

Agilent

Agilent N8480 Series Power Sensors Migration Guide

Application Note



Agilent Technologies

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A New Thermocouple Power Sensor for Average or Complex Modulations Power Measurement

Agilent Technologies is introducing the N8480 Series power sensors to replace its legacy 8480 Series power sensor (excluding the D-model sensor). The new N8480 Series power sensors offers new features, including a better dynamic range up to 55 dB, better measurement accuracy and repeatability, backward compatibility with existing Agilent power meters and built-in EEPROM.

This document compares the legacy 8480 and the new N8480 power sensors. It also outlines the step-by-step migration from 8480 to the N8480 Series with EPM power meter.

Introduction

The 8480 Series power sensor is well recognized as an industry standard for power measurements. It has been available to the industry for over 30 years and is widely used in design, manufacturing, or metrology applications for continuous wave (CW) or complex modulated signals.

Agilent is introducing the N8480 Series power sensors, a new thermocouple power sensors as a replacement for the 8480 Series power sensors (excluding the D-model sensors). It is enhanced with a few key features such as built-in EEPROM, extended dynamic range, wider frequency range, and — most important— better accuracy and repeatability.

The N8480 Series is capable of measuring true average power for CW or complex modulated signals such as WLAN, WiMAX, or pulse signals. The N8480 Series is compatible with the EPM (E4418/19B), EPM-P (E4416A/17A), and P-Series (N1911/12A) power meters. The N8480 Series sensors excluding Option CFT (N848x) measure power from -35 dBm to $+20\text{ dBm}$, at frequencies from 100 kHz to 33 GHz (High frequency sensors — 50 MHz to 50 GHz — will be introduced in 2009).

The N8480 Series sensors with Option CFT (N848x-CFT) has SCPI compatibility with the 8480 Series and covers the dynamic range from -30 dBm to $+20\text{ dBm}$.

Note:

- The legacy power sensors 8481D, 8485D, 8487D, R8486D, Q8486D, V8486A, W8486A are diode-based sensors and are not replaced.
- The N8480 Series power sensors refers to all respective power sensors unless otherwise stated.
- The N8480 Series Standard (N848x) in this document refers to the N8481A, N8482A or N8485A, while the N8480 Series Option CFT (N848x-CFT) refers to the N8481A-CFT, N8482A-CFT and N8485A-CFT.

N8480 Series Power Sensors

Traditionally, legacy 8480 Series power sensors are designed without EEPROM and thus require cal factor data to be manually keyed into the power meter. The new N8480 Series comes with a built-in EEPROM that help users to simplify thier measurement processes by eliminating the needs to key in cal factors manually. Thus users are required to modify the test software to accommodate this new feature of N8480 Series power sensor. In order to maintain backward compatibility with the legacy 8480 Series, the N8480 Series was developed with the following two variants:

- ✓ **N8480 Series Standard (N848x)**
 - E-Series sensor behavior similarity
 - Automatically retrieve the EEPROM's cal factor
 - SCPI commands exactly the same as E-Series sensors

- ✓ **N8480 Series Option CFT (N848x-CFT)**
 - 8480 Series sensor behavior similarity
 - Manually enter the cal factor into power meter
 - Cal factor table label available at the back of the sensor
 - Supports all 8480 SCPI commands



Figure 2. N8480 Series power sensor

Standard (N848x)

The N8480 Series power sensor incorporates the latest sensing technology, with value-added features such as the built-in EEPROM circuit, wider dynamic range, and better linearity and accuracy.

Similar to the E-Series power sensors, the N8480 Series power sensors are designed with built-in EEPROM to store the sensor's characteristics such as model number, serial number, linearity, temperature compensation, calibration factors, and so forth. This feature ensures that this correction data will be loaded into the power meter when the sensor is moved from one power meter to another power meter. Therefore, it provides ease of use and convenience to the users.

- ✓ Frequency range: 100 kHz to 33 GHz*
- ✓ Wider dynamic range: -35 to +20 dBm (5 dB improvement from legacy 8480 Series)
- ✓ Wider frequency coverage: 100 kHz to 33 GHz (50 MHz to 50 GHz will be launched in 2009)*
- ✓ Excellent power linearity for better accuracy*
- ✓ EEPROM feature to store cal factors
- ✓ Compatible with EPM, EPM-P, and P-Series power meters (only applicable when use with compatible firmware)*

Option CFT (N848x-CFT)

The N848x-CFT behave as the legacy 8480 Series sensors. User are required to enter the cal factor data manually for particular frequency prior to make a measurement or, enter the sensor cal factor table manually and select the frequency of signal to be measured.

