# SG9000 RF Signal Generator




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

## Key Performance Specifications

- 400 kHz to 450 MHz, 1 Hz Step Resolution
- CW, AM, DSBSC, FM & ARB PSK, APSK, QAM Waveform Family
- -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 *
- Reference Level Calibrator: 0 dBm ± 0.1 dB at 50 MHz
- Frequency Sweep
- Dynamic RF Level Control Simplifies Receiver AGC Attack/Release Time and Stability Measurements

## Key User Features

- Windows-10/11 User Interface (UI)
- SCPI[1] 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 kV DC 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 SCPI[1] 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.

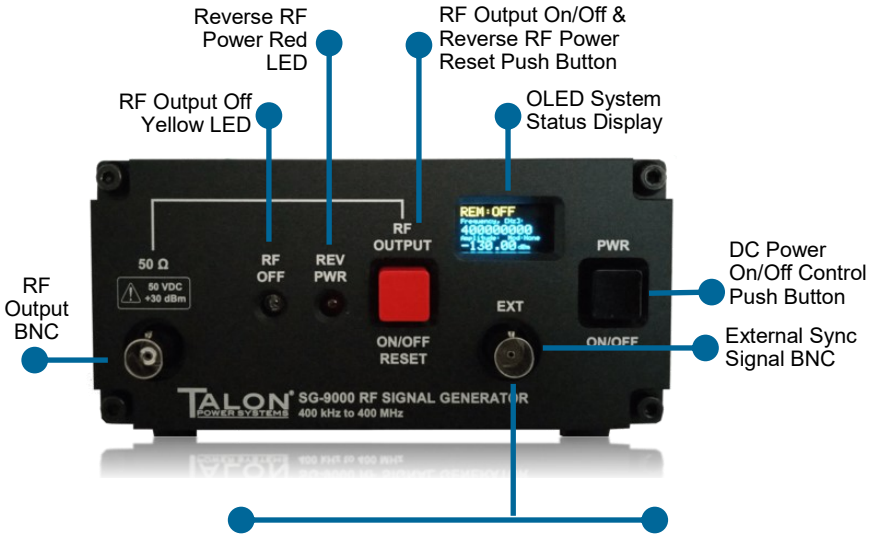


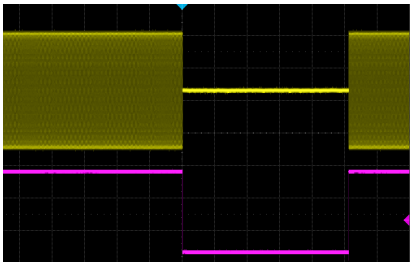

* Phase Noise Levels: Typical, Measured at a 20 kHz Offset, FC = 398.7 MHz

1. SCPI: Standard Commands for Programmable Instruments

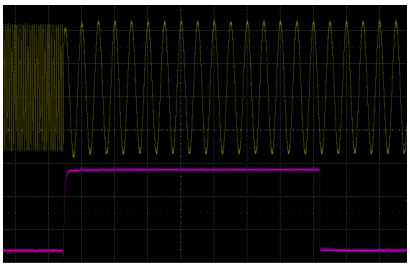
## Front Panel Key Operating Features

- **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 µs 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 µs 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.

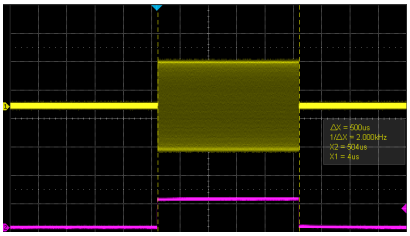


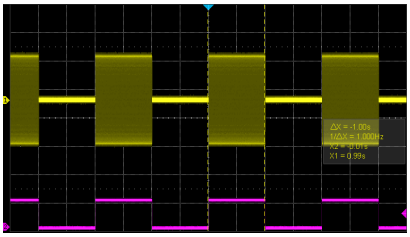
RF Output On/Off Sync, EXT Free Run (Trigger Out)



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



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



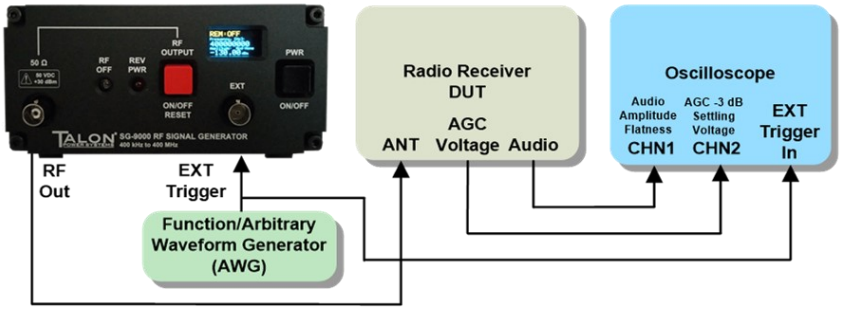
RF Step Level: -50 dBm to -20 dBm 1000 ms Intervals, EXT Trigger In

