Agilent
U2000 Series USB Power Sensors

Data Sheet

Agilent Technologies

Features

- **Perform power measurement without a power meter**
- **Frequency range from 9 kHz to 24 GHz (sensor dependent)**
- **Dynamic range from –60 dBm to +20 dBm**
- **Internal zeroing capability and external calibration-free measurements**
- **Simplified measurement setup with built-in triggering**

Introduction

The Agilent U2000 Series USB power sensors are average, dynamic wide-range power sensors that can be used with a PC or any selected Agilent USB-based instrument. With internal zeroing, there is no need to disconnect the sensor or power off the device-under-test (DUT). The U2000 Series does not require any 50 MHz reference signal calibration, thus allowing factory calibration to ensure measurement accuracy.

All the specifications provided in this data sheet are valid ONLY after proper calibration of the power sensor and apply to continuous wave (CW) signals unless otherwise stated.

The specifications are valid for a temperature range from 0 °C to +55 °C unless otherwise stated. Specifications provided for a temperature of 25 °C ± 10 °C are valid for a relative humidity range of 15% to 75% and conform to the standard environmental test conditions.

The U2000 Series USB power sensors have two independent measurement paths (high and low power paths) as shown below:

Table 1: Low power path and high power path for Agilent U2000 Series USB power sensors

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

Table 2: Product specifications for Agilent U2000 Series USB power sensors

Model	Frequency Range	Maximum SWR (25 °C±10 °C)	Maximum SWR (0-55 °C)	Maximum Power	Connector Type
U2000A	10 MHz to 18.0 GHz	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	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	+25 dBm (320 mW) average +33 dBm peak (2 W) <10 us	Type-N (m)
U2001A	10 MHz to 6.0 GHz	10 MHz to 30 MHz: 1.15 30 MHz to 2 GHz: 1.13 2 GHz to 6 GHz: 1.19	10 MHz to 30 MHz: 1.21 30 MHz to 2 GHz: 1.15 2 GHz to 6 GHz: 1.20	+25 dBm (320 mW) average +33 dBm peak (2 W) <10 us	Type-N (m)
U2002A	50 MHz to 24 GHz	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	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	+25 dBm (320 mW) average +33 dBm peak (2 W) <10 us	3.5 mm (m)
U2004A	9 kHz to 6.0 GHz	9 kHz to 2 GHz: 1.13 2 GHz to 6 GHz: 1.19	9 kHz to 2 GHz: 1.15 2 GHz to 6 GHz: 1.20	+25 dBm (320 mW) average +33 dBm peak (2 W) <10 us	Type-N (m)

Why Zeroing Is Important For U2000 Series USB Power Sensor?

Zeroing a power sensor is performed to reduce zero offset and noise impact to improve RF power measurement accuracy. The U2000 Series USB power sensor has two types of zeroing, namely the Internal Zeroing (INT) and External Zeroing (EXT)[1].

When performing External Zeroing, the RF signal source (typically signal output from a device under test) should be turned off or disconnected from the power sensor input, then the power sensor is zeroed. For Internal Zeroing, the RF signal source can be turned on or left connected to the power sensor input. The power sensor will isolate the RF signal source from the diode sensor before zeroing.

Users are recommended to perform external zeroing for input signals power below -30 dBm to obtain a maximum degree of accuracy in their measurements. External Zeroing can be used for RF signal level that falls into the power dynamic range (from –60 dBm to 20 dBm). Figure 1 shows the External Zeroing setting in the N1918A Power Panel.

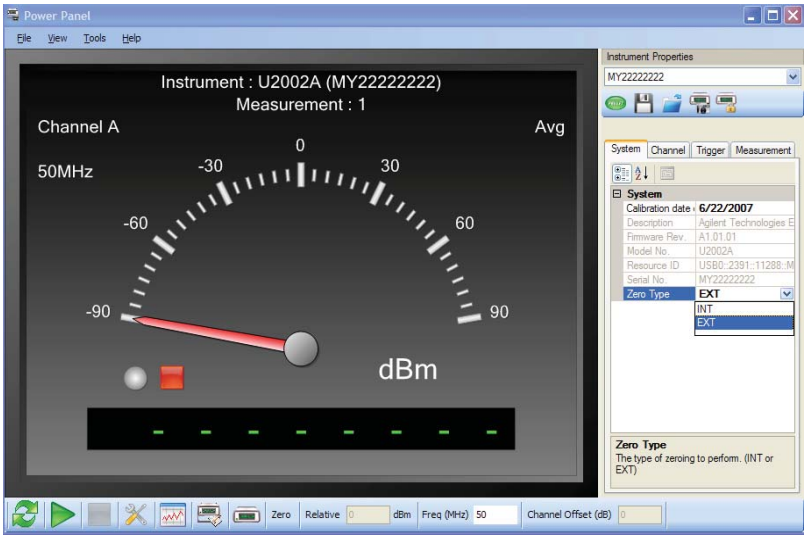


Figure 1: Setting External Zeroing (EXT) in the N1918A Power Panel

1 The specifications stated in this data sheet are applicable for External Zeroing unless otherwise specified.

Typical SWR Chart (25 °C ±10 °C)

