Agilent U2000 Series USB Power Sensors

Operating and Service Guide

Agilent Technologies

Notices

Manual Part Number

U2000-90405

Edition

First Edition, August 30, 2007

Printed in Malaysia

Agilent Technologies, Inc.
3501 Stevens Creek Blvd.
Santa Clara, CA 95052 USA

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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
	Alternating current
	Both direct and alternating current
	Three-phase alternating current
	Earth (ground) terminal
	Protective conductor terminal
	Frame or chassis terminal
	Equipotentiality
	Off (supply)

	Direct current
	Alternating current
	Caution, risk of electric shock.
	Caution, risk of danger (refer to this manual for specific Warning or Caution information.
	Caution, hot surface.
	Out position of a bi-stable push control.
	In position of a bi-stable push control.

Regulatory Markings

 ESD	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.
 ISM 1- A	The CE mark shows that the product complies with all the relevant European Legal Directives.
 N10149	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.
	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.
ICES/NMB - 001	ICES/NMB-001 indicates that this ISM device complies with Canadian ICES-001. Cet appareil ISM est confomre à la norme NMB-001 du Canada

Waste Electrical and Electronic Equipment (WEEE) Directive 20002/96/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

www.agilent.com/environment/product

for more information.

General Safety Information

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Agilent Technologies, Inc. assumes no liability for the customer's failure to comply with these requirements.

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 personnels.

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
- IEC 61326:2002 / EN61326:1997+A1:1998+A2:2001+A3:2003

Agilent Technologies	**DECLARATION OF CONFORMITY** According to EN ISO/IEC 17050-1:2004	CE

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 Power Sensors
Models Number: U2000A, U2001A, U2002A, 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 (89/336/EEC, amended by 93/68/EEC)

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:

25 June 2007
Date

Mack Soh
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. D.00 U2000 Series DoC Revision 1.0

Product Regulations

EMC

	Performance Criteria
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)	B
IEC 61000-4-3:1995 / EN 61000-4-3:1996 (3V/m, 80% AM)	A
IEC 61000-4-4:1995 / EN 61000-4-4:1995 (EFT 0.5kV line-line, 1kV line-earth)	B
IEC 61000-4-5:1995 / EN 61000-4-5:1995 (Surge 0.5kV line-line, 1kV line-earth)	B
IEC 61000-4-6:1996 / EN 61000-4-6:1996 (3V, 0.15~80 MHz, 80% AM, power line)	A
IEC 61000-4-11:1994 / EN 61000-4-11:1994 (Dips 1 cycle, 100%)	B
Canada: ICES-001:2004	
Australia/New Zealand: AS/NZS CISPR11:2004	

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 89/336/EEC (including 93/68/EEC) and carries the CE Marking accordingly (European Union).

[1]Performance 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 confomre 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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1 Introduction

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

General Information

This guide contains information of the initial inspection, operation, specifications and repair of the U2000 Series USB power sensors.

Figure 1-1 Agilent U2000 Series USB Power Sensors

System Requirements

The U2000 Series USB power sensors allow you to display power measurement on a PC or other Agilent instruments without the need of a separate power meter. The compact USB power sensor contains the circuits needed in a conventional power meter and sensor all in the small sensor casing. It provides plug- and- play connectivity which enables fast connection of the USB power sensors to a PC and its lightweight allows you to carry the portable sensor to anywhere. Prior to using the U2000 Series USB power sensors, there are several system requirements as shown below:

- PC or any device which has USB host capability
- Agilent IO Libraries Suite 14.0 or above, users are encouraged to obtain the newest version of Agilent Libraries Suite for a better performance
- Agilent N1918A Power Analysis Manager (The 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 that offers more features and capabilities)

The U2000 Series USB Power Sensors in Details

Most power sensors used for measuring average power employ either thermocouple or diode technologies. Diode based sensors frequently rely on the application of correction factors to extend their dynamic range beyond their square law response region, typically - 70 dBm to - 20 dBm. However, while this technique achieves wide dynamic range capability, 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 provide accurate measurements but are bandwidth limited.

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 proposed by Szente et. al. in 1990[1]. Figure 1- 2 shows a block diagram of this technique.

