Keysight Technologies
Compatibility of USB Power Sensors with Keysight Instruments

Application Note

KEYSIGHT TECHNOLOGIES

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Use USB Power Sensors as a Keysight Instruments Accessory

In many of today's power measurement applications there is a need to make power measurements and use other instruments such as a spectrum analyzer, vector network analyzer or signal generator. Traditional power-measurement methodologies require a power meter and a power sensor. This situation increases the costs of a test system significantly. Alternatively, Keysight Technologies, Inc. USB power sensors can be used as an accessory with other Keysight instruments, allowing the power measurement to be done via Keysight instruments, and perform other specific power measurement applications without the need for a PC/laptop.

This application note explains how the Keysight USB power sensor performs source power calibration with the N5230A PNA-L, and scalar analysis of a frequency converter with the E5071C ENA vector network analyzer. The USB power sensors are able to augment the FieldFox handheld analyzer, N9340A handheld spectrum analyzer, and MXG signal generator with a power meter function, as well as provide user flatness correction (UFC) with external leveling using the MXG signal generator.

Keysight USB Power Sensors

Making an accurate power measurement requires both a power meter and power sensor. The power sensor converts the RF signal and microwave signal into analog signals. Subsequently, the power meter performs the statistical processing and displays the result in decimal/trace format. Today, the combination of a power meter and power sensor makes the USB power sensor a standalone instrument that provides an affordable solution for power measurement. Results of the power measurement can be retrieved through the power measurement Windows-based software application (Keysight N1918A power analysis manager) on the PC via a USB cable or SCPI commands. The power-measurement readings are retrieved using standard SCPI commands or VIV-COM/IVI-C drivers. The SCPI-based command set provides a user-friendly programming environment and allows the use of the same method of communication for both the power sensor and the power meter.

Keysight offers three families of USB power sensors compatible with other Keysight instruments such as the vector network analyzer, spectrum analyzer, signal generator, cable and antenna tester, and FieldFox handheld analyzer:

– U2000A Series USB average power sensors
– U2020 X-Series USB peak and average power sensors
– U8480 Series USB thermocouple power sensors

When USB power sensors are connected to these instruments without the need of PC/laptop, they can be powered up to perform the specific application.

Figure 1. Keysight USB power sensors

USB Power Sensor's Compatibility with Keysight Instruments

Keysight instruments such as vector network analyzers, spectrum analyzers, signal generators, cable and antenna testers, and FieldFox RF analyzers are now compatible with the Keysight USB power sensors (see Table 1 and Figure 2). Each compatible instrument has built-in firmware to support the USB power sensor, unless it specifically requires N1918A Power Analysis Manager software or the Visual Basic Assistant (VBA) application.

Vector network analyzer (PNA, PNA-X and PNA-L)

To perform the source power calibration and provide the output power in order to measure gain compression, intermodulation distortion, and other device parameters accurately.

Vector network analyzer (ENA)

To perform scalar analysis of a frequency converter, which requires the VBA application.

Signal generator (EXG and MXG)

To perform user flatness correction (UFC) with external leveling. Also turns the instrument into a power meter. Displays power measurement with its built-in user interface (UI), which integrates the display of USB power sensor measurements Supports and displays two USB power sensor measurements on a signal generator display.

Table 1. Keysight USB power sensors compatible with Keysight instruments

		Keysight USB power sensors		
Keysight instruments	**Model number**	**U2000A Series**	**U2020 X-Series**	**U8480 Series**
Vector network analyzer	PNA: E836xA/B/C	Yes	Yes	Yes
	PNA: N522xA	Yes	Yes	Yes
	PNA-X: N5242A	Yes	Yes	Yes
	PNA-L: N5230A/C	Yes	Yes	Yes
	ENA: E506xA/B	Yes[1]	No	No
Spectrum analyzer	Handheld: N934xA/B/C	Yes	Yes	No
	RF Spectrum Analyzer: N9320B	Yes	Yes	No
	MXA: N9020A	Yes[2]	Yes[2]	Yes[2]
	EXA: N9010A	Yes[2]	Yes[2]	Yes[2]
	PXA: N9030A	Yes[2]	Yes[2]	Yes[2]
Signal generator	EXG: N517xB	Yes	Yes	Yes
	MXG: N518xA/B & N516xA	Yes	Yes	Yes
Cable and antenna tester	Handheld: N9330A/B	Yes	Yes	No
FieldFox handheld analyzer	N991xA Microware Combination Analyzer	Yes	Yes	Yes
	N992xA Microware Vector Network Analyzer	Yes	Yes	Yes
	N993xA Microware Spectrum Analyzer	Yes	Yes	Yes

[1] Able to perform scalar analysis of a frequency converter which requires the VBA application

[2] Refer to the Power Analysis Manager N1918A Installation Guide (N1918A-90002) for PC hardware requirements.