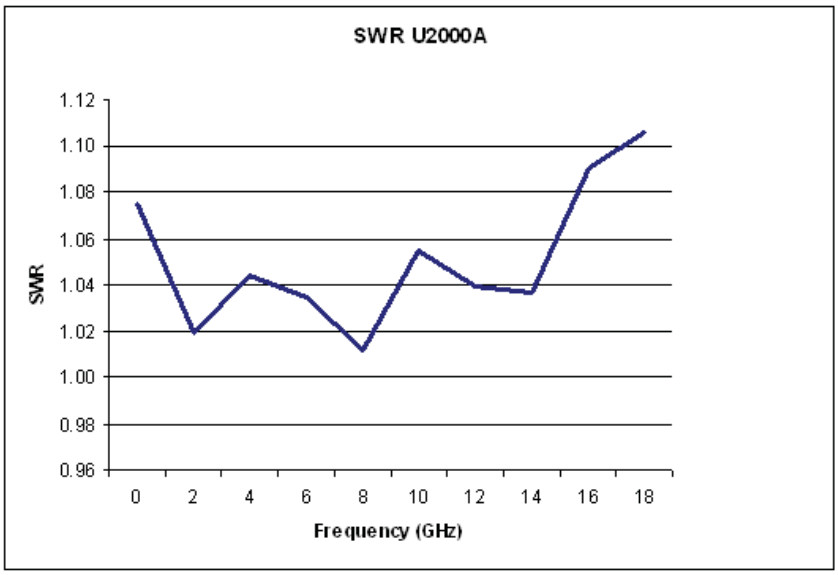


Figure 2: Typical SWR chart for U2000A, 10 MHz to 18 GHz (25 °C ±10 °C)

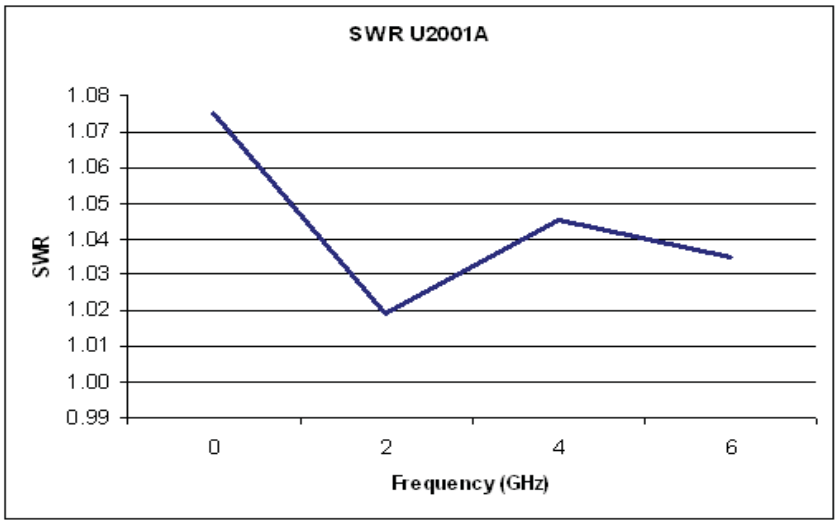


Figure 3: Typical SWR chart for U2001A, 10 MHz to 6 GHz (25 °C ±10 °C)