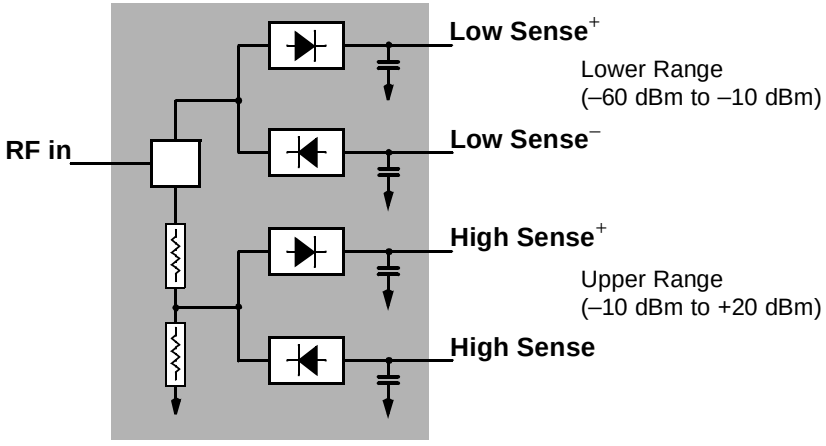

Figure 1-2 Simplified Block Diagram of Diode Pair/Attenuator/Diode Pair

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

This technique ensures 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 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 damage[2] 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 multitone 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 Milimeter-Wave Applications.

[2] Refer "Damage Level" on page 26 for maximum power handling specifications.

Getting Started

Initial Inspection

Inspect the shipping container for damage. 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 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.

Checking Power Sensor Firmware

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

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:

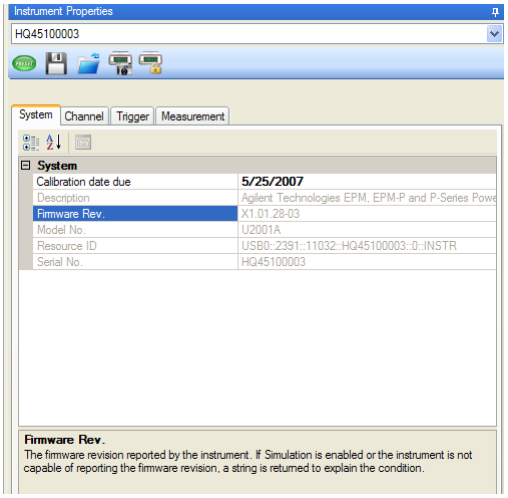

Figure 1-3 Power Analysis Manager Instrument Properties panel

- You are advisable to set the calibration due date. Click the calendar beside **Calibration due date** to set the new calibration date.

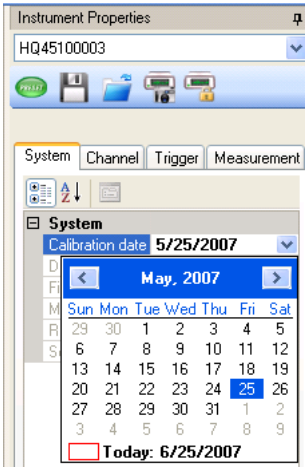

Figure 1-4 Calibration due date display

VEE Program

- You can also check the firmware revision of the power sensor by using the following SCPI command:

  ```
  *IDN?
  ```

2 Making Measurements

This chapter shows you how to use the Agilent U2000 Series USB power sensors to make power measurements on signals with different modulation formats.

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 the Figure 2- 1 in the next page.

Range	Power Level
1	–60 dBm to –35 dBm
2	–38 dBm to –15 dBm
3	–20 dBm to –9 dBm
4	–11 dBm to –5 dBm
5	–7 dBm to 15 dBm
6	10 dBm to 20 dBm

NOTE Averaging settings can also be manually configured.

