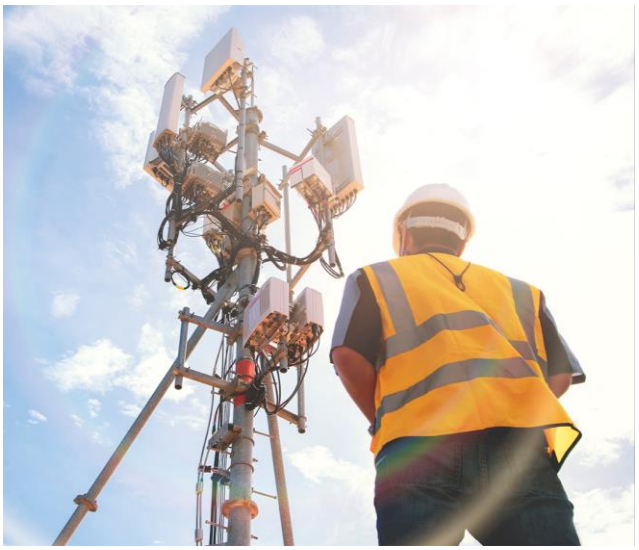
Model 12100 Series
RF Power Sensors



Features

- Converge from 9kHz - 50GHz
- Accurate power measurements on any modulated signal
- Dynamic range: -60 dBm to +25 dBm
- Variety of options such as triggering, security, and analog outputs
- Command compatible with U2000
- SPI and I2C interfaces
- USBTMC, USBHID IVI foundation, and SCPI command set
- Extensive internal memory for trace and long term logging
- Real time clock and backup

Model 12100 Series

9 kHz to 8 GHz RF Power Sensor

Applications

- ATE
- Direct Control
- Research and Development
- Manufacturing
- Radar, satellite, and telecommunications

CONTENTS

GENERAL DESCRIPTION

Berkeley Nucleonics is excited to release our newest line of RF average power sensors: the Model 12100 Series. These versatile and easy-to-use sensors boast an impressive 9 kHz to 50 GHz bandwidth. With a dynamic range of -60 dBm to 26 dBm, these sensors can measure even the most subtle RF signals with industry-leading accuracy. This makes the Model 12100 an ideal choice for any RF application where obtaining true average power readings are critical for project success. Measuring average power on any type of modulation (802.11ac, gsm, cdma 2000, DCMA (IS-95), TDMA, Multi-Tone, OFDM, CW, QAM, etc) has never been easier. Since 1963 Berkeley Nucleonics has provided the highest standard of test and measurement equipment and the Model 12100 RF average power sensor is no exception.

These sensors offer simple, plug and play operation. This means no zeroing, no calibration before use, and no bulky meters and cable harnesses to manage. The Model 12100 sensors can be used with minimal setup time and hassle, saving valuable hours and allowing users to take measurements almost immediately whether they are in a lab or in the field. With a deep internal memory and internal or external triggering, long term data logging is managed elegantly. While at the forefront of RF power measurement technology, our innovative technology will not destroy your budget. We leverage modern components and chip sets which drive down cost. Our new sensor family is compact and rugged, unmatched in traceable power accuracy and yet costeffective for the budget constraints of our time. Visit the product page for a growing range of options addressing programmatic and embedded applications, excellent SCPI options, a real time clock and more.

BNC PowerEye is an included software package giving users a suite of handy tools. The software is easy to install, straightforward to use, and able to deliver information vital to RF engineers. A demo version is available online at www.berkeleynucleonics.com and software tools are always free. Whether you have needs for large system integration and user specified data inputs/outputs, or smaller, on-the-bench R&D projects, the Model 12100 sensor deserves your consideration. A quick phone call, email or live ‘engineer-chat’ will quickly illustrate why the T&M industry has turned to Berkeley Nucleonics routinely for over 60 years. We look forward to hearing from you.