## Radio Receiver Automatic Gain Control (AGC) Evaluation 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 µs.

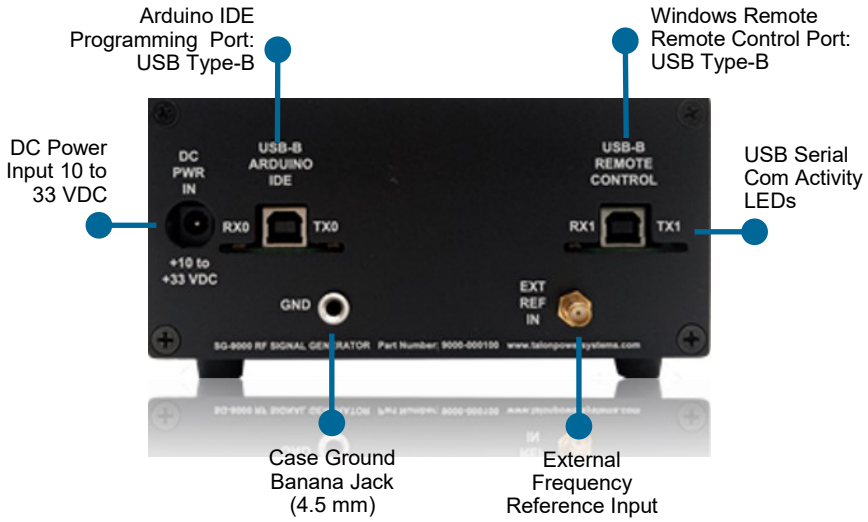
- **EXT IN Trigger RF On/RF Off** evaluates receiver AGC attack timing from an RF Off state (≤ -140 dBm) to an RF On level within the selectable RF power range of -135 dBm to +10 dBm. Conversely, AGC release timing can be measured from the RF On to RF Off state.
- **EXT IN Trigger, RF Step Level** evaluates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

**Radio Receiver Automatic Gain Control (AGC) Evaluation**



## Rear Panel Key Connectivity Features

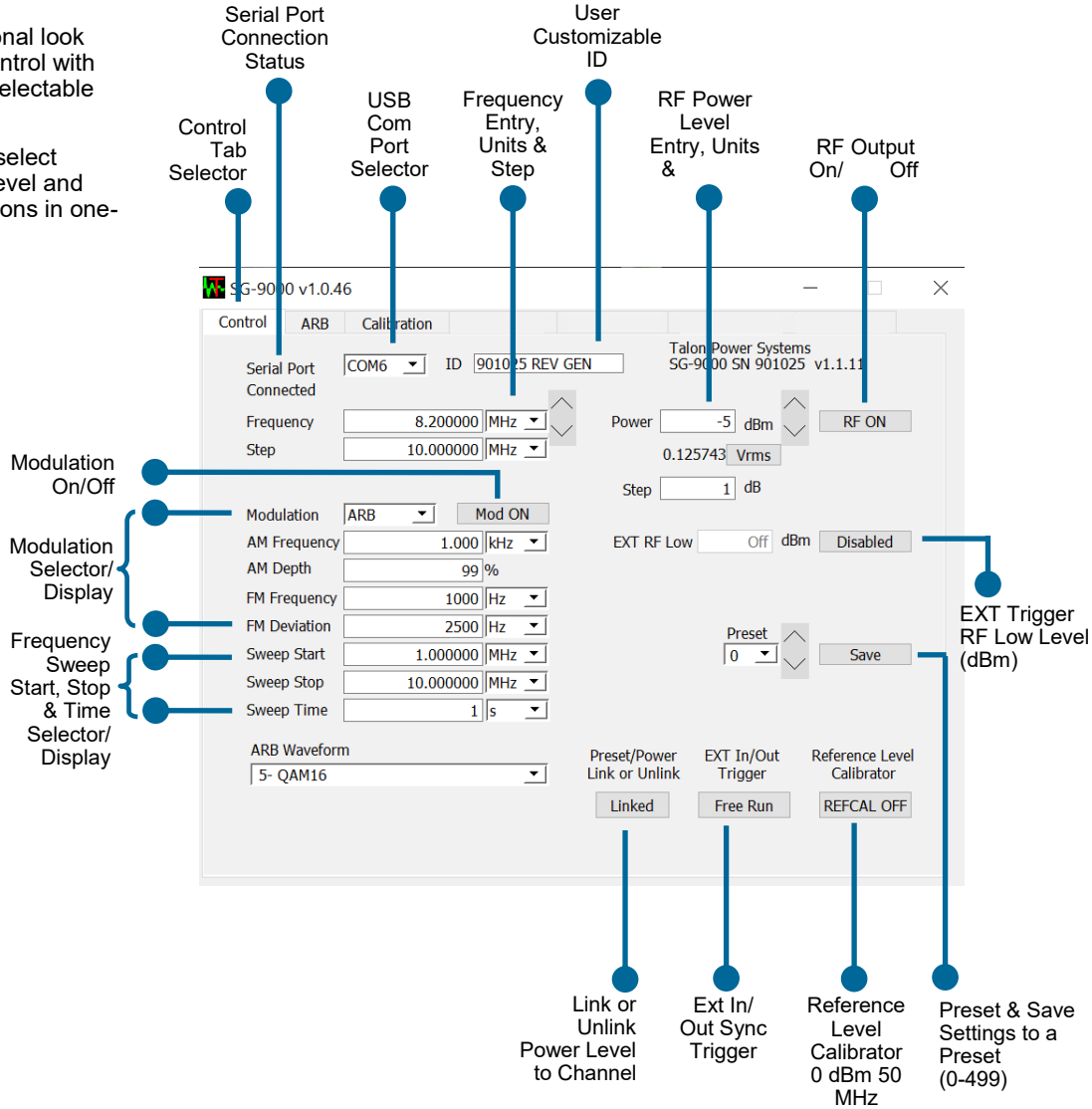
- **DC PWR IN** accepts 10 to 33 VDC, reverse polarity/transient protected and galvanically isolated from the input power source.
- **PROGRAMMING PORT (RX0/TX0)** supports Arduino IDE firmware upgrade.
- **REMOTE CONTROL (RX1/TX1)** USB-B port, supports the SG9000 Windows-10/11 remote control application.
- **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**, Banna 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 to easily select frequency, modulation, RF power level and store those the selected configurations in one-of-fifty channel locations.