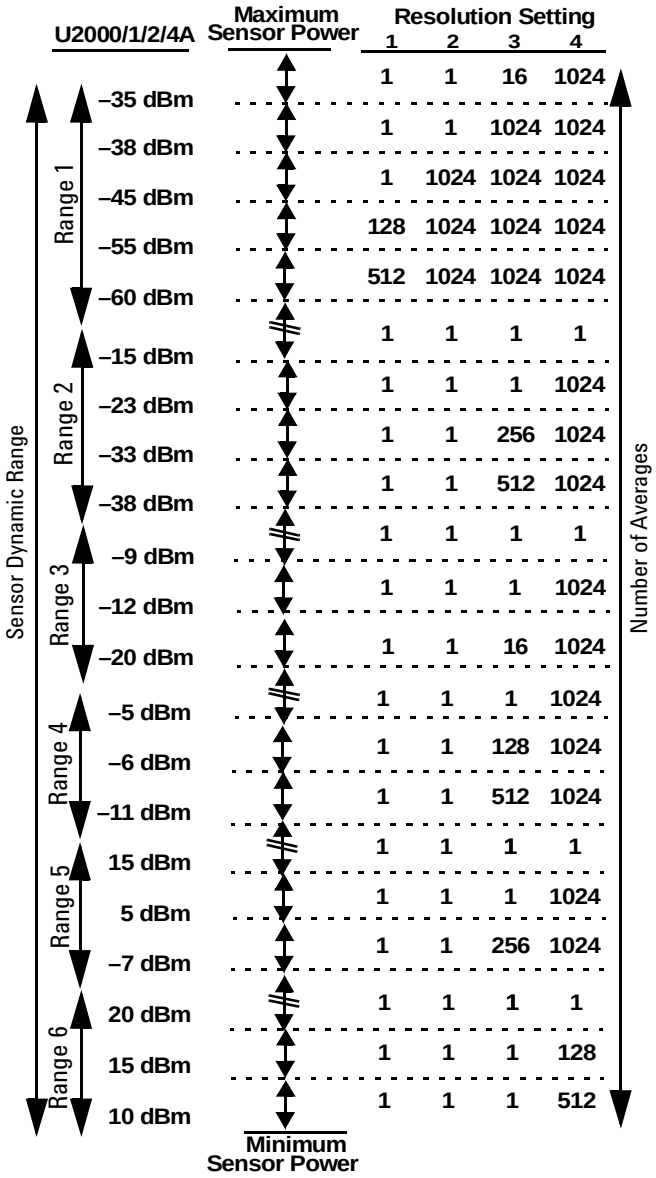

Figure 2-1 Auto-averaging Settings

Spread Spectrum and Multitone Signal Measurements

To achieve high data transfer rates within a given bandwidth, many transmission schemes are based around phase and amplitude (I and Q) modulation. These include CDMA, W-CDMA and digital television. These signals are characterized by their appearance on a spectrum analyzer display – a high amplitude noise-like signal of bandwidths up to 20 MHz. An 8 MHz bandwidth digital television signal is shown in Figure 2-2.

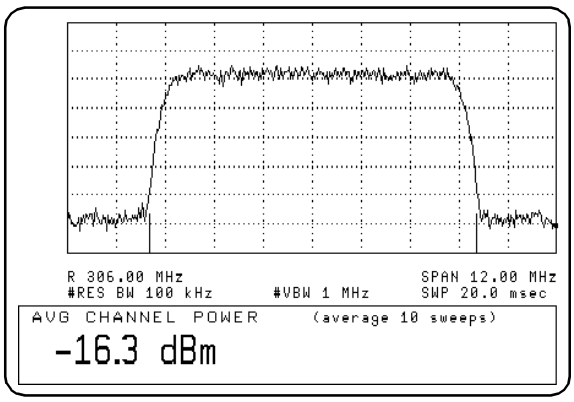

Figure 2-2 Spread Spectrum Signal

Average power measurement over a wide dynamic range of all multitone signals using the U2000 Series requires either tuned/swept signal analyzer methods.

The diode pair/attenuator/diode pair architecture of the U2000 Series USB power sensors is ideally suited to the average power measurement of these signals. The sensors have wide dynamic range (80 dB max, sensor dependent) and are bandwidth independent.

Some signal modulation formats such as orthogonal-frequency-division multiplexing (OFDM) and CDMA have large crest factors. U2000A, U2001A, U2002A and U2004 power sensors can measure +20 dBm average power even in the presence of +13 dB peaks as long as the peak pulse duration is less than 10 microseconds.

CDMA Signal Measurements

Figure 2-3 shows typical results obtained when measuring a CDMA signal. In these examples, the error is determined by measuring the source at the amplitude of interest, with and without CDMA modulation, adding attenuation until the difference between the two values stops changing. The CW sensor in Figure 2-3 uses correction factors to correct for power levels beyond its square law operating region.

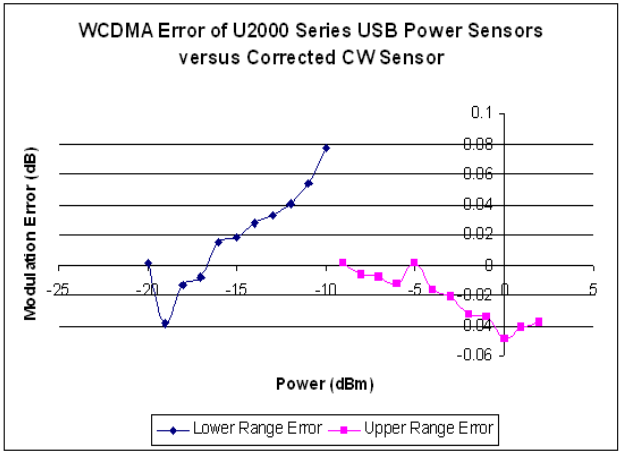

Figure 2-3 Wideband CDMA Error of the U2000 Series USB power sensors versus corrected CW sensor

Multitone Signal Measurements

In addition to wide dynamic range, the U2000A USB power sensor also has an exceptionally flat calibration factor versus frequency response across the entire frequency range as shown in Figure 2- 4. This is ideal for amplifier intermodulation distortion measurements where the components of the two- tone or multitone test signal can be separated by hundreds of MHz.