- ✓ Dynamic Range: -30 to +20 dBm (same as legacy 8480 Series)
- ✓ Backward compatible with 8480 Series SCPI codes
- ✓ EEPROM feature is disabled to maintain backward compatibility with 8480

* Applicable to both N8480 Series power sensors standard and Option CFT

Key Specifications and Features

Key Specifications

Table 1: Comparison of Agilent 8480 and N8480 Series power sensors

	848x (Legacy Power Sensor)	N848x (Standard)	N848x-CFT (Option CFT)
Frequency	8481A: 10 MHz – 18 GHz 8482A: 100 KHz – 4.2 GHz 8485A: 50 MHz – 33 GHz	N8481A: 10 MHz – 18 GHz N8482A: 100 KHz – 6 GHz N8485A: 10 MHz – 33 GHz	N8481A: 10 MHz – 18 GHz N8482A: 100 KHz – 6 GHz N8485A: 10 MHz – 33 GHz
Dynamic Range	–30 dBm to +20 dBm	–35 dBm to +20 dBm	–30 dBm to +20 dBm
Operations	Average thermocouple sensor	Behave like E-Series	Behave like 8480 Series
EEPROM	Manually enter cal factors into power meter	EEPROM’s cal factors automatically loaded into power meter	Manually enter cal factors into power meter
Cal Factor Label	Cal factor label is attached to the sensor’s cover	No cal factor label is attached to the sensor’s cover	Cal factor label is attached to the sensor’s cover
Programming Code	SCPI compliance	SCPI commands same as E-Series power sensor	SCPI commands same as 8480 Series power sensor
Dimension (mm)	38 (W) x 30 (H) x 105 (L) for 8481/2A 38 (W) x 30 (H) x 95 (L) for 8485A	38 (W) x 30 (H) x 130 (L) for N8481/2A 38 (W) x 30 (H) x 121 (L) for N8485A	38 (W) x 30 (H) x 130 (L) for N8481/2A 38 (W) x 30 (H) x 121 (L) for N8485A
Linearity	3% (> 10 dBm)	0.8% (> 15 dBm at 25°C ±10°C) 0.52% (–1 dBm to 15 dBm at 25°C ±10°C)	0.8% (> 15 dBm at 25°C ±10°C) 0.52% (–1 dBm to 15 dBm at 25°C ±10°C)
Zero Set	±50 nW	±25 nW	±63 nW
Zero Drift	< ±10 nW	< ±3 nW	< ±7 nW
Measurement Noise	< 110 nW	< 80 nW	< 114 nW



Figure 5. 8481A and N8481A sensor physical comparison

Power Meter Compatibility

The N8480 Series power sensors operate with the Agilent EPM (E4418/19B), EPM-P (E4416/7A) and P-Series (N1911/2A) power meters (see Table 2). Firmware upgrades of the supported power meters are needed to ensure compatibility with the N8480 Series power sensors (see Table 3).

Go to www.agilent.com/find/pm_firmware to download the latest firmware release. You may also locate the EPM and EPM-P Series power meters' firmware and firmware upgrade procedure in the *N8480 Series Power Sensors Product Reference CD*. Download the firmware upgrade procedure, and follow the process to upgrade the power meter's firmware.

The legacy 8480 Series power sensors are designed for the use with the power meters as shown in Table 2. To ensure power meter compatibility, user's may need to migrate the unsupported power meter to EPM power meters when they migrate the legacy 8480 Series to the new N8480 Series power sensor.

For help to migrate the 435/6/7/8A/B power meter to the EPM power meter, refer to the application note "Agilent EPM Series 437B and 438A Compatibility, Literature Number: 5968-4519E."

Table 2. Power meter supportability comparison between 8480 Series and N8480 Series power sensor

	848x	N848x (standard)	N848x-CFT
435/6/7/8A/B	Yes	No	No
53147/8/9A	Yes	No	No
E7495A/B	Yes	No	No
70100A	Yes	No	No
E1416A	Yes	No	No
EPM, E4418/19B	Yes	Yes	Yes
EPM-P, E4416/17A	Yes	Yes	Yes
P-Series, N1911/12A	Yes	Yes	Yes
P-Series Modular, N8262A	Yes	No	No

Table 3. Power meter firmware revision supported by N8480 Series power sensor

Power Meter	Model Number	Compatible Firmware Revision
EPM Series Power Meter	E4418B	A1.09.00 and above
	E4419B	A2.09.00 and above
EPM-P Series Power Meter	E4416A	A1.05.00 and above
	E4417A	A2.05.00 and above
P-Series Power Meter	N1911A	A.05.00 and above
	N1912A	

