

Agilent U2000 Series USB Power Sensors

Operating and Service Guide



Agilent Technologies

Notices

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Safety Notices

WARNING

















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CAUTION





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The following symbols on the instrument and in the documentation indicate precautions which must be taken to maintain safe operation of the instrument.

	Direct current		On (supply)
	Alternating current		Off (supply)
	Both direct and alternating current		Equipotential protected throughout by DOUBLE INSULATION or REINFORCED INSULATION
	Three-phase alternating current		Caution, risk of electric shock.
	Earth (ground) terminal		Caution, risk of danger (refer to this manual for specific Warning or Caution information).
	Protective conductor terminal		Caution, hot surface.
	Frame or chassis terminal		Out position of a bi-stable push control.
	Equipotentiality		In position of a bi-stable push control.

Regulatory Markings

 <p>ESD Sensitive</p>	<p>This symbol indicates that a device, or part of a device, may be susceptible to electrostatic discharges (ESD) which can result in damage to the product. Observe ESD precautions given on the product, or its user documentation, when handling equipment bearing this mark.</p>
	<p>The CE mark shows that the product complies with all the relevant European Legal Directives.</p>
	<p>The C-tick mark is a registered trademark of the Spectrum management Agency of Australia. This signifies compliance with the Australian EMC Framework regulations under the terms of the Radio Communications Act of 1992.</p>
	<p>This product complies with the WEEE Directive (2002/96/EC) marking equipment. The affixed product label indicates that you must not discard this electrical/electronic product in domestic household waste.</p>
<p>ICES/NMB - 001</p>	<p>ICES/NMB-001 indicates that this ISM device complies with Canadian ICES-001. Cet appareil ISM est conforme à la norme NMB-001 du Canada</p>

Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC

This instruction complies with the WEEE Directive (2002/96/EC) marking requirement. This affixed product label indicates that you must not discard this electrical/electronic product in domestic household waste.

Product Category:

With reference to the equipment types in the WEEE Directive Annex 1, this instrument is classified as a "Monitoring and Control Instrument" product.

The affixed product label is shown as below:



Do not dispose in domestic household waste

To return this unwanted instrument, contact your nearest Agilent office, or visit

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WARNING

BEFORE CONNECTING THE POWER SENSOR TO OTHER INSTRUMENTS ensure that all instruments are connected to the protective (earth) ground. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in personal injury.

CAUTION

- Use the device with the cables provided.
 - Repair or service that is not covered in this manual should only be performed by qualified personnel.
-

Environment Conditions

This instrument is designed for indoor use only. The table shows the general requirements for the product.

Environment Conditions	Requirements
Temperature	0 °C to +55 °C (operating) –30 °C to +70 °C (non-operating)
Humidity	Operating up to 95% at 40 °C (non-condensing) Non-operating up to 90% at 65 °C (non-condensing)
Altitude	Operating up to 4,600 metres (15,000 feet) Non-operating up to 4,600 metres (15, 000 feet)
Pollution	Degree 2

CAUTION

The Agilent U2000 Series USB power sensors comply with the following safety and EMC requirements:

- IEC 61010-1:2001 / EN 61010-1:2001 (2nd edition)
- IEC 61326:2002 / EN61326:1997+A1:1998+A2:2001+A3:2003
- Canada: ICES-001:2004
- Australia/New Zealand: AS/NZS CISPR11:2004



Agilent Technologies

DECLARATION OF CONFORMITY
According to EN ISO/IEC 17050-1:2004



Manufacturer's Name: Agilent Technologies Microwave Products (M) Sdn. Bhd
Manufacturer's Address: Bayan Lepas Free Industrial Zone,
11900, Bayan Lepas, Penang, Malaysia

Declares under sole responsibility that the product as originally delivered

Product Name: Agilent U2000 Series USB Power Sensor
Models Number: U2000A, U2000B, U2000H, U2001A, U2001B, U2001H,
U2002A, U2002H, U2004A
Product Options: This declaration covers all options of the above product(s)

complies with the essential requirements of the following applicable European Directives, and carries the CE marking accordingly:

Low Voltage Directive (2006/95/EC)
EMC Directive (2004/108/EC)

and conforms with the following product standards:

EMC	Standard	Limit
	IEC 61326:2002 / EN 61326:1997+A1:1998+A2:2001+A3:2003	
	CISPR 11:1990 / EN55011:1990	Class A Group 1
	IEC 61000-4-2:1995 / EN 61000-4-2:1995	4 kV CD, 8 kV AD
	IEC 61000-4-3:1995 / EN 61000-4-3:1996	3 V/m, 80-1000 MHz
	IEC 61000-4-4:1995 / EN 61000-4-4:1995	0.5 kV signal lines, 1 kV power lines
	IEC 61000-4-5:1995 / EN 61000-4-5:1995	0.5 kV line-line, 1 kV line-ground
	IEC 61000-4-6:1996 / EN 61000-4-6:1996	3 V, 0.15-80 MHz
	IEC 61000-4-11:1994 / EN 61000-4-11:1994	1 cycle / 100%

Canada: ICES-001:2004
Australia/New Zealand: AS/NZS CISPR11:2004

The product was tested in a typical configuration with Agilent Technologies test systems.

Safety IEC 61010-1:2001 / EN 61010-1:2001

This DoC applies to above-listed products placed on the EU market after:

03-July-2008

Date

Tay Eng Su

Quality Manager

For further information, please contact your local Agilent Technologies sales office, agent or distributor,
or Agilent Technologies Deutschland GmbH, Herrenberger Straße 130, 71034 Böblingen, Germany.

Template: A5971-5302-2, Rev. E

U2000 Series

DoC Revision 2.0

Product Regulations

EMC

IEC 61326-1:2002 / EN 61326-1:1997+A1:1998+A2:2001+A3:2003

CISPR 11:1990 / EN 55011:1990 – Group 1 Class A

IEC 61000-4-2:1995 / EN 61000-4-2:1995 (ESD 4kV CD, 8kV AD)

IEC 61000-4-3:1995 / EN 61000-4-3:1996 (3V/m, 80% AM)

IEC 61000-4-4:1995 / EN 61000-4-4:1995 (EFT 0.5kV line-line, 1kV line-earth)

IEC 61000-4-5:1995 / EN 61000-4-5:1995 (Surge 0.5kV line-line, 1kV line-earth)

IEC 61000-4-6:1996 / EN 61000-4-6:1996 (3V, 0.15-80 MHz, 80% AM, power line)

IEC 61000-4-11:1994 / EN 61000-4-11:1994 (Dips 1 cycle, 100%)

Canada: ICES-001:2004

Australia/New Zealand: AS/NZS CISPR11:2004

Performance Criteria

A
A
B
B
A
B

Safety IEC 61010-1:2001 / EN 61010-1:2001

Additional Information:

The product herewith complies with the essential requirements of the Low Voltage Directive 2006/95/EC and the EMC Directive 2004/108/EC and carries the CE Marking accordingly (European Union).

¹Performance Criteria:

A Pass - Normal operation, no effect.

B Pass - Temporary degradation, self recoverable.

C Pass - Temporary degradation, operator intervention required.

D Fail - Not recoverable, component damage.

N/A – Not applicable

Notes:

Regulatory Information for Canada

ICES/NMB-001:2004

This ISM device complies with Canadian ICES-001.

Cet appareil ISM est conforme à la norme NMB-001 du Canada.

Regulatory Information for Australia/New Zealand

This ISM device complies with Australian/New Zealand AS/NZS CISPR11:2004

 **N10149**

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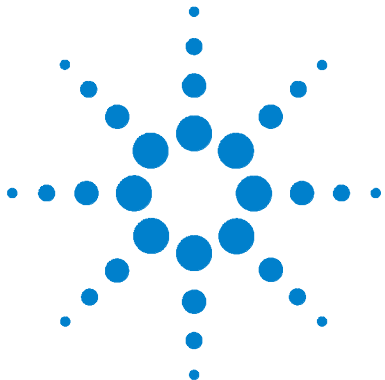
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1 Introduction

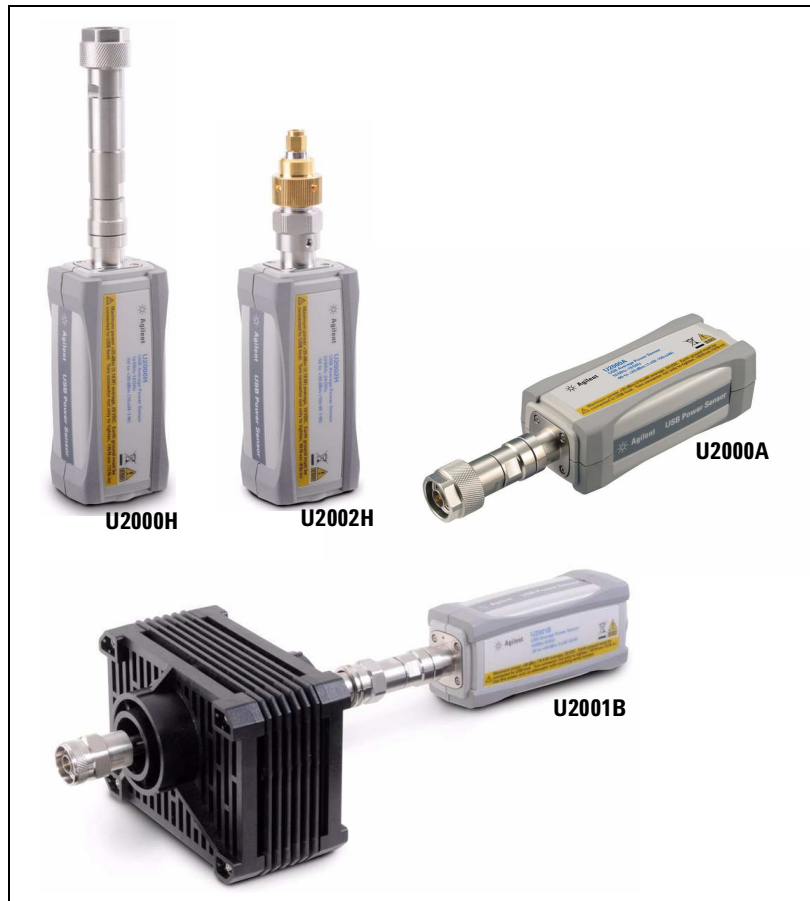
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This chapter introduces the Agilent U2000 Series USB power sensors with details on the operation, minimum power sensor requirements, hardware installation and configuration, and a brief introduction of the Agilent N1918A Power Analysis Manager.

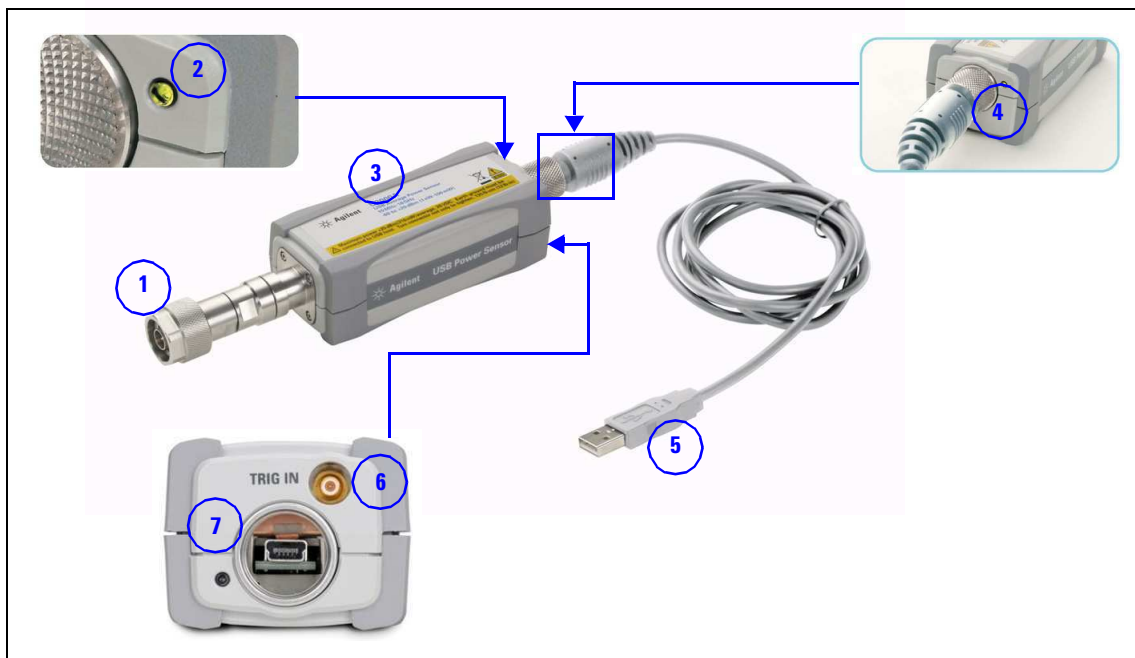


General Information

This guide contains information about the initial inspection, operation, specifications and repair of the U2000 Series USB power sensors. The figure below shows the Agilent U2000 Series USB Power Sensors family.



