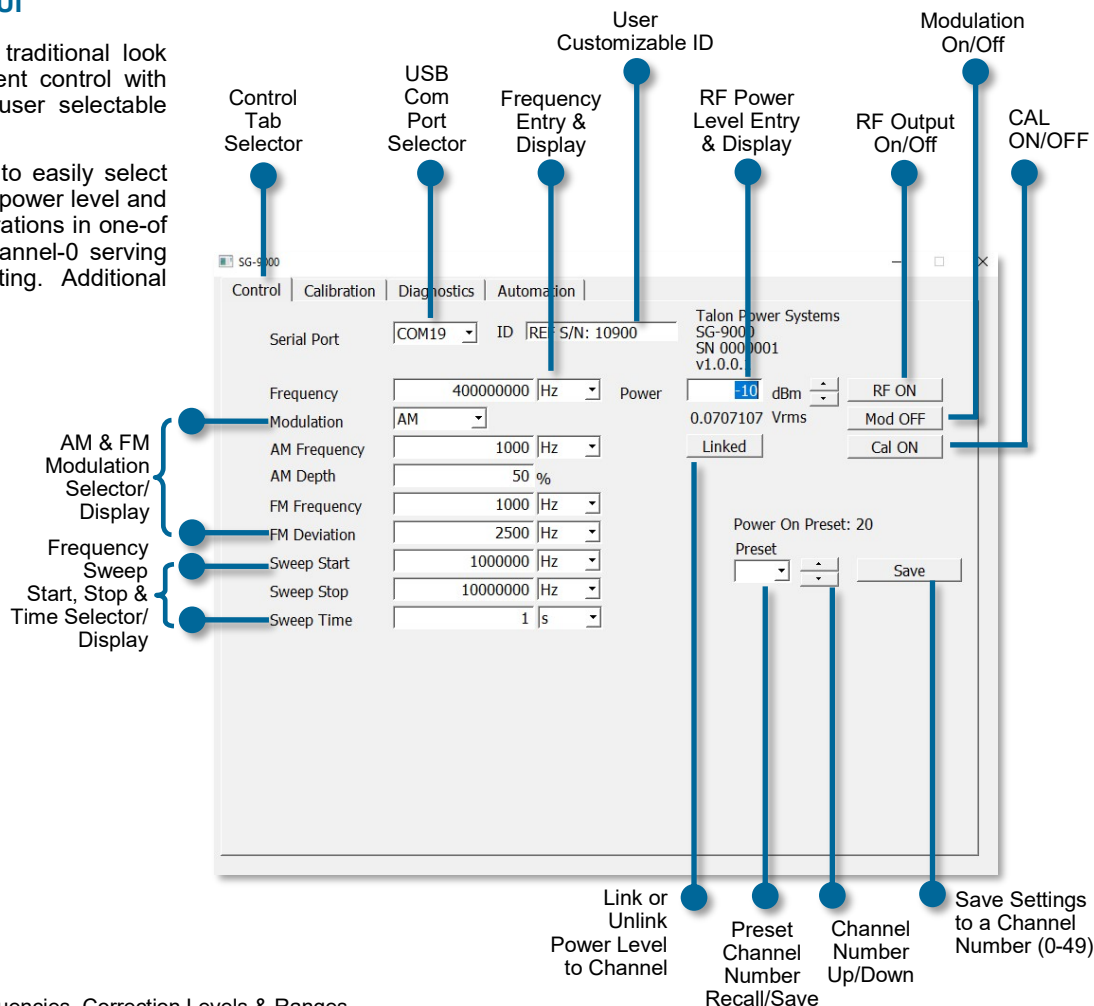


## Windows Remote Control UI

The SG-9000 UI delivers the traditional look and feel of Windows' instrument control with operation organized in three user selectable tabs:

**The Control Tab** allows you to easily select frequency, modulation, and RF power level and can store the selection configurations in one-of-fifty channel locations with channel-0 serving as the power-on default setting. Additional capabilities include:

- USB Windows Control Port Selection
- RF Output On/Off Control
- RF Output Level in dBm and  $\mu V$  rms
- Link or Unlink the RF Power Level to the Selected Channel
- User Customizable ID to Help Identify Signal Generator Task in a Multi-Generator Application