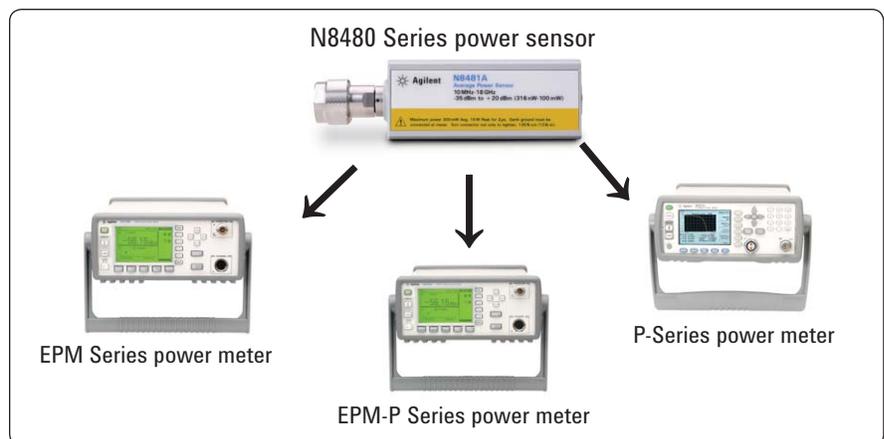


Figure 6. Power Meter compatibility

SCPI Compatibility

Figure 4 illustrates the SCPI-command compatibility of 8480, N848x, and N848x-CFT. The N848x-CFT provides SCPI backward compatibility with legacy 8480 power sensor SCPI commands. No software change is needed in the existing test system for the N848X-CFT power sensor when working with a power meter. Users are only required to upgrade the power meter firmware to the latest revision in order to operate with the N8480-CFT.

The N8480 Series provides an enhanced SCPI command set that is in general backward compatible with the 8480 Series power sensor. However, due to some new features and functions, some SCPI commands that work on the N8480 are unable to work on the 8480 and vice versa. For this reason, N848x-CFT is created for customers who need a full backward compatibility with the 8480 Series legacy power sensor.

Most of the SCPI commands supported by the legacy 8480 Series power sensor and N848x-CFT but not supported by the new N848x are related to the entry, delete, rename, and selection of the sensor calibration factor table in the power meter (see Table 4). This is due to cal factors that will be automatically downloaded from the sensor EEPROM.

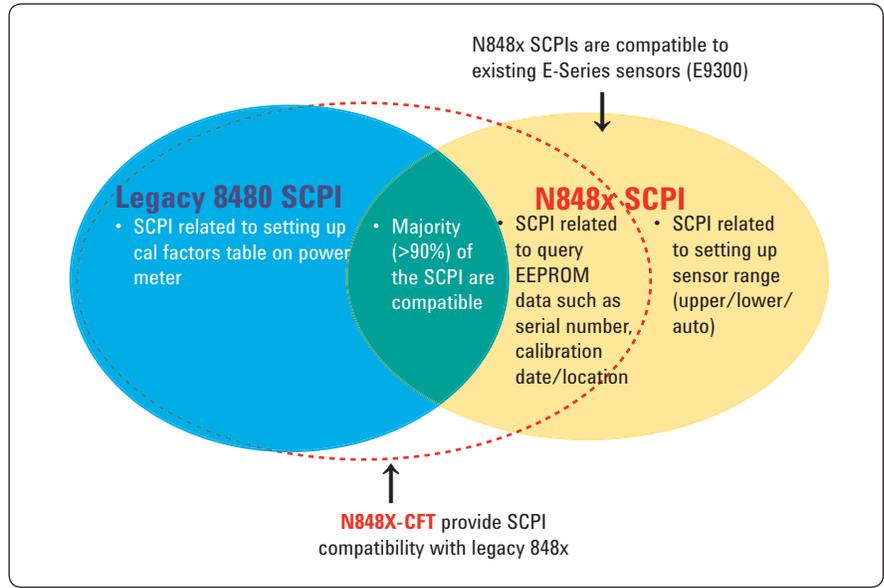


Figure 4. SCPI command compatibility for 8480, N848x, and N848x-CFT

Table 4. SCPI commands supported by 848x and N848x-CFT but not supported by the N848x

SCPI Commands	Function
CALibration:RCFactor	Setup the correct reference cal factors
SENSe1:CORRection:CSET1:STATe OFF/ON	Turn OFF/ON the sensor calibration table
SENSe1:CORRection:CSET1[:SELe ct] <string>	Select sensor calibration table.
SENSe1:CORRection:CSET1:STATe ON	Enable sensor calibration table
CORR:CSET1?	Query sensor calibration table for channel A
SENS2:V2P DTYP	Select the D type linearity correction to be applied for channel B

There are some SCPI commands supported by N848x and N848x-CFT but not supported by the legacy 8480 power sensor (see Table 5). Most of the SCPI commands supported by N848x and N848x-CFT are related to EEPROM data such as calibration date, location of calibration, and serial number of sensor. These SCPIs are not supported by the legacy 8480 because EEPROM is unavailable in these sensors.

Table 6 shows the SCPIs supported by N848x (standard option) only. The SCPI commands are related to sensor ranging; lower, upper, or auto range. There is only one range in the 8480 Series and N8480-CFT; thus, range-switching commands are not supported.

