LadyBug Technologies, LLC

LB5926A-LAN

True-RMS Power Sensor
With HiSLIP LAN Interface

LB5926A-LAN Power Sensor

Key PowerSensor+™ Specifications

- **Frequency Range: 1 MHz to 26.5 GHz**
- **Dynamic Range: -60 dBm to +26 dBm**
- **< 1.28:1 Typical VSWR**
- **1.71% Typical total RSS error @18 GHz**
  (See example on page 15 of this document)
- **Standard Connector 3.5mm Male**
- **RMS Responding & modulation independent**
- **Interface: HiSLIP over Ethernet, LAN with PoE**
- **Industry compatible IEEE 488.2 SCPI Command Set**
- **Thermally Stable - no drift**
- **No User Zero required before use**
- **Full dynamic range processed with each sample**
- **Optional unattended autonomous capability & measurement storage**
- **Security Options**

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General Description

The LB5926A is a high accuracy True-RMS Power Sensor for general purpose use. The sensor utilizes a highly accurate, thermally stabilized, two path, RMS responding, square law diode detection scheme. The sensor makes accurate measurements on any signal regardless of its modulation bandwidth.

The sensor's patented thermally stable technology means that measurements do not drift and user zeroing & calibration before use are eliminated. Measurement interruption due to automatic calibration is also eliminated bolstering the performance and reliability of ATE systems. Unlike competitive sensors, it is never necessary to disconnect the source to zero your LB5900 series sensor.

The sensor utilizes standard SCPI commands and is compatible with competitive VISA IO libraries.

The sensor includes a rich set of triggering capabilities such as level controlled internal triggering, external triggering, delays, hold off and more.

Optional UOP, Unattended Operation can be set to store and retrieve measurement data while off line. Once measurements are set up, a computer or power meter is not required to operate the sensor making it ideal for unattended applications. A high accuracy real time clock included.

Optional Recorder (calibrated analog output) for leveling and control applications. Note: Since measurements and setup is through LAN, utilizing Analog Recorder Out (Option 001) requires manual setup using multiple SCPI commands through an Interactive IO or automated ATE system.

Option MIL prevents the sensor from accepting any writes to non-volatile memory assuring data security.

Option SEC, Secure Erase allows the user to erase all user set non-volatile memory including customer calibration, presets, offsets, FDO's (Frequency dependent offset) and UOP memory.

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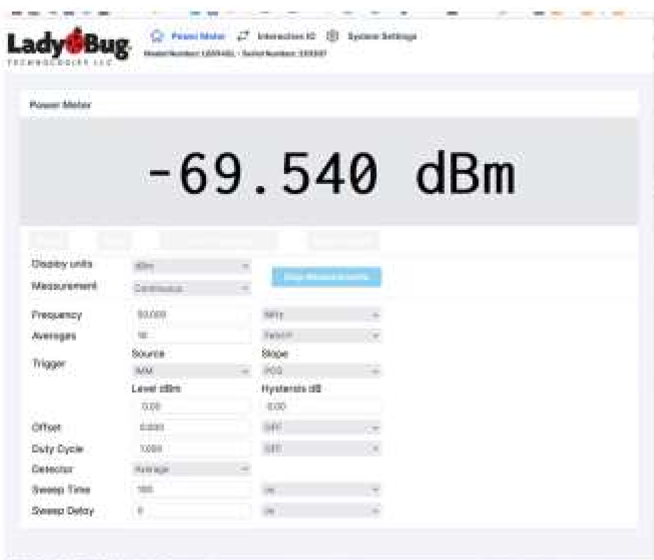
Web Based Power Meter Features

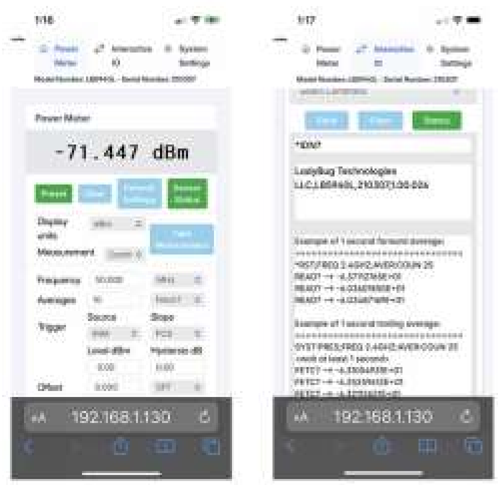
LB5900 series sensors with LAN can utilize the built in web power meter application. This browser based application includes measurement capabilities as well as an Interactive IO that allows users to send programmatic SCPI commands and queries.