Handheld/RF spectrum analyzer and cable and antenna tester

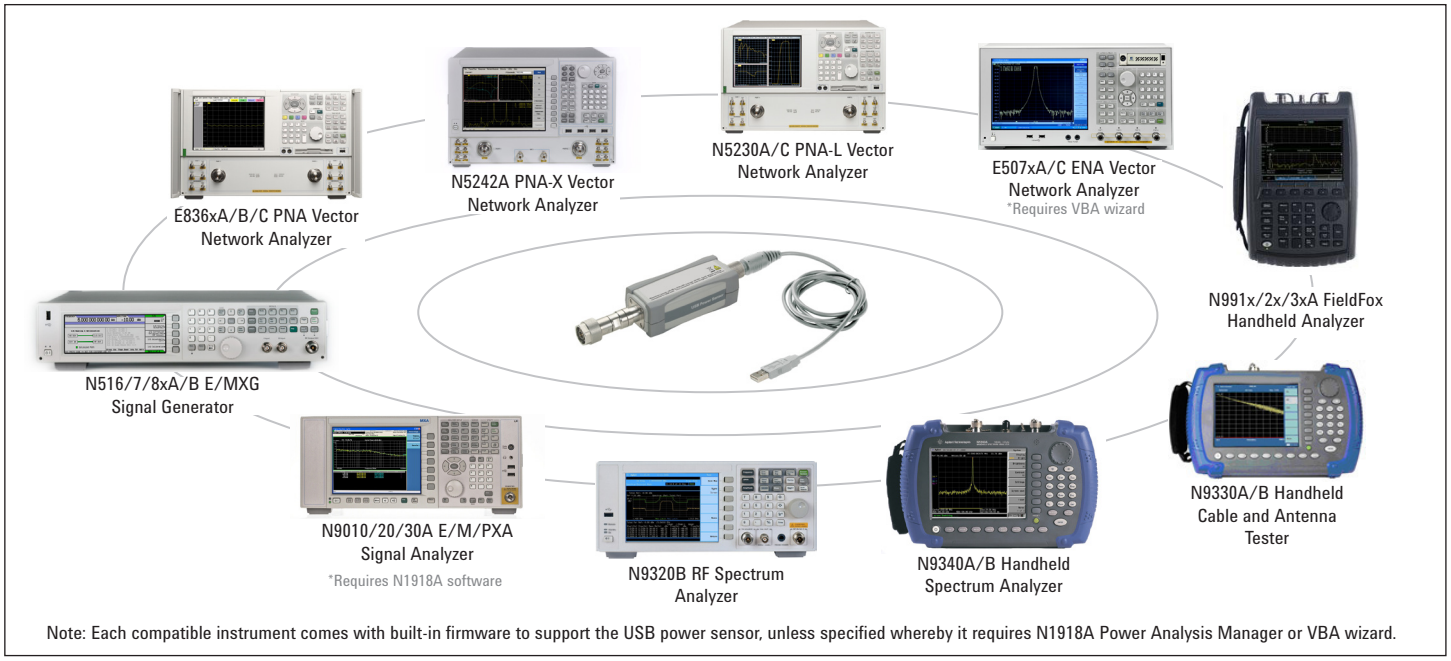
Turns the instrument into a power meter. Displays power measurement with its built-in user interface (UI), which integrates the display of USB power sensor measurements.

FieldFox handheld analyzer

Turns the instrument into a power meter. Displays power measurement with its built-in user interface (UI). Supports average and peak power measurements under Free Run mode, as well as pulse measurement under Continuous mode.

Spectrum analyzer (MXA, EXA and PXA)

To display the power measurement on spectrum analyzer with the free N1918A Power Analysis Manager software.



Note: Each compatible instrument comes with built-in firmware to support the USB power sensor, unless specified whereby it requires N1918A Power Analysis Manager or VBA wizard.

Figure 2. USB power sensors' compatibility with Keysight instruments

How Does It Work?

N5230C PNA-L vector network analyzer

– To perform the source-power calibration.

– To provide output power in order to measure gain compression, inter-modulation distortion, and other device parameters accurately.

With source power calibration, the power at a certain point is calibrated, to be within the range of the uncertainty of the power meter and sensor.[1]

Traditionally, the source power calibration is performed through GPIB connectivity and supported by the Keysight power meter and sensor (see Figure 3). This solution requires a big space for storing the power meter and sensor in the production test area, along with considerable expense, to acquire power meter and sensor just for source power calibration purposes. Today, USB power sensors offer a solution that is integrated with the PNA. The USB power sensors are used to replace both power meter and sensor (see Figure 4) in the source power calibration process. A USB sensor provides the direct connection into PNA USB port via USB plug-and-play connectivity. Throughout the source power calibration process, the PNA can be configured to detect the power meter (via GPIB) or USB power sensor (via USB) from the power meter setting of the PNA (see Figure 5).

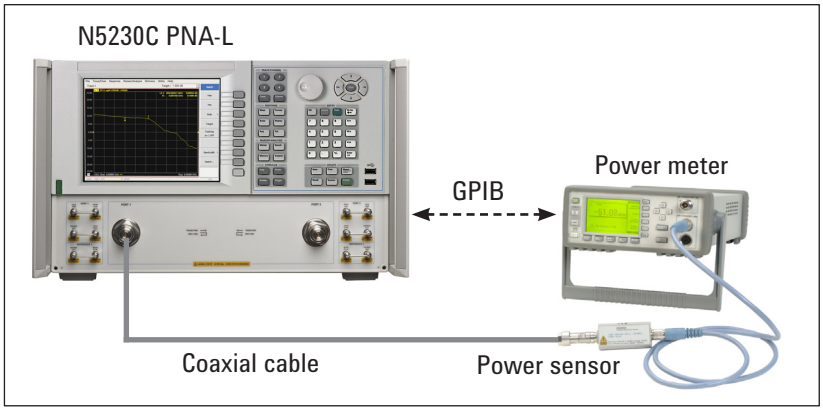


Figure 3. Source Power Cal using both power meter and power sensor connected to PNA through GPIB connection

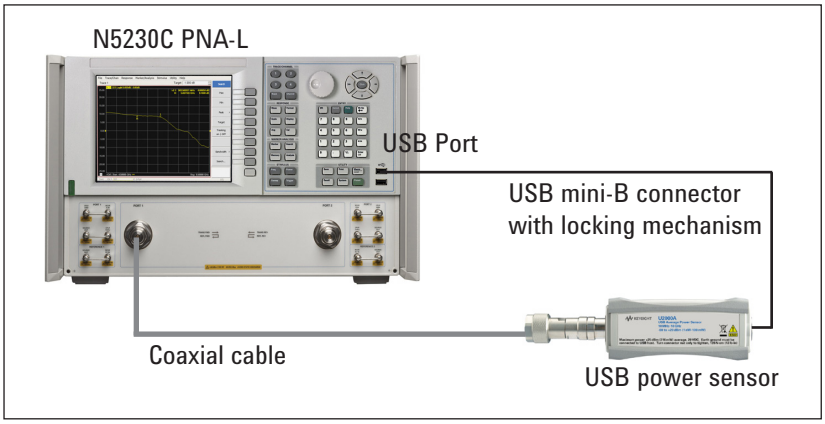


Figure 4. USB power sensor connecting directly to a PNA USB port through USB mini-B connector