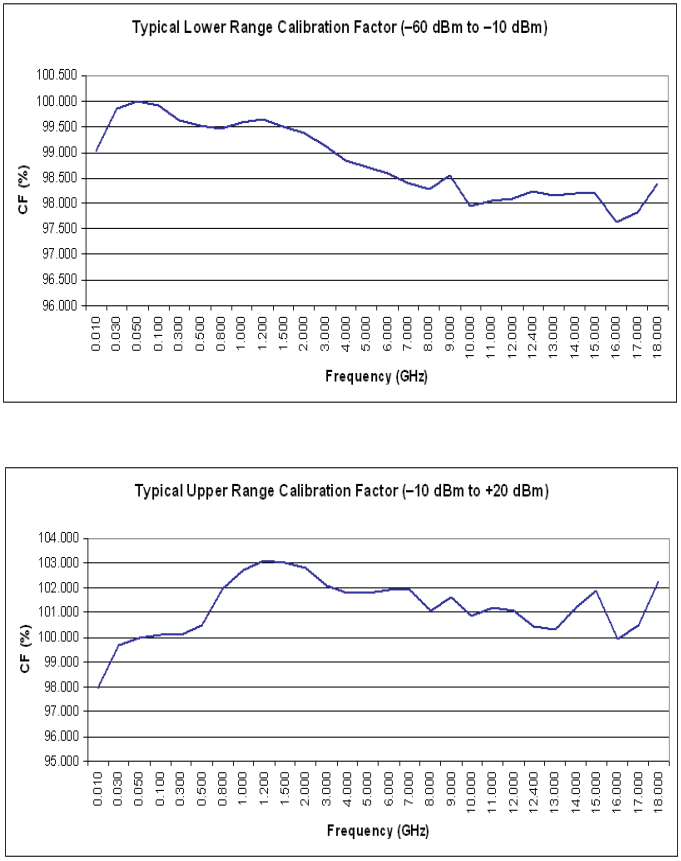

Figure 2-4 Calibration Factors versus Frequency

Electromagnetic Compatibility (EMC) Measurements

The low frequency range of the U2004A USB power sensor is an ideal choice for making EMC measurements to Comite International Special Perturbations Radioelectriques (CISPR) requirements, and electromagnetic interference (EMI) test applications such as the radiated immunity test (IEC61000- 4- 3).

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 Figure 3- 5 on Page 26.

CAUTION The U2004A USB power sensors are DC coupled. DC voltages in excess of the maximum value (5 VDC) can damage the sensing diode.

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.

CAUTION

To prevent damage to your sensor, do not excess the power levels specified in the section "Damage Level" on page 26.

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

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 dBm ± 0.5 dBm

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, using an Agilent U2000/1/4A sensor, where the range switch point is –10 ± 1 dBm in a pulsed signal 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 Series USB power sensors. In auto- ranging mode (“AUTO”), the U2000 Series USB power sensors determine the average power level is below –10 dBm and selects 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 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 considerably more filtering.

Speed and Averaging

The same signal also requires that consideration is given to measurement speed. As shown above, in auto- ranging mode the U2000 Series USB power sensors determine the average power level is below –10 dBm and selects 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 11.)

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 11.) 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 whilst 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.

3
Specifications and Characteristics

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 Agilent USB- based instrument.

The specifications specified in this chapter are valid ONLY after proper calibration of the power sensor and apply for continuous wave (CW) signals unless otherwise stated. Specifications apply over the temperature range 0 °C to +55 °C unless otherwise stated.

Specifications quoted over the temperature range 25 °C ±10 °C apply over 15% to 75% relative humidity and conform to the standard environmental test conditions.

The dynamic range of the U2000 Series USB power sensors is –60 dBm to +20 dBm and the range is divided to two independent measurement paths — high and low power paths as shown below.

Sensor	Low Power Path	High Power Path
U2000A, U2001A, U2002A, U2004A	–60 dBm to –10 dBm	–10 dBm to +20 dBm

Some specifications are detailed for individual measurement path, with the automatic switching point at –10 dBm for the U2000A, U2001A, U2002A and U2004A.

Supplemental characteristics, which are shown in italics, are intended to provide information useful in applying the power sensors by giving typical, but non- warranted performance parameters. These characteristics are shown in *italics* or denoted as "*typical*", "*nominal*" or "*approximate*".