WEB Based Power Meter features include

- Automatically size adjust to desktops, phones, and other screens
- Easily make and control average power measurements
- Utilize advanced measurement capabilities, such as triggering
- Easily default to standard settings
- Control the sensor's LAN settings
- Built into the sensor, nothing to download
- Set and enable simple offset
- Set and enable Duty Cycle correction



Power Meter on a PC



Power Meter Interactive IO
on a small phone

Example sensor Internal Webpages on desktop computer and small phone

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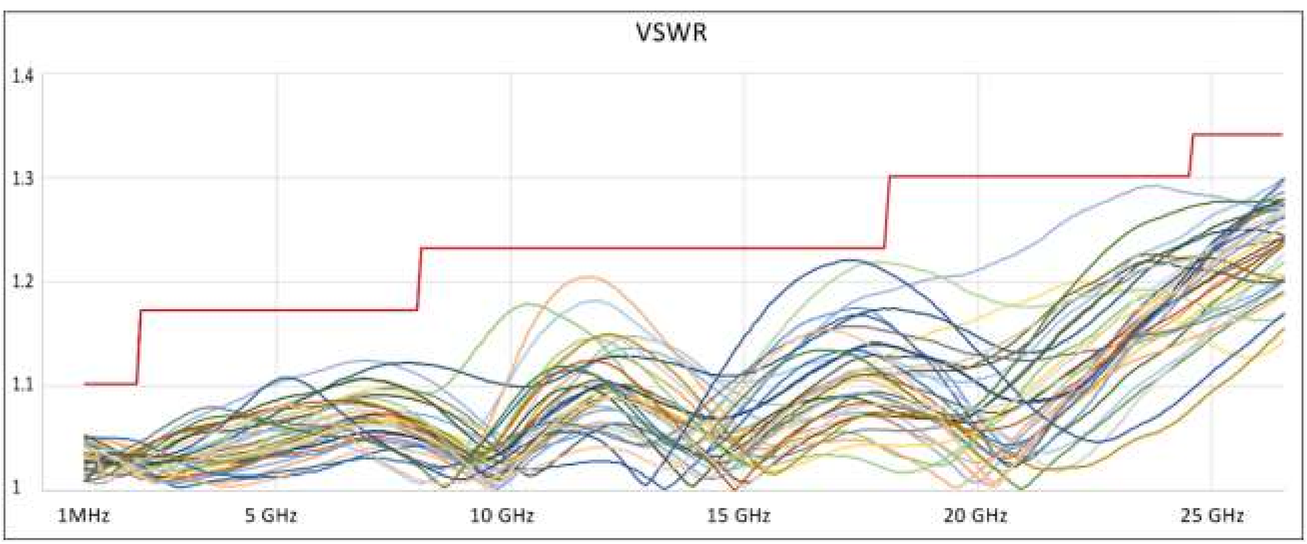
Parameter	Specification	
Connector	3.5 mm Male	
Frequency Range	1 MHz to 26.5 GHz	
Dynamic Range (Calibrated Measurement Range)	Average Mode (default) -60 dBm to +26 dBm	
	Normal Mode -40 dBm to +26 dBm	-45 dBm to +26 dBm (Typical)
Maximum Power Level		
Continuous average power	+26 dBm (400 mW)	Damage Level: +29 dBm (800 mW)
Peak pulse power[1]	+33 dBm (2 W)	Damage Level: +36 dBm (4 W)
Maximum energy per pulse[1]	20 W-us	Damage Level: 40 W-us
Maximum DC input voltage	16 VDC (On the RF Input)	
Recommended Calibration Cycle	1 year	

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

Accuracy (Total RSS Unc = $\sqrt{(Mm^2+CF^2+L^2+N^2+T^2+Z^2)}$)

Mm (Mismatch); CF (Cal Factor); N (Noise); L (Linearity); T (Temperature); Z (Zero Offset). All uncertainty terms are converted to percentages for RSS calculation. 2 Use the following formula to determine Zero Offset uncertainty (%): Z = (Zero Offset Power / Measured Power)*100. 3 Linearity and Zero Offset are measured as a combined specification as LadyBug sensors require no meter zeroing or reference calibration before use. Please refer to *Initial Stabilization Time* section for additional details.