Product Overview



No.	Part	Functions
1	RF input port	Allows RF/microwave signal input
2	LED indicator	Indicates the states of the power sensor. Refer to “LED Indicator Guide” for more information.
3	Sensor body	Contains the core components of the power sensor
4	Physical lock mechanism	Enable secure locking mechanism
5	USB compliant cable	To connect the power sensor to the PC or other instruments
6	External trigger port	Enable synchronization with external instruments or events
7	USB port	Enable USB connectivity

LED Indicator Guide

The LED indicator is found at the rear panel of the U2000 Series USB power sensor. The following table shows the LED indicators' state and its description.

Table 1-1 States of LED indicator and its description

LED indicator	Description
GREEN blinking	Device in communication mode. Example: Sending SCPI commands or reading data.
RED blinking	Error - Highest priority event The error is due to HW/OS/Self-test. All other LED indicators will not function while having this error. The error message can be read by sending SYST:ERR? command. Users are advised to return the U2000 Series USB power sensor to Agilent.
RED	Error. Use SYST:ERR? to read the error message. Reading the error message will also clear the LED indication. Users are advised to read the message as some of the error might cause measurement errors. Example of error cause: 1 SCPI command syntax error 2 Invalid Zero
AMBER	Zeroing is in progress. Sending SCPI commands during the zeroing process will cause error. This will cause the LED indicator to turn RED.

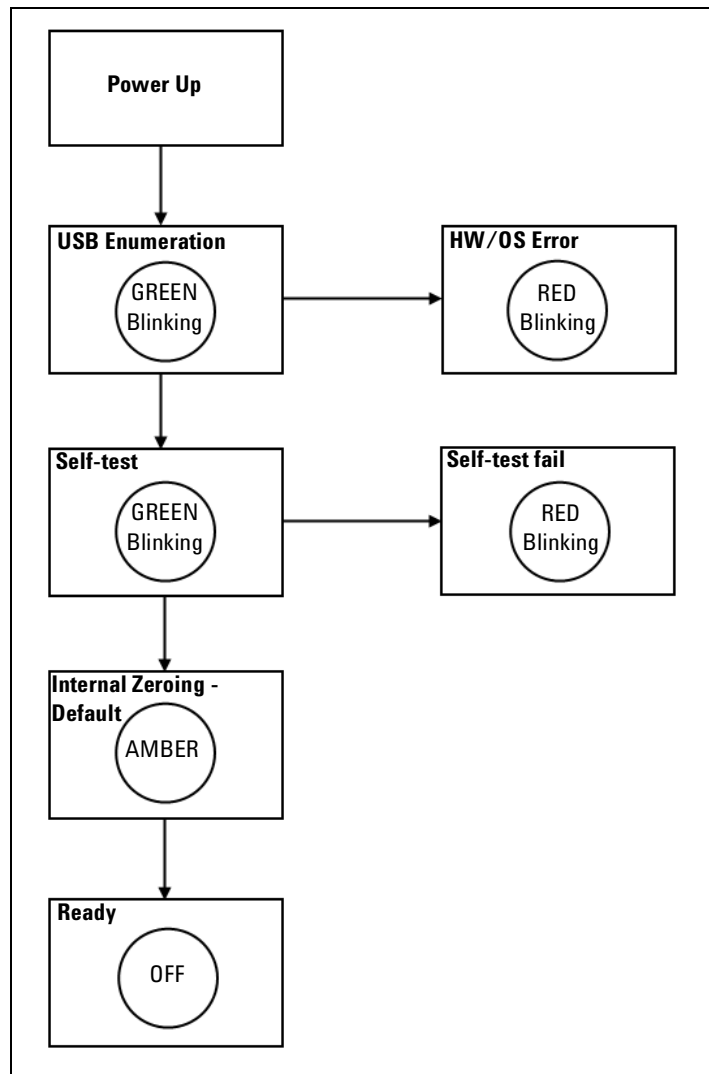


Figure 1-1 LED indicator sequence power-up

Principles of Operation

The U2000 Series USB power sensors function as power meter and power sensor in one device. The U2000 Series has the capability of sensing the signal, acquiring the data and signal conditioning, processing the data and fulfilling communication function as in other Agilent test instruments.

The low power measurement path is a 2-diode stacks and the high power path contains 5-diode stacks which extend the dynamic range square-law detection. The range selection is performed automatically by the product based on the measured power levels. The sensing element technology has been previously used in the popular E9300 Series sensors. The new U2000 Series includes all the signal conditioning and analog-to-digital formatting functions that have been in use for several years. Thus, you can be assured that the U2000 Series USB power sensors will deliver highly predictable results.*

The main component for the sensing element of the U2000 Series is the RF input port assembly which provides a 50 Ω load to the RF signal applied to the power sensor. A dual range GaAs diode air/attenuator/diode pair assembly in the RF input port rectifies the applied RF to produce dc voltages (high and low ranges) which vary with the RF power across the 50 Ω load. Thus the voltage varies with the RF power dissipated in the load.

The low-level dc voltage from the RF input port assembly is picked up by the signal conditioning part of the product which consists of high isolation switches, chopper circuitry and high gain amplifier. Differential electronics is maintained from the sensing element up to the 14-bit Analog-to-Digital Converter (ADC) for signal integrity and noise immunity. Amplification and signal conditioning assure that drift and gain stability are not compromised before hitting the high performance 14-bit Analog-to-Digital Converter modules. From there, the digitized power data enters the processor which operates as an on-board computer for the self-contained sensor.

Products control and processing is provided by an embedded processor with Digital Signal Processing (DSP) capability which is supported by a

* Agilent Fundamentals of RF and Microwave Power Measurements (Part 2), Power Sensors and Instrumentation, Literature Number 5988-9214EN

Anderson, Alan B., October, 2000, Measuring Power Levels in Modern Communication Systems, MW/RF Magazine

64 MB SDRAM. The available processing power enables the implementation of Correction Algorithm such as Linearity Correction, Calibration Factor, Temperature Compensation Algorithm and Internal Zeroing algorithm. The correction factors for the products are stored in a 3 MB Flash memory. In the Temperature Compensation Algorithm and Internal Zeroing algorithm implementation, the processor continuously monitors product temperatures using a thermistor which is located in the vicinity of the diode sensing element as shown in [Figure 1-3](#). The trigger input port which is based on TTL enables the product to synchronize with events. The U2000 Series supports high data rate transfer of 480 Mb/s through the Universal Serial Bus (USB) connectivity which is USB-TMC compliance.

External zeroing is performed similar to other power sensors - the RF power is removed from the sensor by the user and then the sensor is zeroed. Internal zeroing is a new type of zeroing whereby the RF power can be left connected to the sensor while it is being zeroed. The power sensor will remove the RF power from the diode sensor internally in the sensor.

During the external zeroing process, the data from the front end circuitry which includes the RF diode sensing element, signal conditioning, and data acquisition circuit will be acquired. The zero information is then used. Do not apply any RF/microwave signals to the bulkhead during external zeroing processes. Any RF/microwave signals pick-up by the diode sensor during the external zeroing will be considered as part of the noise.

During internal zeroing process, high isolation switches are opened in the sensor to isolate the diode sensor from the electronic circuitry. With the available processing power from the embedded DSP in the product, the internal zeroing algorithm is applied to the internal zero data. The internal zeroing process simplifies the product operation by removing the circuitry noise without requiring the RF signal to be removed from the product. Hence, internal zeroing is able to provide the convenience of performing a zero with the RF/microwave signal present.

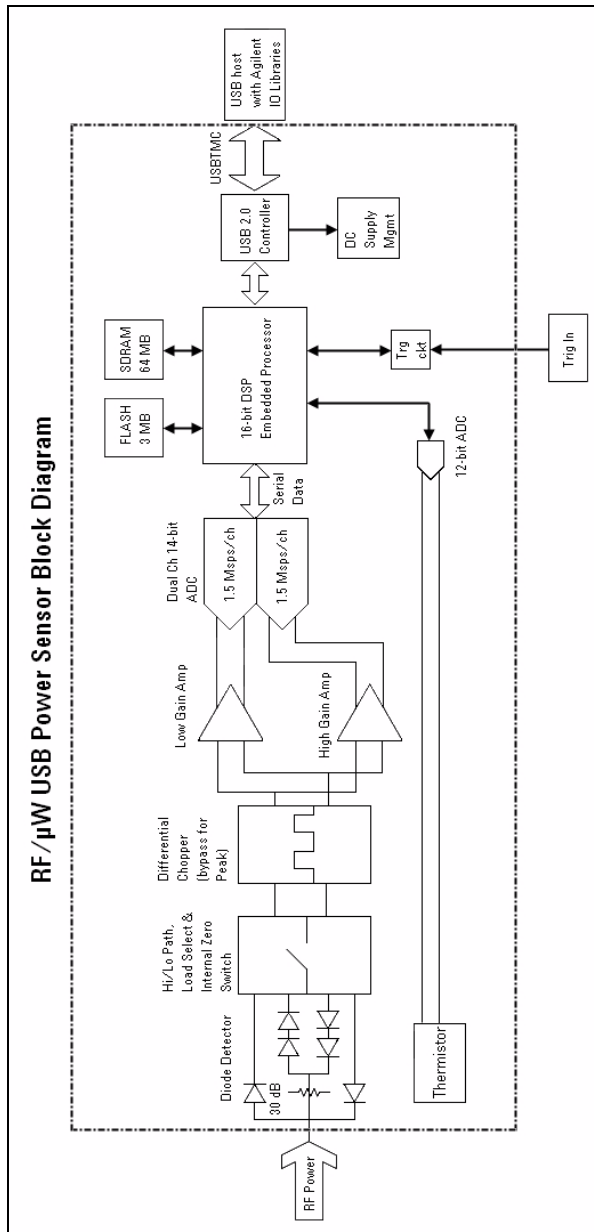


Figure 1-2 Block diagram of the RF/microwave USB power sensor

The U2000 Series USB Power Sensors in Detail

Most of the power sensors used for measuring average power employ either thermocouple or diode technology. Diode-based sensors frequently rely on the application of correction factors to extend their dynamic range beyond their square law response region, typically from -70 dBm to -20 dBm. While this technique achieves a wide dynamic range capability, however, it is limited to continuous wave (CW) signals outside the square law region. Modulated signals must be padded down or at low levels, with their average and peak power levels within the diode square law region, to be measured accurately. Accurate average power measurement of high-level signals carrying modulation cannot be obtained using a CW correction factor technique. Specialized modulation sensors are able to provide accurate measurements but are limited by the bandwidth.

The U2000 Series USB power sensors are true average, wide dynamic range RF/microwave power sensors. They are based on a dual sensor diode pair/ attenuator/diode pair as proposed by Szente et. al. in 1990¹. Figure 1-3 shows a block diagram of this technique.