## Simplify Measurement Tasks

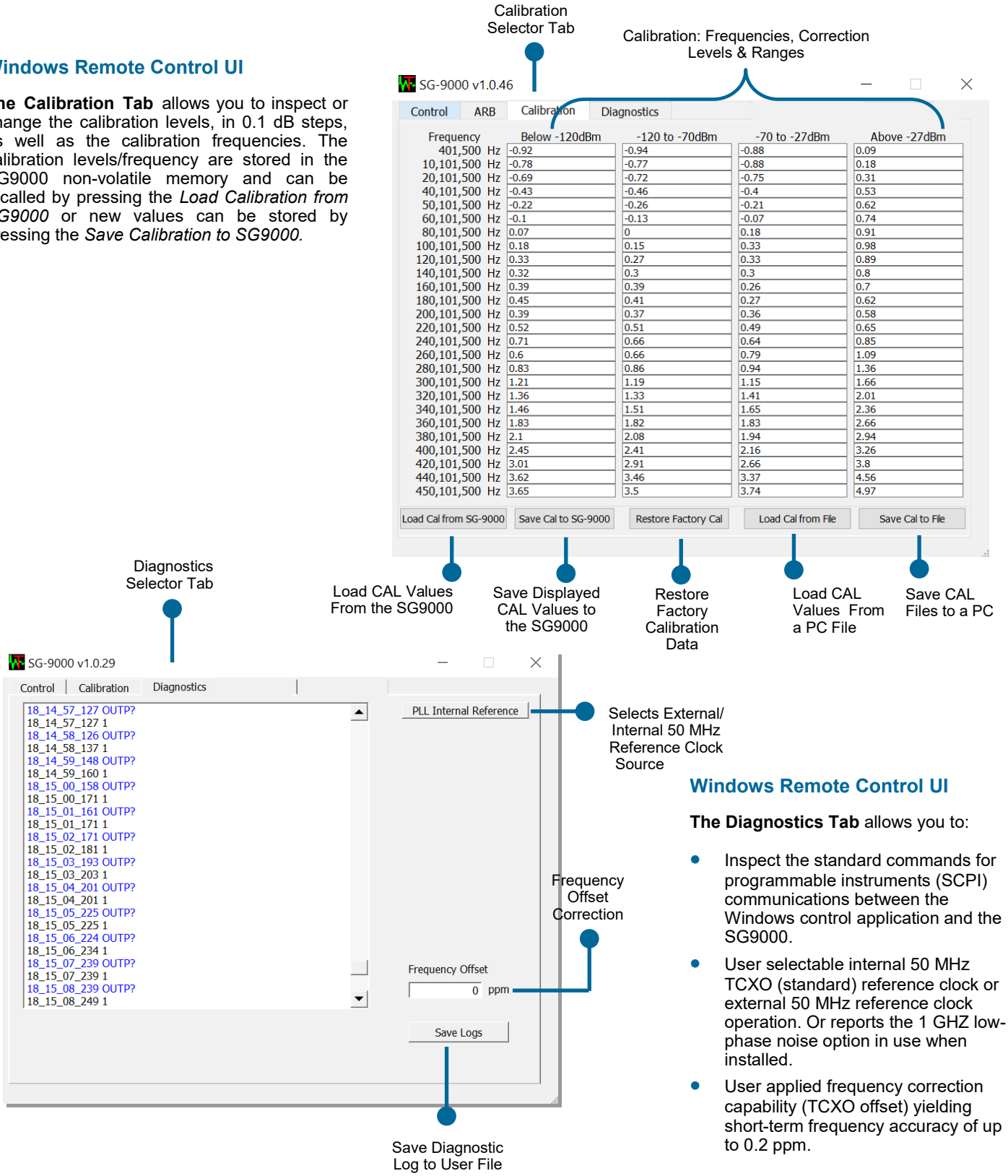
**EXT RF Low** external trigger RF step level. A convenient utility for evaluating receiver AGC attack/release timing and stability performance.