Parameter	Specification	Typical
Match (3.5 mm)		
1 MHz to 2 GHz	1.13 VSWR	1.05 VSWR
2 GHz to 8 GHz	1.18 VSWR	1.07 VSWR
8 GHz to 18 GHz	1.23 VSWR	1.09 VSWR
18 GHz to 24.5 GHz	1.30 VSWR	1.14 VSWR
24.5 GHz to 26.5 GHz	1.35 VSWR	1.22 VSWR



Match (VSWR) Specification Maximum (red line)
Typical Production Test Data

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Parameter	Specification	Typical
Calibration Factor Unc[1] (3.5 mm Male)	K=2 (K is coverage factor)	K=1
5 MHz to 2 GHz	2.23%	1.12%
2 GHz to 10 GHz	2.45%	1.23%
10 GHz to 18 GHz	2.85%	1.43%
18 GHz to 26.5 GHz	2.9%	1.45%
Linearity Unc[2]		
+10 dBm to +20 dBm	3.0%	1.0%
-10 dBm to +10 dBm	2.0%	0.5%
-20 dBm to -10 dBm	3.5%	1.5%
-60 dBm to -20 dBm	2.0%	0.5%

Calibration Factor and Linearity notes:

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

Parameter	Specification	Typical
Zero Offset[1,2] (Average Mode)	{[(1.0nW @ 25ºC) + |ΔT| x(0.075nW/ºC)] ± 0.01nW /month}	{[(0.5nW @ 25ºC) + |ΔT| x(0.0375nW/ºC)] ± 0.005nW /month}
Zero Offset[1,2] (Normal Mode)	50 nW +/- 1 nW/month	25 nW +/- 1 nW/month

Zero Offset Notes

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 LadyBug sensors require no meter zeroing or reference calibration before use.

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Parameter	Specification	Typical
Average Mode Noise[1,2]		
-40 dBm to +26 dBm[3]	0.35%	0.025% to 0.15%[4]
-60 dBm to -40 dBm	0.5nW[5]	0.2nW[6]
Normal Mode Noise 2ms Gate[1,7]		
+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[8]		
+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:

1. Noise is two times the standard deviation of 100 measurement points
2. Number of Averages for each measurement rate
   Normal 16; Double 32; Super 384
3. For Normal measurement rate, when averages above 16 and power is above -40 dBm noise error is insignificant
4. Varies with power level
5. 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
6. 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
7. Auto Range ON
8. Noise is two times the standard deviation of a 10,000 point time domain trace taken at maximum time domain resolution. One sample per point.

Parameter	**Specification**	**Typical**
Temperature Unc (Average Mode)		
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)		
20°C - 30°C	0%	0%

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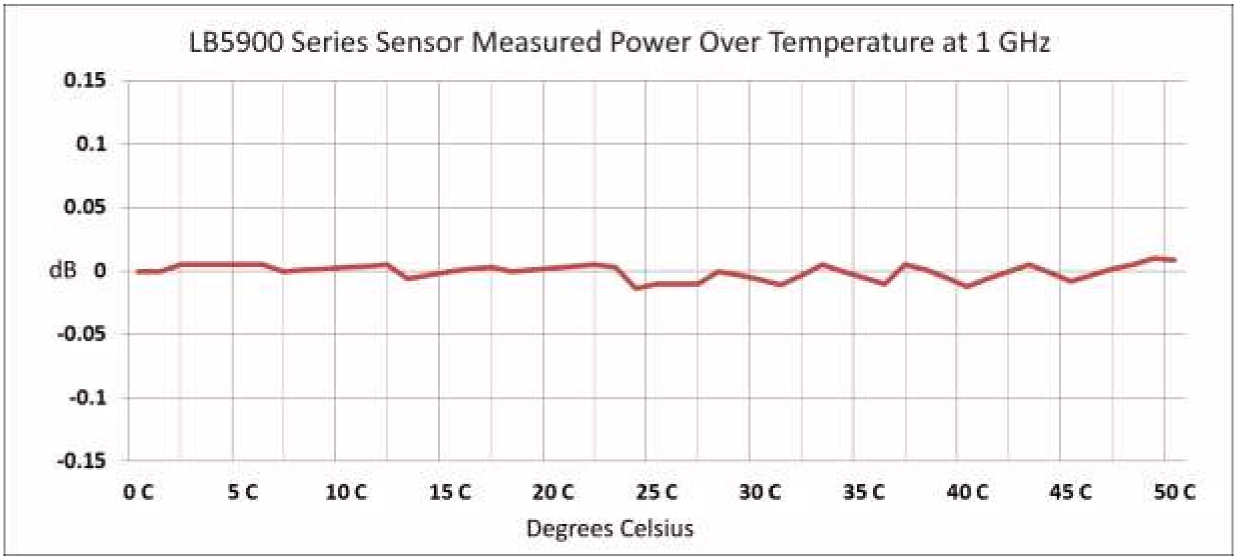
Thermal Stability