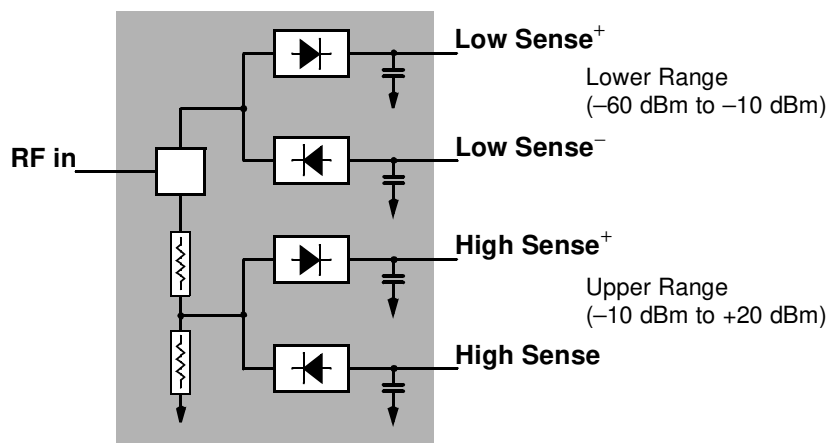


Figure 1-3 Simplified Block Diagram of Diode Pair/Attenuator/Diode Pair

¹ US Patent #4943764, assigned to Hewlett-Packard Company

This technique will ensure the diodes in the selected signal path are kept in their square law region, thus the output current (and voltage) is proportional to the input power. The diode pair/attenuator/diode pair assembly can yield the average of complex modulation formats across a wide dynamic range, irrespective of the signal bandwidth. The dual range Modified Barrier Integrated Diode (MBID)¹ package includes further refinements to improve power handling allowing accurate measurement of high level signals with high crest factors without incurring damage² to the sensor.

These sensors measure average RF power on a wide variety of modulated signals and are independent of the modulation bandwidth. They are ideally suited to the average power measurement of multi-tone and spread spectrum signals such as CDMA, W-CDMA and digital television formats.

¹ November 1986 Hewlett-Packard Journal pages 14-2, "Diode Integrated Circuits for Millimeter-Wave Applications.

² Refer to "[Maximum Power](#)" on page 42 for maximum power handling specifications.

Getting Started

Initial Inspection

Inspect the shipping container for damages. If the shipping container or packaging material is damaged, it should be kept until the contents of the shipment have been checked mechanically and electrically. If there is any mechanical damage, notify the nearest Agilent Technologies office. Keep the damaged shipping materials (if any) for inspection by the carrier and a Agilent Technologies representative. If required, you can find a list of Agilent Technologies Sales and Service offices on the last page of the guide.

Package Contents Checklist

Inspect and verify the following items for the standard purchase of the U2000 Series USB power sensors. If there are missing items, contact the nearest Agilent Sales Office.

- Trigger cable BNC Male to SMB female 50 Ω , 1.5 m, U2000-60005
- Power sensor cable: 1.5 m (U2000-60002), 3.0 m (U2000-60003), or 5.0 m (U2000-60004)
- U2000 Series USB Power Sensor Programming Guide, U2000-90411
- U2000 Series USB Power Sensor Operating and Service Guide (English), U2000-90405
- U2000 Series USB Power Sensor Documentation CD, U2000-90002
- N1918A Power Analysis Manager Assembly, N1918-60001

System Requirements

The U2000 Series USB power sensor is able to display power measurements on a PC or other Agilent instruments without the need for a separate power meter. The USB power sensor is a combination of power meter and power sensor, all in a compact sensor casing. It provides plug-and-play connectivity which enables fast connection between the USB power sensors and a PC.

Prior to using the U2000 Series USB power sensors, please ensure that the following minimum power sensor requirements are met:

- PC or any device that has USB host capability
- Agilent IO Libraries Suite 14.2 or above, users are encouraged to obtain the latest version of Agilent Libraries Suite for better performance
- *Optional:* Agilent N1918A Power Analysis Manager (Basic Power Panel is bundled with the purchase of the U2000 Series USB power sensors, while users can also obtain the advanced Power Analyzer which is an optional licensed software with additional features and capabilities)*
- The U2000 Series can also be programmed using remote programming software such as Agilent VEE, LabVIEW, and Microsoft® Visual Basics.

Checking the Power Sensor Firmware

There are two ways that can be used to check the firmware revision of the power sensor:

Agilent IO Libraries Suite 14.2

- By using the Agilent IO Libraries Suite version 14.2 or above, you can check the model code, serial number, firmware revision, and USB address. The VISA address is the USB address (see below).

```
VISA address: USB0::2391::11544::MY47400105::0::INSTR
```

* Refer to the *N1918A Power Analysis Manager Data Sheet*, 5989-6612EN for more information on the features of the Power Panel and Power Analyzer.

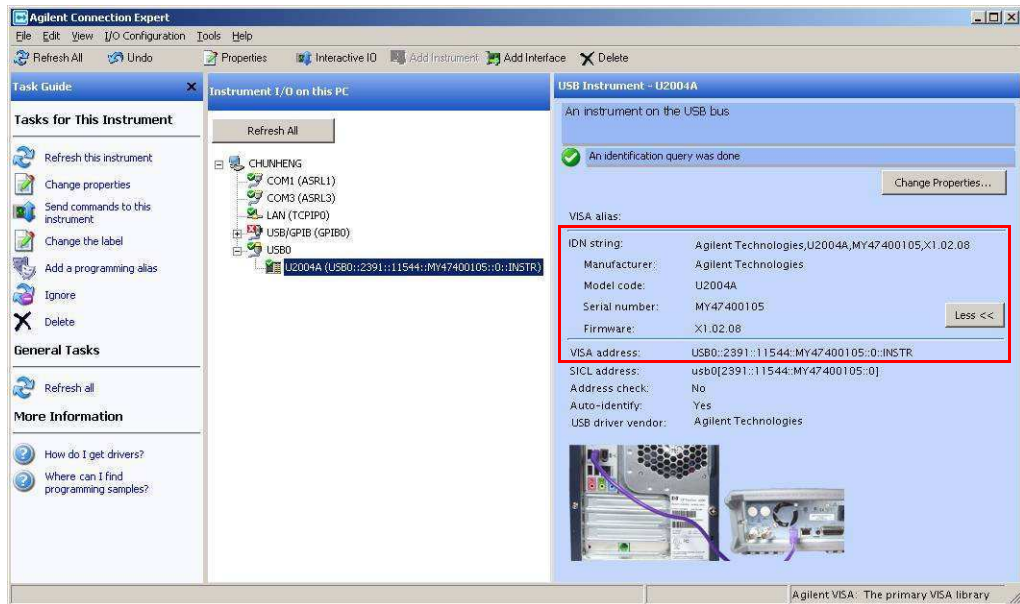


Figure 1-4 Agilent IO Libraries Suite

Agilent N1918A Power Analysis Manager

- By using N1918A Power Analysis Manager, you can check the description, firmware revision, model number, resource ID and serial number as shown below:

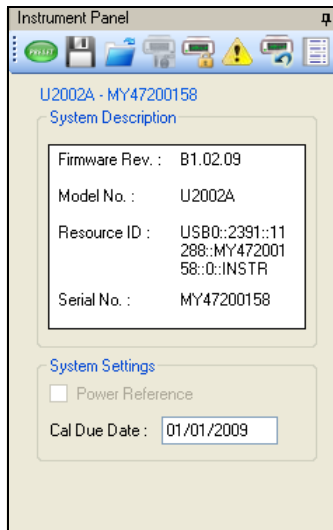


Figure 1-5 Power Analysis Manager Instrument Properties panel

- It is advisable to set the calibration due date. Refer to [page 20](#) for more details.

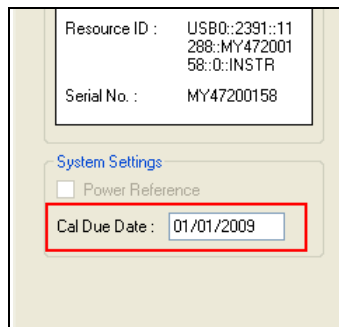


Figure 1-6 Calibration due date display

Hardware Installation and Configuration

A. Installing your U2000 Series USB power sensor

U2000 Series offers USB plug-and-play capability, with the proficiency of power meter and power sensor in a unit that enables users to obtain measurement readings via N1918A Power Analysis Manager.

Follow the instructions below to install and configure the U2000 Series.

- 1 Connect your U2000 Series USB power sensor to the PC using the USB cable provided. Connect the cable's mini-B plug to your U2000 Series sensor and the other end of the cable (type-A plug) to any USB host on your PC.
- 2 The PC will automatically detect the connected sensor and the Found New Hardware Wizard window will appear as shown below.



Figure 1-7 Found New Hardware Wizard window

- 3 Select **Yes, this time only** and click **Next** to proceed.
- 4 On the following window, select **Install the software automatically (Recommended)** and click **Next**.

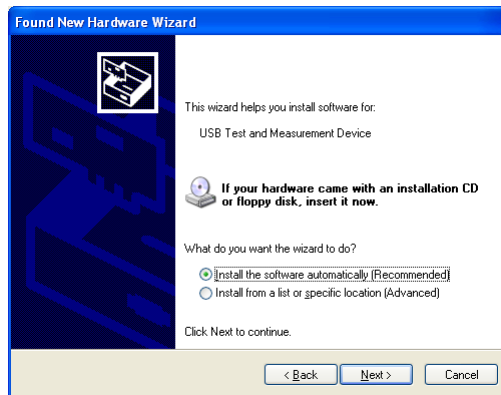


Figure 1-8 Found New Hardware Wizard driver installation

- 5 A warning message will appear in the Hardware Installation window, as shown below. Click **Continue Anyway** to proceed with the installation of the driver.



Figure 1-9 Hardware installation warning message

NOTE

If you do not wish to receive similar warning message in future, follow the instructions below.

- 1 Go to **Start > Control Panel** and double-click System.
- 2 Select **Hardware** tab, on the Drivers panel click **Driver Signing** and the Driver Signing Options dialog box will appear.
- 3 Select **Ignore** to disable the warning message.

- 6 Click **Finish** when the installation has completed.



Figure 1-10 Completing hardware driver installations

- 7 Once the driver installation has completed, the Assign USB device alias window may appear as shown below. Each time a USB device is plugged in, this dialog will be shown. To configure or disable this dialog, select an options in the **Show this dialog** panel and click **OK**.

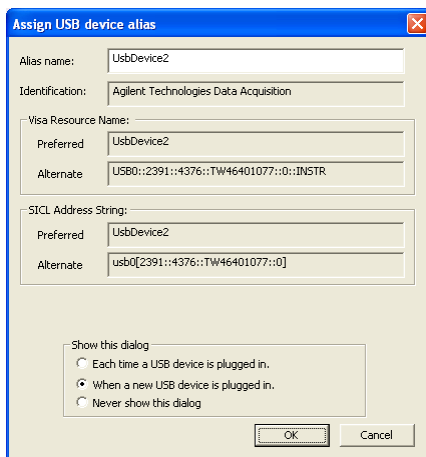


Figure 1-11 USB device alias configuration

B. Verifying your connected power sensor

- 1 To verify your connected sensor, go to **Start > All Programs > Agilent IO Libraries Suite > Agilent Connection Expert** to launch Agilent Connection Expert.
- 2 Your connected USB sensor will be detected and shown on the **Instrument I/O on this PC** panel as shown in the following figure.

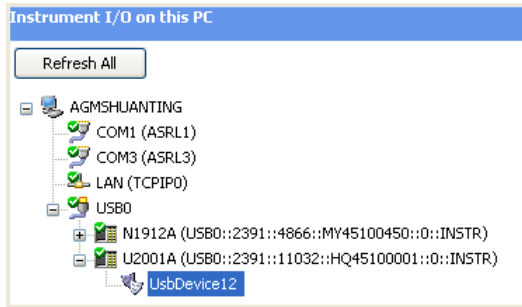


Figure 1-12 Agilent Connection Expert with list of instrument I/O on the PC

- 3 Select the U2000 USB sensor on the list of USB device connected to the PC and right-click. A context menu will appear and select **Send Command To This Instrument** and the Agilent Interactive IO dialog box will appear as shown below.