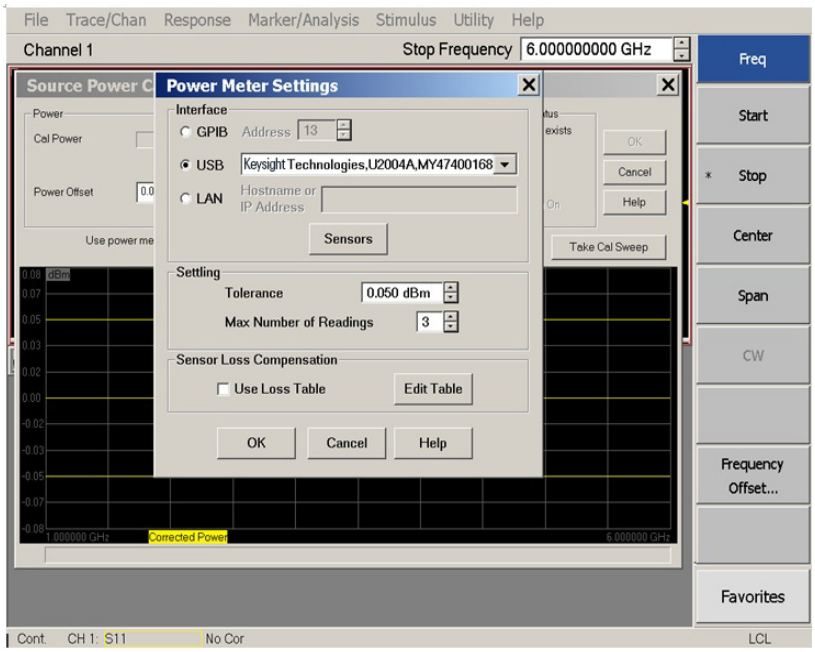


Figure 5. PNA's power meter setting for configuring USB sensor via USB connectivity

1. *For details of the source power calibration procedure, please refer to the Keysight Web site's PNA Source Power Cal procedure online help file (Power Calibration, under the Calibrating a Measurement section). You can readily obtain the procedure from Network Analyzer's Help menu.*

How Does It Work? (continued)

Figure 6 and Figure 7 show the results of source power calibration for EPM and USB power sensors respectively. The PNA source is stepped through the specified range (in this example, stepped from 1 to 6 GHz), and power (at 0 dBm) is measured with the power meter and USB power sensor. At each data point, the source power is adjusted until the measured power is within the specified accuracy level.

The source power calibration results can be saved in a Microsoft Excel file and the two results combined in a single graph for comparison (see Figure 8). The results appear to be comparable and within the ±0.05 dB limit line.

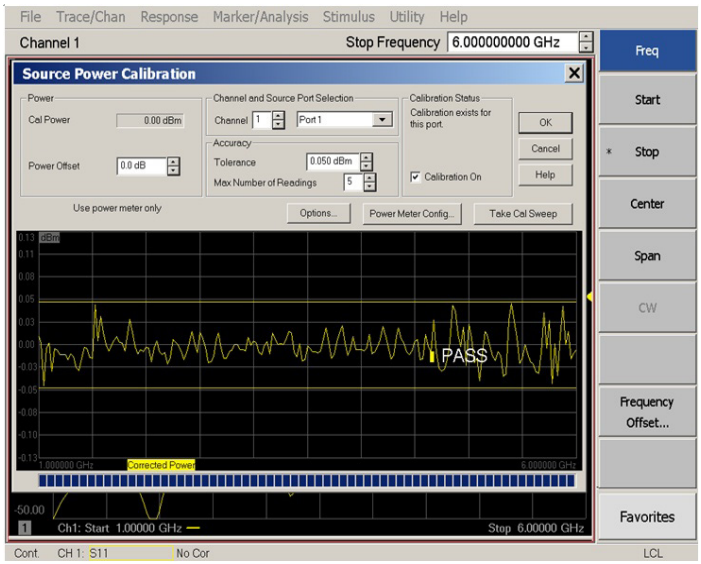


Figure 6. Source power calibration result with EPM and E9301A power meter and sensor

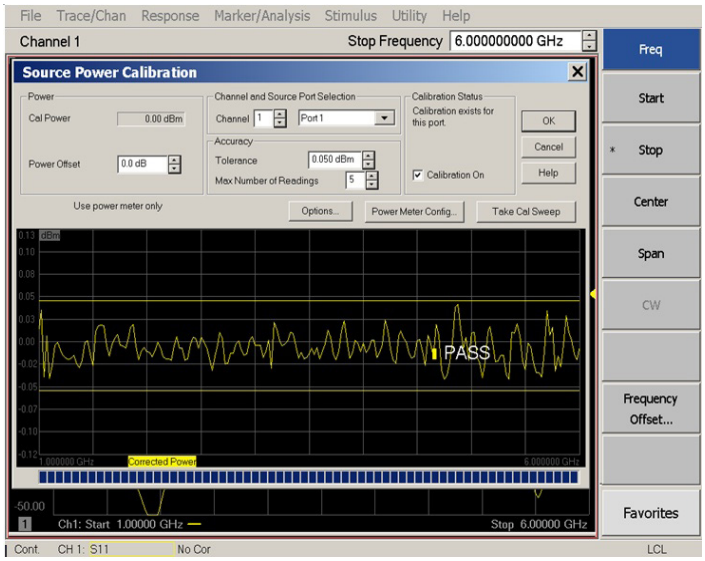


Figure 7. Source power calibration result with USB power sensor

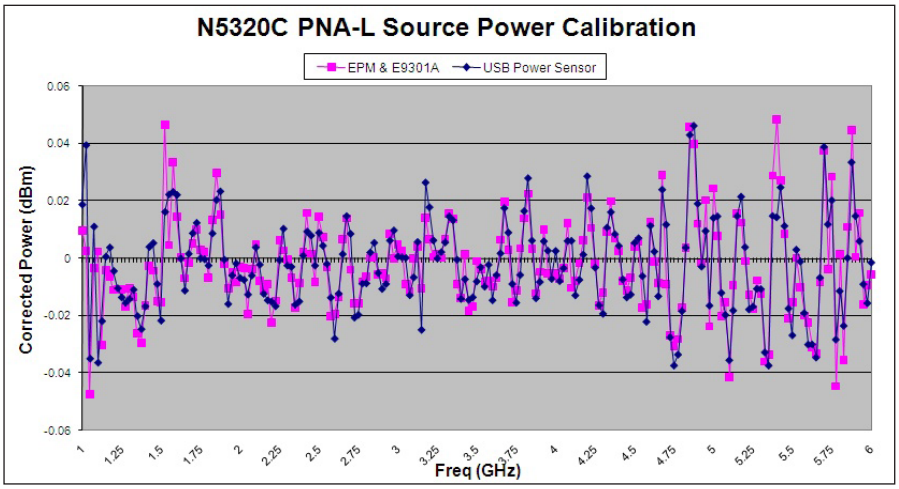


Figure 8. EPM power meter and USB power sensor source power calibration data comparison

How Does It Work? (continued)

E5071C ENA vector network analyzer

– To perform scalar analysis of a frequency converter which requires a VBA application through U2000 Series USB power sensor.