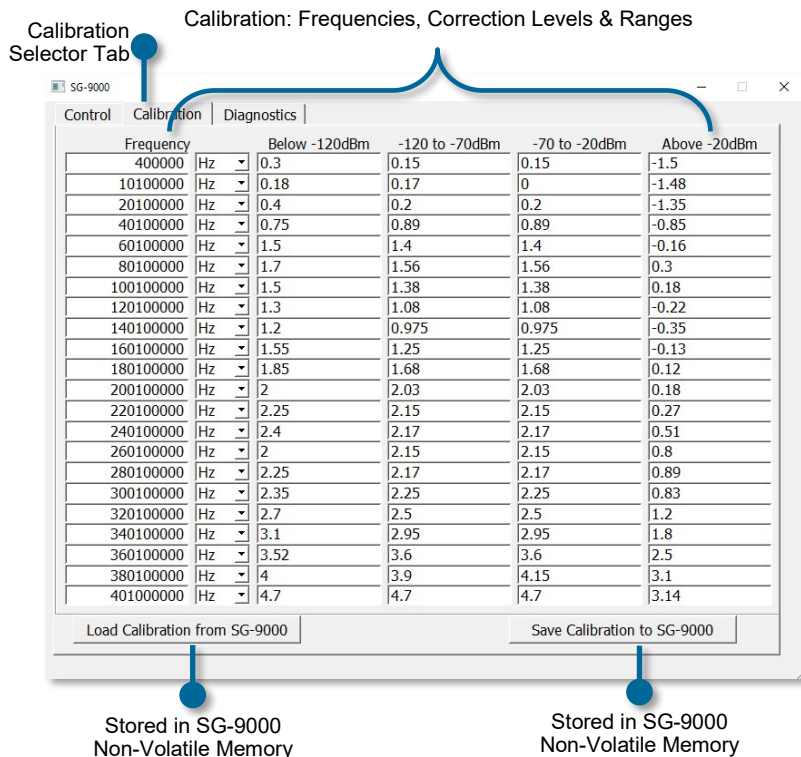
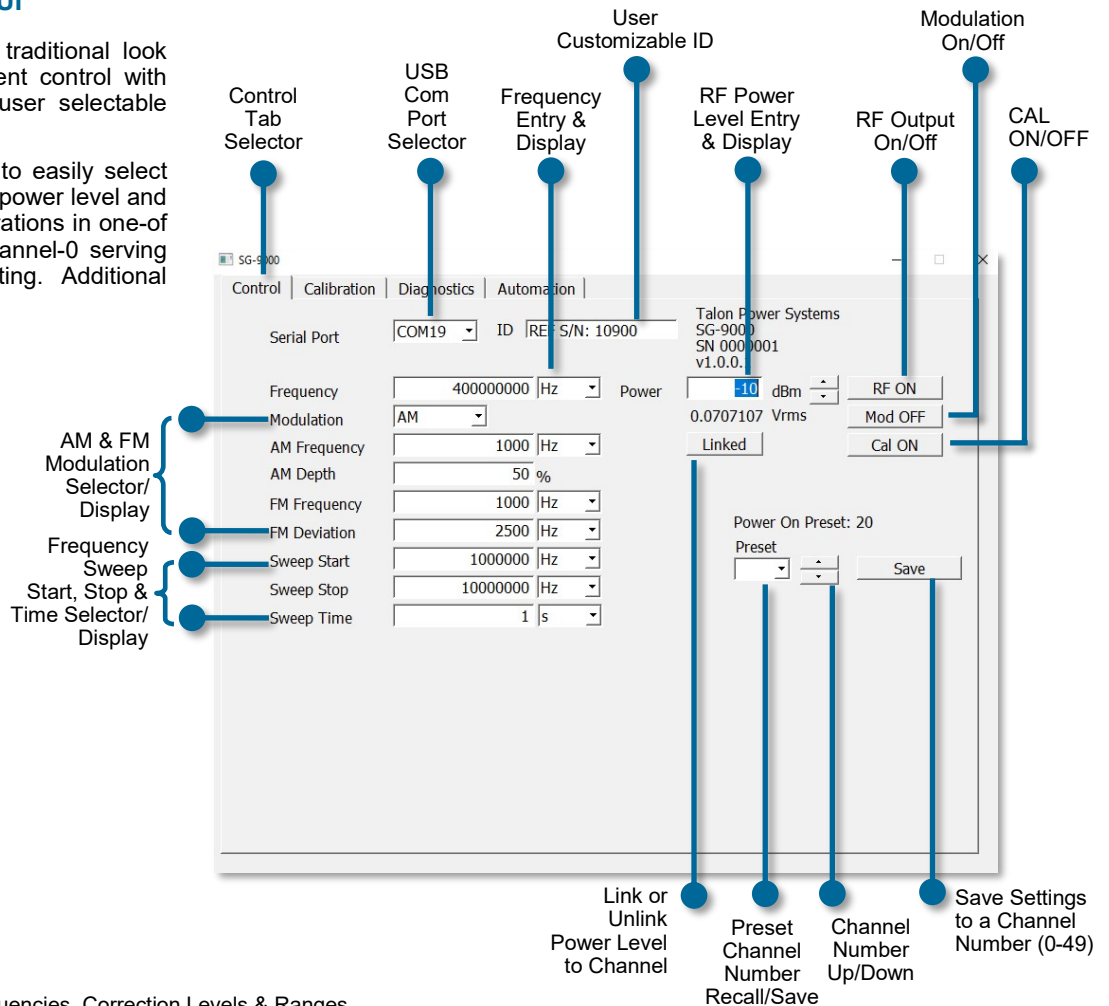
**The Calibration Tab** allows you to inspect or change the calibration levels, in 0.1 dB steps, as well as the calibration frequencies. The calibration levels/frequency are stored in the SG-9000 non-volatile memory and can be recalled by pressing the *Load Calibration from SG-9000* or new values can be stored by pressing the *Save Calibration to SG-9000*.