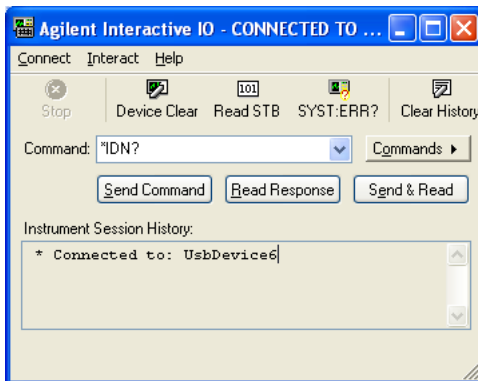


Figure 1-13 Agilent Interactive IO dialog box

- To verify your connected power sensor, send the default SCPI command `*IDN?` to the power sensor by clicking **Send & Read**. The device's response will appear in the **Instrument Session History** panel as shown in the following figure.

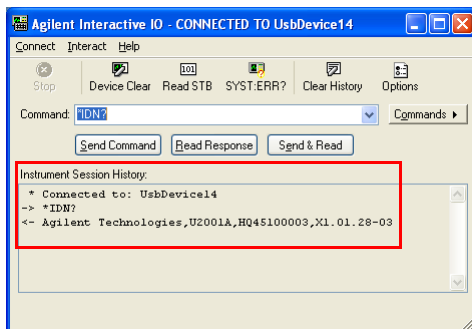


Figure 1-14 Identification of your connected power sensor displayed

- This verify that your U2000 Series USB power sensor has been connected and properly installed on your PC.

C. Configuring your power sensor via Power Analysis Manager

- 1 Go to **Start > All Programs > Agilent N1918A Power Analysis Manager > Advance > Power Analyzer** to launch your Power Analysis Manager.
- 2 With your power sensor still connected, a pop-up reminder dialog will appear when you launch the Power Analysis Manager. The reminder message will appear under two conditions:
 - a You have not set any calibration due date for your U2000 Series. The reminder prompts you to set your calibration due date.
 - b Your calibration date is due and the reminder prompts you to send your U2000 Series for calibration.
- 3 Click **OK** and you may proceed to set the calibration due date or connect a new sensor to proceed.
- 4 To set the calibration due date, go to Instrument Panel, in the System tab, input the due date of your calibration in the Cal Due Date property.

NOTE

For remote interface configurations of P-Series power meters, refer to **Remote Interface Configurations** in *Agilent P-Series Power Meters Installation Guide* and for remote interface configuration of N8262A P-Series modular power meters, refer to *N8262A P-Series Modular Power Meters Installation Guide*.



2 Making Measurements

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Power Sensor Configuration Settings

The calibration data of U2000 Series USB power sensors is automatically read by referring to the specified range as shown in Figure 2-1 on the next page.

Power Path	Power Level (U2000/1/2/4A)	Power Level (U2000/1/2H)	Power Level (U2000/1B)
Low Power Path	-60 dBm to -35 dBm	-50 dBm to -25 dBm	-30 dBm to -5 dBm
	-38 dBm to -15 dBm	-28 dBm to -5 dBm	+8 dBm to +15 dBm
	-20 dBm to -9 dBm	-10 dBm to -1 dBm	+10 dBm to +21 dBm
High Power Path	-11 dBm to -5 dBm	-1 dBm to +5 dBm	+19 dBm to +25 dBm
	-7 dBm to +15 dBm	+3 dBm to +25 dBm	+23 dBm to +44 dBm
	+10 dBm to +20 dBm	+20 dBm to +30 dBm	

NOTE

Averaging settings can also be manually configured.

In Figure 2-1, the dotted-line arrow  indicates the internal range based on the internal circuitry of the power sensor. The ranges will be automatically selected in correspondence with the power level to best fit the operating conditions and settings.

	Expected Power			Maximum Sensor Power Within a Range	Resolution Setting			
	U2000/1B	U2000/1/2H	U2000/1/2/4A		1	2	3	4
Sensor Dynamic Range	High Power Path	44 dBm	30 dBm	20 dBm	1	1	1	1
		35 dBm	25 dBm	15 dBm	1	1	1	128
		23 dBm	20 dBm	10 dBm	1	1	1	512
		25 dBm	25 dBm	15 dBm	1	1	1	1
		24 dBm	15 dBm	5 dBm	1	1	1	1024
		19 dBm	3 dBm	-7 dBm	1	1	256	1024
		21 dBm	5 dBm	-5 dBm	1	1	1	1024
		18 dBm	4 dBm	-6 dBm	1	1	128	1024
		10 dBm	-1 dBm	-11 dBm	1	1	512	1024
		15 dBm	1 dBm	-9 dBm	1	1	1	1
	Low Power Path	7 dBm	-2 dBm	-12 dBm	1	1	1	1024
		-3 dBm	-10 dBm	-20 dBm	1	1	16	1024
		-8 dBm	-5 dBm	-15 dBm	1	1	1	1
		-5 dBm	-13 dBm	-23 dBm	1	1	1	1024
		-8 dBm	-23 dBm	-33 dBm	1	1	256	1024
		-5 dBm	-28 dBm	-38 dBm	1	1	512	1024
		-8 dBm	-25 dBm	-35 dBm	1	1	16	1024
		-15 dBm	-28 dBm	-38 dBm	1	1	1024	1024
		-25 dBm	-35 dBm	-45 dBm	1	1024	1024	1024
		-30 dBm	-45 dBm	-55 dBm	128	1024	1024	1024
	-50 dBm	-60 dBm	512	1024	1024	1024		
			Minimum Sensor Power Within a Range					

Figure 2-1 Auto-Averaging Settings

Measurement Accuracy and Speed

With U2000 Series USB power sensors, the range can be set either automatically or manually. Use auto-ranging when you are not sure of the power level you are about to measure.

The DC coupling of the U2004A USB power sensor input allows excellent low frequency coverage. However, the presence of any DC voltages mixed with the signal will have an adverse effect on the accuracy of the power measurement, see [on Page 46](#).

CAUTION

To prevent damage to your sensor, do not exceed the power levels specified in the section “[Maximum Power](#)” on page 42.

The U2004A USB Power Sensor is DC coupled. DC voltages in excess of the maximum value (5 VDC) can damage the sensing diode.

Setting the Range

There are two manual settings, “LOWER” and “UPPER”. The LOWER range uses the more sensitive path and the UPPER range uses the attenuated path in the U2000 Series USB power sensors (see [Table 2-1](#)).

Table 2-1 Sensor Ranges

Sensor	LOWER range	UPPER range
U2000A, U2001A, U2002A, U2004A	-60 dBm to -10 dBm	-10 dBm to +20 dBm
U2000H, U2001H, U2002H	-50 dBm to 0 dBm	0 dBm to +30 dBm
U2000B, U2001B	-30 dBm to +20 dBm	+20 dBm to +44 dBm

The default is “AUTO”. In AUTO the range crossover value depends on the sensor model being used (see [Table 2-2](#)).

Table 2-2 Range Crossover Values

Sensor	Range Crossover Values
U2000A, U2001A, U2002A, U2004A	$-10 \text{ dBm} \pm 1 \text{ dB}$
U2000H, U2001H, U2002H	$0 \text{ dBm} \pm 1 \text{ dB}$
U2000B, U2001B	$+20 \text{ dBm} \pm 1 \text{ dB}$

Measurement Considerations

While auto-ranging is a good starting point, it is not ideal for all measurements. Signal conditions such as crest factor or duty cycle may cause the power sensor to select a range which is not the optimum configuration for your specific measurement needs. Signals with average power levels close to the range switch point require you to consider your needs for measurement accuracy and speed.

For example, a U2000/1/4A sensor, where the range switch point is $-10 \pm 1 \text{ dBm}$ in a pulsed signal, should be configured as follows:

Characteristic	Value
Peak Amplitude	-6 dBm
Duty Cycle	25%

The calculated average power is -12 dBm .

Accuracy

The value of -12 dBm lies in the lower range of the U2000/1/4A sensor. In auto-ranging mode (“AUTO”), the U2000/1/4A sensor determine the average power level is below -10 dBm and select the low power path. However, the peak amplitude of -6 dBm is beyond the specified square law response range of the low power path diodes. The high power path (-10 dBm to $+20 \text{ dBm}$) should be used to ensure a more accurate measurement of this signal. However, range holding in “UPPER” (the high power path), for a more accurate measurement, results in a considerably increased number of filtering processes.

Speed and Averaging

The same signal also requires a specific consideration of the measurement speed. As shown above, in auto-ranging mode the U2000/1/4A sensor determine the average power level is below -10 dBm and select the low power path. With auto-averaging configured, minimal filtering is applied. Values of one to four for average power levels above -20 dBm are used in the low power path. (Refer to “[Auto-Averaging Settings](#)” on page 23.)

If the range is held in “UPPER” for more accuracy, the measurement is slower. More filtering is applied due to the increase in noise susceptibility at the less sensitive area of the high power path. Values of one to 128 for average power levels less than -10 dBm are used. (Again, refer to “[Auto-Averaging Settings](#)” on page 23.) Manually lowering the filter settings speeds up the measurement but can result in an unwanted level of jitter.

Summary

Attention must be paid to signals where the average power levels are in the low power path range while the peaks are in the high power path range. You can achieve best accuracy by selecting the high power path or achieve best speed by selecting the low power path.

INTernal and EXTernal Zeroing

Zeroing a power sensor is performed in order to reduce zero measurement offset and noise impact to improve the accuracy of RF power measurement. The U2000 Series USB power sensors have two types of zeroing; INTernal zeroing and EXTernal zeroing.

INTernal zeroing is a new type of zeroing process whereby RF/Microwave power can be left connected to the sensor while it is being zeroed. High isolation switches are opened in the sensor to isolate the diode sensor from the electronic circuitry. With the available processing power from the Embedded DSP in the product, the INTernal zeroing algorithm is applied to the internal zeroing data. Hence, INTernal zeroing provides the convenience of performing a zero with the RF/microwave signal present. This feature makes INTernal zeroing more convenient, but one may only use INTernal zeroing if zero set (INTernal) is within the user's application requirements.

EXTernal zeroing process is a two-step process. The RF/Microwave signal to be measured must be removed from the product and then the product can be zeroed. Do not apply any RF/microwave signals to the RF input port during EXTernal zeroing processes. Any RF/microwave signals pick-up by the diode sensor during EXTernal zeroing will be considered as part of the noise. EXTernal zeroing generally has better zero set performance. The INT or EXT zeroing selection should be made based on the measurement needs.

Users can choose to use either INTernal zeroing or EXTernal zeroing. The sensor is defaulted with INTernal zero every time it is power up. [Figure 2-2](#) shows the illustration on how to set the EXTernal zeroing if the N1918A Power Panel tool is used.

2 Making Measurements

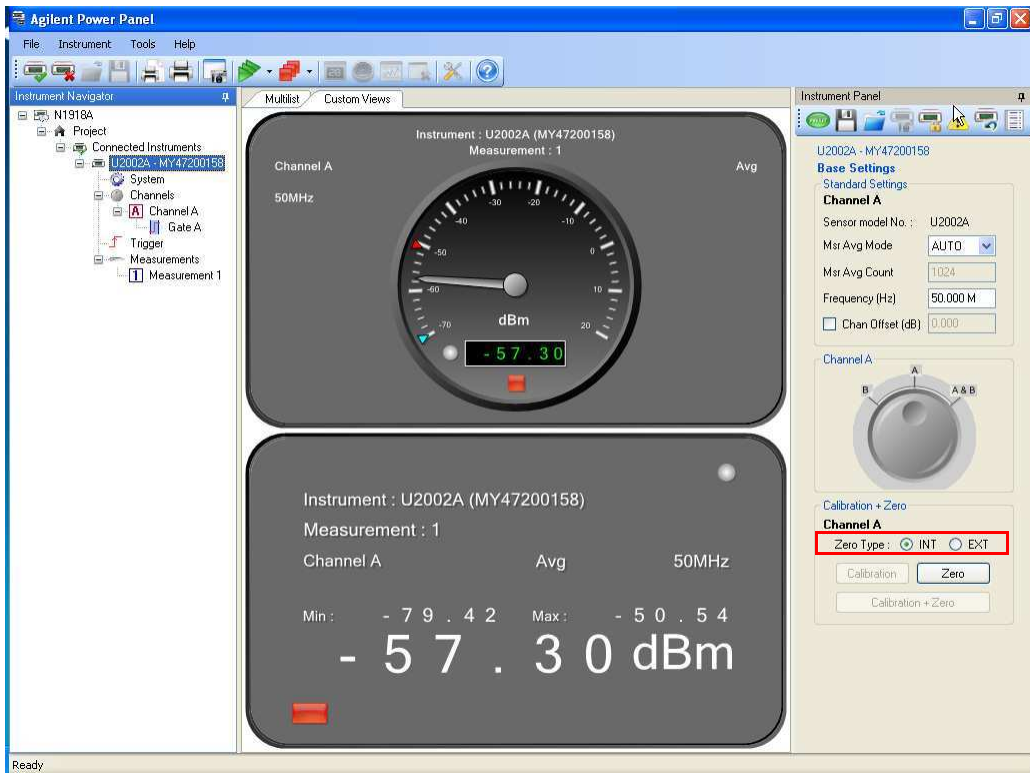


Figure 2-2 Select either INT or EXT from the Zero Type option

Power Sweep and Frequency Sweep

The frequency sweep and power sweep features provide a measurement automation between the U2000 Series USB power sensor and the signal source. This feature reduces the communication path and improves test time by eliminating the need of PC-instrument communication.