SPECIFICATIONS

Frequency Range	**12108L:** 9 kHz to 8 GHz **12108S:** 1 MHz to 8 GHz **12118L:** 9 kHz to 18 GHz **12118S:** 1 MHz to 18 GHz **12126L:** 9 kHz to 26.5 GHz **12126S:** 1 MHz to 26.5 GHz **12140L:** 9 kHz to 40 GHz **12140S:** 1 MHz to 40 GHz **12144L:** 9 kHz to 44 GHz **12144S:** 1 MHz to 44 GHz **12150L:** 9 kHz to 50 GHz **12150S:** 1 MHz to 50 GHz **12154L:** 9 kHz to 54 GHz	
Input Power Range	-60 to +26 dBm	
Continuous Average Power	+26 dBm (400 mW)	**Damage Level:** +29 dBm (800 mW)
Peak Pulse Power	+33 dBm (2 W)	**Damage Level:** +36 dBm (4 W)
Maximum Energy Per Pulse	20 W-us	**Damage Level:** 40 W-us
Maximum DC Input Voltage	**Low:** 10 VDC (On the RF Input) **Standard:** 16 VDC (On the RF Input)	
Typical VSWR	**12108L/12108S/12118L:** < 1.1:1 **12118S:** < 1.10:1 **12126L:** < 1.14:1 **12126S:** < 1.28:1 **12140L/12144L/12144S:** < 1.28:1 @ 40 GHz **12140S:** < 1.28:1 **12150L:** < 1.39 **12150S:** < 1.39 **12154L:** <1.28:1 @ 44 GHz; <1.94:1 @ 54 GHz	
Typical Total RSS Error	**12108L:** 1.31% **12108S:** 1.09% **12118L/12118S:** 1.3% @15 GHz **12126L:** 1.71% @18 GHz **12126S/12140L/12140S:** 2.87% @30 GHz **12144L/12144S:** 2.77% @44 GHz **12150L:** 2.77% @50 GHz **12150S:** 2.77% @50 GHz **12154L:** 2.77% @ 44 GHz; 3.73% @ 54 GHz	
Standard Connector	**12108L/12108S/12118L/12118S:** High quality Type-N male **12126L/2126S:** High quality 3.5 mm male **12140L/12140S:** 2.92 mm Male **12144L/12144S:** High quality 2.4mm male **12150L:** High quality 2.4mm male **12150S:** High quality 2.4mm male **12154L:** high quality 2.4mm male	
Recommended Calibration Cycle	1 year	

Note 1: Pulse repetition must respect average power over anyone pulse duty cycle, regardless of varying duty cycle