ENA has a Frequency Offset mode (FOM) option used to measure the frequency converter device accurately. The offset of source and receiver port frequency can be defined precisely. The receiver port can detect the down-converter or up-converter signal. There are limitations to using FOM to measure the frequency converter device. First, the local oscillator (LO) signal of the device under test (DUT) has to be known and locked to the source or receiver port frequency of a network analyzer. Otherwise, the difference between predicted intermediate frequency (IF) signal and actual IF signal is directly converted to a magnitude error because of the intermediate frequency bandwidth (IFBW) filter shape implemented in these network analyzers.

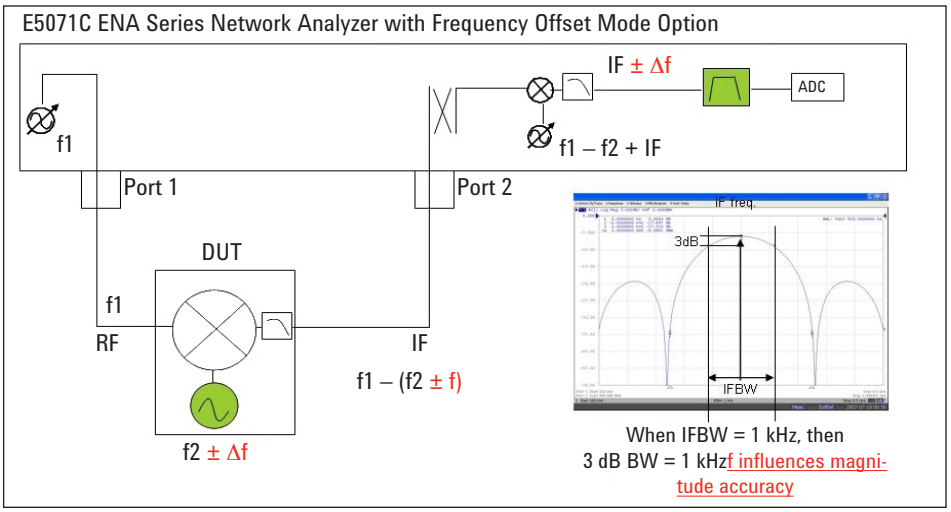


Figure 9. IFBW versus LO frequency drifts with FOM mode

Figure 9 shows the ENA setup in FOM. IFBW is set to 1 kHz, and the 3 dB bandwidth (BW) of the IFBW filter is approximately 1 kHz. If the actual output frequency of the DUT has an offset such as 500 Hz (=BW/2) from target frequency, the magnitude result has a 3 dB error. When the output signal drifts, the measurement results are also changed at the same time.

You can overcome the limitation of FOM by using the USB power sensor (with network analyzer VBA, a sample wizard is available) as a broadband power detector (see Figure 10). The USB power sensor is used to measure all power in its bandwidth, and the measurement result are stable and not influenced by output signal offset or drift (see Figure 11). For instance, the USB power sensor provides USB plug-and-play connectivity and easy setup in the network analyzer.

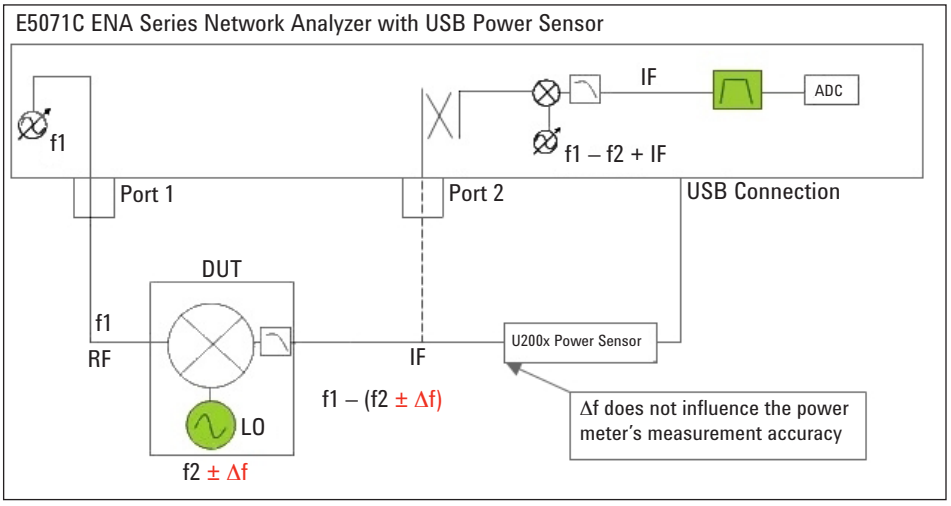


Figure 10. USB power sensor (broadband detect) versus LO Frequency drift

How Does It Work? (continued)

Figure 11 and Figure 12 show the measurement result of locked and drifted LO signals by FOM (see the blue trace) and the USB power sensor (see the red trace) respectively. The measurement result of the USB power sensor shows that it has good correlation with the FOM result at locked signal, and is stable with drifted LO signal.

For details of the frequency offset procedure and operation of VBA with the USB power sensor, please refer to the *Keysight Simple Scalar Network Analysis of Frequency Converter Devices using U2000 USB Power Sensor Series with ENA Series Network Analyzers, Application Note*