**REFCAL (Reference Level Calibrator)** sets the RF power level to 0 dBm ± 0.1 dB[1] at 50 MHz. 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.*




## 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. Or reports the 1 GHZ low-phase noise option in use when installed.
- User applied frequency correction capability (TCXO offset) yielding short-term frequency accuracy of up to 0.2 ppm.

## SCPI Command Support

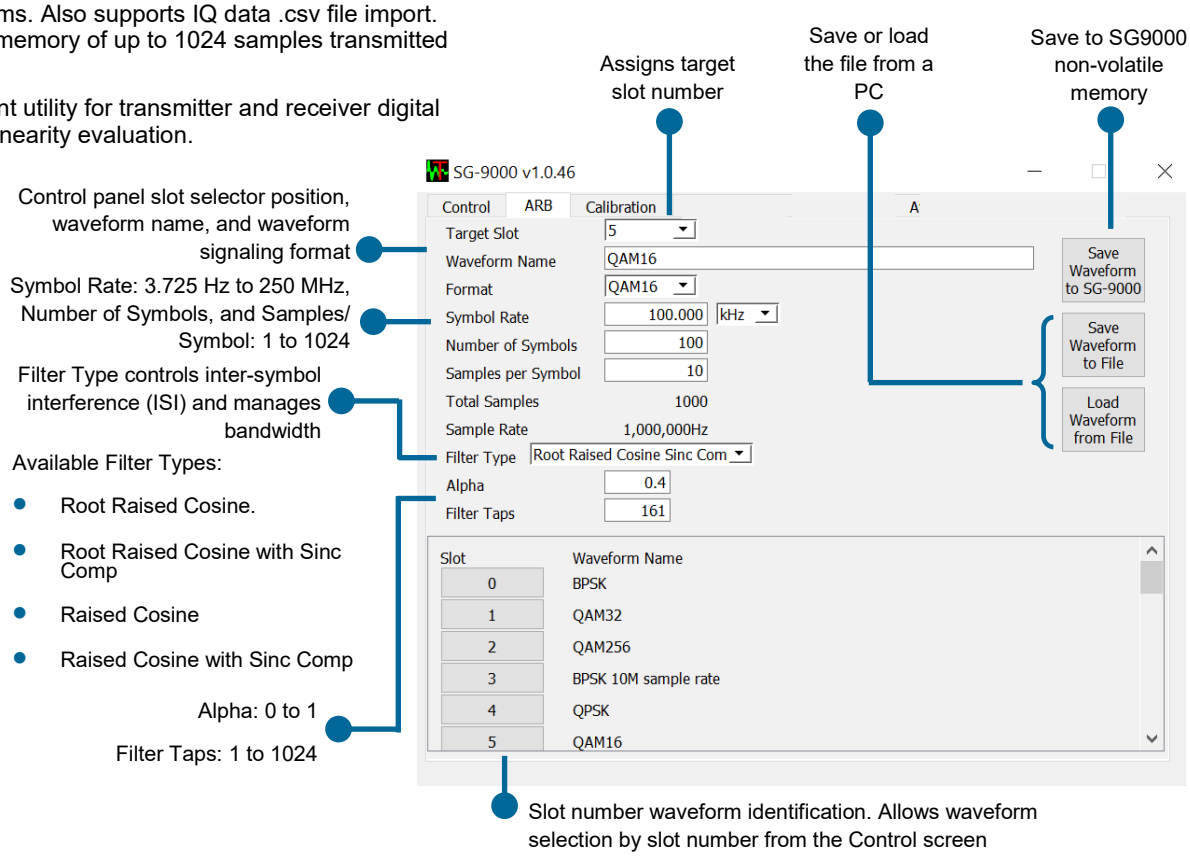
- SCPI commands support all available functions and operating conditions, such as: FREQuency, POWer, AM:STATe, AM:FREQuency, etc.