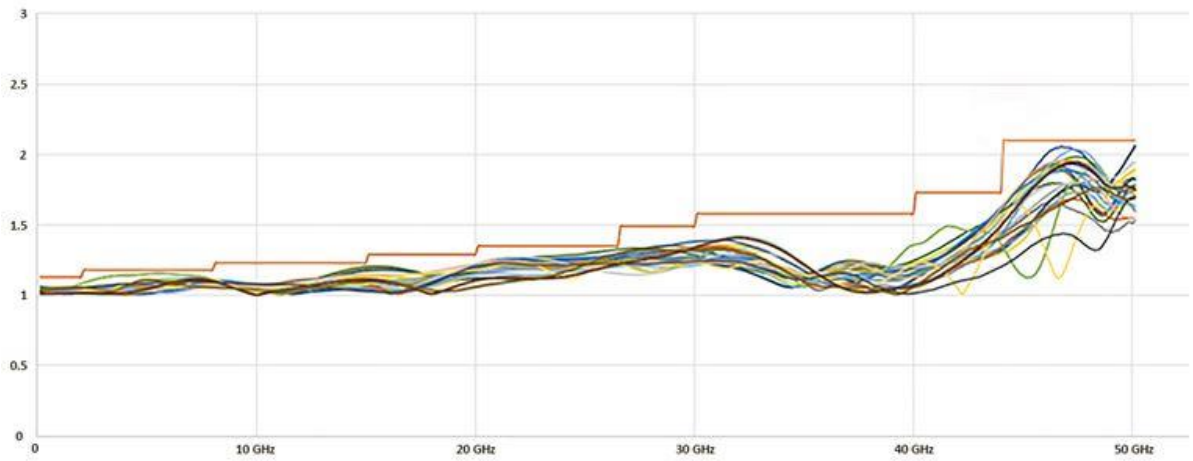
VSWR SPECIFICATIONS

12100L Series

Model	Parameter	Specifcation
	Match (Type-N male)	(VSWR)
All 12100L Series	9 kHz to 15 kHz	1.45
	15 kHz to 40 kHz	1.25
	40 kHz to 2 GHz	1.13
	2 GHz to 8 GHz	1.18
	Match (Type-N male)	(VSWR)
12118L and above	8 GHz to 15 GHz	1.23
	15 GHz to 18 GHz	1.29
	Match (3.5 mm)	(VSWR)
12126L and above	8 GHz to 18 GHz	1.23
	18 GHz to 24.5 GHz	1.30
	24.5 GHz to 26.5 GHz	1.35
	Match (2.92 mm)	(VSWR)
12140L and above	26.5 GHz to 30 GHz	1.49
	30 GHz to 40 GHz	1.58
	Match (2.4 mm connector)	(VSWR)
12144L	40 GHz to 44 GHz 1	1.73
12150L	44 GHz to 50 GHz	1.39
12154L	50 GHz to 54 GHz	2.20

12100S Series

Model	Parameter	Specification
	Match (Type-N male)	(VSWR)
121008S and above	1 MHz to 2 GHz	1.13
	2 GHz to 8 GHz	1.18
	Match (Type-N male)	
12118S	8 GHz to 15 GHz	1.23
	15 GHz to 18 GHz	1.29
	Match (3.5 mm)	(VSWR)
12126S	8 GHz to 18 GHz	1.23
	18 GHz to 24.5 GHz	1.30
	24.5 GHz to 26.5 GHz	1.35
	Match (2.92 mm)	(VSWR)
12140S and above	15 GHz to 20 GHz	1.29
	20 GHz to 26.5 GHz	1.35
	26.5 GHz to 30 GHz	1.49
	30 GHz to 40 GHz	1.58
	Match (2.4 mm connector)	(VSWR)
12144S	40 GHz to 44 GHz	1.73
12150S	44 GHz to 50 GHz	1.39



Model 12100 Series: Match (VSWR) Specification Maximum (orange line) Typical Production Test Data

12100L Series

Model	Parameter	Specifcation
	Calibration Factor Unc (Type-N Male)	K=2 (K is coverage factor)
12108L – 12140L	9 kHz to 15 kHz	2.88%
	40 kHz to 2 GHz	2.23%
	2 GHz to 8 GHz	2.45%
	Calibration Factor Unc (Type-N Male)	K=2 (K is coverage factor)
12118L - 12140L	10 GHz to 18 GHz	2.85%
	Calibration Factor Unc (3.55mm Male)	K=2 (K is coverage factor)
12126L/12140L	18 GHz to 26.5 GHz	2.9%
	Calibration Factor Unc (2.9mm Male)	K=2 (K is coverage factor)
12140L	26.5 GHz to 30 GHz	3.42%
	30 GHz to 40 GHz	3.9%
	Calibration Factor Unc (2.4mm Male)	K=2 (K is coverage factor)
12144L/12150L	9 kHz to 40 kHz	2.88%
	40 kHz to 2 GHz	2.23%
	2 GHz to 8 GHz	2.45%
	10 GHz to 18 GHz	2.85%
	18 GHz to 26.5 GHz	2.9%
	26.5 GHz to 30 GHz	2.65%
	30 GHz to 40 GHz	2.82%
	40 GHz to 44 GHz	2.94%
	44 GHz to 50 GHz	3.42%
	50 GHz to 54 GHz	5.81%
	Linearity Unc	
	+10 dBm to +20 dBm	3.0%
	-10 dBm to +10 dBm	2.0%
	-20 dBm to -10 dBm	3.5%
	-60 dBm to -20 dBm	2.0%