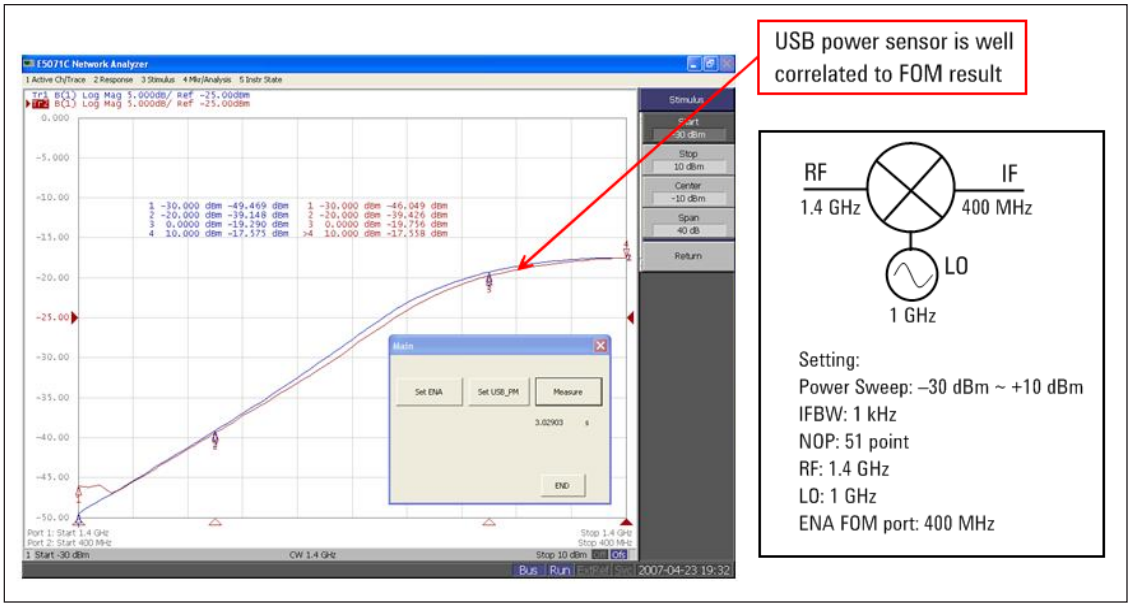


Figure 11. Measurement results with "Locked" LO (RF Power versus IF Power)

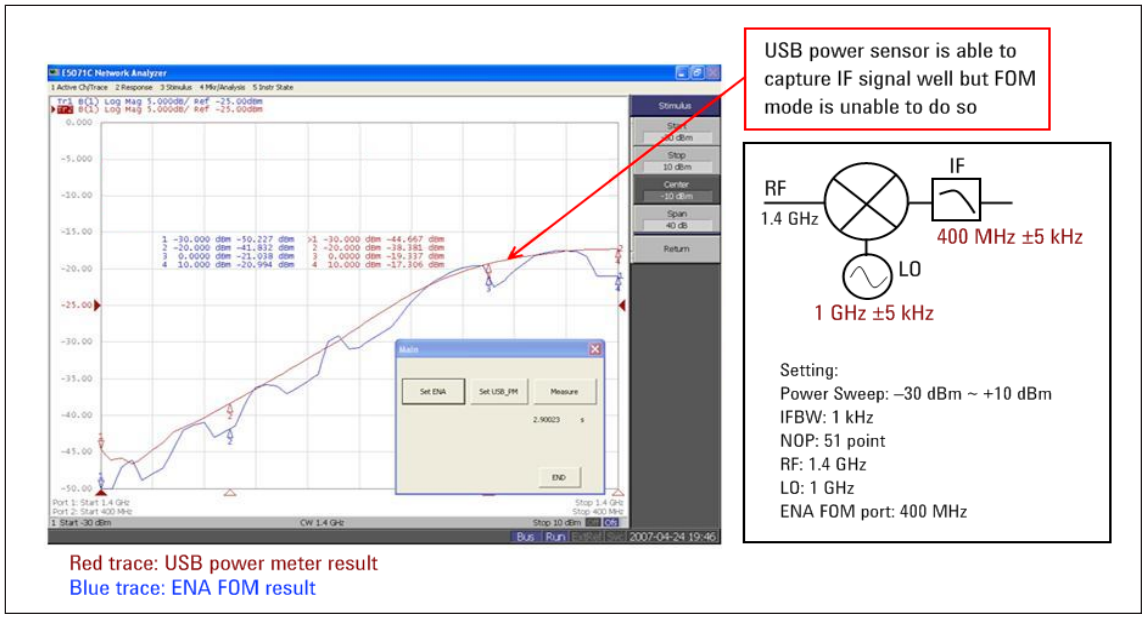


Figure 12. Measurement results with "Drifted" LO (RF Power versus IF Power)

How Does It Work? (continued)

N9340A handheld spectrum analyzer

– Turns the handheld spectrum analyzer into a power meter.

– Displays power measurement with its built-in user interface (UI), which integrates the display of USB power sensor measurements.

Keystrokes surrounded by [ ] represent front-panel hardkeys of the instruments, while keystrokes surrounded by { } represent softkeys.

Instructions

1. Power up the N9340A. Connect the USB power sensor to the USB port of the N9340A (see Figure 13).

Figure 13. HHSA connect with USB power sensor.

2. Press [Mode], use [↑] or [↓] to select the {Power Meter} then press [ENTER] (see Figure 14).

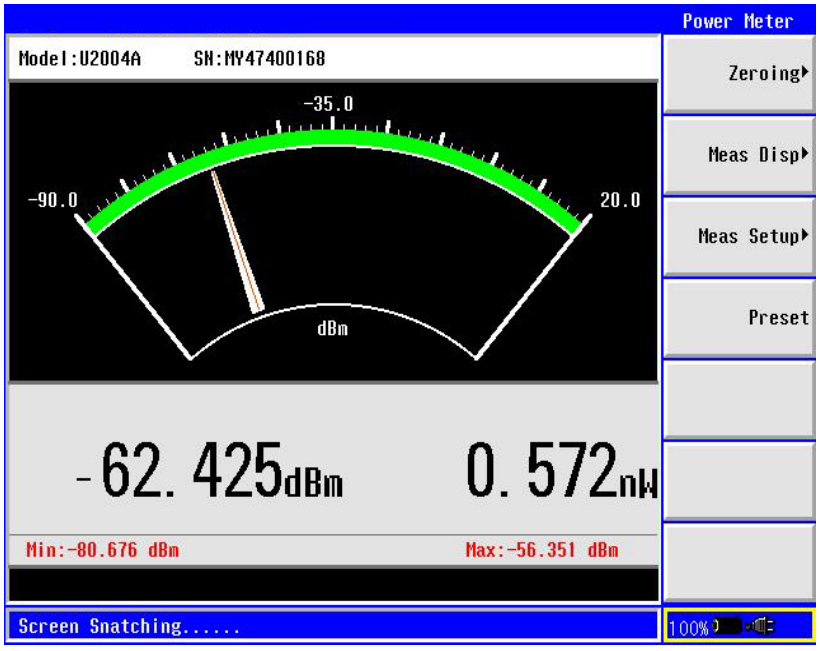


Figure 14. N9340A HHSA turns into a power-meter measurement

Power meter menu

– Zeroing: Access to zeroing and calibration menu.
– Meas Disp: Access to measurement display menu and to configure the displayed measurement resolution and format.
– Meas Setup: Set up the relative measurement or set display offsets.
– Preset: Preset the USB power sensor.