Specifications

Frequency Range

Model	Frequency Range
U2000A	10 MHz to 18.0 GHz
U2001A	10 MHz to 6.0 GHz
U2002A	50 MHz to 24 GHz
U2004A	9 kHz to 6.0 GHz

Connector Type

Model	Connector Type
U2000A	N-Type (m)
U2001A	N-Type (m)
U2002A	3.5 mm (m)
U2004A	N-Type (m)

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

Maximum SWR (0 °C ±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

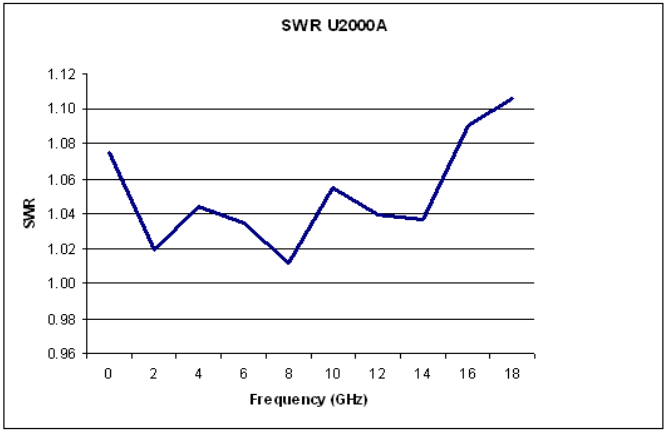

Figure 3-1 U2000A Typical SWR (25 °C ±10 °C)

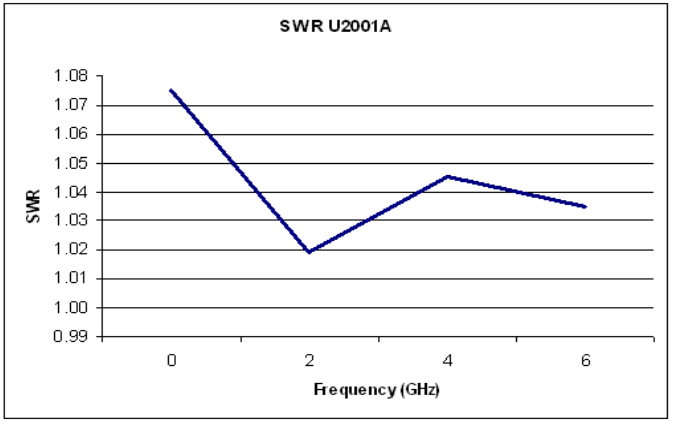

Figure 3-2 U2001A Typical SWR (25 °C ±10 °C)

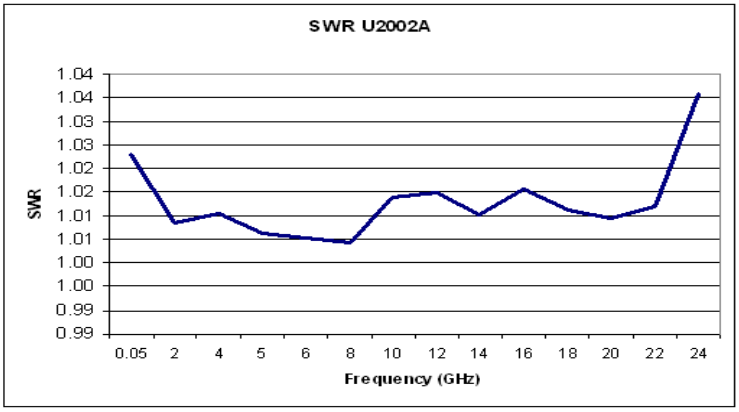

Figure 3-3 U2002A Typical SWR (25 °C ±10 °C)

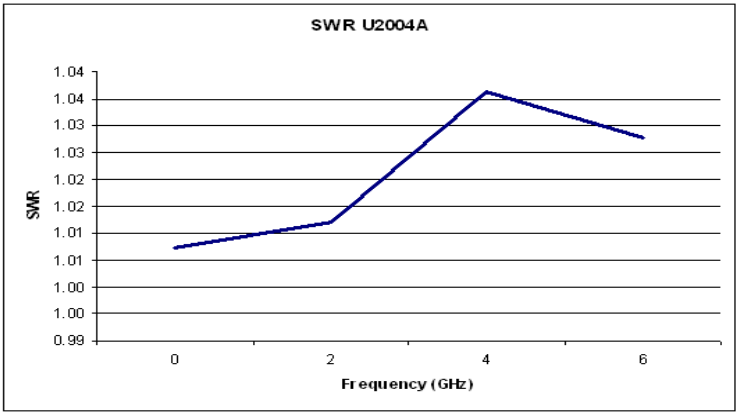

Figure 3-4 U2004A Typical SWR (25 °C ±10 °C)

Damage Level

+25 dBm (320 mW) average
+33 dBm peak (2 W) <10µs

Maximum DC Voltage

The U2004A USB power sensor is DC coupled. DC coupling of the input allows excellent low frequency coverage. However, the presence of DC voltages mixed with the signal will have an effect on the accuracy of the power measurement (see graph below).