12100S Series

Model	Parameter	Specification
	Calibration Factor Unc (Type-N Male)	K=2 (K is coverage factor)
12108S/12118S	5 MHz to 2 GHz	1.79%
	2 GHz to 8 GHz	1.53%
	Calibration Factor Unc (Type-N Male)	K=2 (K is coverage factor)
12118S	2 GHz to 10 GHz	1.53%
	10 GHz to 18 GHz	1.78%
	Calibration Factor Unc1(3.5mm Male)	K=2 (K is coverage factor)
12126S - 12144S	5 MHz to 2 GHz	2.23%
	2 GHz to 10 GHz	2.45%
	10 GHz to 18 GHz	2.85%
	18 GHz to 26.5 GHz	2.9%
	Calibration Factor Unc1(2.92mm Male)	K=2 (K is coverage factor)
12140S	26.5 GHz to 30 GHz	3.42%
	30 GHz to 40 GHz	3.9%
	Calibration Factor Unc1(2.4mm Male)	K=2 (K is coverage factor)
12144S/12150S	26.5 GHz to 30 GHz	2.65%
	30 GHz to 40 GHz	2.82%
	40 GHz to 44 GHz	2.94%
	Linearity Unc	
	+10 dBm to +20 dBm	3.0%
	-10 dBm to +10 dBm	2.0%
	-20 dBm to -10 dBm	3.5%
	-60 dBm to -20 dBm	2.0%

Calibration Factor and Linearity notes for Model 12100S Series:

1. For Noraml Mode add 1%
2. For Normal Mode add 1.5%

NOISE SPECIFICATIONS

Parameter	Specification	Typical
Average Mode Noise		
-40 dBm to +26 dBm3	0.35%	0.025% to 0.15%[4]
-60 dBm to -40 dBm	0.5nW[5]	0.2nW[6]
Normal Mode Noise 2ms Gate		
+10 dBm to +26 dBm	0.35%	0.15%
0 dBm to +10 dBm	0.5%	0.25%
-8 dBm to 0 dBm	1.0%	0.5%
-25 dBm to -8 dBm	1.5%	0.75%
-38 dBm to -25 dBm	28 nW	20 nW
-45 dBm to -38 dBm	95 nW	50 nW
Normal Mode Noise 1us Gate		
+10 dBm to +26 dBm	0.45%	0.18%
0 dBm to +10 dBm	3%	2%
-38 dBm to 0 dBm	8.5%	1% to 4%

Noise notes for Model 12100L Series:

3. Noise is two times the standard deviation of 100 measurement points
4. Number of Averages for each measurement rate
   Normal 16; Double 32; Super 384
5. For Normal measurement rate, when averages above 16 and power is above -40 dBm noise error is insignificant
6. Varies with power level
7. Noise is determined by multiplying the value by 4/sqrt(Normal measurement rate averages)
   Example 1(Specification): For 1024 Averages noise is less than 0.5nW*(4/sqrt(1024)) = 0.063nW
   Example 2(Specification): For 128 Averages noise is less than 0.5nW*(4/sqrt(128)) = 0.18nW
8. Noise is determined by multiplying the value by 4/sqrt(Normal measurement rate averages) Example 1(Typical): For 1024 Averages noise is less than 0.2nW*(4/sqrt(1024)) = 0.025nW Example 2(Typical): For 128 Averages noise is less than 0.2nW*(4/sqrt(128)) = 0.071nW

ZERO OFFSET SPECIFICATIONS

Model	Parameter	Specification
All 12100 Series	Zero Offset (Average Mode)	{[(1.0nW @ 25ºC) + |ΔT| x(0.075nW/ºC)] ± 0.01nW /month}
12100S Series	Zero Offset (Normal Mode)	50 nW +/- 1 nW/month

Zero Offset notes for all Model 12100 Series:

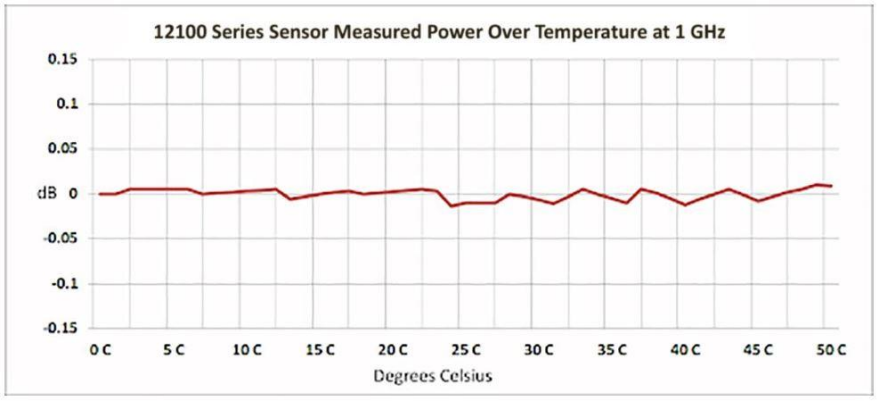
1. Use the following formula to determine Zero Offset uncertainty (%): Z = (Zero Offset Power / Measured Power)*100.
2. Linearity and Zero Offset are measured as a combined specification as Berkeley Nucleonics' sensors require no meter zeroing or reference calibration before use.

TEMPERATURE SPECIFICATIONS

Model	Parameter	Specification	Typical
	Temperature Unc (Average Mode)		
All 12100 Series	40°C - 55°C	2.5%	0.5%
	30°C - 40°C	0.5%	0%
	20°C - 30°C	0%	0%
	10°C - 20°C	0.5%	0%
	0°C - 10°C	2.5%	0.5%
	Temperature Unc (Normal Mode)		

Thermal Stability

Berkeley Nucleonics' thermal stability technology is utilized in the Model 12100 Series. Measurements remain stable over the entire operating temperature range. No user intervention, zeroing or calibration is required. This patented process also defines the zero-power conditions and eliminates zeroing requirements. Measurements are not interrupted for zeroing or calibration.



KEY FEATURES

- RMS Responding & modulation independent
- **Interfaces:** USBTMC and USBHID – Optional SPI or I2C TTL
- Industry compatible IEEE 488.2 SCPI Command Set
- Command compatible
- Thermally Stable – no drift
- No user Zero required before use
- Compatible with Windows, LINUX & More
- Full dynamic range processed with each sample
- Optional unattended autonomous capability & measurement storage
- **Security Options:** MIL and SEC

BNC POWEREYE PRECISION METER SOFTWARE

The Model 12100L series sensors use BNC PowerEye Precision Power Meter software. The software allows users to make a wide variety of measurements from basic average power measurements to complex triggered measurements. Refer to the BNC PowerEye user's manual for further information.

In addition to BNC PowerEye, Berkeley Nucleonics provides an interactive IO utility with source code, a Persona utility, plus a variety of programmatic code and support.

BNC POWEREYE PRECISION POWER METER FEATURES

- For use with any 12100 Series Sensor
- Two sensor calculation windows with calculations for Gain, Loss VSWR, Reflection Coefficient, Mismatch Loss, Return Loss
- USB threading increases performance when using multiple sensors
- Triggering control including setting Level, Delay, Slope, Hysteresis, Impedance, more.
- Tabular logging with file storage and retrieval
- Controls Option UOP (Unattended Operation) and Option 001 (Analog Recorder Out)
- Recorder Out (analog out) control for scaling etc.
- Offset controls including simple offset and frequency dependent offset tables