Instructions

3. Press {Zeroing ►} to perform the internal or external zeroing if necessary (see Figure 15).

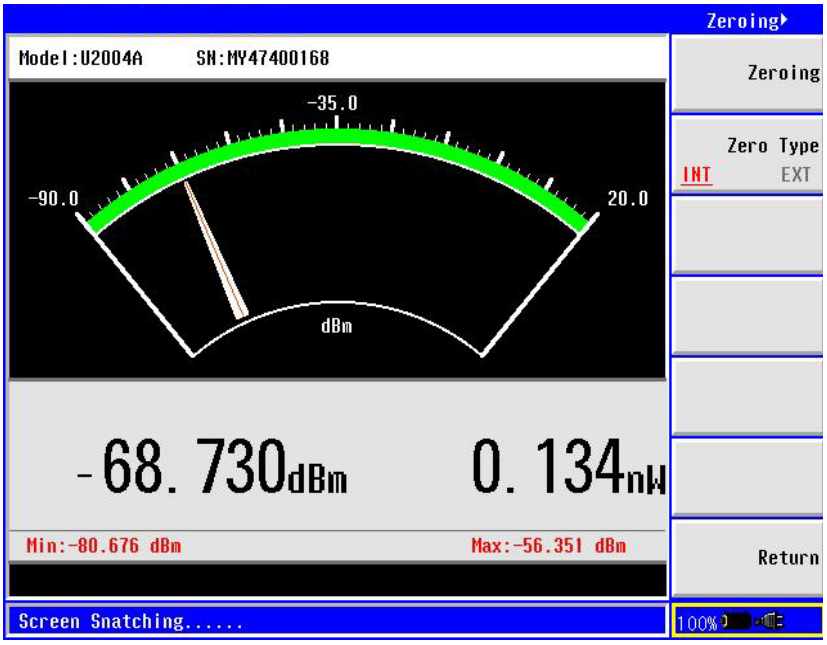


Figure 15. External and Internal Zeroing are performed to reduce the zero offset and noise impact in order to measure power accurately

Internal zeroing

Internal zeroing uses an electronic switch to isolate the power sensor bulkhead from the internal measurement circuitry during the procedure, allowing the sensor to be physically connected to an active RF source when internally zeroing. Therefore, you do not need to disconnect the RF source or power off the external source during an internal zeroing procedure. This feature makes internal zeroing more convenient, but you may only use internal zeroing if zero set (Internal) is within the application requirements.

External zeroing (applicable to the U2000 Series USB average power sensor only)

In external zeroing, the sensor does not use the electronic switch to isolate the measurement circuitry from the bulkhead. In this case, the RF power must be removed from the bulkhead either by turning the source off or physically removing it from the sensor during the external zeroing procedure. External zeroing generally has better zero set performance. The INT or EXT zeroing selection should be made based on the measurement needs.

By default, internal zeroing is performed by the firmware when the USB sensor is connected to the N9340A HHSA.

Instructions

4. Press {Return}. > {Meas Disp ►} (see Figure 16)

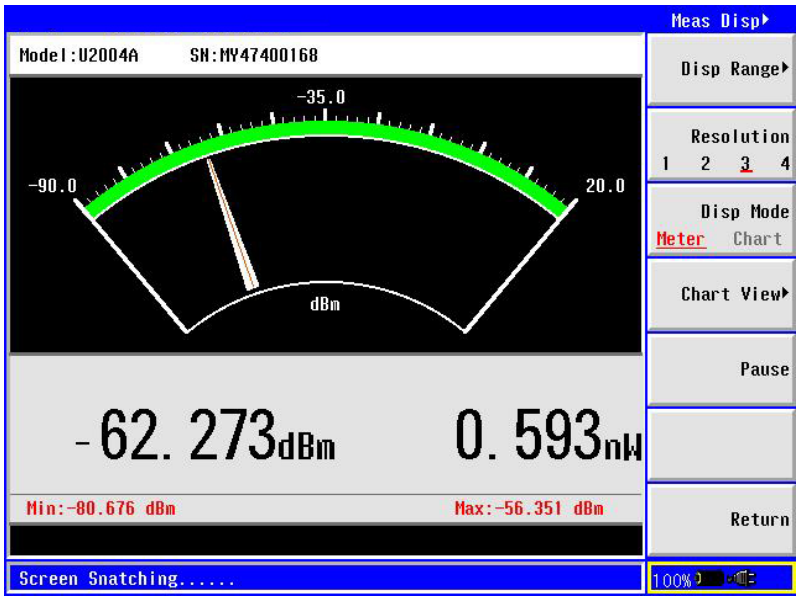


Figure 16. Meas Disp menu allows you to configure the display measurement and resolution

The Meas Disp (Measurement Display) menu allows you to configure the measurement display as follows:

- Disp Range: Indicates the top and bottom range of display measurement.
- Resolution: Indicates the measurement resolution's numeric type in four different levels (1, 2, 3, or 4). The default Resolution is 3.
- Disp Mode: You can configure the measurement display either in meter or chart format. The default Disp Mode is Meter.
- Chart View: Switches the measurement display to chart view.
- Pause: Pauses or continues the measurements.

To view the measurement in chart or graph format, press {Disp Mode} > {Chart} (see Figure 17).

