

N8480S Series Balance Thermocouple Power Sensors

DC to 18/50 GHz

N8480SBSA Balance Thermocouple Power Sensor Software Application

Introduction

The Keysight N8480S Series Balance Thermocouple Power Sensors are intended to be used as measurement standards for RF power. They are suitable for use in a microcalorimeter-based primary measurement standard and as a secondary or reference measurement standard. The new balance thermocouple power sensors offer a broad frequency range DC up to 18/50 GHz, high maximum input power of +20dBm, fast measurement speed/settling time as well as ease of maintenance.



The new series of balance thermocouple power sensors introduce a new measurement method that is suitable for the highest echelon of RF power traceability. These power sensors are intended to be used within microcalorimeters as a primary measurement standard and individually as a transfer or reference measurement standard for RF power in coaxial sensors available in Type-N and 2.4mm connector styles. It is based on the calorimetric style power measurement where the measurement approach is direct DC to RF power substitution. The unknown RF power is substituted by traceable DC power.

The Keysight N8480S Series balance thermocouple power sensors are designed with dual thermopile power detectors constructed on a single chip. There are two sets of thermopiles in the detectors that are constructed to be closely matched for power cancelation and thermal stability. One set of thermopiles detects the heat generated by RF power in the load resistor and the second set of thermopiles detects heat generated by a DC-fed load resistor. When the DC power applied to the DC load resistor is equivalent to the RF power, the two thermopiles will be equivalent, and the sensor is at balance.