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

Maximum DC voltage: 5 VDC (U2004A only)

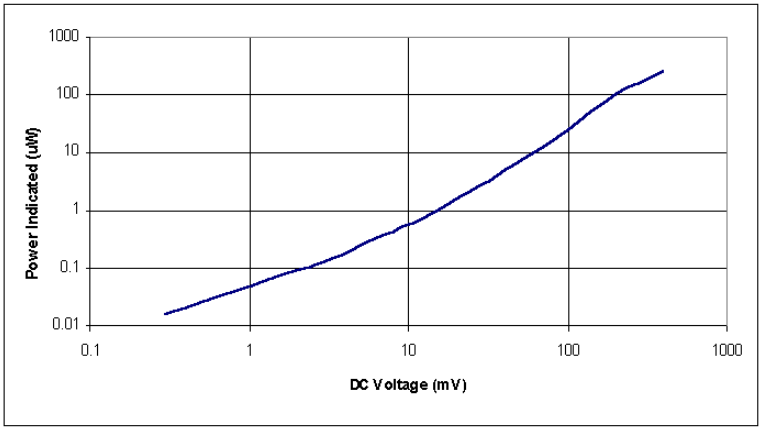

Figure 3-5 Typical Power Error Introduced in a U2004A USB power sensor by DC Voltage

Power Linearity

After zero and calibration at ambient environmental conditions.

Power Level	Linearity 25 °C ± 10 °C	Linearity 0 °C to 55 °C
–60 dBm to –10 dBm	±3.0%	±3.5%
–10 dBm to 0 dBm	±3.0%	±3.5%
0 dBm to +20 dBm	±3.0%	±3.5%

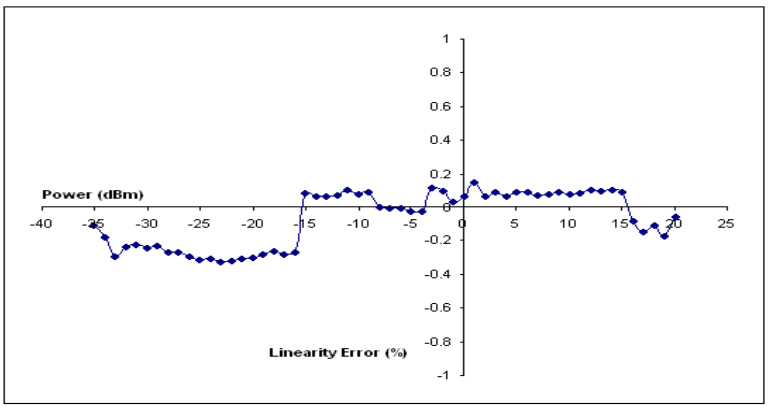

Figure 3-6 Typical Power Linearity at 25 °C, after zero and calibration, with associated measurement uncertainty

Range	–60 to –35 dBm	–38 to –15 dBm	–20 to –9 dBm	–11 to –5 dBm	–7 to 15 dBm	10 to 20 dBm
Measurement Uncertainty	±1.52%	±1.52%	±1.69%	±1.69%	±1.96%	±1.61%

Switching Point

The U2000 Series USB 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 near to the –10 dBm point, **Switching Point Hysteresis** is added. This hysteresis causes the low power path to remain selected until approximately –9.5 dBm. As the power level increases above –9.5 dBm, the high power path will be selected. The high power path remains selected until approximately –10.5 dBm. As the power level decreases below –10.5 dBm, the low power path will be selected.

	Error
Offset at Switch Point	≤±0.5% (≤±0.02 dB) typical
Switching Point Hysteresis	0.5 dB typical

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 a 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.

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	*25 ms*[1]