Figure 17. Measurement display in chart format

Instructions

5. Press {Return} >. {Meas Setup} (see Figure 18).

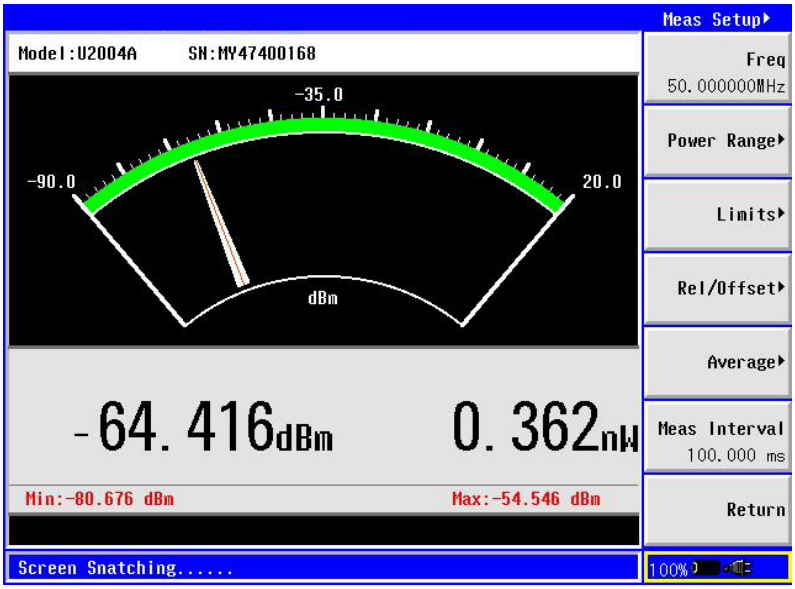


Figure 18. Measurement Setup menu with meter-view display measurement

Meas Setup (Measurement Setup) menu allows you to set up the relative measurement or set display offsets.

– Freq: Allows the frequency of the RF signal that you are measuring to be set. It optimizes the accuracy and minimizes measurement uncertainty, especially when making comparative measurements between signals.

– Power range: Allows you to set the power range to Auto or Manual. Using Auto range is encouraged when there is uncertainty about the power level to be measured.

  In Manual range, there are two manual setting: Lower and Upper. Lower range covers the power from –60 to –10 dBm. Upper range covers the power from –10 to +20 dBm.

– Limits: Indicates if the measurement result is beyond the configured upper or lower limit.

– Rel/Offset: Rel (Relative) mode enables a comparison of a measurement result to a reference value. The relative reading, or difference, can be displayed in either dB or %. The offset setting can be configured to compensate for signal loss or gain (in dB) in the test setup.

– Averaging: Allows the measurement averaging to be set in Auto or Manual mode, to average power readings.

  The purpose of averaging is to reduce noise, obtain the desired resolution, and reduce the jitter in the measurement results. Increasing the value of the measurement average reduces measurement noise, but the measurement time is increased. The default of Averaging is Auto.

– Step detect: Reduces 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.

– Meas interval: Allows you to set the time (in s or ms) to capture the new power measurement continuously.

How Does It Work? (continued)

N5183A MXG Signal Generator

– To perform user flatness correction (UFC) with external leveling to improve power accuracy and flatness.

– To provide dual display measurement of two USB power sensors.

User flatness correction with external leveling provides the ability to have extremely flat output power at the testing interface beyond the signal generator's RF output connector. If an external device (such as amplifier, attenuator, coupler, detector, divider, or long cable) is placed between the RF output connector and the testing interface, it will introduce additional gain or loss as well as frequency response mismatch to the whole system. Therefore, it is necessary to perform the UFC with external leveling to remove this type of influence. In this case, the USB power sensor integrated with the MXG offers a solution. The USB power sensor is directly connected to MXG's front panel USB port (see Figure 19) provides remote programming function. The MXG's built-in UFC personality allows you to configure the calibration array, start and stop frequency and number of the frequency points to be corrected. The setup function will observe the difference between measured power and calibrated power.

The correction factors of the UFC process are shown in Figure 20. For details of operation and procedure on UFC with external leveling and power measurement, please refer to *Keysight How to Utilize User Flatness Correction with External Leveling Using USB Power Sensor on MXG Signal Generator, Application Note* and *Keysight N5161A/62A/81A/82A/83A MXG Signal Generators, User's Guide*.

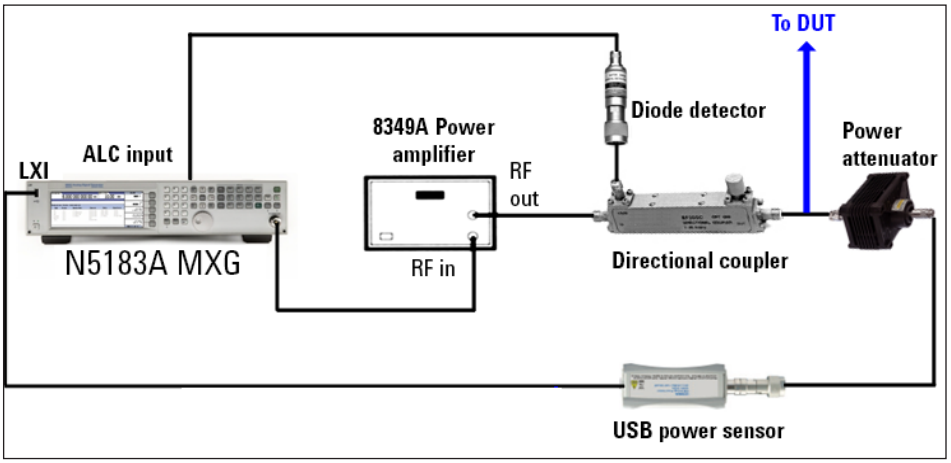


Figure 19. Connection diagram of USB sensor to MXG for UFC external leveling

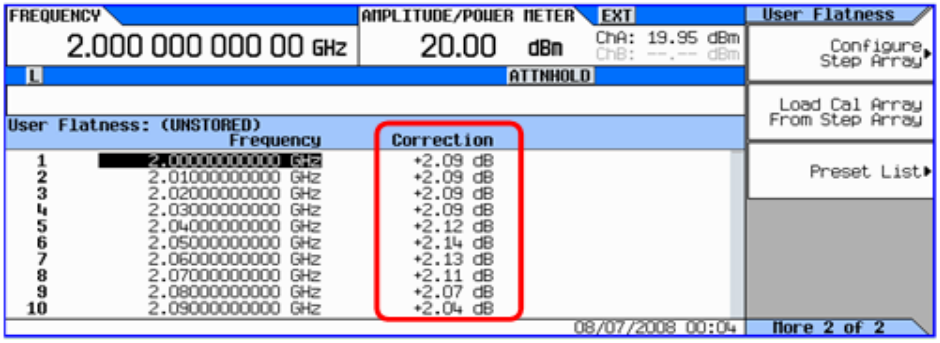


Figure 20. Correction factors automatically performed and display on MXG

Dual Power Meter Display Function on MXG

The dual power meter display function can be used to display the current frequency and average power of either one or two power sensors. For each channel, you can control the settings for On/Off, channel frequency, channel offset, averaging and measurement units, and the dual power meter display feature.