## Analog and Digital Modulation

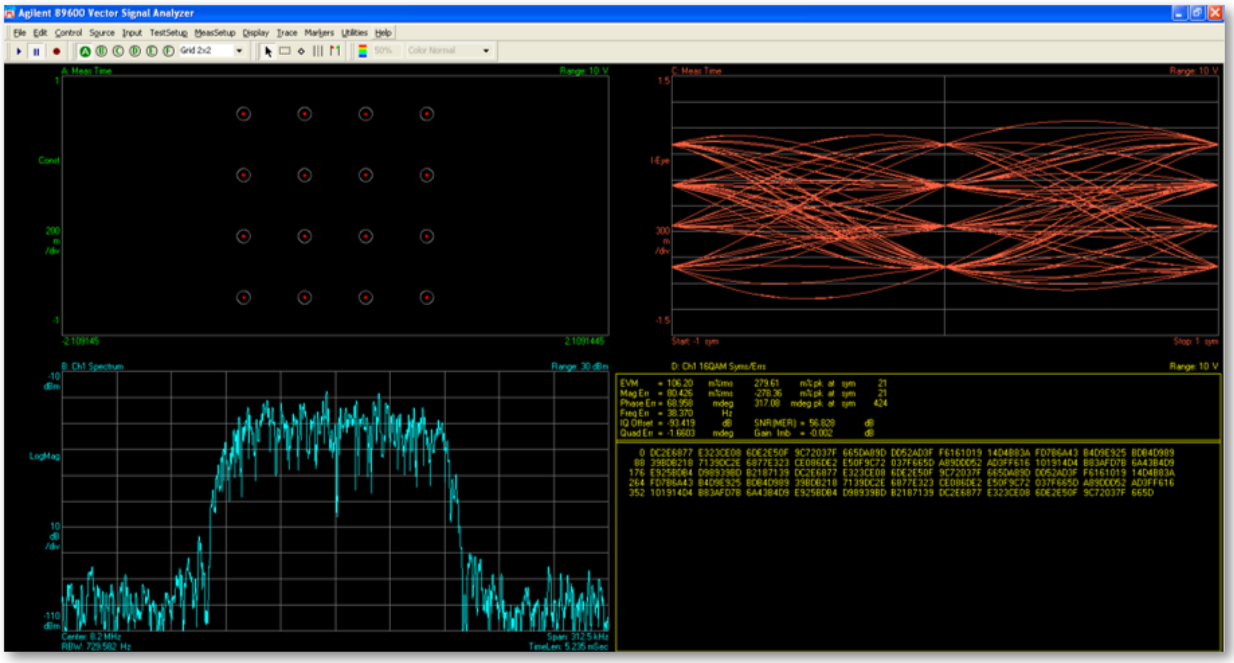
**Analog** CW, AM, DSB-SC, FM, and Frequency Sweep.

**Digital ARB (Arbitrary Waveform) Test Generator** with customizable BPSK, QPSK, 8-PSK, QAM-16, QAM-32, QAM-64, QAM-256, APSK-16, and APSK-32 waveforms. Also supports IQ data .csv file import. Waveform memory of up to 1024 samples transmitted repetitively.

A convenient utility for transmitter and receiver digital waveform linearity evaluation.




Agilent 89600 Vector Signal Analyzer QAM-16 EVM Performance: 0.1% rms



## 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.

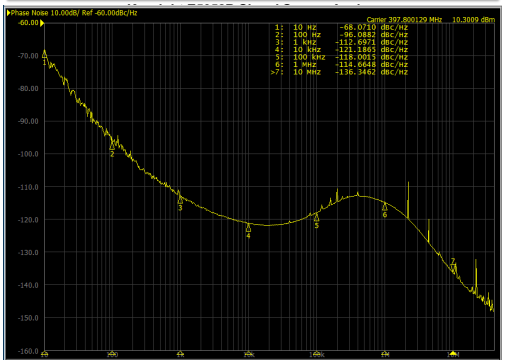
**Frequency Reference Key Features Table**

| 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 |



**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**

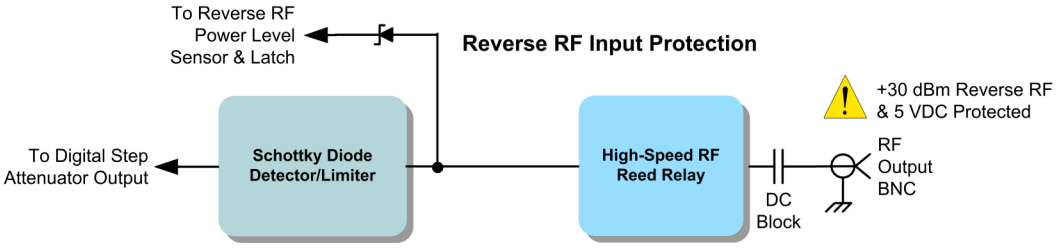
**Keysight E5052B Signal Source Analyzer**