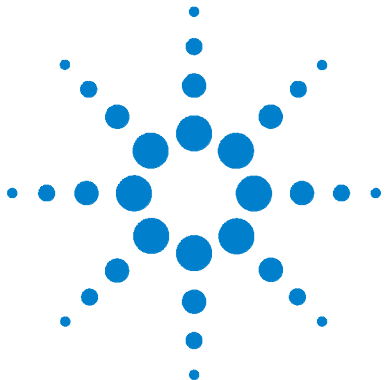
To perform frequency sweep operation, users are required to set the start frequency, stop frequency and number of step for the signal source. By default, the step value is set to 0. The number of step ranges from 0 to 2048.

Connect the signal source TRIG OUT to the USB power sensor TRIG IN. Once the sweeping operation starts, the signal source will step through each frequency point within the preset range. Each step will send a TTL signal to the USB power sensor notifying it to measure the signal power. Only a one-way synchronization occurs in this process which is from the signal source to the USB power sensor.

A proper dwell time must be set in the signal generator to ensure all the measurement readings in USB power sensor are settled before stepping through the next frequency point. The same process is applicable to the power sweep operation.

Step Detection

To reduce the filter settling time after a significant step in the measured power, the filter can be set to re-initialize upon detection of a step increase or decrease in the measured power. Step detection can be set in both manual and automatic filter modes. Refer to the *U2000 Series Programming Guide* for more details on how to enable or disable the step detection.



3 Specifications and Characteristics

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This chapter describes the specifications and characteristics of your Agilent U2000 Series USB power sensors.



Introduction

The U2000 Series USB power sensors are average, wide dynamic range power sensors that can be used with a PC or any selected USB-based Agilent instrument.

The specifications contained in this chapter are valid **ONLY** after proper calibration of the power sensor and apply to continuous wave (CW) signals unless otherwise stated. The recommended calibration interval for this product is 1 year. Specifications apply over a temperature range 0 °C to +55 °C unless otherwise stated.

Specifications quoted over a temperature range of 25 °C \pm 10 °C apply to a relative humidity of 15% to 75% and conform to the standard environmental test conditions. These specifications are valid after a 30-minute warm-up period.

The dynamic range of the U2000 Series USB power sensors is –60 dBm to +44 dBm and the range is divided into two independent measurement paths – a high and a low power path, as shown below:

Sensor	Low Power Path	High Power Path
U2000A, U2001A, U2002A, U2004A	–60 dBm to –10 dBm	–10 dBm to +20 dBm
U2000H, U2001H, U2002H	–50 dBm to 0 dBm	0 dBm to +30 dBm
U2000B, U2001B	–30 dBm to +20 dBm	+20 dBm to +44 dBm

Some specifications are detailed for individual measurement paths, with the automatic switching point at:

- –10 dBm for U2000/1/2/4A
- 0 dBm for the U2000/1/2H
- +20 dBm for U2000/1B

Supplemental characteristics, which are shown in italics, are intended to provide useful information with regard to applying the power sensors in that they contain typical, but non-warranted performance parameters. These characteristics are shown in *italics* or denoted as “*typical*”, “*nominal*” or “*approximate*”.

Specifications

Frequency and Power Ranges

Model	Frequency Range	Power Range
U2000A	10 MHz to 18.0 GHz	-60 dBm to +20 dBm
U2001A	10 MHz to 6.0 GHz	
U2002A	50 MHz to 24 GHz	
U2004A	9 kHz to 6.0 GHz	
U2000H	10 MHz to 18 GHz	-50 dBm to +30 dBm
U2001H	10 MHz to 6 GHz	
U2002H	50 MHz to 24 GHz	
U2000B	10 MHz to 18 GHz	-30 dBm to +44 dBm
U2001B	10 MHz to 6 GHz	

Connector Type

Model	Connector Type	Impedance
U2000/1/4A	N-Type (m)	50 Ω
U2002A	3.5 mm (m)	50 Ω
U2000/1H	N-Type (m)	50 Ω
U2002H	3.5 mm (m)	50 Ω
U2000/1B	N-Type (m)	50 Ω

Maximum SWR (25 °C ±10 °C)

Model	Frequency	SWR
U2000A	10 MHz to 30 MHz	1.15
	30 MHz to 2 GHz	1.13
	2 GHz to 14 GHz	1.19
	14 GHz to 16 GHz	1.22
	16 GHz to 18 GHz	1.26
U2001A	10 MHz to 30 MHz	1.15
	30 MHz to 2 GHz	1.13
	2 GHz to 6 GHz	1.19
U2002A	50 MHz to 2 GHz	1.13
	2 GHz to 14 GHz	1.19
	14 GHz to 16 GHz	1.22
	16 GHz to 18 GHz	1.26
	18 GHz to 24 GHz	1.30
U2004A	9 kHz to 2 GHz	1.13
	2 GHz to 6 GHz	1.19
U2000B	10 MHz to 2 GHz	1.12
	2 GHz to 12.4 GHz	1.17
	12.4 GHz to 18 GHz	1.24
U2001B	10 MHz to 2 GHz	1.12
	2 GHz to 6 GHz	1.17
U2000H	10 MHz to 8 GHz	1.15
	8 GHz to 12.4 GHz	1.25
	12.4 GHz to 18 GHz	1.28

U2001H	10 MHz to 6 GHz	1.15
U2002H	50 MHz to 8 GHz	1.15
	8 GHz to 12.4 GHz	1.25
	12.4 GHz to 18 GHz	1.28
	18 GHz to 24 GHz	1.30

SWR Plots for U2000 Series USB Power Sensors

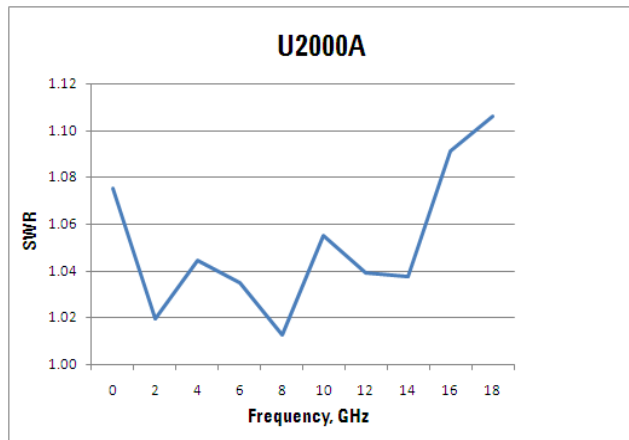


Figure 3-1 U2000A Typical SWR (25 °C ±10 °C)

3 Specifications and Characteristics

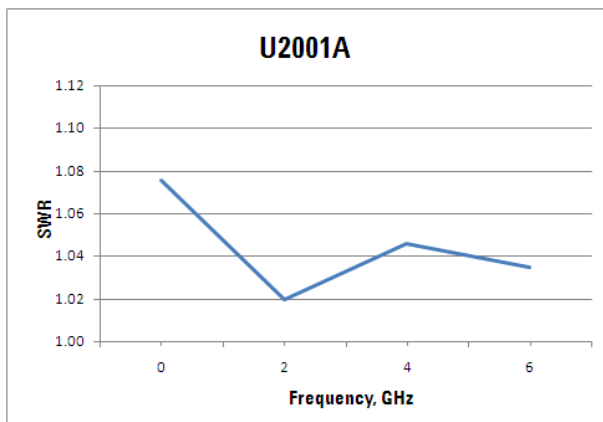


Figure 3-2 U2001A Typical SWR (25 °C ±10 °C)

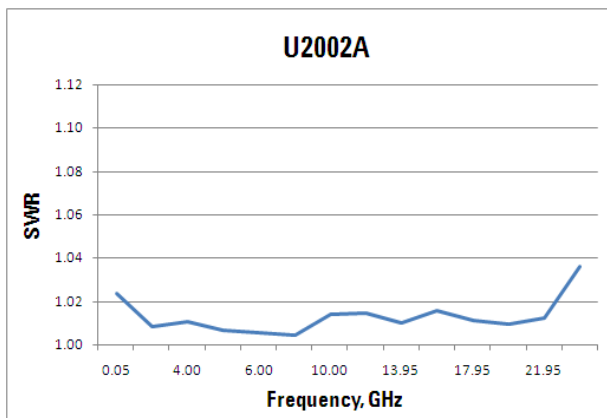


Figure 3-3 U2002A Typical SWR (25 °C ±10 °C)

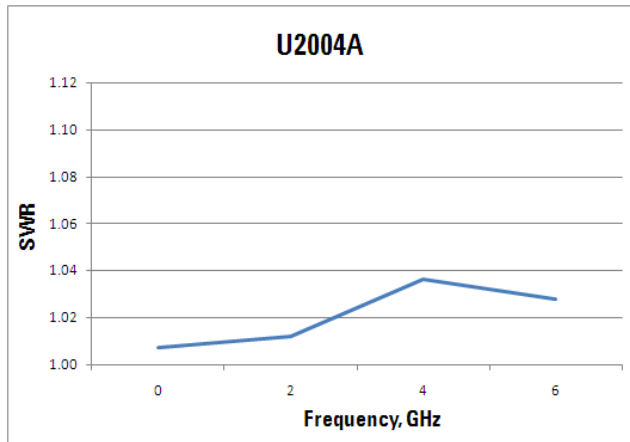


Figure 3-4 U2004A Typical SWR (25 °C ±10 °C)

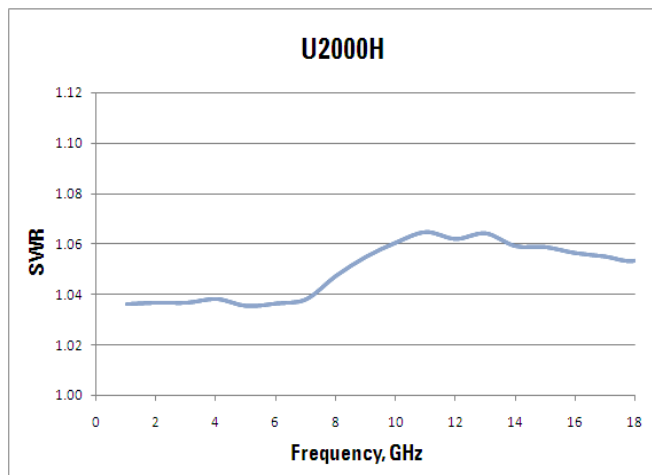


Figure 3-5 U2000H Typical SWR (25 °C ±10 °C)