To use two USB power sensors with the MXG N518xA or N516xA, a USB hub (with power supply) can be connected to the MXG's front panel USB port (see Figure 21). Alternatively, the MXG B version, N518xB and EXG N517xB signal generators come with two USB ports on the front panel. Without the need for an external USB hub, two USB power sensors can be connected directly and turn the signal generator into two channel power measurement and acquiring the measurement simultaneously.

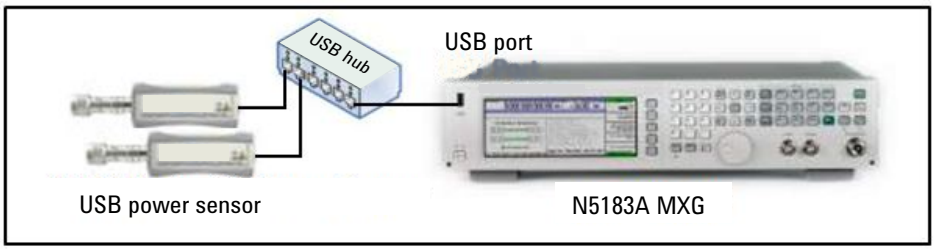


Figure 21. Connection diagram of two USB power sensors on MXG via external USB hub

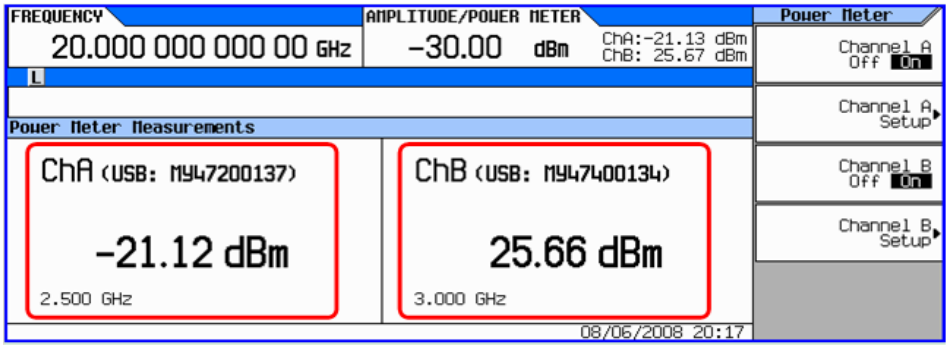


Figure 22. Dual power meter display function on MXG signal generator

How Does It Work?

FieldFox handheld analyzer

– Displays power measurement with its built-in user interface (UI), which integrates the display of USB power sensor measurements

Once the USB power sensors are connected to FieldFox, the user can switch the FieldFox to power meter mode and power readings will display on the FieldFox screen. The UI of power meter measurement provides the minimum configuration of power measurement such as frequency, averaging, single/continuous measurement, detection mode, zeroing, and display units measurement. Average and peak power measurement can be done via FieldFox depending on the USB power sensors.

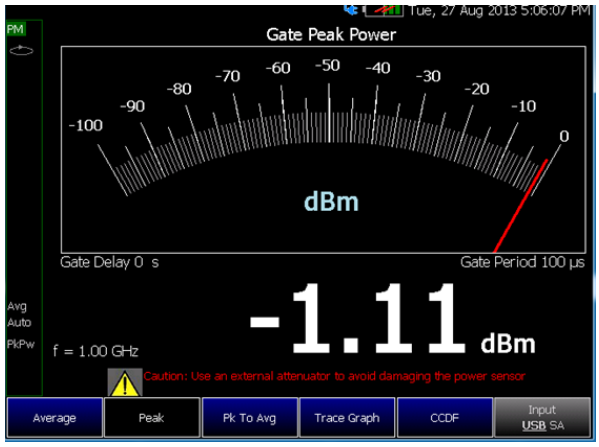


Figure 23. Power meter measurement UI in FieldFox

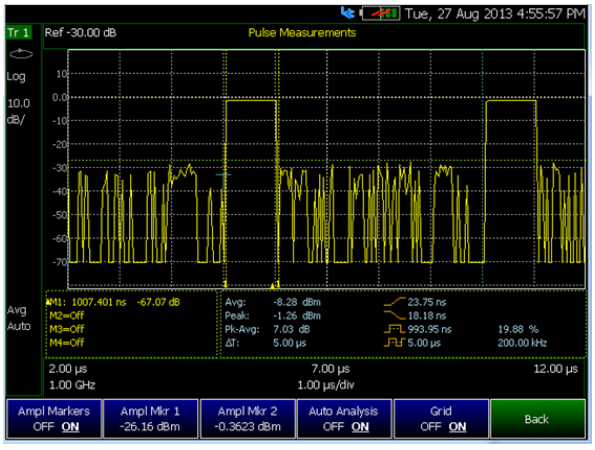


Figure 24. Pulse measurement mode require U2020 X-Series USB peak and average power sensors to measure the RF pulse signal

Conclusion

The USB power sensors are compact and portable, easy to use, and cost effective for you as they provide the following benefits:

– Compatibility with other Keysight instruments such as vector network analyzer, spectrum analyzer, signal generators, cable and antenna testers, and FieldFox handheld analyzers.

– Portability for field applications. The smaller size and light weight of the USB power sensors allows you to carry them to the site for field applications.

– Simplified measurement setup with USB power, plug-and-play connectivity, and builtin triggering circuit.

– Lower cost without compromising on performance or quality. Standalone USB power sensors do not need a power meter to provide accurate power measurement via PC/laptop or other Keysight instrument.

Related Literature

[1] *Keysight U2000 Series USB Power Sensors, Technical Overview*
Literature Number: 5989-6279EN

[2] *Keysight N9340A Handheld Spectrum Analyzer, Technical Overview*
Literature Number: 5989-5071EN

[3] *Keysight Handheld Cable and Antenna Tester, Technical Overview*
Literature Number: 5989-5522EN

[4] *Keysight Simple Scalar Network Analysis of Frequency Converter Devices using the U2000 USB Power Sensor Series with the ENA Network Analyzer, Application Note*
Literature Number: 5989-8689EN

Product Web Site

For most up-to-date and complete application and product information, visit Keysight Web site at the following URL:

www.keysight.com/find/usbsensor

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