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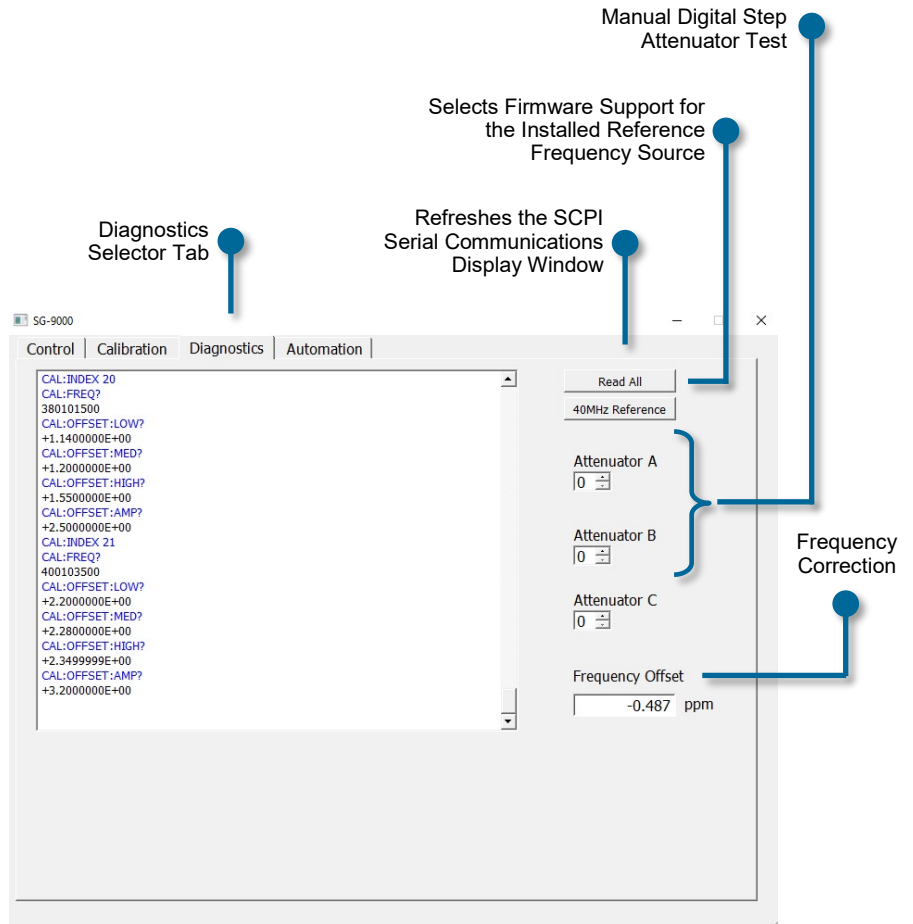
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## Windows Remote Control UI

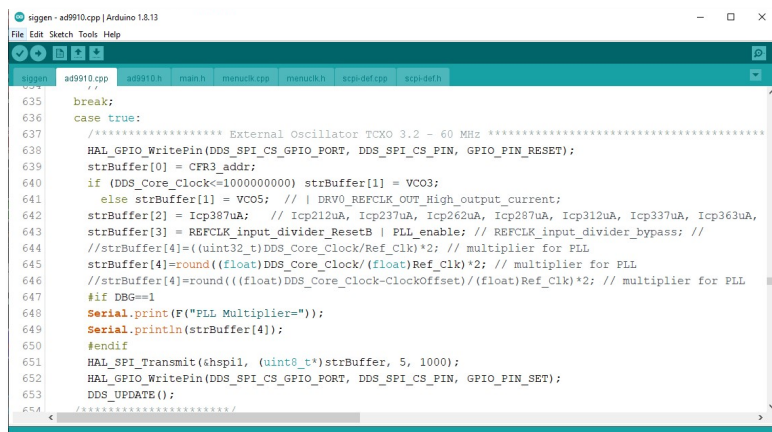
The **Diagnostics Tab** allows you to:

- Inspect the standard commands for programmable instruments (SCPI) communications between the Windows control application and the SG-9000
- Select firmware support for the standard 40 MHz TCXO/optional GPSDO reference PLL operation or optional direct 1 GHz TCXO reference operation
- Test the individual digital step attenuators by manually setting and evaluating each attenuator in 0.5 dB steps across the 30.5 dB operating range
- User frequency correction capability. Applies a TCXO offset yielding short-term frequency accuracy of 0.2 ppm.



## Software & SCPI Commands

- Open Source ATmega2560 MCU software developed in the popular, no-cost Arduino integrated development environment (IDE) allows you to customize code for your specific test application
- SCPI commands support all available functions and operating conditions, such as:
  - FREquency
  - Power
  - AM:STaTe
  - AM:FREquency
  - etc.



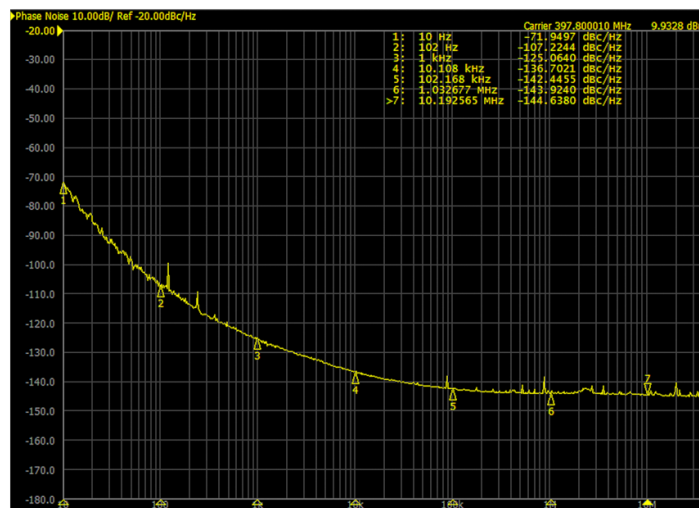
SCPI: [Standard Commands for Programmable Instruments](#)

## AD9910 Frequency Reference

The AD9910 DDS uses a 1 GHz frequency reference, 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	PHASE NOISE	COST
50 MHz TCXO	$\pm 2$ ppm	$\pm 2$ ppm	Good	Standard (Lowest cost)
<a href="#">1 GHz Ultra Low Phase Noise TCXO</a>	$\pm 0.5$ ppm $\pm 1$ ppm max	$\pm 1$ ppm	Best	Option 020
<a href="#">GPSDO</a> (external)	GPS SV Cesium Frequency Reference: $1 \times 10^{-12}$ Typical		Good	Option 030