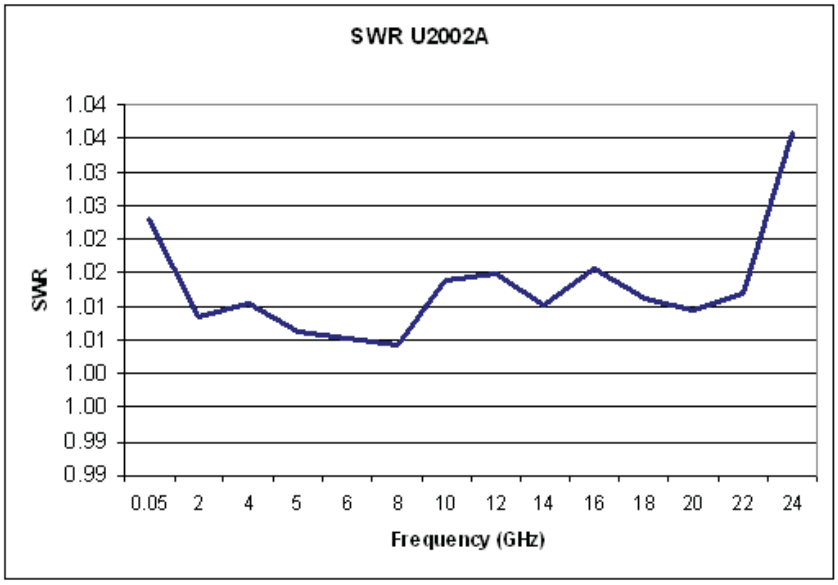


Figure 4: Typical SWR chart for U2002A, 50 MHz to 24 GHz (25 °C ±10 °C)

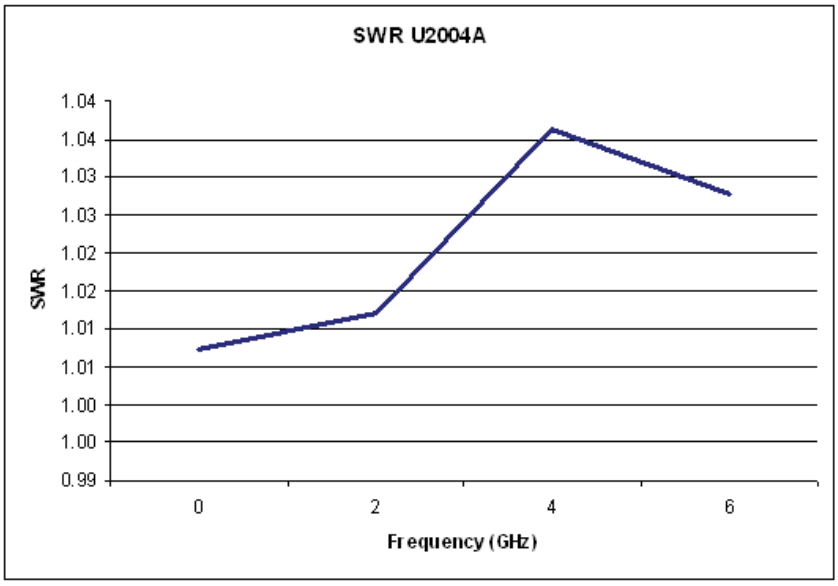
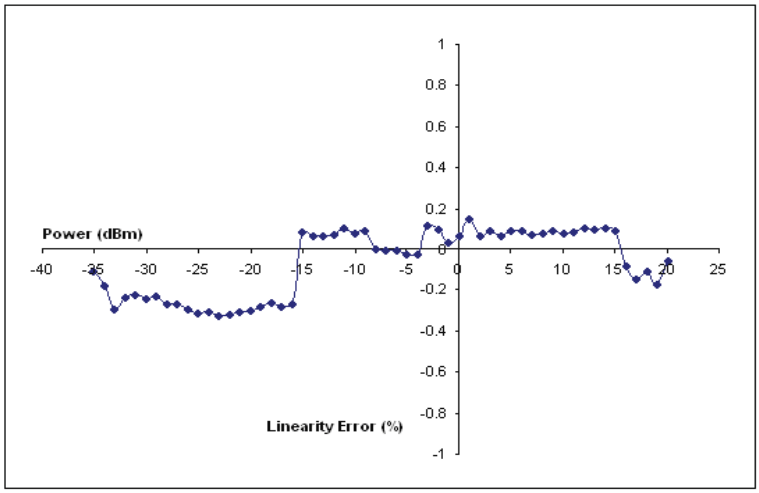


Figure 5: Typical SWR chart for U2001A, 9 kHz to 6 GHz (25 °C ±10 °C)

Power Linearity

Table 3: Power Linearity (after zero at ambient environment conditions)[1]

Sensor	Power	Linearity (25 °C±10 °C)	Linearity (0-55 °C)
U2000A, U2001A, U2002A, U2004A	–60 dBm to +20 dBm	±3.0%	±3.5%



Power range	Measurement uncertainty[1]
–60 dBm to –35 dBm	±1.52%
–38 dBm to –15 dBm	±1.52%
–20 dBm to –9 dBm	±1.69%
–11 dBm to –5 dBm	±1.69%
–7 dBm to 15 dBm	±1.96%
10 dBm to 20 dBm	±1.61%

Figure 6: Typical U2000 Series USB power sensors Power Linearity at 25 °C, after zero with associated measurement uncertainty

1 Measurement uncertainty and Linearity specifications stated above are applicable for both External Zeroing and Internal Zeroing (with power ranging from -30 dBm to + 20 dBm).