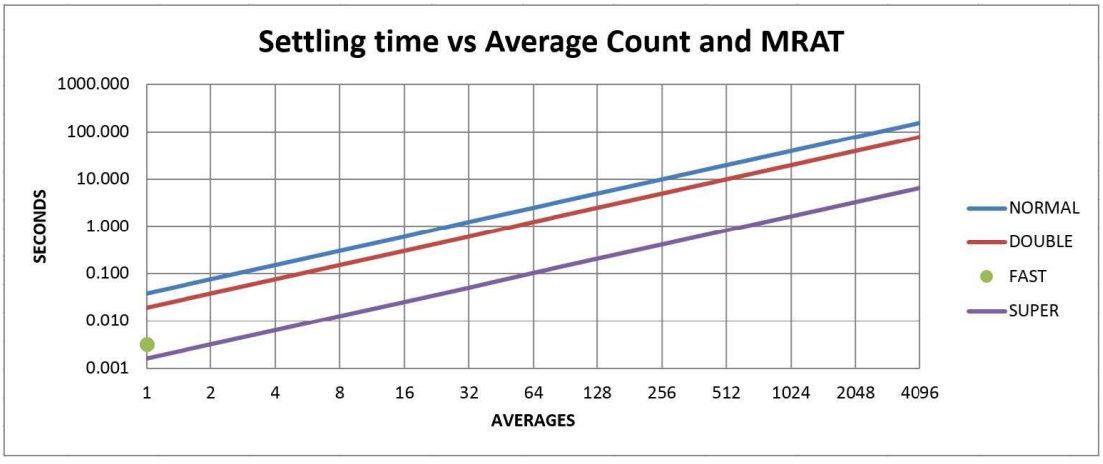
All 12100 Series: Average Detector Mode Measurement Rate (MRAT)

Setting	Normal	Double	Fast	Super
Samples per measurement	384	192	32	16
Number of Averages per Measurement	1 to 1024	1 to 1024	1	1 to 4069
Measurement time per Average	38.4ms	19.2ms	3.2ms	1.6ms

12100 Series: Normal Detector Mode Video Bandwidth

Parameter	Minimum	Typical
Auto Range	8 kHz	10 kHz
Number of Averages per Range = 1 (-15 dBm (typical) to 26 dBm)	40 kHz	60 kHz
Range = 0 (-45 dBm to -12 dBm (typical)	8 kHz	10 kHz

Setting time in seconds for Average Detector Mode; 30 dB decreasing power step



Interface Connectivity

The 12100 series sensors support both USBTMC and USB HID. Direct control of the sensor is also possible using optional SPI and I2C interface ports. These connectivity functions are optimized for programmatic control as well as unattended and logged power measurements. The sensors can be set up, controlled and data taken from any of the connectivity options. Berkeley Nucleonics' sensors are provided with a full featured application that utilizes the sensor's USB interfaces. Refer to the Option SPI documentation for information regarding I2C and SPI interfaces.

USBTMC	USB488 compliant
USB HID	USB Human Interface Device Class compliant
SPI / I^2C (Option SPI)	Cable and connector are included with option SPI. Cable may also be used to power the sensor for unattended applications.

Remote Programming

The sensor is designed for full programmatic control in ATE systems and other applications requiring remote programming. 12100 Series sensors use SCPI (Standard Commands for Programmable Instruments) commands. The sensor's three connectivity options use the SCPI command set.

Supporting Ports	USBTMC, USB HID, SPI/I^2C
Command Set	SCPI (Standard Commands for Programmable Instruments)
Compatibility	Compatible with systems using USBTMC programmatic control, NI™ & Agilent™ Visa IO libraries, Agilent™ U2000 & others using SCPI command set.*

***Agilent is a trademark of Agilent Technologies Inc; NI is a trademark of National Instruments, Inc.**

Analog Recorder Output

Option 001, Analog Recorder Out. Recorder Output is a filtered analog output that can be used for various purposes. The output provides an accurate scaled voltage representing the power level of the signal. The output is linear (not log dB) and can be scaled. When enabled, Recorder Out uses the same SMB port used by Trigger Out making the port unavailable for triggering use. Trigger in is not affected.

Output filter bandwidth	Average Detector mode: 0.001 Hz to 32 Hz (settable) Normal Detector mode: 0.001 Hz to 81 Hz (settable)
Output range	0 to 1 Volt into 1,000 Ohms. Note: Potential of 2.5 Volts when set as Recorder Out; or 5 Volts when used as Trigger Output
Output impedance	1 k Ohms
Resolution	+/- 25 µV
DC Offset	0 to 5 mV
Scale	Linear
Connector	SMB Male (shared with Trigger Out and Wideband Video Out)

Triggering

The 12100 Series Sensors' trigger functions including slope, level, trigger delay, hold off and rearm delay can be set. External trigger Input and are available for gated measurements, synchronizing multiple sensors, or other purposes. Trigger Input and output use SMB Male connectors, these may be shared with other options.