Table 5. SCPI commands supported by N848x and N848x-CFT but not supported by the 8480 Series power sensors

SCPI Commands	Function
SERV:SENS1:CDATE?	Query calibration date for channel A
SERV:SENS1:CPL?	Query calibration location for channel A
SERV:SENS1:SNUM?	Query serial number for channel A

Table 6. SCPI commands supported by N848x (standard option) only

SCPI Commands	Function
MEAS1? -30, DEF, (@1)	Perform power measurement with three optional parameters: expected power level, display resolution, and channel. In this example, -30 dBm is the expected power level
CONF1 -30, DEF, (@2)	Configure the upper window to make a measurement with three optional parameters: expected power level, display resolution, and channel. In this example, -30 dBm is the expected power level
SENS1:POW:AC:RANG 0 1	Set to lower or upper range
SENS1:POW:AC:RANG AUTO ON	Enable auto-ranging of the sensor
SERV:SENS:CAL	To access cal factor data in the EEPROM (only available when use with P-series or EPM-P power meter)

Zeroing and Calibration

Standard (N848x)

Similar to E-Series and P-Series power sensors, N8480 Series power sensors require zero and calibration routines to be performed with the power meter to ensure the accurate measurement. The Agilent N8480 Series power sensor sets the reference calibration factor automatically. The power meter automatically reads the calibration factor (CF) data that stored in the EEPROM of the sensor and uses it to make corrections. Users no longer need to manually key-in the calibration factor into the power meter to optimize measurement accuracy.

Option-CFT (N848x-CFT)

Calibration Factor Data Key-In into Power Meter

Similar to the 8480 Series power sensor, Agilent N848x-CFT require users to set the reference calibration factor. The calibration factor must be manually entered into the power meter. Sensor calibration tables are used to store the measurement calibration factors, supplied with each power sensor on the calibration factor (CF) label pasted on every Option CFT unit. The calibration factors are used to correct measurement results.

There are two methods of providing correction data to the power meter, depending on the setting. If the power meter's sensor calibration table is turned OFF and the sensor calibration tables are not used, perform the following steps to make a measurement:

Step	Description
1	Zero and calibrate the power meter with the sensor connected.
2	Set the calibration factor by referring to the CF label on the sensor base on the frequency of the signal you want to measure.
3	Make the measurement.

In the second method, with the power meter's sensor calibration table is turned ON, and the sensor calibration tables are used. This provides you with a quick and convenient method for making power measurements at a range of frequencies using one or more power sensors. Note that with the sensor calibration table selected, the reference calibration table (RCF) from the table overrides any value previously set. To use sensor calibration tables:

Step	Description
1	Edit a sensor calibration table if necessary.
2	Select the sensor calibration table.
3	Enable the sensor calibration table.
4	Zero and calibrate the power meter.
5	Specify the frequency of the signal you want to measure. The calibration factor is automatically set by the power meter from the sensor calibration table.
6	Make the measurement.

Measurement Range Selection

The N848x have two measurement ranges: Upper range covers the dynamic range from -1 dBm to +20 dBm, whereas lower range covers the dynamic range from -35 dBm to -1 dBm (see Table 7). With N848x sensors, the range can be set either automatically or manually. The manual range is invariably used to obtain faster measurement speed because the up/down range-switching associated with auto ranging is inhibited. Use autoranging when you are not sure of the power level you will be measuring.

By default, the N848x sensor is set to AUTO range upon connecting to the power meter and covers the dynamic range from -35 dBm to +20 dBm (55 dB). The power meter thus will select the most suitable range for making the measurement.

The N848x-CFT sensors only have a single range (UPPER range), from -30 dBm to +20 dBm (50 dBm). Therefore, range selection is not allowed.

Measurement Speed

Like 8480 Series power sensors, N8480 Series power sensors' measurement speeds are available in NORMAL and DOUBLE (2x) mode. The speed setting controls the cycle time of the measurement; i.e., 50 ms and 25 ms respectively. The typical maximum speed is shown in Table 8.

Fast speed is not available for N8480 Series power sensors. In Normal and Double modes, the power meter is operating at full instrument functionality.

Table 7. N848x (standard) measurement range selection

Sensor	Range Setting	Lower Range	Upper Range
N848x (standard)	AUTO (default)	-35 dBm to -1 dBm	-1 dBm to +20 dBm
	LOWER	-35 dBm to -1 dBm	-
	UPPER	-	-30 dBm to +20 dBm

Setting the Range

To set the range manually, use the following command:

```
[SENSe[1]]:POWer:AC:RANGe <numeric_value>
```

If the <numeric_value> is set to:

- 0, the sensor's lower range is selected.
- 1, the sensor's upper range is selected.

To enable autoranging use the following command:

```
[SENSe[1]]: POWer:AC:RANGe:AUTO ON
```

Table 8. Measurement speed for N848x and N848x-CFT series power sensor.