**Recommended GPSDO:**
***Mini Precision GPS Reference Clock***
**Source:** Leo Bodnar Electronics

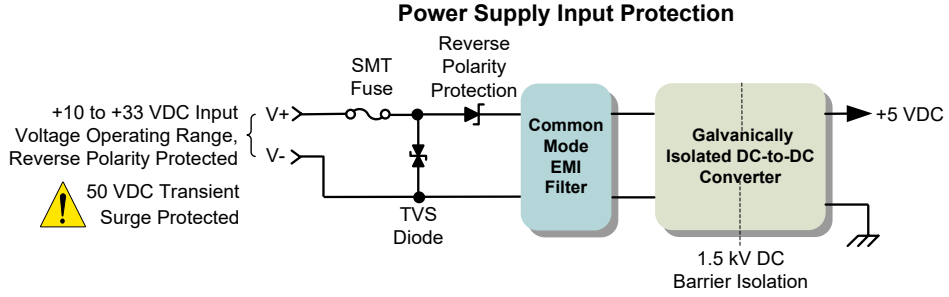


## Key Protection Features

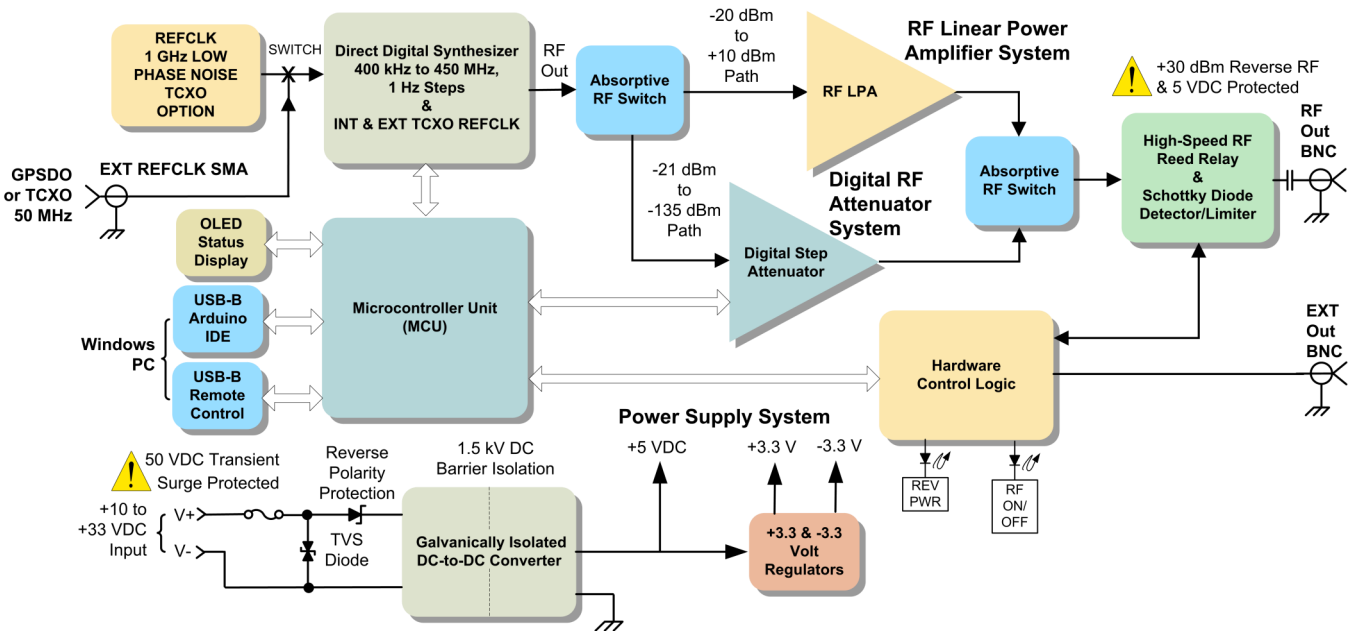
- **RF Input Protection** for the inadvertent application of reverse RF up to +30 dBm is achieved through a high-speed RF reed relay and a Schottky diode limiter. In operation, levels above +20 dBm will latch the RF output reed-relay open. During the relay's 0.05 ms transition time, reverse power is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