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

Table 3-1 Settling Time for Normal Mode and x2 Mode

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

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

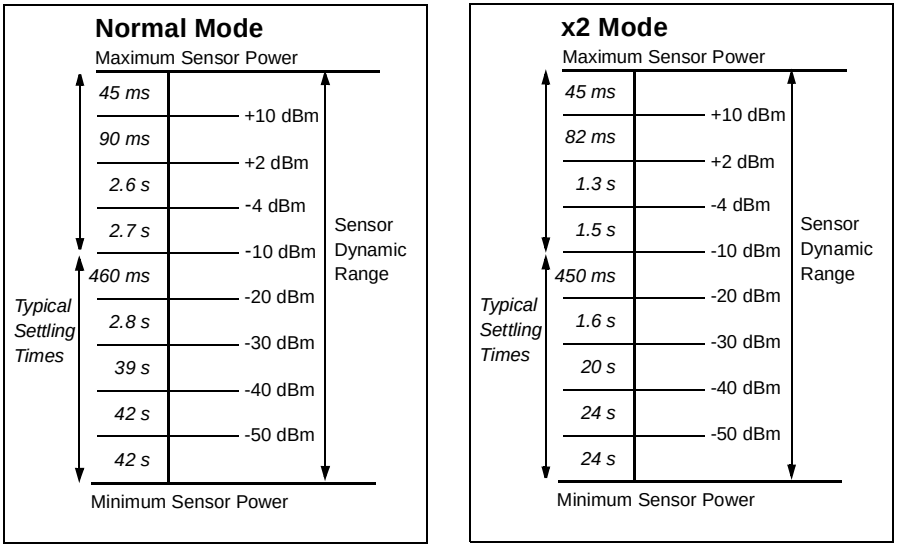

Figure 3-7 *Autofilter, default resolution, 10 dB decreasing power step (not across the switching point)*

Table 3-2 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)	*2.0*	*1.8*	*1.7*	*1.5*	*1.0*	*0.95*	*0.74*	*0.55*	*0.39*	*0.29*	*0.21*
Noise Multiplier (s) (x2 Mode)	*2.7*	*2.4*	*2.0*	*1.6*	*1.0*	*0.91*	*0.78*	*0.53*	*0.34*	*0.29*	*0.20*

Calibration Factor and Reflection Coefficient

Calibration Factor (CF) and Reflection Coefficient (Rho) data are provided in the Certificate of Calibration (CoC) that comes with the purchase of U2000 Series USB power sensors. This data is unique to each sensor. If you have more than one sensor, match the serial number on the CoC with the serial number on the power sensor you are using. The CF corrects for the frequency response of the sensor.

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 are two calibration factor uncertainty tables for each sensor. The uncertainty analysis for the calibration of the sensors was done in accordance with 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	
	Uncertainty (25 °C ±10 °C)	
	–60 dBm to –10 dBm	–10 dBm to +20 dBm
10 MHz to 30 MHz	±1.70%	±1.69%
30 MHz to 2 GHz	±1.62%	±1.62%
2 GHz to 14 GHz	±1.97%	±1.96%
14 GHz to 16 GHz	±2.33%	±2.33%
16 GHz to 18 GHz	±3.09%	±3.08%

Frequency	U2001A	
	Uncertainty (25 °C ±10 °C)	
	–60 dBm to –10 dBm	–10 dBm to +20 dBm
10 MHz to 30 MHz	±1.70%	±1.69%
30 MHz to 2 GHz	±1.62%	±1.62%
2 GHz to 6 GHz	±1.78%	±1.75%

Frequency	U2002A	
	Uncertainty (25 °C ±10 °C)	
	–60 dBm to –10 dBm	–10 dBm to +20 dBm
50 MHz to 2 GHz	±1.98%	±1.97%
2 GHz to 14 GHz	±2.27%	±2.25%
14 GHz to 16 GHz	±2.34%	±2.33%
16 GHz to 18 GHz	±2.38%	±2.37%
18 GHz to 24 GHz	±2.73%	±2.72%

Frequency	U2004A	
	Uncertainty (25 °C ±10 °C)	
	–60 dBm to –10 dBm	–10 dBm to +20 dBm
9 kHz to 10 MHz	±1.75%	±1.72%
10 MHz to 30 MHz	±1.73%	±1.71%
30 MHz to 500 MHz	±1.73%	±1.71%
500 MHz to 1.2 GHz	±1.61%	±1.59%
1.2 GHz to 6 GHz	±1.69%	±1.65%

General Characteristic

	Physical Characteristics
Net Weight	U2000/1/4A: 0.262 kg (0.6 lb) U2002A: 0.226 kg (0.5 lb)
Dimensions (U2000/1/4A)	Length: 163.75 mm (6.4 in) Width: 46.00 mm (1.8 in) Height: 35.90 mm (1.4 in)
Dimensions (U2002A)	Length: 134.37 mm (5.3 in) Width: 46.00 mm (1.8 in) Height: 35.90 mm (1.4 in)

	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)

4 Service

This chapter describes the performance test, replaceable parts information and servicing details.