Sensor Type	Measurement speed (readings/second)	
	Normal	Double (x2)
N848x	20	40
N848x CFT	20	40

Setting the Measurement Speed

To set the measurement speed, use the following command:

```
[SENSe[1]]:MRATe <NORMAl | DOUBle>
```

or

```
[SENSe[1]]:SPEed <20|40>
```

To check the measurement speed, use the following command:

```
[SENSe[1]]:SPEed?
```

or

```
[SENSe[1]]:MRATe?
```

Measurement Accuracy and Repeatability

This section show the experiment results of measurement accuracy and repeatability for 8481A legacy power sensors compared with N8481A power sensors. The experiment was carried out under the conditions described below. See Figure 7 for setup configuration:

- i) Frequency = 1 GHz
- ii) Power level = +20, 0, -30 & -35 dBm
- iii) Test time duration = 15 hours
- iv) Measurement reading = 1 measurement reading per minute

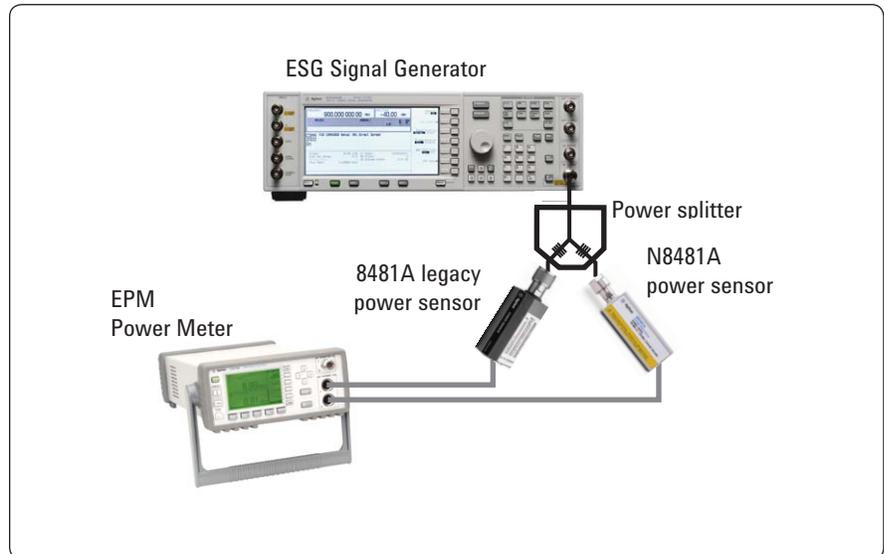


Figure 7. EPM, 8481A, N8481A, and ESG configuration diagram

The graph in Figure 8 shows the measurement accuracy and repeatability of 8481A compared with the N8481A at power level +20 dBm. Both power sensors show ± 0.01 dB measurement accuracy and repeatability.

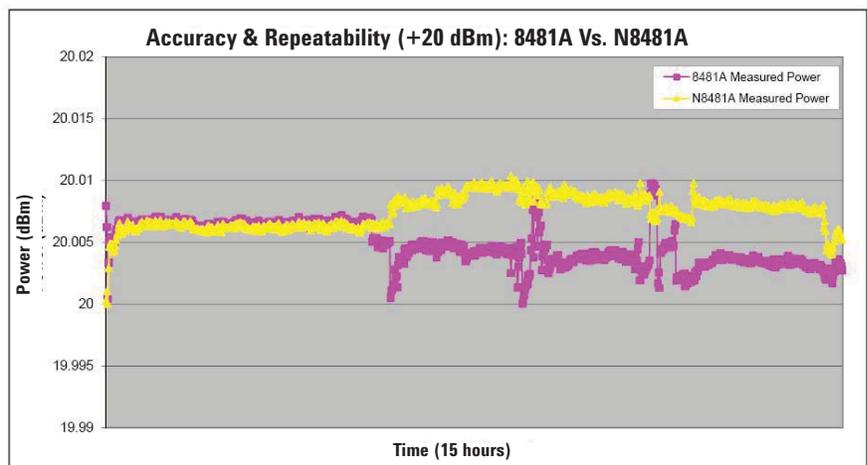


Figure 8. Measurement accuracy and repeatability graph, 8481A vs. N8481A at power level +20 dBm.

The graph in Figure 9 shows the measurement accuracy and repeatability of 8481A compared with the N8481A at power level 0 dBm. Both power sensors show ± 0.008 dB measurement accuracy and repeatability.