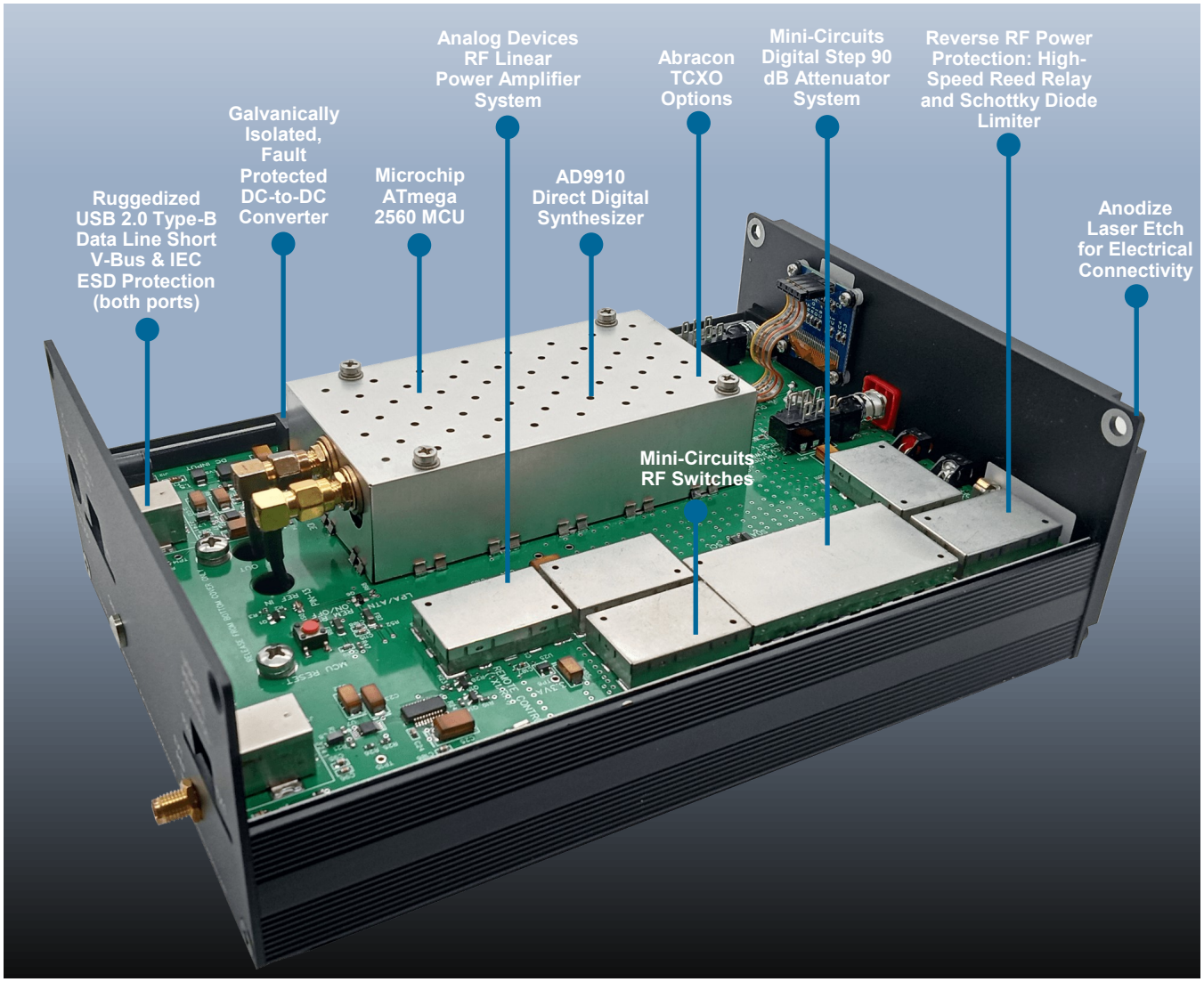



- **DC Power Input Protection** is provided by a slow-blow fuse, 600-Wpk transient voltage suppressor (TVS) diode, line-to-line and line-to-ground bypass capacitors, a series reverse-polarity Schottky power diode, and common mode EMI filter. In addition, the dc -to-dc converter galvanically isolates the input DC power from the 5-volt system through a 1.5 kV DC 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.