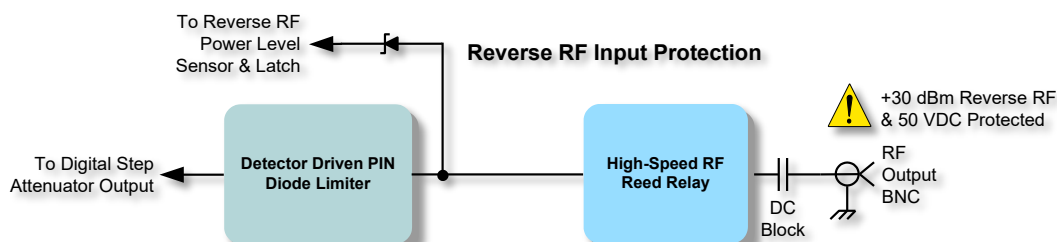
Recommended GPSDO:  
Mini Precision GPS Reference Clock  
Source: [Leo Bodnar Electronics](#)



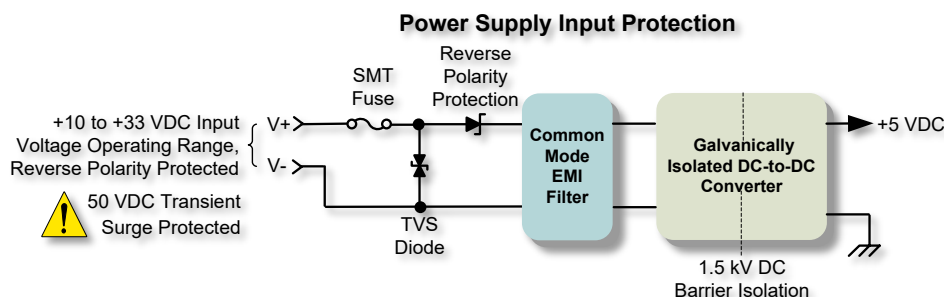
Phase Noise: -136 dBm/Hz at 10 kHz Offset, 397.8 MHz +10 dBm;  
Option 020 1 GHz Reference Clock; Keysight E5052B Signal Source Analyzer