3 Specifications and Characteristics

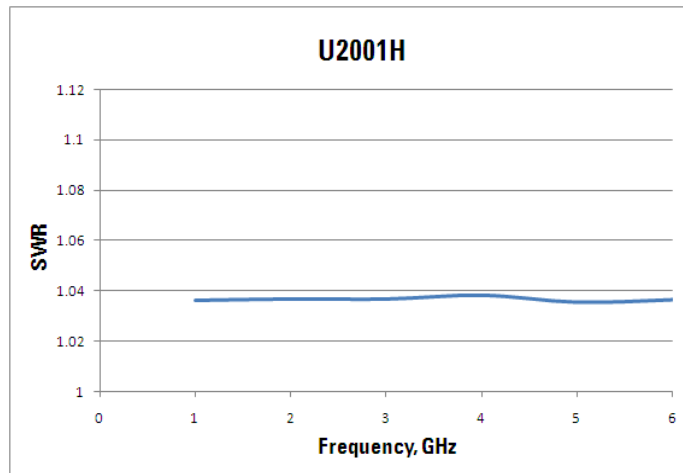


Figure 3-6 U2001H Typical SWR (25 °C ±10 °C)

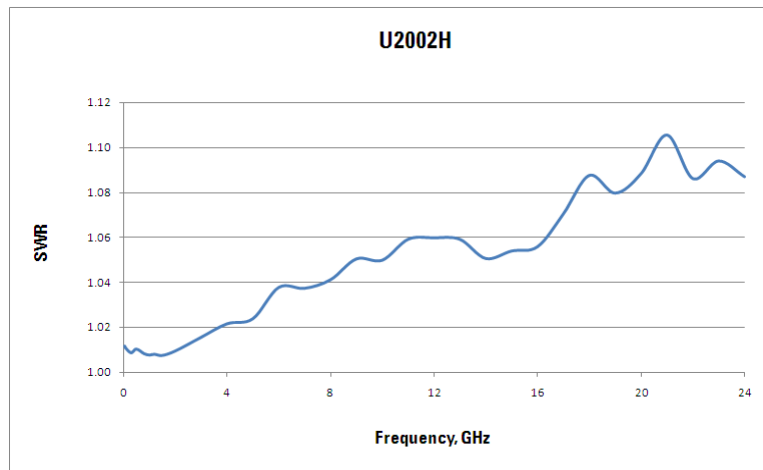


Figure 3-7 U2002H Typical SWR (25 °C ±10 °C)

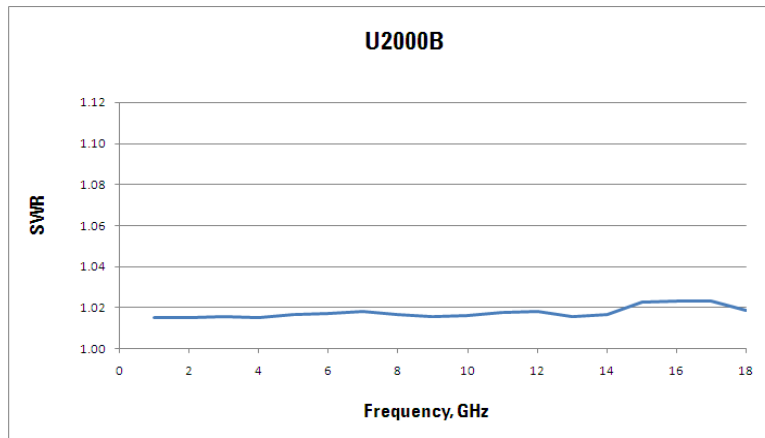


Figure 3-8 U2000B Typical SWR (25 °C ±10 °C)

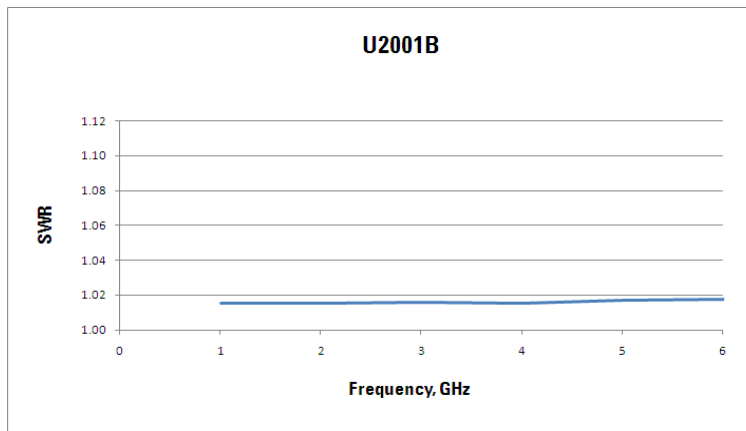


Figure 3-9 U2001B Typical SWR (25 °C ±10 °C)

Maximum SWR (0 °C to 55 °C)

Model	Frequency	SWR
U2000A	10 MHz to 30 MHz	1.21
	30 MHz to 2 GHz	1.15
	2 GHz to 14 GHz	1.20
	14 GHz to 16 GHz	1.23
	16 GHz to 18 GHz	1.27
U2001A	10 MHz to 30 MHz	1.21
	30 MHz to 2 GHz	1.15
	2 GHz to 6 GHz	1.20
U2002A	50 MHz to 2 GHz	1.15
	2 GHz to 14 GHz	1.20
	14 GHz to 16 GHz	1.23
	16 GHz to 18 GHz	1.27
	18 GHz to 24 GHz	1.30
U2004A	9 kHz to 2 GHz	1.15
	2 GHz to 6 GHz	1.20
U2000B	10 MHz to 2 GHz	1.14
	2 GHz to 12.4 GHz	1.18
	12.4 GHz to 18 GHz	1.25
U2001B	10 MHz to 2 GHz	1.14
	2 GHz to 6 GHz	1.18

U2000H	10 MHz to 8 GHz	1.17
	8 GHz to 12.4 GHz	1.26
	12.4 GHz to 18 GHz	1.29
U2001H	10 MHz to 6 GHz	1.17
U2002H	50 MHz to 8 GHz	1.17
	8 GHz to 12.4 GHz	1.26
	12.4 GHz to 18 GHz	1.29
	18 GHz to 24 GHz	1.31

Maximum Power

Models	Maximum Power
U2000/1/2A	+25 dBm (320 mW) average, 20 VDC +33 dBm peak (2 W) <10 μ s
U20004A	+25 dBm (320 mW) average, 5 VDC +33 dBm peak (2 W) <10 μ s
U2000/1H	+33 dBm (2 W) average, 20 VDC +50 dBm (100 W) peak for 1 μ s
U2002H	+33 dBm (2 W) average, 10 VDC +50 dBm (100 W) peak for 1 μ s
U2000/1B	+45 dBm (30 W) average, 20 VDC +47 dBm (50 W) peak for 1 μ s

CAUTION

The U2004A USB power sensor is DC coupled. DC coupling of the input allows excellent low frequency coverage. However, the presence of external DC component signals may affect the accuracy of the power measurement. Users are advised to use suitable external DC block for the DC component removal.

DC voltages in excess of the maximum value (5 V) can damage the sensing diode.

Power Accuracy

After zeroing and calibration at ambient environmental conditions.

Table 3-1 Power Accuracy* (with exclusions)

Model	Power Level	Accuracy 25 °C ±10 °C	Accuracy 0 °C to 55 °C
U2000/1/2/4A	-60 dBm to +20 dBm	±3.0%	±3.5%
U2000/1/2H	-50 dBm to +30 dBm	±4.0%	±5.0%
U2000/1B	-30 dBm to +44 dBm	±3.5%	±4.0%

With conditions as follows:

- After zeroing**
- Number of averages = 1024
- After 30 minutes of power-on warm-up

* The accuracy is essentially a combination of linearity, instrumentation accuracy, and traceability to absolute accuracy at 50 MHz, 0 dBm. Note: Mismatch Uncertainty, Cal-Factor Uncertainty, and Power level dependent terms (Zero-Set, Drift, and Noise) are excluded in this specification and specified elsewhere in this guide.

** It is strongly advisable to perform external zeroing on the U2000 Series USB power sensor for power measurement level below -30 dBm for accurate measurements. During the external zeroing process, the RF input signal must be switched off or the device-under-test disconnected from the U2000 Series USB power sensor.

3 Specifications and Characteristics

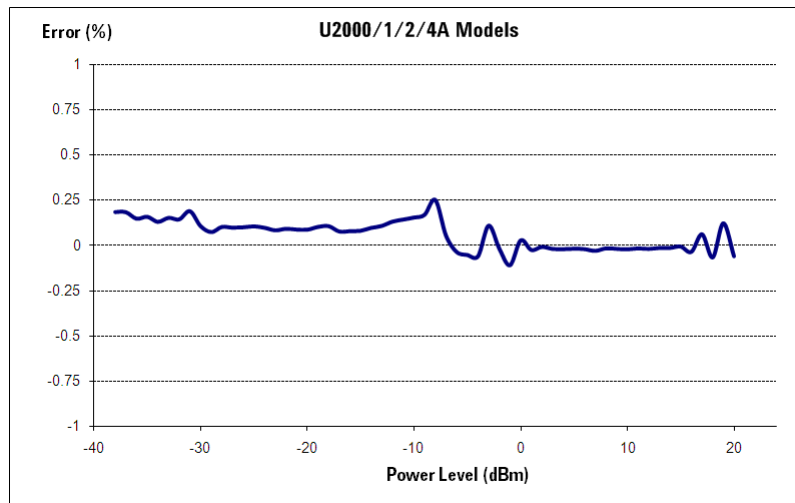


Figure 3-10 Typical power accuracy at 25 °C for U2000/1/2/4A models¹

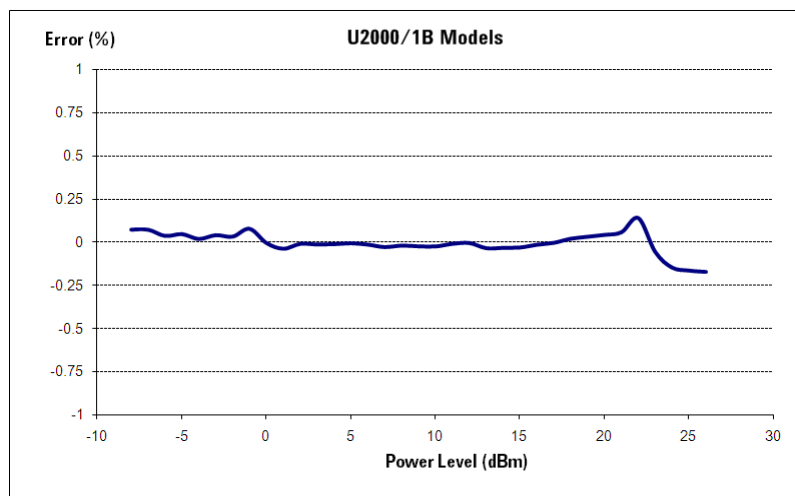


Figure 3-11 Typical power accuracy at 25 °C for U2000/1B models¹

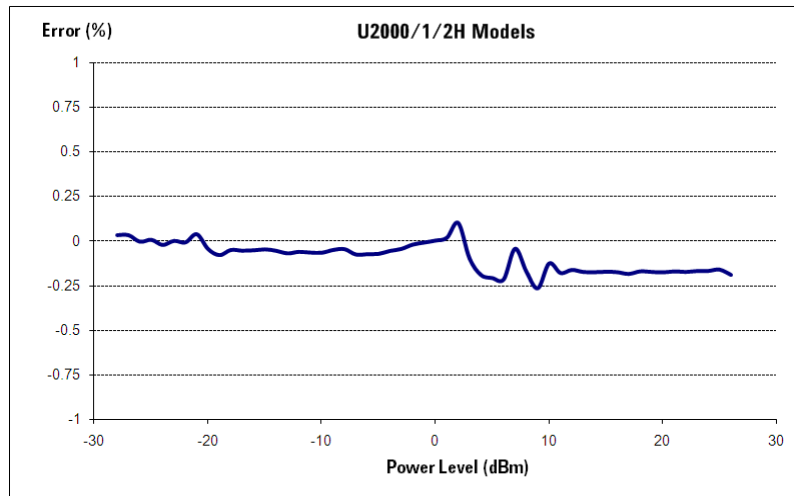


Figure 3-12 Typical power accuracy at 25 °C for U2000/1/2H models¹

- 1** Measurement Uncertainty* $\leq 1.6\%$. At room temperature and excluding power level dependent terms (Zero Set, Drift and Noise).