General	
Trigger source	Internal (signal level), Immediate, External / Internal triggering not supported(12144L)
Trigger Delay range	+/- 10 Seconds
Auto trigger delay	Varies based on resolution setting (Default 45 ms). Average Mode: 11 ms to 61 ms / Trace Mode: 44 us to 244 us (12108S)
Resolution	1us
Trigger Out pulse width	500 ns
Trigger Out level	Maximum ≈ VUSB ≈ 5.5VDC (typical). Typical high level 4.0V with 600 ohm load (With VUSB=5.0V). Max low level 0.8 V. Minimum load resistance 200 ohms.

Internal Triggering	
Level	Settable to approximately -50 dBm to 20 dBm
Level resolution	0.1 dB
Slope	Positive or Negative
Hysteresis	Settable to 0 dB to 3 dB

External Triggering	
Trigger Input	Min high level 2.0 Volts, Max low level 0.8 Volts
Input Load	Selectable 100 kΩ or 50Ω
Triming requirements	Minimum pulse: Width 25 ns (on), 25 ns (off); Repetition: 50 ns (min)
Absolute input limits	+5.5 Volts maximum; -0.5 Volts minimum

Store, Recall and Logging Memory

The 12100 series contains volatile and non-volatile memory.

Store and recall functions for the sensor's state and register functions such as Frequency, Averages and Analog Recorder Out settings have a lifetime of 1 million write and erase cycles.

When Option UOP is present, the sensor contains separate, non-volatile flash memory that is designed for long term logging of measurements.

Note: If option MIL (security) is ordered, non-volatileflash memory is not accessible. This includes all state and register functions such as Frequency, Averages, Analog Recorder Out etc.

Memory & Storage Specifications

Parameter	Specification
Non-volatile NAND flash	50 Million measurements
Maximum storage rate	1000 measurements per second

Unattended Operation (UOP)

Unattended operation is used to make autonomous measurements. Once set up using a computer, the sensor only requires power to function. Measurements are stored in the sensor's non-volatile memory and are time stamped using the sensor's internal real time clock. The option allows the use of trigger functions. Recorder output can be enabled while in unattended operation allowing calibrated analog output functions with no computer or power meter connected. Power can be applied using a USB power only cable or if Option SPI has been purchased, its ribbon cable can be used to apply power. Measurement storage using UOP is not possible when Option MIL is installed.

Real Time Clock

If Option UOP is present, the 12100 Series Sensors contain a real time clock that is used to timestamp logged measurements. When the sensor is powered on, the sensor's high accuracy time base is used to increase the accuracy of the real time clock.

Time Accuracy	Typical: Un-powered 20 ppm at 25 degrees Celsius; Under power & stable, 2 ppm (disciplined by high accuracy time-base). Consult the factory for further information.
Functionality	Provides timestamp data for measurements stored in memory. When used with Option UOC (unattended operation), can deactivate low power mode, trigger measurements and activate low power mode
Backup	Super cap. When fully charged, it provides 1 day (typical) RTC operation with no power applied to the sensor. Minimum charge time 5 minutes.

Environmental	Operating	Storage
Temperature	0°C to 55°C	-25°C to 85°C
Humidity	15% - 95% non-condensing	15% - 95% non-condensing
Altitude	10,000 feet (3,000 meters)	50,000 feet (15,000 meters)

Initial Stabilization Time

For general use, the 12100 series sensors are stable 5 minutes after electrical power is applied. Specifications detailed in this datasheet are valid ONLY after a 30 minute warm up period and for continuous wave (CW) signals unless otherwise stated. The recommended calibration interval for this product is one year. Specifications apply over the listed temperature and relative humidity range unless otherwise stated.

Option MIL

Option MIL is designed to address security and data sanitization issues. When purchased with this option, the user cannot write to any non-volatile memory. Consult the factory for additional information regarding option MIL.