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 meter automatically selects the appropriate power level path. To avoid unnecessary switching when the power level comes close to the –10 dBm point, a Switching Point Hysteresis is added. This hysteresis causes the low power path to remain selected until approximately –9.5 dBm has been reached. When 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 has been reached. When the power level decreases below –10.5 dBm, the low power path will be selected.

Switching point linearity: **Typically <±0.5% (<±0.02 dB)**
Switching point hysteresis: **Typically 0.5 dB**

Table 4: Zero Set, Zero Drift and Measurement Noise with the associated range

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

Settling Time for Normal Mode and x2 Mode

Number of Averages	1	2	4	5	16	32	64	128	256	512	1, 024
Settling Time1 (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 Time1 (s) (x2 Mode)	*0.042*	*0.05*	*0.09*	*0.17*	*0.34*	*0.66*	*1.0*	*2.6*	*5.2*	*10.4*	*20.9*

Noise Multiplier for Normal Mode and x2 Mode

Number of Averages	1	2	4	5	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 (CF) and Reflection Coefficient (Rho)

Calibration Factor (CF) and Reflection Coefficient (Rho) data is 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, you should match the serial number on the CoC with the serial number on the power sensor that you are using. The CF corrects the frequency response of the sensor.

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

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SWR = (1 + Rho)/(1 - Rho)
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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 is 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.

Table 5: Calibration factor uncertainties for U2000A

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%

Table 6: Calibration factor uncertainties for U2001A

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%

Table 7: Calibration factor uncertainties for U2002A

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%

Table 8: Calibration factor uncertainties for U2004A

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 Characteristics

This instrument is designed for indoor use only. The table below shows the general requirements for the U2000 Series USB power sensors.

Temperature	0 °C to +55 °C (operating)
	–30 °C to +70 °C (non-operating)
Relative 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
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 Environment	The sensor should be stored in a clean, dry environment
Storage Temperature	–30 °C to +70 °C

Figure 7: Dimensional drawing of U2000 Series USB power sensors

Features

- **Enhanced visualization with larger and more flexible display formats**
- **Powerful graph functions**
- **Display multi-channel power measurements (with more than 10 displays on one window)**
- **Convenient data logging and storing up to seven days**
- **Time-saving options to save and restore instrument settings**
- **Measurement limit and alert function optimized for remote operation**
- **Quick and easy application screen printing option**

Agilent N1918A Power Analysis Manager

The Agilent N1918A Power Analysis Manager is a PC-based application software running on Microsoft® Windows XP Professional SP2 that is targeted to extend the capabilities of U2000 Series USB power sensors. The N1918A is a suite of software applications that comprises a basic version, which contains a standard graphical user interface (GUI), and an advanced version as an optional software license, which provides for advanced pulse analyses, multi-channel power measurements, statistical analyses, and a recording function. Users can use these software applications to track problems at any stage of their design process, from simulation to the final prototype. The software is flexible and can accept data from multiple front ends.

The following section contains the specifications for using the Agilent N1918A Power Analysis Manager with the U2000 Series USB power sensors.

Zero and Cal:
For performing internal zeroing, internal calibration, and external zeroing. No external calibration required.

Display units:
Absolute: Watts or dBm
Relative: Percent or dB

Display resolution:
Resolution of 1.0, 0.1, 0.01, and 0.001 dB in log mode, or one to four digits in linear mode.

Default resolution:
0.01 dB in log mode, three digits in linear mode.

Range:
1 kHz to 999.9 GHz, configurable on the basis of a 1-kHz step scale.

Relative:
Displays all successive measurements in relation to user-specific values.

Offset:
Allows power measurements to be offset by –100 dB to +100 dB, confi gurable in 0.001 dB increments, to compensate for external loss or gain.

Save and Restore Instrument Settings:
The Power Analysis Manager offers an option that allows users to save the instrument settings in *.prop format files. This enables users to restore their instrument settings by simply loading the relevant instrument property files whenever the same settings are required.

dBm/W:
Selectable units of either Watts or dBm in absolute power; or percentage of dB for relative measurements.

Duty cycle:
Duty cycle values between 0.001% to 99.999% can be entered in increments of 0.01% to display a pulse power representation of measured power. The following equation is used to calculate the display pulse power value:

Pulse Power
= Measured Power/Duty Cycle

Limits:
High and low limits can be set in the range between –150.00 dBm to +230.000 dBm, in 0.001 dBm increments.

Preset default values:
Channel Offset (dB) = 0
Duty Cycle Off
Frequency 50 MHz
AUTO Average
AUTO Range
Free Run Mode
Measurement Unit dBm

Measurement speed:
- 110 readings/sec in FAST mode
- 1000 readings/sec in buffered mode of 50 readings

Current requirement:
Approximately 200 mA maximum current for USB

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