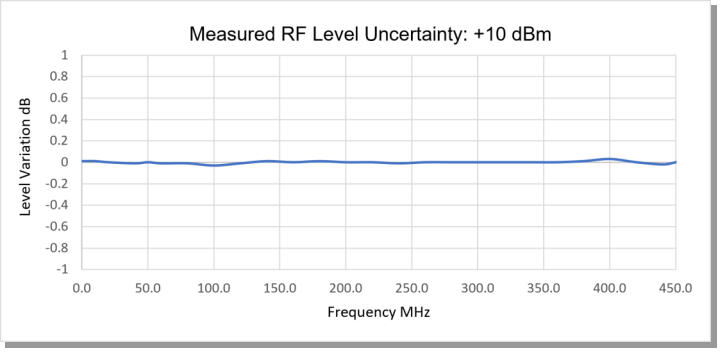


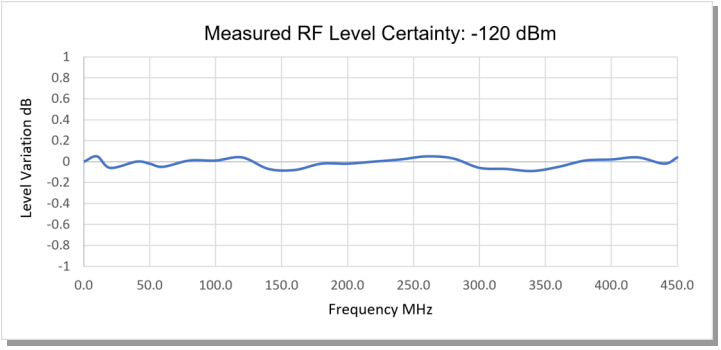
## Block Diagram & Interior View

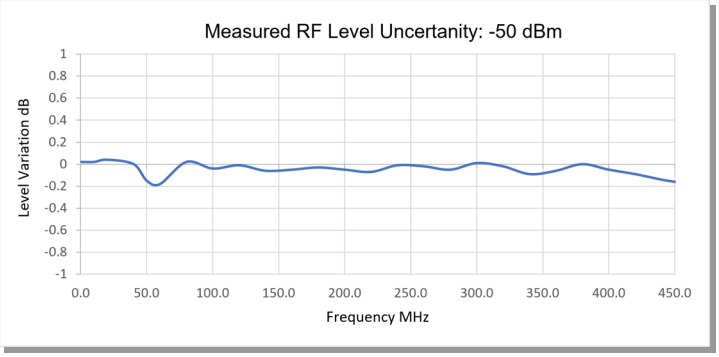


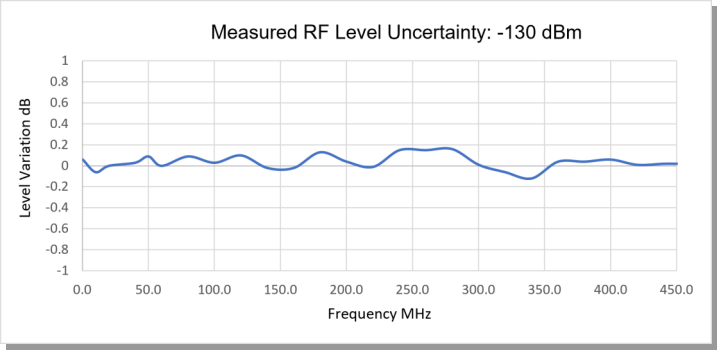



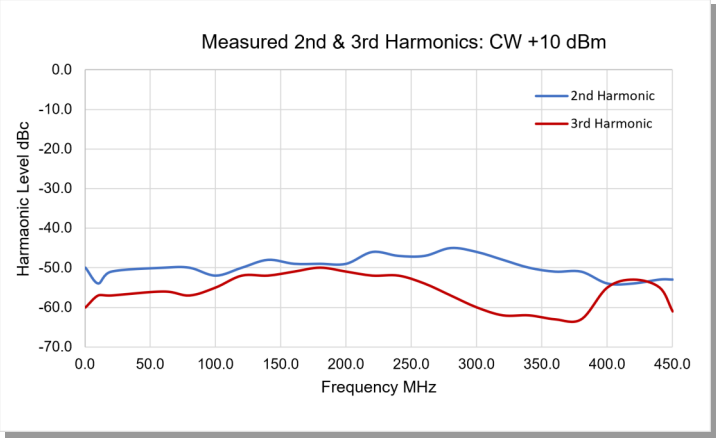
## Measured Performance:
## RF Level Uncertainty, Harmonic Content & Linearity

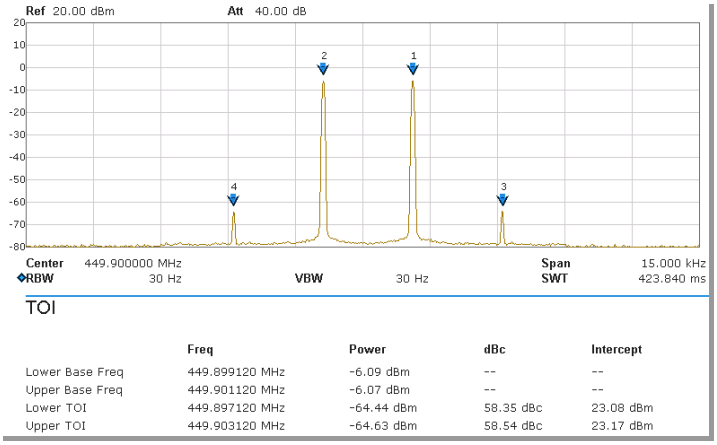



| | Freq | Power | dBc | Intercept |
|---|---|---|---|---|
| Lower Base Freq | 449.899120 MHz | -6.09 dBm | -- | -- |
| Upper Base Freq | 449.901120 MHz | -6.07 dBm | -- | -- |
| Lower TOI | 449.897120 MHz | -64.44 dBm | 58.35 dBc | 23.08 dBm |
| Upper TOI | 449.903120 MHz | -64.63 dBm | 58.54 dBc | 23.17 dBm |

**Linearity Performance**
**449.9 MHz, 0 dBm PEP, DSBSC 2 kHz Tone Spacing**
**3rd Order IMD Products: 64 dB below PEP (58 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: 500 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: ≤ ± 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: ≤ ±0.1 dB over 8-hours @ 25° C

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 µs, Trigger low RF-off delay: ±10 µs

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 µs

### 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, Fc = 398.7 MHz, 20 kHz offset

1 GHz TCXO (Option 020): -139 dBc/Hz typical, Fc = 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

3rd Order IMD (449.9 MHz, 2 kHz Spacing, 0 dBm PEP): > 60 dB below PEP typical

### 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

### ARB Waveform Test Generator

Waveforms: BPSK, QPSK, 8-PSK, QAM-16, QAM-32, QAM-64, QAM-256, APSK-16, APSK-32, and IQ data .csv file import

Waveform Memory: Up to 1024 samples transmitted repetitively

Symbol Rate: 3.725 Hz to 250 MHz

Samples/Symbol: 1 to 1024

Filter Types: Root Raised Cosine, Root Raised Cosine with Sinc Compensation, Raised Cosine, and Raised Cosine with Sinc Compensation

Alpha: 0 to 1; Filter Taps: 1 to 1024

EVM: 0.1% Typical

### Frequency Sweep

Sweep Type: Linear

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

Sweep Mode: Continuous

Sweep Time: 10 ns to 1000 seconds

Dwell Time: 100µs fixed for sweeps > 250 ms

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

EXT In Trigger: Single shot 15 µs 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 ± 8kV 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 kV DC 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: Linear AC transformer/bridge rectifier, 18 VDC 9 W output, 120 VAC ± 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 µs 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 ±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 | 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.




**Copyright** © 2020 by Talon Power Systems LLC. All rights reserved

**Disclaimer:** Talon Power Systems reserves the right to make changes to any products herein to improve reliability, function or design.

Talon Power Systems does not assume any liability arising out of the application or use of any product described herein.

Specifications, descriptions, and illustrative material in this literature are as accurate as known at the time of publication, but are subject to change without notice.

Printed in the United States

9000-000513 Rev-A 06-Nov-26 © Talon Power Systems