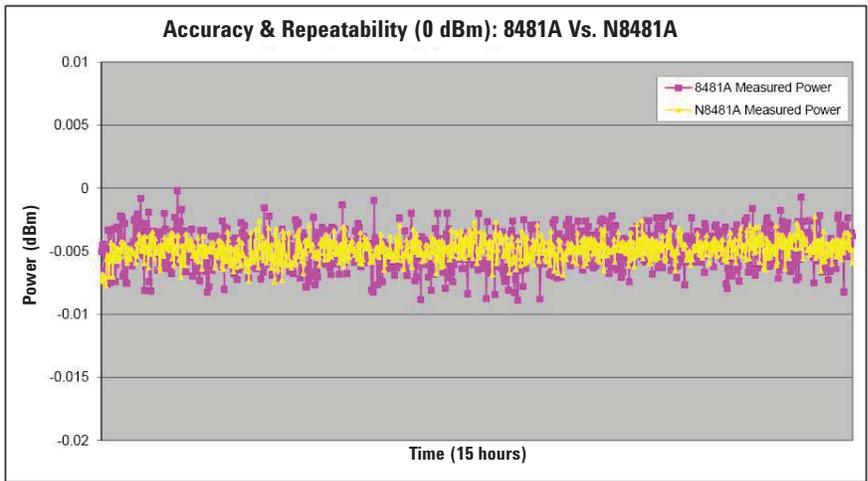


Figure 9. Measurement accuracy and repeatability graph, 8481A vs. N8481A at power level 0 dBm.

The graph in Figure 10 shows the measurement accuracy and repeatability of 8481A vs. N8481A at power level -30 dBm. At this power level, 8481A power sensor show ± 0.4 dB variance measurement repeatability and accuracy versus ± 0.1 dB for N8481A.

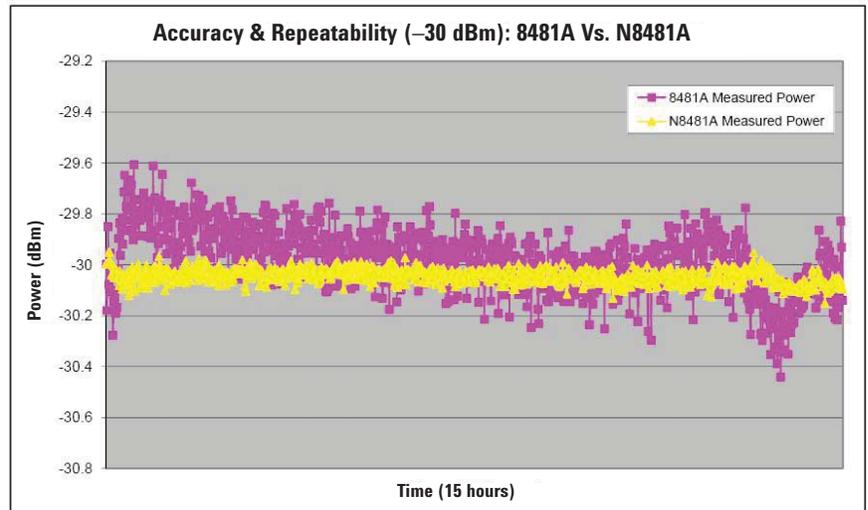


Figure 10. Measurement accuracy and repeatability graph, 8481A vs. N8481A at power level -30 dBm.

Figure 10 shows the graph of measurement accuracy and repeatability for N8481A at power level -35 dBm. The N8481A achieves ± 0.2 dB repeatability at -35 dBm. At -35 dBm, the power level is beyond the power range of the 8481A, and therefore no experiment has been done.

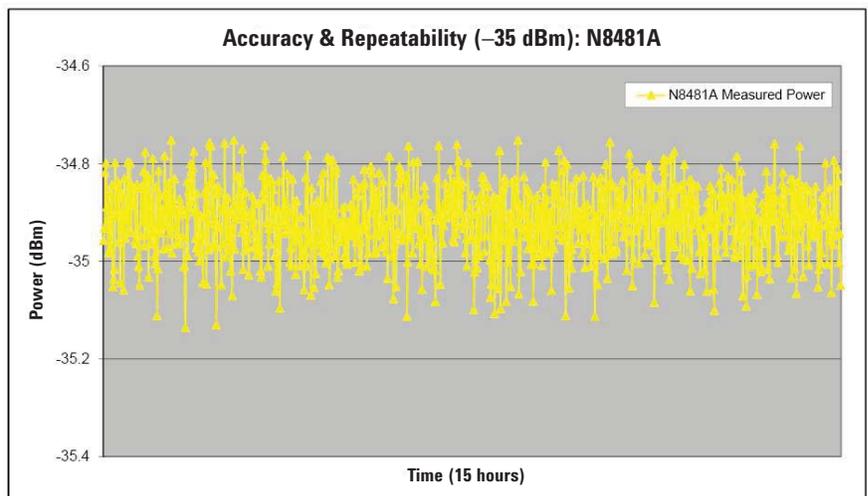


Figure 11. Measurement accuracy and repeatability graph for N8481A at power level -35 dBm.