## Key Protection Features

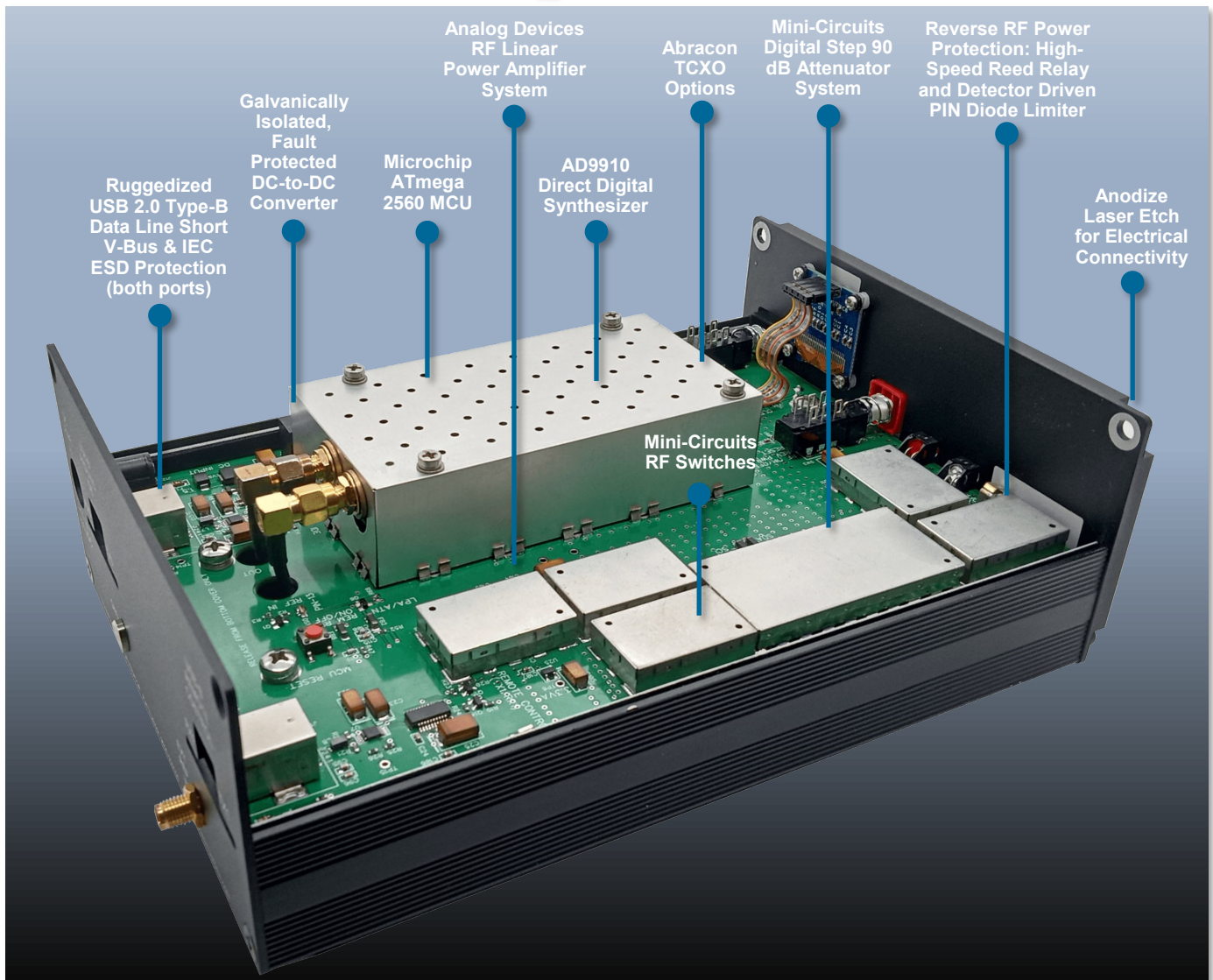
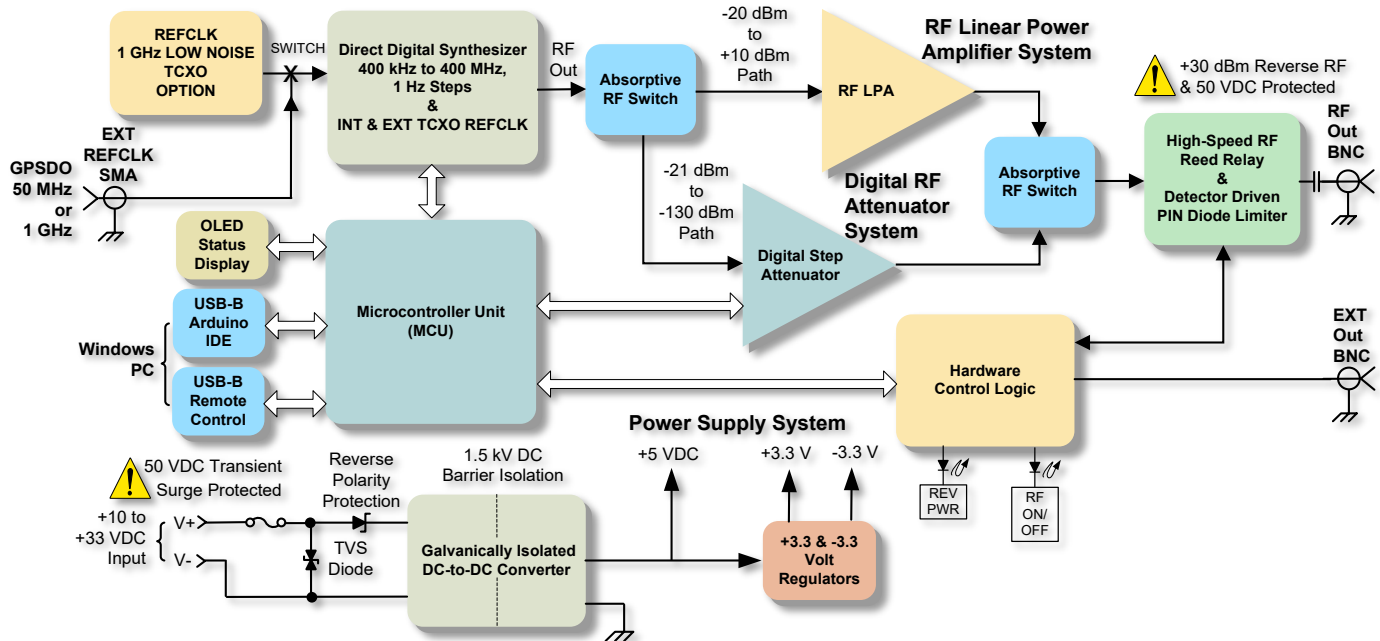
- RF Input Protection** for the inadvertent application of reverse RF up to +30 dBm is achieved through a high-speed RF reed relay and a detector-driven PIN diode limiter. In operation, levels above +20 dBm will latch the RF output reed-relay open. During the relay's 0.05 ms transition time, reverse power is clamped to a safe-level by the PIN diode limiter. A series output capacitor blocks DC voltages up to 50 VDC.