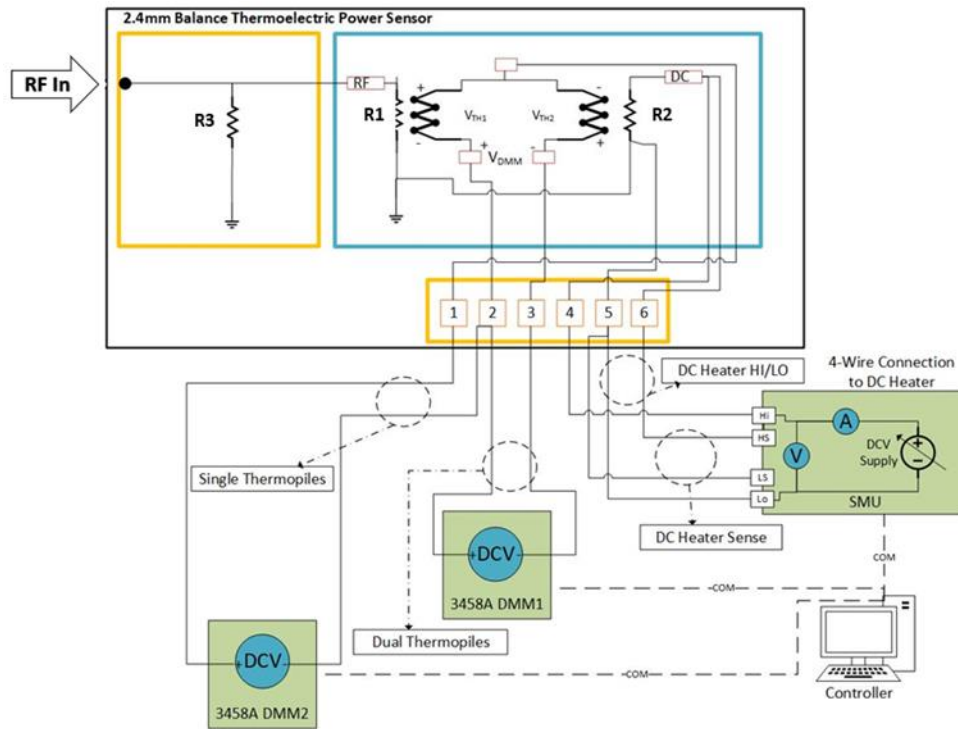


Figure 1. Measurement setup of the new balance thermocouple power sensors

The new series balance thermoelectric power standard mainly consists of a thermocouple IC that is built on a thin-film circuit in a cartridge assembly that serves as a transition from coaxial to co-planar waveguide (CPW) in a bulkhead assembly. In the direct RF-DC substitution RF power measurement setup, load resistor R1 acts as a heater to the thermopile that dissipates RF power, PRF, that generates voltage difference across the RF side of thermopiles VTH1. DC power or Low Frequency (LF) Power, PDC, can be dissipated in R2 to generate VTH2 across the DC side thermopiles. The RF and DC thermopiles are arranged in reverse polarity so that the voltages across the thermopiles are canceled out at the equilibrium or when at balance.

Performance Specifications

Specification definitions

There are two types of product specifications:

- **Warranted specifications** are specifications which are covered by the product warranty and apply over a range of 0 to 55 °C unless otherwise noted. Warranted specifications include measurement uncertainty calculated with a 95% confidence.
- **Characteristic specifications** are specifications that are not warranted. They describe product performance that is useful in the application of the product. These characteristics are shown in *italics*.

Characteristic information is representative of the product. In many cases, it may also be supplemental to a warranted specification. Characteristic specifications are not verified on all units. There are several types of characteristic specifications. They can be divided into two groups:

One group of characteristic types describes 'attributes' common to all products of a given model or option. Examples of characteristics that describe 'attributes' are the product weight and '50-ohm input Type-N connector'. In these examples, product weight is an 'approximate' value, and a 50-ohm input is 'nominal'. These two terms are most widely used when describing a product's 'attribute'.

The second group describes 'statistically' the aggregate performance of the population of products. These characteristics describe the expected behavior of the population of products. They do not guarantee the performance of any individual product. No measurement uncertainty value is accounted for in the specification. These specifications are referred to as 'typical'.

The power sensors will meet its specifications when:

- Stored for a minimum of two hours at a stable temperature within the operating temperature range, and turned on for at least 30 minutes
- The power sensors are within its recommended calibration period
- Used in accordance with the information provided in the User's Guide

Specifications

N8480S Series Balance Thermocouple Power Sensors

	N8481S	N8487S
Frequency range	DC to 18 GHz	DC to 50 GHz
Power range	-35 to +20 dBm	-35 to +20 dBm
Connector type	N-Type (male)	2.4 mm (male)
Maximum input RF power	CW Signal: 316 mW / +25 dBm (50 Ohm impedance) Modulated Pulse Signal: 15 W / +42 dBm (2 us)	
Maximum input DC power	316 mW / +25dBm	

Typical Specifications				
		N8481S	N8487S	Units
Typical load resistance	Measured at Coaxial connector	50.9	50.7	Ohm
DC heater resistance	Measured at DC connector	50.1	96.6	
Thermocouple resistance	Single (RF side)	8.6	8.3	k Ohm
	Dual (RF and DC)	17.1	16.5	
Sensitivity¹	RF connector at 25 °C	1070	1080	mV/W
	DC connector at 25 °C	1050	2070	

1. Thermocouple sensitivity is a ratio of thermocouple output voltage to the input power (V/W) for single thermopiles.

SWR

Frequency	N8481S	
	SWR	SWR (0 to +55 °C)
DC to 1 GHz	1.05	1.06
> 1 to 4 GHz	1.07	1.08
> 4 to 12.4 GHz	1.12	1.13
> 12.4 to 18 GHz	1.15	1.16