LadyBug's patented thermal stability technology is utilized in the LB5926A-LAN sensor. 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.



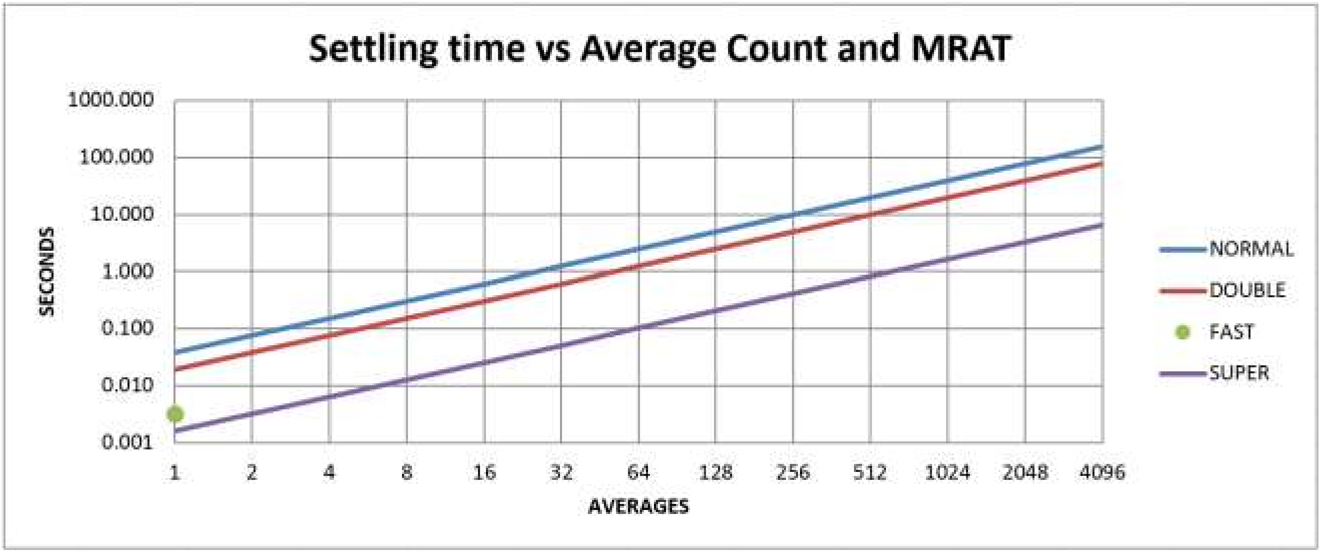
Average Detector Mode Measurement Rate (MRAT)

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

Normal Detector Mode Video Bandwidth

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

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



Remote Programming

The sensor is designed for full programmatic control in ATE systems and other applications requiring remote programming. LB5900-LAN Series sensors use SCPI (Standard Commands for Programmable Instruments) commands.

Supporting Ports	Ethernet LAN
Command Set	SCPI (Standard Commands for Programmable Instruments)
Compatibility	Compatible with systems using HiSLIP such as, NI™ & Keysight™ Visa IO libraries using SCPI command set.*

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

Analog Recorder Output

Option 001, Analog Recorder Out. Recorder Output is a calibrated filtered analog output. The output provides an accurate scaled voltage representing 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. Requires setup using multiple SCPI commands.

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

LB5900 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.
Trigger Delay range	+/- 10 Seconds
Auto trigger delay	Varies based on resolution setting (Default 45 ms). Average Mode: 11 ms to 61 ms.
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 -50dBm to 20dBm
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 50 Ω
Timing 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

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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, Store & Recall data, User Cal, Simple offsets and FDO tables. The process is an *erase - random overwrite - erase* process. For additional security users can execute the command repeatedly. The option is not available if Option MIL is purchased because non-volatile memory writes are disallowed with the option.

Store, Recall and Logging Memory

The LB5926A contains volatile and non-volatile memory.