Sanitization Option (SEC)

The sanitization option adds secure erase capability. When the SEC command is executed, all non-volatile memory is erased including User Presets, Persona information, Store & Recall data, User Cal, Simple offsets and FDO tables. The process is anerase - random overwrite eraseprocess. For additional security users can executethe command repeatedly. The option is not available if Option MIL is purchased because non-volatile memory writes are disallowed with the option.

MODEL 12100 SERIES: ORDERING OPTIONS

ATE Mounting Bracket (Also shown with SPI cable)

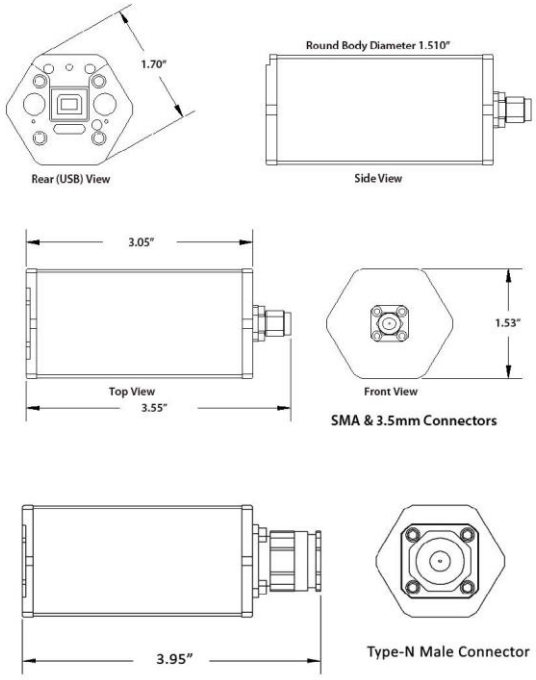
Secure USB Cable

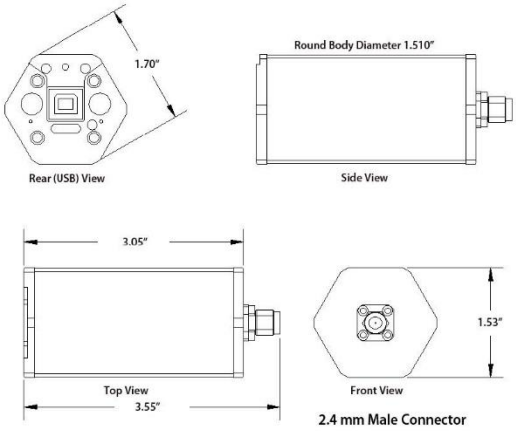
SPI / I^2C Demonstration Kit Available

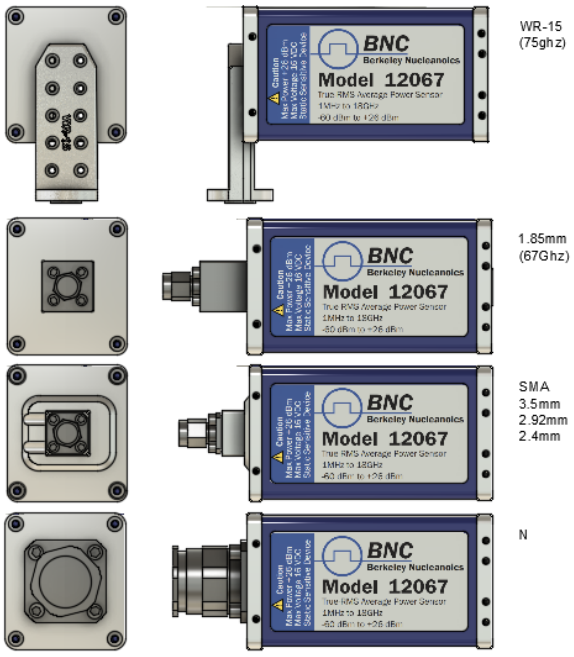
Optional Connectors Available

MODEL 12100 SERIES OUTLINE DRAWINGS

Dimension tolerance +/- 0.063”







DOCUMENT HISTORY

Version	Date	Author	Notes
2.1	2024-4	at	Edited temperature specifications

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