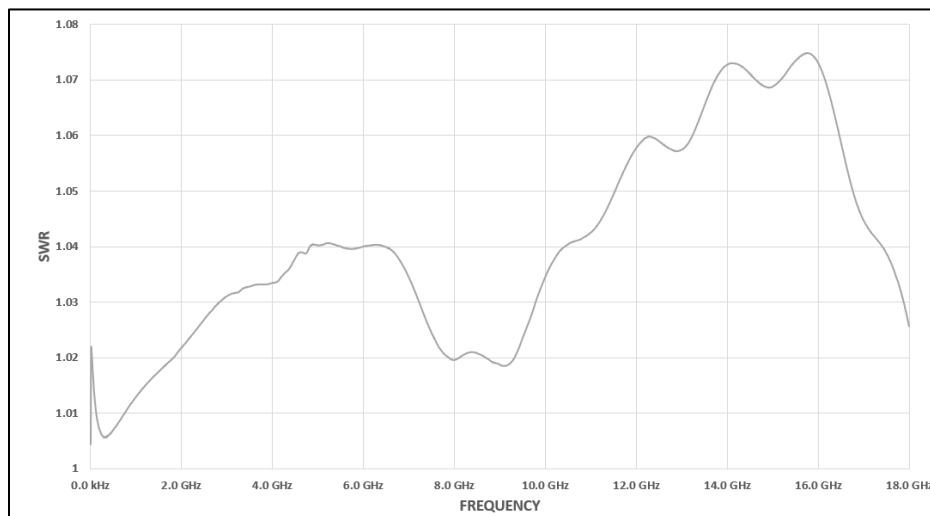


Figure 2. Typical SWR for N8481S power sensor

N8487S

Frequency	SWR	SWR (0 to +55 °C)
DC to 2 GHz	1.05	1.06
> 2 to 12.4 GHz	1.09	1.10
> 12.4 to 18 GHz	1.11	1.12
> 18 to 26.5 GHz	1.17	1.18
> 26.5 to 40 GHz	1.28	1.29
> 40 to 50 GHz	1.34	1.39

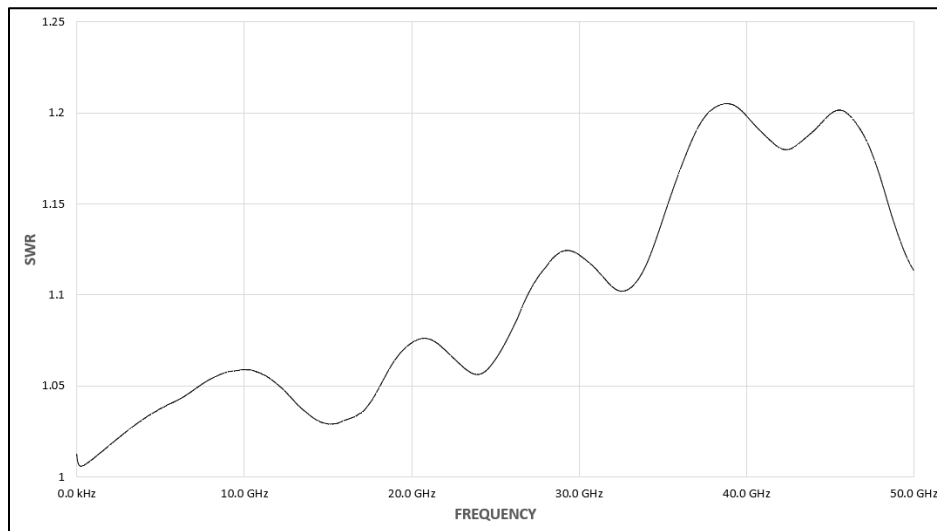


Figure 3. Typical SWR for N8487S power sensor

Calibration Factor Uncertainty

Calibration Factor uncertainty is published as relative uncertainty whereas the product Calibration Factor is published as absolute.