* Refer to *Agilent Fundamentals of RF and Microwave Power Measurements (Part 3) Power Measurement Uncertainty per International Guide* (Application Note 1449-3), 5988-9215EN for more information.

Switching Point

The U2000/1/2/4A power sensors have two paths, a low power path covering -60 dBm to -10 dBm and a high power path covering -10 dBm to +20 dBm. The power sensor automatically selects the proper power level path. To avoid unnecessary switching when the power level is close to the -10 dBm point, **Switching Point Hysteresis** is added. This hysteresis causes the low power path to remain selected until approximately -9 dBm has been reached. As the power level increases above -9 dBm, the high power path will be selected. The high power path remains selected until approximately -11 dBm has been reached. As the power level decreases below -11 dBm, the low power path will be selected.

As for the U2000/1/2H and U2000/1B power sensors, to avoid unnecessary switching when the power level is near the switch point, **Switching Point Hysteresis** has been added. This hysteresis causes the low power path to remain selected until approximately 1 dB above the switch point as the power level is increased. Above this power, the high power path is selected. The high power path remains selected until approximately 1 dB below the switch point as the signal level decreases. Below this power, the lower path is selected. 20 dBm is the switch point for the U2000/1/2H sensors while the U2000/1B sensors switch at 0 dBm.

	Error
Offset at Switch Point	$\leq \pm 0.5\%$ ($\leq \pm 0.02$ dB) typical
Switching Point Hysteresis	1 dB typical

Zero Set, Zero Drift, and Measurement Noise

For U2000/1/2A,

Range ¹	Zero Set (Internal)	Zero Set (External)	Zero Drift ²	Measurement Noise ³	Noise Per Sample ⁴
-60 dBm to -35 dBm	±1.5 nW	±600 pW	200 pW	1 nW	N/A
-38 dBm to -15 dBm	±2 nW	±1.5 nW	400 pW	1.5 nW	90 nW
-20 dBm to -9 dBm	±12 nW	±10 nW	1.5 nW	15 nW	1 μW
-11 dBm to -5 dBm	±2 μW	±500 nW	50 nW	650 nW	55 μW
-7 dBm to 15 dBm	±4 μW	±1 μW	500 nW	1 μW	85 μW
10 dBm to 20 dBm	±6 μW	±5 μW	2 μW	10 μW	550 μW

For U2004A,

Range ¹	Zero Set (Internal)	Zero Set (External)	Zero Drift ²	Measurement Noise ³
-60 dBm to -35 dBm	±2.8 nW	±600 pW	200 pW	1 nW
-38 dBm to -15 dBm	±3 nW	±1.5 nW	400 pW	1.5 nW
-20 dBm to -9 dBm	±12 nW	±10 nW	1.5 nW	15 nW
-11 dBm to -5 dBm	±2 μW	±500 nW	50 nW	650 nW
-7 dBm to 15 dBm	±4 μW	±1 μW	500 nW	1 μW
10 dBm to 20 dBm	±6 μW	±5 μW	2 μW	10 μW

For U2000/1/2H,

Range ¹	Zero Set (Internal)	Zero Set (External)	Zero Drift ²	Measurement Noise ³	Noise Per Sample ⁴
-50 dBm to -25 dBm	±15 nW	±8 nW	2 nW	10 nW	N/A
-28 dBm to -5 dBm	±20 nW	±20 nW	4 nW	15 nW	900 nW
-10 dBm to 1 dBm	±120 nW	±100 nW	15 nW	150 nW	10 μW
-1 dBm to 5 dBm	±20 μW	±20 μW	500 nW	6.5 μW	550 μW
3 dBm to 25 dBm	±40 μW	±30 μW	5 μW	10 μW	850 μW
20 dBm to 30 dBm	±60 μW	±60 μW	20 μW	100 μW	5.5 mW

3 Specifications and Characteristics

For U2000/1B,

Range ¹	Zero Set (Internal)	Zero Set (External)	Zero Drift ²	Measurement Noise ³	Noise Per Sample ⁴
-30 dBm to -5 dBm	±1.8 µW	±800 nW	200 nW	1 µW	N/A
-8 dBm to 15 dBm	±2 µW	±2 µW	400 nW	1.5 µW	90 µW
10 dBm to 21 dBm	±12 µW	±10 µW	1.5 µW	15 µW	1 mW
19 dBm to 25 dBm	±2 mW	±1 mW	50 nW	650 µW	55 mW
23 dBm to 44 dBm	±4 mW	±2 mW	500 µW	1 mW	85 mW

1 Condition: (i) 0 °C to 55 °C and (ii) 40 °C, 95% relative humidity.

2 Within one hour after zero set, at a constant temperature, after 24-hour warm-up of the power sensor.

3 The number of averages at 16 for **Normal** mode, measured over one minute interval and two standard deviations.

4 The Noise Per Sample specification is only applicable for gated power working range stated in the [“Time-gated Measurements”](#) table.

NOTE

The Zero Set, Zero Drift, and Measurement Noise specifications are only applicable to U2000 Series USB power sensors with serial prefix as shown below:

U2000A Serial prefix MY480/SG480 and above

U2001A Serial prefix MY481/SG481 and above

U2002A Serial prefix MY482/SG482 and above

U2004A Serial prefix MY484/SG484 and above

For power sensors with earlier prefixes, refer to [“Appendix A: Zero Set, Zero Drift, and Measurement Noise”](#) on page 70.

Settling time

In **FAST** mode (using Free Run trigger), for a 10 dB decreasing power step, the settling time is:

	Time
U2000 Series USB Power Sensors	<i>25 ms¹</i>

¹ When a power step crosses the auto-range switch point of the sensor, add 25 ms.

Table 3-2 Settling Time for Normal Mode and x2 Mode

Number of Averages	1	2	4	8	16	32	64	128	256	512	1,024
Settling Time¹ (s) (Normal Mode)	<i>0.045</i>	<i>0.09</i>	<i>0.17</i>	<i>0.34</i>	<i>0.66</i>	<i>1.3</i>	<i>2.6</i>	<i>5.2</i>	<i>10.4</i>	<i>20.9</i>	<i>41.9</i>
Settling Time¹ (s) (x2 Mode)	<i>0.042</i>	<i>0.05</i>	<i>0.09</i>	<i>0.17</i>	<i>0.34</i>	<i>0.66</i>	<i>1.3</i>	<i>2.6</i>	<i>5.2</i>	<i>10.4</i>	<i>20.9</i>

¹ Manual filter, 10 dB decreasing power step (not across the switching point)

Table 3-3 Noise Multiplier for Normal Mode and x2 Mode

Number of Averages	1	2	4	8	16	32	64	128	256	512	1,024
Noise Multiplier (s) (Normal Mode)	<i>2.0</i>	<i>1.8</i>	<i>1.7</i>	<i>1.5</i>	<i>1.0</i>	<i>0.95</i>	<i>0.74</i>	<i>0.55</i>	<i>0.39</i>	<i>0.29</i>	<i>0.21</i>
Noise Multiplier (s) (x2 Mode)	<i>2.7</i>	<i>2.4</i>	<i>2.0</i>	<i>1.6</i>	<i>1.0</i>	<i>0.91</i>	<i>0.78</i>	<i>0.53</i>	<i>0.34</i>	<i>0.29</i>	<i>0.20</i>

3 Specifications and Characteristics

		Maximum sensor power within a range			
	X2 Mode	Normal Mode	U2000/1/2/4A	U2000/1/2H	U2000/1B
Typical Settling Times	45 ms	45 ms	+10 dBm	+20 dBm	+40 dBm
	82 ms	90 ms	+2 dBm	+12 dBm	+32 dBm
	1.3 s	2.6 s	-4 dBm	+6 dBm	+26 dBm
	1.5 s	2.7 s	-10 dBm	0 dBm	+20 dBm
	450 ms	460 ms	-20 dBm	-10 dBm	+10 dBm
	1.6 s	2.8 s	-30 dBm	-20 dBm	0 dBm
	20 s	39 s	-40 dBm	-30 dBm	-10 dBm
	24 s	42 s	-50 dBm	-40 dBm	-20 dBm
	24 s	42 s			
			Minimum sensor power within a range		

Sensor Dynamic Range

Figure 3-13 U2000 Series Autofilter, default resolution, 10 dB decreasing power step (not across the switching point)

Calibration Factor and Reflection Coefficient

The Calibration Factor (CF) corrects the frequency response of the sensor.

The Reflection Coefficient (Rho, or ρ) relates to the SWR based on the following formula:

$$SWR = \frac{1 + \rho}{1 - \rho}$$

Maximum uncertainties of the CF data are listed in the following tables. As the U2000 Series USB power sensors have two independent measurement paths (high and low power paths), there is only one set of CF data used for both high and low power paths for each sensor. The uncertainty analysis for the calibration of the sensors was done in accordance with the ISO Guide. The uncertainty data reported on the calibration certificate is the expanded uncertainty with a 95% confidence level and a coverage factor of two.

Cal Factor Uncertainty

Frequency	U2000A
	Maximum CF Uncertainty (25 °C ±10 °C)
10 MHz to 30 MHz	1.8%
30 MHz to 2 GHz	1.6%
2 GHz to 14 GHz	2.0%
14 GHz to 16 GHz	2.2%
16 GHz to 18 GHz	2.2%

Frequency	U2001A
	Maximum CF Uncertainty (25 °C ±10 °C)
10 MHz to 30 MHz	1.8%
30 MHz to 2 GHz	1.6%
2 GHz to 6 GHz	2.0%

Frequency	U2002A
	Maximum CF Uncertainty (25 °C ±10 °C)
50 MHz to 2 GHz	2.0%
2 GHz to 14 GHz	2.5%
14 GHz to 16 GHz	2.7%
16 GHz to 18 GHz	2.7%
18 GHz to 24 GHz	3.0%

Frequency	U2004A
	Maximum CF Uncertainty (25 °C ±10 °C)
9 kHz to 2 GHz	1.8%
2 GHz to 6 GHz	1.8%

Frequency	U2000B
	Maximum CF Uncertainty (25 °C ±10 °C)
10 MHz to 2 GHz	1.8%
2 GHz to 12.4 GHz	2.0%
12.4 GHz to 18 GHz	2.2%

Frequency	U2001B
	Maximum CF Uncertainty (25 °C ±10 °C)
10 MHz to 2 GHz	1.8%
2 GHz to 6 GHz	2.0%

Frequency	U2000H
	Maximum CF Uncertainty (25 °C ±10 °C)
10 MHz to 8 GHz	2.0%
8 GHz to 12.4 GHz	2.0%
12.4 GHz to 18 GHz	2.2%

3 Specifications and Characteristics

Frequency	U2001H
	Maximum CF Uncertainty (25 °C ±10 °C)
10 MHz to 6 GHz	2.0%

Frequency	U2002H
	Maximum CF Uncertainty (25 °C ±10 °C)
50 MHz to 8 GHz	2.5%
8 GHz to 12.4 GHz	2.5%
12.4 GHz to 18 GHz	2.7%
18 GHz to 24 GHz	3.0%

Trigger

External TTL Trigger Input	
Trigger low	<1.1 V
Trigger high	>1.9 V
Minimum trigger pulse width	35 ns
Minimum trigger repetition period	80 ns
Trigger latency	11 μ s \pm 2 μ s

Time-gated Measurements

Time-gate Parameters	U2000 Series Performance*
Sampling rate	1.47 Msps
Gate sweep time	$0 \text{ s} < \text{Sweep time} < 0.15 \text{ s}$
Gate offset time	$0 \text{ s} < \text{Offset time} < 0.15 \text{ s}$
Gate resolution	$\pm 1 \text{ } \mu\text{s}$
Gated power	U2000/1/2A: -25 dBm to +20 dBm U2000/1/2H: -15 dBm to +30 dBm U2000/1B: +5 dBm to +44 dBm
Measurement speed	10 ms/reading (Gate sweep time $\leq 2 \text{ ms}$, Gate sweep time + Gate offset $< 2.3 \text{ ms}$, measurement rate FAST)

* Not applicable for U2004A

NOTE

The total value of gate sweep time and gate offset time has to be less than 0.15 s, (Sweep time + Offset time $< 0.15 \text{ s}$).