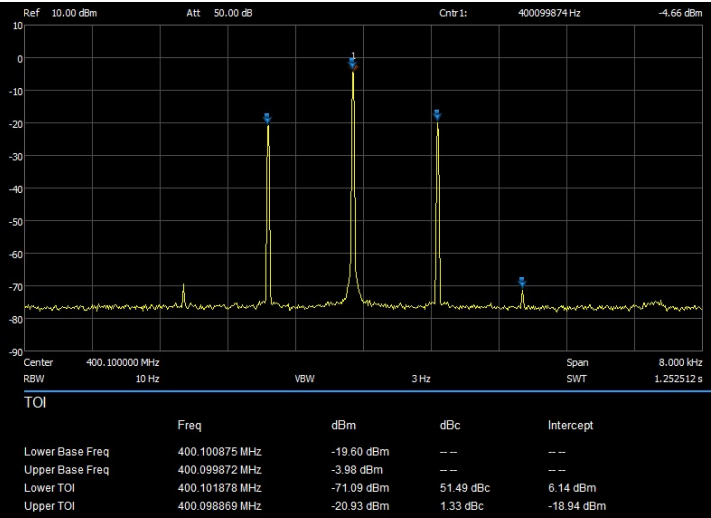
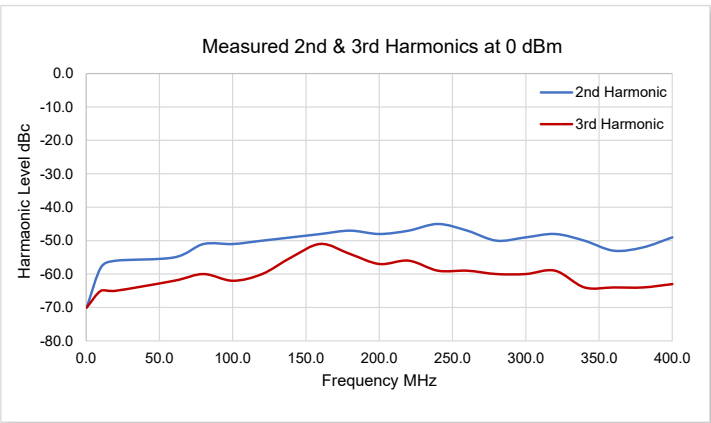
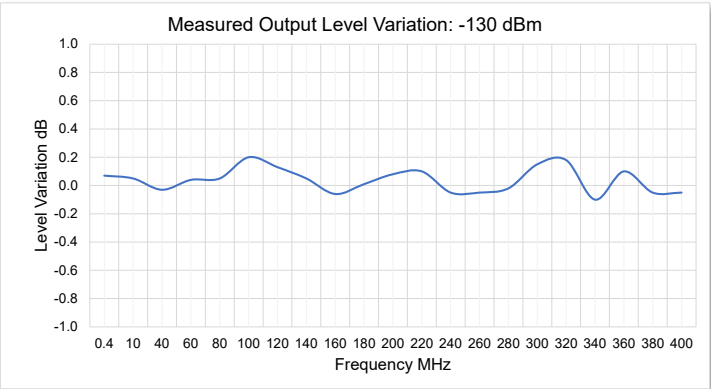
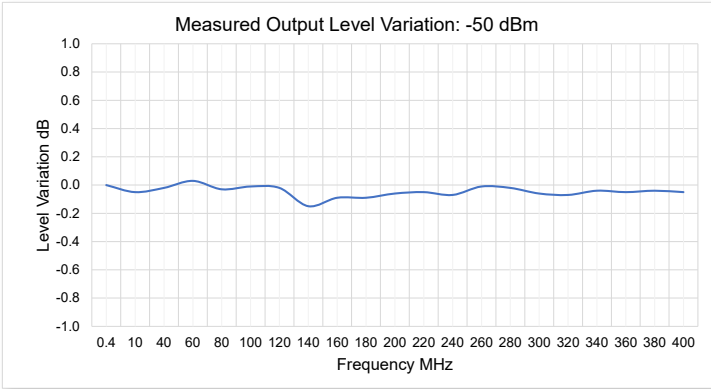
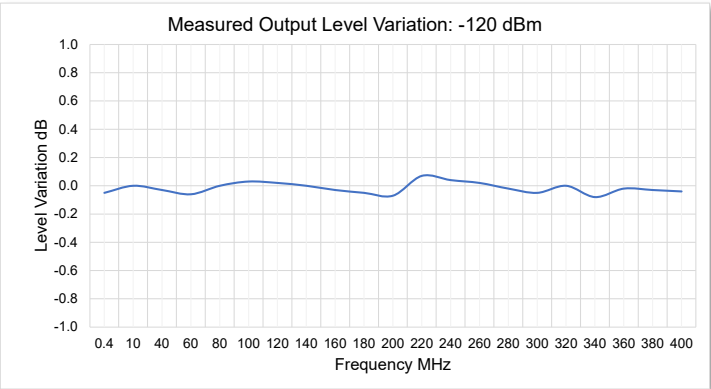
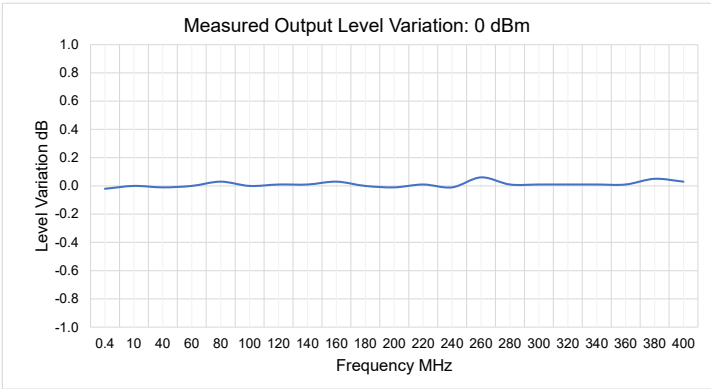
- DC Power Input Protection** is provided by a slow-blow fuse, 600-Wpk transient voltage suppressor (TVS) diode, line-to-line and line-to-ground bypass capacitors, a series reverse-polarity Schottky power diode, and common mode EMI filter. In addition, the dc-to-dc converter galvanically isolates the input DC power from the 5-volt system through a 1.5 kVDC rated physical isolation barrier. This rugged input power architecture makes the SG-9000 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 Output Level Variation, Harmonic Content, Phase Noise & Linearity



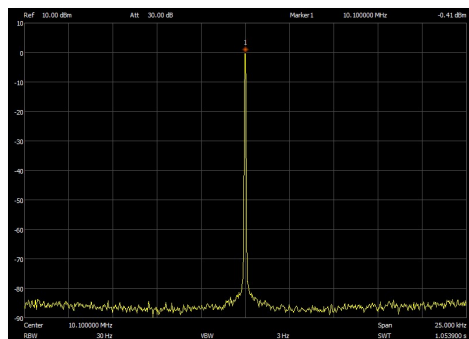
System Level Linearity Performance  
400.1 MHz, 0 dBm PEP; AM: 1 kHz/100%  
3rd Order IMD Product: 51.49 dBc  
(Option 020: 1-GHz TCXO)