Store & 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-volatile flash memory is not accessible. This includes all state and register functions such as Frequency, Averages, Analog Recorder Out etc.

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 setup using a computer, the sensor only requires power to function. Measurements are stored in the sensors 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 LB5900 Series Sensors contains a real time clock that is used to time stamp logged measurements. When the sensor is powered on, the sensors 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 time stamp 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, 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, LB5900 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. The recommended calibration interval for this product is one year. Specifications apply over the listed temperature and relative humidity range unless otherwise stated.

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Uncertainty Calculation Work Sheet

Use this sheet to calculate uncertainty for a specific set of conditions using the root sum of squares method.

Conditions

Operating Frequency (GHz)	
Power Level (dBm)	
DUT Match (VSWR)	
Temperature (°C)	

Sensor characteristics at conditions

Cal Factor (% & Actual)		
Linearity (% & Actual)		
Noise (% & Actual)		
Uncertainty Due To Temperature (% & Actual)		
Match (VSWR)		
Zero Offset		

1. Calculate Sensor reflection coefficient, ρ from Sensor VSWR

   ρ_{sens} = (VSWR-1)/(VSWR+1)

   ρ_{sens} =

2. Calculate DUT reflection coefficient, ρ from DUT VSWR

   ρ_{DUT} = (VSWR-1)/(VSWR+1)

   ρ_{DUT} =

Note: Reflection coefficient can be calculated from return loss using the formula $\rho=10^{(-RL/20)}$

3. Calculate total match uncertainty

   $Mm = (1+(\rho_{sens} * \rho_{DUT}))^2-1$

   Mm =

4. Calculate Zero Offset uncertainty (See Specification and notations)

   a. Convert power from dBm to Linear

      Linear Power = $10^{(PowdBm/10)}$

      Linear Power =

   b. Calculate Zero Offset

      Zero Offset = (Zero Offset Specification/Linear Power)

      Zero Offset =

5. Calculate Total RSS uncertainty

   Uncertainty (%) = $\sqrt{(Mm^{2+}CF^2+L^2+N^2+T^2+Z^2)}*100$

   Uncertainty (%) =

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Uncertainty Calculation Work Sheet Example

This sheet was completed using typical sensor data.

Conditions

Operating Frequency (GHz)	18
Power Level (dBm)	-20
DUT Match (VSWR)	1.20
Temperature (°C)	25

Sensor characteristics at conditions

Cal Factor (% & Actual)	1.43%	0.0143
Linearity (% & Actual)	0.5%	0.005
Noise (% & Actual)	0.15%	0.0015
Uncertainty Due To Temperature (% & Actual)	0%	0.0
Match (VSWR)		1.09:1
Zero Offset		3.5E-10

1. Calculate Sensor reflection coefficient, ρ from Sensor VSWR

   ρ_{sens} = (VSWR-1)/(VSWR+1)

   ρ_{sens} = (1.09-1)/(1.09+1) = .043

2. Calculate DUT reflection coefficient, ρ from DUT VSWR

   ρ_{DUT} = (VSWR-1)/(VSWR+1)

   ρ_{DUT} = (1.2-1)/(1.2+1) = 0.091

Note: Reflection coefficient can be calculated from return loss using the formula $\rho=10^{(-RL/20)}$

3. Calculate total match uncertainty

   Mm = $(1+(\rho_{sens} * \rho_{DUT}))^2-1$

   Mm = $(1+(.091*.091))^2-1$ = 0.0078

4. Calculate Zero Offset uncertainty (See Specification and notations)
   a. Convert power from dBm to Linear

      Linear Power = $10^{(PowdBm/10)}$

      Linear Power = $10^{(-20/10)}$ = .01mw
   b. Calculate Zero Offset

      Zero Offset = (Zero Offset Specification/Linear Power)

      Zero Offset = (0.35nw / .01mw) = .000035

5. Calculate Total RSS uncertainty

6. Uncertainty (%) = $\sqrt{(Mm^{2+}CF^2+L^2+N^2+T^2+Z^2)}$*100

   Uncertainty (%) = $\sqrt{(.0078^{2+}0.0143^2+.005^2+.0015^2+0.0^2+.0000350^2)}$ = .0171 = 1.71%

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LB59XXX-LAN Outline drawings

Please refer to the product page for any LB5900 Series Power sensor for CAD drawings and additional information. www.ladybug-tech.com