Frequency	N8481S		N8487S	
	CF uncertainty % (25 ± 3 °C)	CF uncertainty % (0 to +55 °C)	CF uncertainty % (25 ± 3 °C)	CF uncertainty % (0 to +55 °C)
0.0 kHz	±0.85	±1.15	±1.10	±1.25
100.0 kHz	±0.85	±1.15	±1.10	±1.25
200.0 kHz	±0.85	±1.15	±1.10	±1.25
300.0 kHz	±0.85	±1.15	±1.10	±1.25
500.0 kHz	±0.85	±1.15	±1.10	±1.25
1.0 MHz	±0.85	±1.15	±1.10	±1.25
2.0 MHz	±0.85	±1.15	±1.10	±1.25
3.0 MHz	±0.85	±1.15	±1.10	±1.25
5.0 MHz	±0.85	±1.15	±1.10	±1.25
10.0 MHz	±0.85	±1.15	±1.10	±1.25
20.0 MHz	±0.85	±1.15	±1.10	±1.25
30.0 MHz	±0.85	±1.15	±1.10	±1.25
40.0 MHz	±0.85	±1.15	±1.00	±1.25
50.0 MHz	±0.85	±1.15	±1.00	±1.25
60.0 MHz	±0.85	±1.15	±1.00	±1.25
70.0 MHz	±0.85	±1.15	±1.00	±1.25
80.0 MHz	±0.90	±1.20	±1.00	±1.25
90.0 MHz	±0.90	±1.20	±1.00	±1.25
100.0 MHz	±0.90	±1.20	±1.00	±1.25
200.0 MHz	±1.00	±1.20	±1.00	±1.25
300.0 MHz	±1.00	±1.20	±1.00	±1.25
400.0 MHz	±1.00	±1.20	±1.10	±1.25
500.0 MHz	±1.00	±1.20	±1.10	±1.25
600.0 MHz	±1.00	±1.20	±1.10	±1.25
700.0 MHz	±1.00	±1.20	±1.10	±1.25
800.0 MHz	±1.00	±1.20	±1.10	±1.60
900.0 MHz	±1.00	±1.20	±1.10	±1.60
1.0 GHz	±1.00	±1.20	±1.10	±1.60
2.0 GHz	±0.95	±1.20	±1.20	±1.60
3.0 GHz	±0.95	±1.20	±1.20	±1.60
4.0 GHz	±0.95	±1.20	±1.20	±1.60
5.0 GHz	±0.95	±1.20	±1.20	±1.60
6.0 GHz	±0.95	±1.30	±1.20	±1.60
7.0 GHz	±1.10	±1.30	±1.50	±1.70
8.0 GHz	±1.10	±1.40	±1.50	±2.00
9.0 GHz	±1.10	±1.40	±1.50	±2.00
10.0 GHz	±1.10	±1.40	±1.50	±2.00
11.0 GHz	±1.10	±1.40	±1.50	±2.00
12.0 GHz	±1.10	±1.40	±1.50	±2.00
13.0 GHz	±1.10	±1.75	±1.60	±2.00

N8481S

N8487S

Frequency	CF uncertainty % (25 ± 3 °C)	CF uncertainty % (0 to +55 °C)	CF uncertainty % (25 ± 3°C)	CF uncertainty % (0 to +55 °C)
14.0 GHz	±1.10	±1.75	±1.60	±2.00
15.0 GHz	±1.10	±1.75	±1.60	±2.40
16.0 GHz	±1.20	±1.75	±1.80	±2.40
17.0 GHz	±1.25	±1.80	±1.80	±2.40
18.0 GHz	±1.25	±1.90	±1.80	±2.40
19.0 GHz	-	-	±2.10	±2.40
20.0 GHz	-	-	±2.10	±2.40
21.0 GHz	-	-	±2.10	±2.40
22.0 GHz	-	-	±2.10	±2.40
23.0 GHz	-	-	±2.10	±2.40
24.0 GHz	-	-	±2.10	±2.40
25.0 GHz	-	-	±2.10	±2.50
26.0 GHz	-	-	±2.60	±2.65
27.0 GHz	-	-	±2.60	±2.80
28.0 GHz	-	-	±2.60	±2.90
29.0 GHz	-	-	±2.60	±3.00
30.0 GHz	-	-	±2.60	±3.00
31.0 GHz	-	-	±2.60	±3.00
32.0 GHz	-	-	±2.60	±3.00
33.0 GHz	-	-	±2.80	±3.00
34.0 GHz	-	-	±2.80	±3.60
35.0 GHz	-	-	±2.90	±3.60
36.0 GHz	-	-	±2.90	±3.60
37.0 GHz	-	-	±2.90	±3.60
38.0 GHz	-	-	±2.90	±3.60
39.0 GHz	-	-	±3.90	±3.60
40.0 GHz	-	-	±3.90	±4.20
41.0 GHz	-	-	±3.90	±4.20
42.0 GHz	-	-	±3.60	±4.20
43.0 GHz	-	-	±3.60	±4.20
44.0 GHz	-	-	±3.80	±4.20
45.0 GHz	-	-	±3.80	±4.20
46.0 GHz	-	-	±3.80	±4.20
47.0 GHz	-	-	±3.80	±4.20
48.0 GHz	-	-	±3.80	±4.20
49.0 GHz	-	-	±3.80	±4.20
50.0 GHz	-	-	±3.80	±4.20