Harmonic Levels Measured in 20 MHz Increments

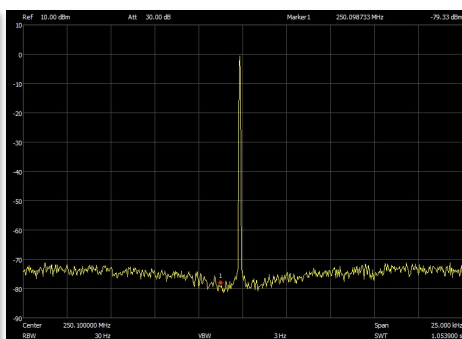


# Measured Performance: Spurious Free Dynamic Range (SFDR) 40 MHz TCXO & 1 GHz TCXO Operation

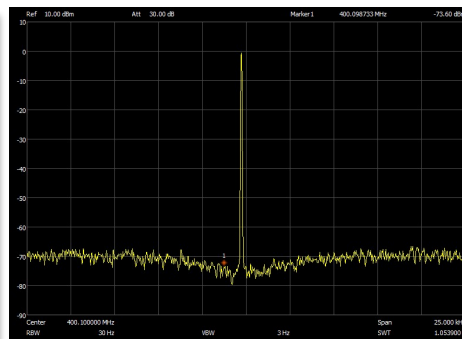
## Narrowband (25 kHz) SFDR at 0 dBm



Narrowband SFDR: 10.1 MHz

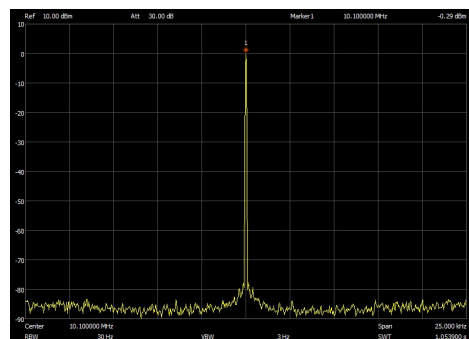


Narrowband SFDR: 250.1 MHz

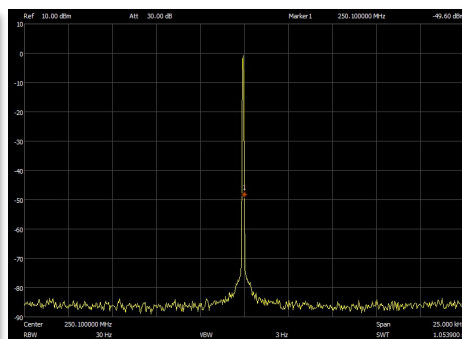


Narrowband SFDR: 400.1 MHz

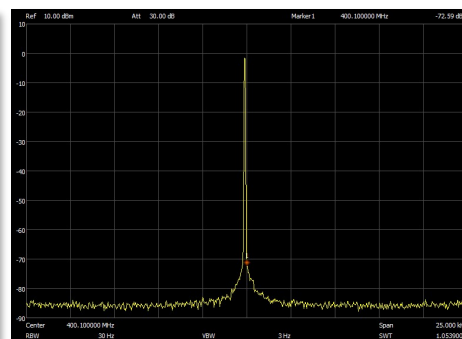
40 MHz TCXO



Narrowband SFDR: 10.1 MHz



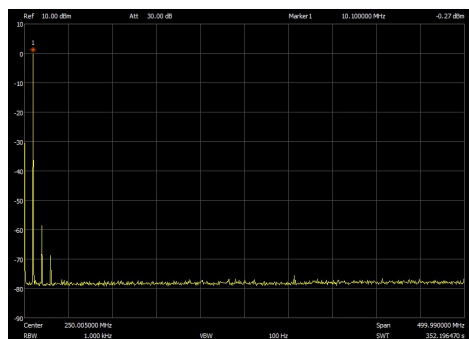
Narrowband SFDR: 250.1 MHz



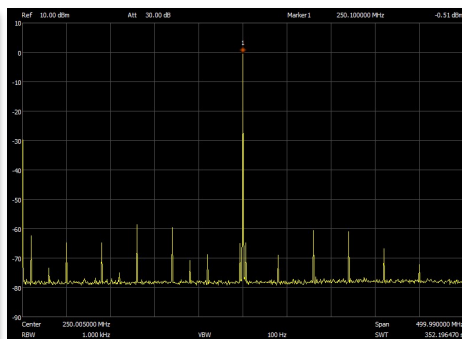
Narrowband SFDR: 400.1 MHz

1 GHz TCXO Option 020

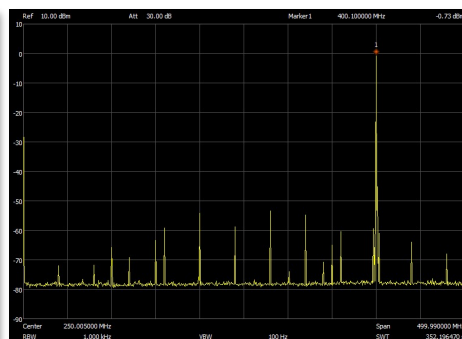
## Wideband (10 kHz to 500 MHz) SFDR at 0 dBm