Step-by-Step Migration Guide from 8480 to N848x with EPM Power Meter

Prior to operate the N8480 Series power sensor, the power meter’s firmware needs to be upgraded to allow compatibility and full functionality. See table 2 and table 3 (Page 5) for the power meter compatibility and firmware revision that support the N8480 Series power sensor.

Note

In some cases, the programming code are written to query the sensor identification before performing the sub-routine process. The legacy 8480 Series power sensor will return “A”, “B”, “D” or “H”. The new 8480 Series power sensor will return the model number stored in the sensor’s EEPROM. See example below:

When `SERVICE:SENSE:TYPE?` is executed, each power sensors will return a different naming convention

- 8480 Series power sensor: A
- N8480 Series power sensor: N8481A
- N8480-CFT Series power sensor: N8481A-CFT

If the user is using the N8480-CFT to replace legacy 8480 sensor, and use `SERVICE:SENSE:TYPE?` to query the sensor identification, user should add N848x-CFT model identification into their programming code.

How to Use N848x with EPM Series Power Meter

Step	Description
1	Make sure the power meter firmware is upgraded to the latest revision.
2	Connect the N8481A to the EPM power meter (see Figure 12).
3	Turn on the power meter.
4	Connect the N8481A power sensor to the POWER REF port of the power meter.
5	Perform zeroing and calibration. Upon powering up, the N8481A power sensor’s calibration factor is automatically downloaded into power meter. Press [Zero/Cal], {Zero}, and {Cal} (see Figure 13).
6	Enter the frequency of the signal you want to measure. Press [Frequency Cal Factor] and {A Freq} (see Figure 14). Press [↑], [↓], [→] or [←] key to change the frequency.
7	Start the measurement.