General Characteristics

Physical Characteristics

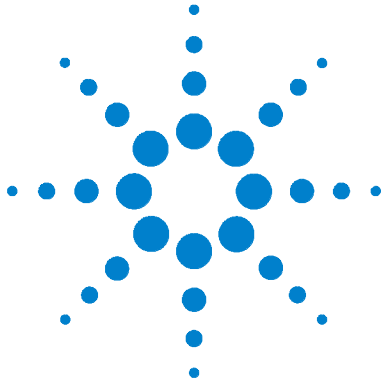
Net Weight	
U2000/1/4A	0.262 kg
U2002A	0.226 kg
U2000/1B	0.762 kg
U2000/1H	0.324 kg
U2002H	0.274 kg
Dimensions (L x W x H)	
U2000/1/4A	163.75 mm x 46.00 mm x 35.90 mm
U2002A	134.37 mm x 46.00 mm x 35.90 mm
U2000/1B	308.00 mm x 115.00 mm x 84.00 mm
U2000/1H	207.00 mm x 46.00 mm x 36.00 mm
U2002H	164.00 mm x 46.00 mm x 36.00 mm

Storage and Shipment

Environment	The sensor should be stored in a clean, dry environment
Temperature	-30 °C to +70 °C (non-operating)
Relative Humidity	Non-operating up to 90% at 65 °C (non-condensing)
Altitude	Non-operating up to 4,600 metres (15,000 feet)

USB Standard

USB Speed	Hi-Speed 2.0
------------------	--------------



4 Service

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This chapter describes the performance test and provides information on replaceable parts as well as on service details.



General Information

This chapter contains information about general maintenance, performance tests, troubleshooting and the repair of U2000 Series USB power sensors.

Cleaning

Use a clean, damp cloth to clean the body of the U2000 Series USB power sensors.

Connector Cleaning

CAUTION

The RF connector beads deteriorate when contacted with hydrocarbon compounds such as acetone, trichloroethylene, carbon tetrachloride, and benzene.

CAUTION

Clean the connector only at a static free workstation. Electrostatic discharge to the center pin of the connector will render the power sensor inoperative.

Keeping in mind its flammable nature, a solution of pure isopropyl or ethyl alcohol can be used to clean the connector.

Clean the connector face using a cotton swab dipped in isopropyl alcohol. If the swab is too big use, use a round wooden toothpick wrapped in a lint-free cotton cloth dipped in isopropyl alcohol.

Refer to Agilent Application Note 326, Principles of Microwave Connector Care (5954-1566) or Microwave Connector Care (08510-90064) for proper cleaning methods.

Performance Test

Standing Wave Ratio (SWR) and Reflection Coefficient (Rho) Performance Test

This section does not establish preset SWR test procedures since there are several test methods and different equipment available for testing the SWR or reflection coefficient. Therefore, the actual accuracy of the test equipment must be accounted for when measuring against instrument specifications to determine a pass or fail condition. The test system used must not exceed the system Rho uncertainties shown in the following tables when testing the U2000 Series USB power sensors.

Table 4-1 Power Sensor SWR and Reflection Coefficient for the U2000A

Frequency	Actual Measurement	Maximum Rho	SWR
10 MHz to 30 MHz		0.070	1.15
30 MHz to 2 GHz		0.061	1.13
2 GHz to 14 GHz		0.087	1.19
14 GHz to 16 GHz		0.099	1.22
16 GHz to 18 GHz		0.115	1.26

Table 4-2 Power Sensor SWR and Reflection Coefficient for the U2001A

Frequency	Actual Measurement	Maximum Rho	SWR
10 MHz to 30 MHz		0.070	1.15
30 MHz to 2 GHz		0.061	1.13
2 GHz to 6 GHz		0.087	1.19

Table 4-3 Power Sensor SWR and Reflection Coefficient for the U2002A

Frequency	Actual Measurement	Maximum Rho	SWR
50 MHz to 2 GHz		0.061	1.13
2 GHz to 14 GHz		0.087	1.19
14 GHz to 16 GHz		0.099	1.22
16 GHz to 18 GHz		0.115	1.26
18 GHz to 24 GHz		0.130	1.30

CAUTION

DC voltages in excess of the maximum value (5 VDC) can damage the sensing diode.

Table 4-4 Power Sensor SWR and Reflection Coefficient for the U2004A

Frequency	Actual Measurement	Maximum Rho	SWR
9 kHz to 2 GHz		0.061	1.13
2 GHz to 6 GHz		0.087	1.19

Table 4-5 Power Sensor SWR and Reflection Coefficient for the U2000H

Frequency	Actual Measurement	Maximum Rho	SWR
10 MHz to 8 GHz		0.070	1.15
8 GHz to 12.4 GHz		0.111	1.25
12.4 GHz to 18 GHz		0.123	1.28

Table 4-6 Power Sensor SWR and Reflection Coefficient for the U2001H

Frequency	Actual Measurement	Maximum Rho	SWR
10 MHz to 6 GHz		0.070	1.15

Table 4-7 Power Sensor SWR and Reflection Coefficient for the U2002H

Frequency	Actual Measurement	Maximum Rho	SWR
50 MHz to 8 GHz		0.070	1.15
8 GHz to 12.4 GHz		0.111	1.25
12.4 GHz to 18 GHz		0.123	1.28
18 GHz to 24 GHz		0.130	1.30

Table 4-8 Power Sensor SWR and Reflection Coefficient for the U2000B

Frequency	Actual Measurement	Maximum Rho	SWR
10 MHz to 2 GHz		0.057	1.12
2 GHz to 12.4 GHz		0.078	1.17
12.4 GHz to 18 GHz		0.107	1.24

Table 4-9 Power Sensor SWR and Reflection Coefficient for the U2001B

Frequency	Actual Measurement	Maximum Rho	SWR
10 MHz to 2 GHz		0.057	1.12
2 GHz to 6 GHz		0.078	1.17

Replaceable Parts

Table 4-10 contains a list of replaceable parts. To order a part, quote the Agilent part number, specify the quantity required, and address the order to the nearest Agilent office.

NOTE

Within the USA, it is better to order directly from the Agilent Parts Center in Roseville, California. Ask your nearest Agilent office for information and forms for the “Direct Mail Order System.” Also your nearest Agilent office can supply toll free telephone numbers for ordering parts and supplies.

Table 4-10 Replaceable Parts

Model	Agilent Part Number	Qty	Description
U2000A	U2000-60006	1	U2000A replacement module
	5190-0062	1	Top label for U2000A
U2001A	U2001-60006	1	U2001A replacement module
	5190-0650	1	Top label for U2001A
U2002A	U2002-60006	1	U2002A replacement module
	5190-0651	1	Top label for U2002A
U2004A	U2004-60006	1	U2004A replacement module
	5190-0652	1	Top label for U2004A
U2000B	U2000-60007	1	U2000B replacement module
	5190-1710	1	Top label for U2000B
U2001B	U2000-60008	1	U2001B replacement module
	5190-1708	1	Top label for U2001B
U2000H	U2000-60009	1	U2000H replacement module
	5190-1709	1	Top label for U2000H
U2001H	U2000-60010	1	U2001H replacement module
	5190-1711	1	Top label for U2001H
U2002H	U2000-60011	1	U2002H replacement module
	5190-1712	1	Top label for U2002H
All models	5190-0061	2	Middle label
	5190-0060	1	Bottom label
	U2000-20001	1	Top cover
	U2000-20003	1	Bottom cover

Service

The following service instructions consist of information on troubleshooting, and repairs.

Troubleshooting

The U2000 Series USB power sensors represent a combination of a power meter and power sensor in one unit. If the LED is red and blinking, it indicates that there is a hardware error or operating system (OS) error in the power sensor. The LED will only be blinking red if the power sensor failed in the self-test. The command `SYSTEM:ERROR` is used to read the exact error messages which occur on the power sensor. Please kindly send the power sensor back to the nearest service centre for repair. Refer to the “[LED Indicator Guide](#)” for more information.

CAUTION

Electrostatic discharge will render the power sensor inoperative. Do not, under any circumstances, open the power sensor unless you and the power sensor are in a static free environment.

Repairing a Defective Sensor

There are no serviceable parts inside the U2000 Series USB power sensors. If the sensor is defective, please send it back to the nearest Agilent Service Center for repair. The entire module of the defective sensor will be replaced with the appropriate replacement module. See [Table 4-10](#).

Disassembly and Reassembly Procedure




Disassembly Procedure

Disassemble the power sensor by performing the following steps:

CAUTION

Disassemble the power sensor only in a static free workstation. Electrostatic discharge renders the power sensor inoperative.

Table 4-11 Disassembly Procedure

	<p>1 Remove the top label.</p>
	<p>2 Loosen three screws by using M2 to remove the housing.</p>
	<p>3 Replace the defective sensor module with a new sensor module. Please refer to Table 4-10.</p>

Reassembly Procedure

Tools required for reassembly:

Tools	Purpose	Qty	Torque value
M2 Torx	To fit the housing	1	3.98 lbs.in

Reassembly instructions:

The reassembly procedures are simply the reversal of the disassembly procedure.

Attenuator Disassembly and Reassembly Procedure for U2000B and U2001B

Disassembly Procedure

Tools required for disassembly:

Tools	Purpose	Torque value
¾" torque wrench	To loosen the attenuator	80 lbs.in
½" wrench	To prevent rotation	N/A

NOTE

The attenuator for U2000B and U2001B must not be disassembled under any circumstances except during annual calibration. Removing the attenuator for U2000B and U2001B will void the calibration.

Table 4-12 Attenuator Disassembly Procedure



- 1 Loosen the connector using the torque wrench.
- 2 After that clean the connector's threads with IPA. Ensure that the crystallized loctite is cleaned properly.

Reassembly Procedure

Tools required for reassembly:

Tools	Purpose	Torque value
Loctite Threadlocker 242	To secure the connection between the attenuator and the sensor's connector	N/A
3/4" torque wrench	To tighten the attenuator	12 lbs.in

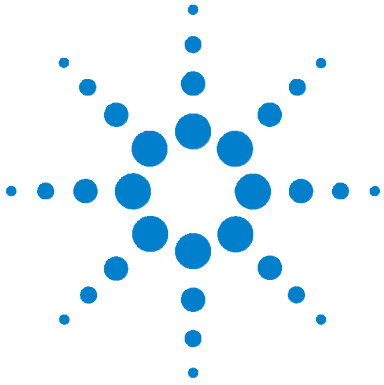
Table 4-13 Attenuator Reassembly Procedure



- 1 Apply one drop of loctite on the first, second, and third threads of the connector.



- 2 Tighten the connector using the torque wrench.



Appendix

Appendix A: Zero Set, Zero Drift, and Measurement Noise 70



Appendix A: Zero Set, Zero Drift, and Measurement Noise

The following specifications in [Table 5-1](#) are only applicable to the U2000 Series USB power sensors with the serial prefix as shown below:

Model	Serial Prefix
U2000A	Serial Prefix MY470/SG470 and below
U2001A	Serial Prefix MY471/SG471 and below
U2002A	Serial Prefix MY472/SG472 and below
U2004A	Serial Prefix MY474/SG474 and below

Table 5-1 Zero Set, Zero Drift, and Measurement Noise

Range ¹	Zero Set	Zero Drift ²	Measurement Noise ³
–60 dBm to –35 dBm	±651 pW	996 pW	1.91 nW
–38 dBm to –15 dBm	±1.13 nW	400 pW	2.24 nW
–20 dBm to –9 dBm	±12.8 nW	6.01 nW	40.8 nW
–11 dBm to –5 dBm	±445 nW	155 nW	1.63 μW
–7 dBm to 15 dBm	±4.26 μW	3.20 μW	861 nW
10 dBm to 20 dBm	±6.84 μW	3.39 μW	19.5 μW

- 1 Condition: (i) 0 °C to 55 °C and (ii) 40 °C, 95% relative humidity.
- 2 Within one hour after zero set, at a constant temperature, after 24-hour warm-up of the power sensor.
- 3 The number of averages at 16 for **Normal** mode, measured over one minute interval and two standard deviations.

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