General Information

This chapter contains information about general maintenance, performance tests, troubleshooting and 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 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	System Rho Uncertainty	Actual Measurement	Maximum Rho
10 MHz to 30 MHz	±0.010		0.070
30 MHz to 2 GHz	±0.010		0.061
2 GHz to 14 GHz	±0.010		0.087
14 GHz to 16 GHz	±0.010		0.099
16 GHz to 18 GHz	±0.010		0.115

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

Frequency	System Rho Uncertainty	Actual Measurement	Maximum Rho
10 MHz to 30 MHz	±0.010		0.070
30 MHz to 2 GHz	±0.010		0.061
2 GHz to 6 GHz	±0.010		0.087

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

Frequency	System Rho Uncertainty	Actual Measurement	Maximum Rho
10 MHz to 30 MHz	±0.010		0.070
30 MHz to 2 GHz	±0.010		0.061
2 GHz to 14 GHz	±0.010		0.087
14 GHz to 16 GHz	±0.010		0.099
16 GHz to 18 GHz	±0.010		0.115
18 GHz to 24 GHz	±0.010		0.130

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	System Rho Uncertainty	Actual Measurement	Maximum Rho
9 kHz to 2 GHz	±0.010		0.061
2 GHz to 6 GHz	±0.010		0.087

Replaceable Parts

Table 4- 5 is 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 4-5 Replaceable Parts

Model	Agilent Part Number	Qty	Description
U2000A	U2000-60006	1	U2000A Replacement Module
U2001A	U2001-60006	1	U2001A Replacement Module
U2002A	U2002-60006	1	U2002A Replacement Module
U2004A	U2004-60006	1	U2004A Replacement Module
U2000/1/2/4A	U2000-60001	1	HOUSING, BOTTOM AND OVERMOLD - PC AND TPE
U2000/1/2/4A	U2000-60003	1	HOUSING, TOP AND OVERMOLD - PC AND TPE

Service

The following service instructions consist of principles of operation, troubleshooting, and repairs.

Principles of Operation

The A1 Bulkhead assembly on the U2000 Series USB power sensors provides a 50 ohm load to the RF signal applied to the power sensor. A dual range GaAs diode pair/attenuator/diode pair assembly in the bulkhead rectifies the applied RF to produce dc voltages (high and low ranges) which vary with the RF power across the 50 ohm load. Thus the voltage varies with the RF power dissipated in the load.

The low- level dc voltages from the bulkhead assembly are amplified before they are transferred on standard cables. The amplification is provided by an input amplifier assembly which consists of a chopper (sampling gate) and an input amplifier. The chopper circuit converts the dc voltages to ac voltages. The chopper is controlled by a 220 Hz square wave generated by the power sensor. The amplitude of the sampling gate output is a 220 Hz square wave which varies with the RF power input. The 220 Hz ac output is applied to an amplifier which provides the input to the power sensor.

The correction data from the non- volatile memory is automatically loaded when U2000 Series USB power sensors is connected. The auto- averaging settings are also configured automatically for use with U2000 Series USB power sensors. This configures the power sensor to operate over the range with that particular sensor's unique correction data applied.

Troubleshooting

Agilent U2000 Series USB Power Sensor is a combination of power meter and power sensor into one unit. If the LED is in red and it is 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.

If the LED is in red, it indicates that the SCPI command is incorrect. In this case, the red LED will only be off after the users have read all the error messages and the sensor will work well after the correct SCPI command is entered.

If the LED is in amber, it indicates that the power sensor is performing zero and calibration.

When the LED turns green and it is blinking, it shows that there is data flow within the USB connection.

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.

Repair of Defective Sensor

There are no serviceable parts inside the U2000 Series USB power sensors. If the sensor is defective, replace the entire “module” with the appropriate sensor module. See Table 4- 5.

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 4-6 Disassembly Procedure

	**1** Remove the top label.
	**2** Loosen three screws by using M2 to remove the housing.
	**3** Replace the defective sensor module with a new sensor module. Please refer to Table 4- 5.

Reassembly Procedure

Tools required for reassembly:

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

Reassembly instructions:

Reassembly procedure is simply a reversal of the disassembly procedure.

The serial number of the sensor module will be different from the original power sensor which has been sent in for repair. After replacing the sensor module, use the following SCPI command to update the serial number so that it matches the original unit's serial number.

```
SERVice:SNUMber <"original serial number">
```

4 Service

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Contact us
To obtain service, warranty or technical support assistance, contact us at the following phone numbers:

United States:
(tel) 800 829 4444 (fax) 800 829 4433
Canada:
(tel) 877 894 4414 (fax) 800 746 4866
China:
(tel) 800 810 0189 (fax) 800 820 2816
Europe:
(tel) 31 20 547 2111
Japan:
(tel) (81) 426 56 7832 (fax) (81) 426 56 7840
Korea:
(tel) (080) 769 0800 (fax) (080) 769 0900
Latin America:
(tel) (305) 269 7500
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Product specifications and descriptions in this document subject to change without notice.

Printed in Malaysia
First Edition, August 30, 2007
U2000-90405

Agilent Technologies