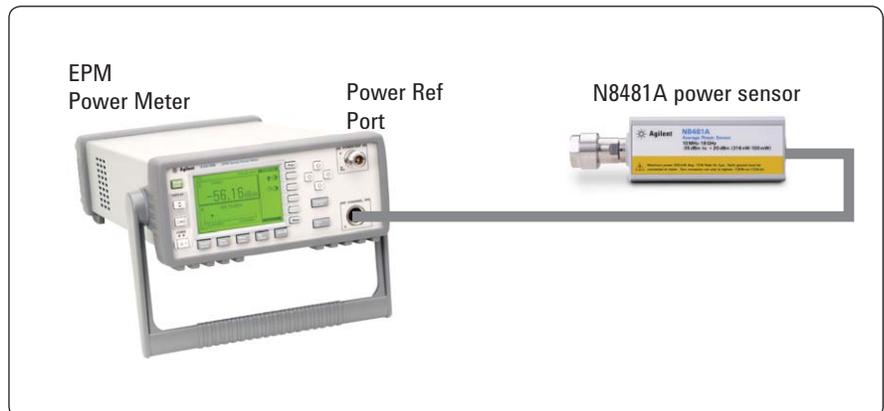


Figure 12. N8481A power sensor and EPM power meter connection configuration

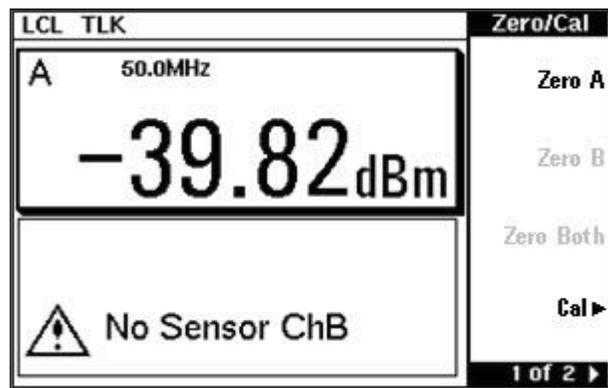


Figure 13. Power meter zero and cal menu

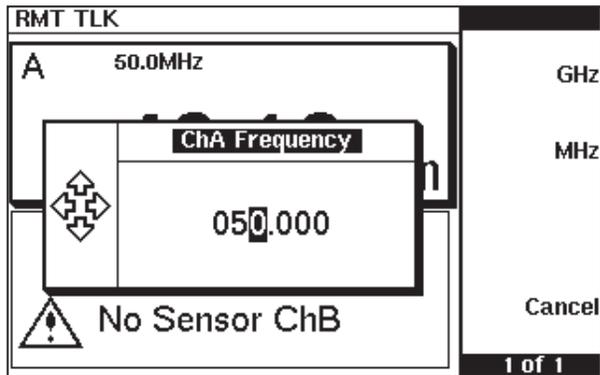


Figure 14. Frequency edit screen

How to Use N848x-CFT with EPM Series Power Meter

Step	Description
1	Make sure the power meter's firmware is upgraded to the latest revision.
2	Connect the N8481A-CFT to the EPM power meter (see figure 15).
3	Turn on the power meter.
4	Key in the cal factor into the power meter. The N8481A-CFT requires that the user manually key the cal-factor value into the power meter, based on the attached CF label on the CFT unit power sensor. i) Press [System Input], {Tables▶} and {Sensor Cal Tables} (see Figure 16) ii) " Manually rename one of the table to "N8481" and key in the cal factor value. In this example, we are using the table 0: "Default." Press {Edit Table}; Press [↑], [↓], [→] or [←] key to add the frequency point and its CF value (see figure 16). After you have done keying in the CF value, press {Done}. iii) Turn on the table cal factor. Press {A Table} to "On" and press {Done} (just as in Figure figure 16) to complete the editing process and save the table.
5	Perform the zeroing and calibration. Press [Zero/ Call] (as in Figure 13)
6	Enter the frequency of the signal you want to measure. Press [Frequency Cal Factor] and {A Freq} (as in Figure 14). Press [↑], [↓], [→] or [←] key to change the frequency.
7	Start the measurement

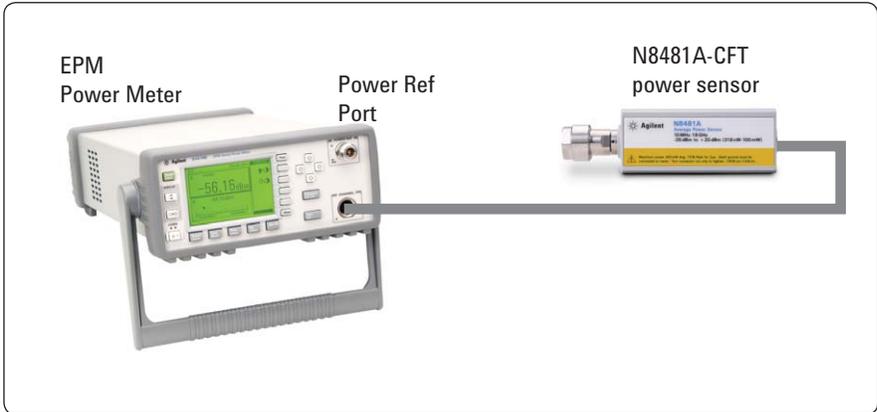


Figure 15. N8481A-CFT power sensor and EPM power meter connection configuration

RMT TLK			Sensor Tbls
Tbl Name	State	Pts	Edit Table
0 DEFAULT	off	2	
1 HP8481A	off	19	A Table
2 HP8482A	off	12	Off On
3 HP8483A	off	10	
4 HP8481D	off	21	B Table
5 HP8485A	off	18	Off On
6 R8486A	off	17	
7 Q8486A	off	19	
8 R8486D	off	0	Done
9 HP8487A	off	54	
			1 of 1

Figure 16: Sensor table selected screen

RMT TLK		Edit Cal
Name: N8481		Change
Ref CF: 100.0%		
Freq	Cal Fac	Insert
100.000MHz	99.9%	
2.000GHz	98.2%	
3.000GHz	97.9%	
4.000GHz	97.6%	Delete
5.000GHz	97.3%	
6.000GHz	97.0%	
7.000GHz	96.6%	Done
8.000GHz	96.1%	
		1 of 1

Figure 17. "Edit Cal" screen

Conclusion

Migrating the 8480 legacy power sensor to the N8480 Series power sensor is a simple process that has been outlined in this application note. Customers will benefit the new features added to the N8480 Series power sensor:

- Built-in EEPROM to store cal factor, N848x (standard option)
Easy calibration without having to manually key-in the calibration factors leads to increased productivity and reduced operator errors.
- Wide dynamic range up to 55 dBm, N848x (standard option)
Extend the measurement dynamic measurement range to 55 dBm for single thermocouples power sensor.
- Better measurement accuracy and repeatability
Measurement accuracy and repeatability are improved, especially at low power ranges, compared with the legacy 8480 power sensor.
- Compatible with Agilent EPM, EPM-P and P-Series power meters
SCPIs backward compatibility of the N8480 Series power sensor minimize the programming re-coding needed. The backward compatibility with Agilent EPM, EPM-P and P-Series power meter protects your investment in Agilent products.

Reference

- Agilent 4 Steps for Making Better Power Measurements – Application Note 64-4D Literature No: 5968-4519E
- Agilent EPM Series 437B and 438A Compatibility – Application Note Literature No: 5968-4519E

Related Literature

- Internal Zeroing and Calibration for RF Power Sensors – Application Note Literature No: 5989-6509EN
- N8480 Agilent N8480 Series Thermocouple Power Sensor Datasheet Literature No: 5989-9333EN

Related Links

- <http://www.agilent.com/find/thermocouplesensor>
- <http://www.agilent.com/find/powermeters>
- http://www.agilent.com/find/pm_firmware



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