Wideband SFDR: 10.1 MHz

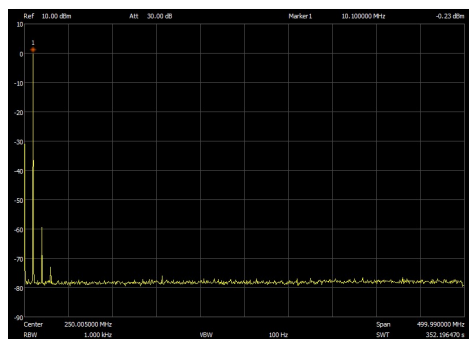


Wideband SFDR: 250.1 MHz

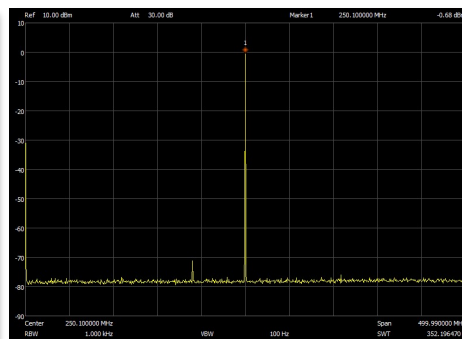


Wideband SFDR: 400.1 MHz

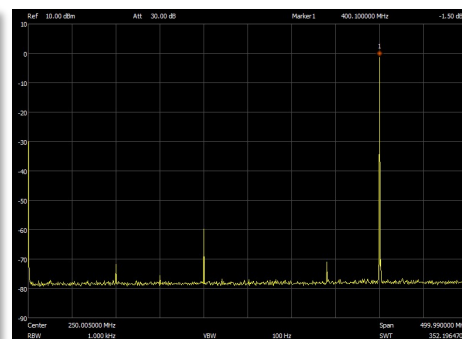
40 MHz TCXO



Wideband SFDR: 10.1 MHz



Wideband SFDR: 250.1 MHz



Wideband SFDR: 400.1 MHz

1 GHz TCXO Option 020

## Specifications

### Frequency Range

Range: 400 kHz to 400.0 MHz

Frequency Control Step Resolution: 1 Hz

Channel Storage: 50 channels

### Frequency Reference Clock

Standard: [40.0 MHz  \$\pm\$  2.0 ppm TCXO](#)

Initial Calibration:  $\pm$  1 ppm

Aging / Year:  $\pm$  1 ppm, Max:  $\pm$  6 ppm over 10-years

Over Temperature Range:  $\pm$  0.5 ppm

Option 020: [1 GHz  \$\pm\$  ppm Ultra Low Phase Noise TCXO](#)

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

Aging / Year:  $\pm$  1 ppm after 1-year

Over Temperature Range:  $\pm$  1 ppm

Option 030: [GPSDO](#)

### RF Power Level & Control

Power Range: -130 dBm to +10 dBm (AM 100 % Modulation & +4 dBm Carrier = +10 dBm PEP max), 50-Ohm

Step Resolution: 0.1 dB

Level Uncertainty: +10 dBm to -130 dBm:  $\leq$  1.1 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:  $\leq$  -135 dBm

RF Range Calibrator Capability: 0 dBm  $\pm$  0.1 dB; 50 MHz

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

RF Output Trigger: TTL-high RF output on, TTL-low RF output off (Front Panel EXT BNC connector); Trigger TTL high RF-on delay: 26  $\mu$ s, RF-off trigger TTL low delay: 123  $\mu$ 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: 50 VDC

Power Off, RF Output Circuit Condition: Open circuit

### Spectral Purity

Narrow-Band (25 kHz) Spurious Free Dynamic Range: -50 dBc (-60 dBc with 1 GHz REFCLK 020 option)

Wide-Band (400 kHz to 500 MHz) Spurious Free Dynamic Range: -45 dBc (-55 dBc with 1 GHz REFCLK 020 option)

Harmonics: 2nd:  $\leq$  -40 dBc, 3rd:  $\leq$  -45 dBc

SSB Phase Noise:

50 MHz TCXO\*: -129 dBc/Hz typical,  $F_c$  = 398.7 MHz, 10 kHz offset

1 GHz TCXO Option 020: -136 dBc/Hz typical,  $F_c$  = 398.7 MHz, 10 kHz offset

\* Design Objective, Pending Measurement Validation

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

### Amplitude Modulation (AM)

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

Modulation Depth: 0% to 100% in 1% steps

Max Linear AM Power: 100 % Modulation & +4 dBm Carrier = +10 dBm PEP max), 50-Ohm

### 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

### 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

Trigger Output: 15  $\mu$ s TTL-high pulse at the low-frequency sweep start (EXT connector)

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 SG-9000 remote controlled software supplied

System Firmware: Arduino open source

### USB Communications

USB Arduino IDE 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  $\pm$  8kV contact discharge  $\pm$  15 kV air gap, TX & RX LED communications activity indicators. Com, bps: 9600; bits: 8; parity: none; stop bit: 1

USB Remote Control Port (Arduino RX1 & TX1): Ruggedized USB 2.0 Type-B with data line short to V-bus protection & IEC ESD protection (IEC 61000-4-2 & ISO 10605 for  $\pm$  8kV contact discharge  $\pm$  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 Indicator: LED illuminated red

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

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

**Rear Panel Connectors**

USB Arduino IDE: USB Type-B

Remote Control (RX1/TX1): 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

Supplied Items	
Description	Part Number
SG-9000 RF Signal Generator, TCXO 40 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, SG-9000 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, $\pm$ 1 ppm, Ultra Low	9000-000165
Option 030: GPSDO 40.0 MHz Input Kit	9000-000262

**All specifications** are warranted performance specifications with guaranteed tolerance limits using the standard supplied 40 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.

**PRELIMINARY RELEASE**

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