General Specifications

Model	Dimensions (Length x Width x Height)	Weight	Connector
N8481S	87 mm x 26 mm x 28 mm	120 grams (0.265 lb.)	N-type (male)
N8487S	72 mm x 26 mm x 28 mm	100 grams (0.220 lb.)	2.4mm (male)

Operating environment	
Temperature	0 to +55 °C
Humidity	Maximum 95% RH up to 40 °C (non-condensing)
Altitude	Up to 4,572 meters (15,000 feet)

Storage conditions	
Temperature	-40 to +70 °C
Humidity	Up to 90% RH at 65 °C (non-condensing)
Altitude	Up to 4,572 meters (15,000 feet)

Others	
Calibration Interval	1 year

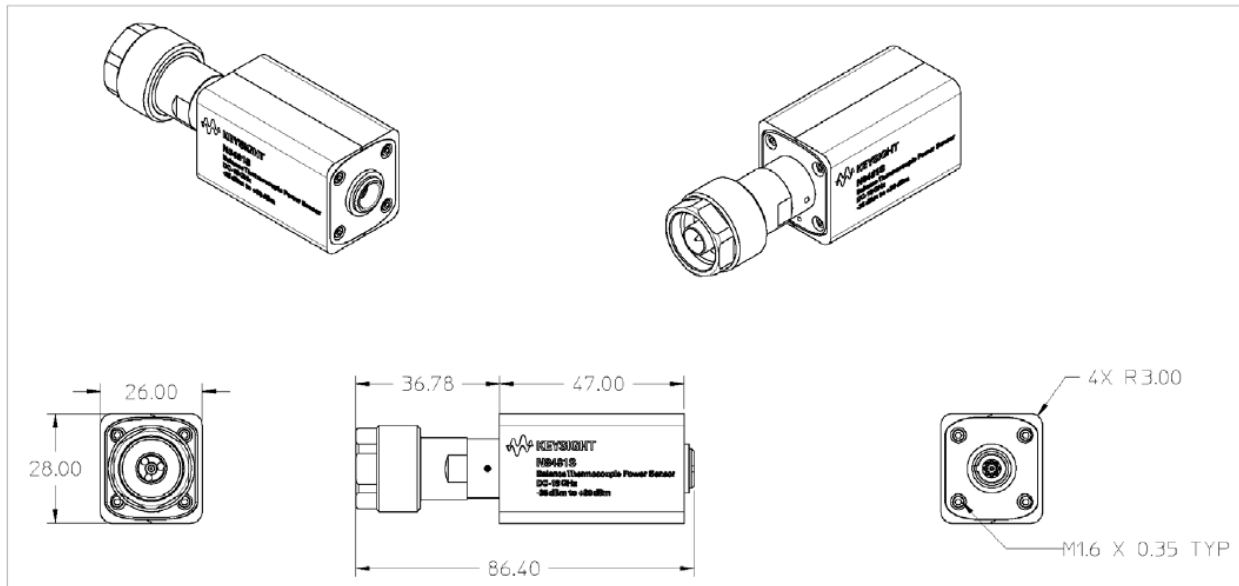


Figure 4. N8481S power sensor dimension

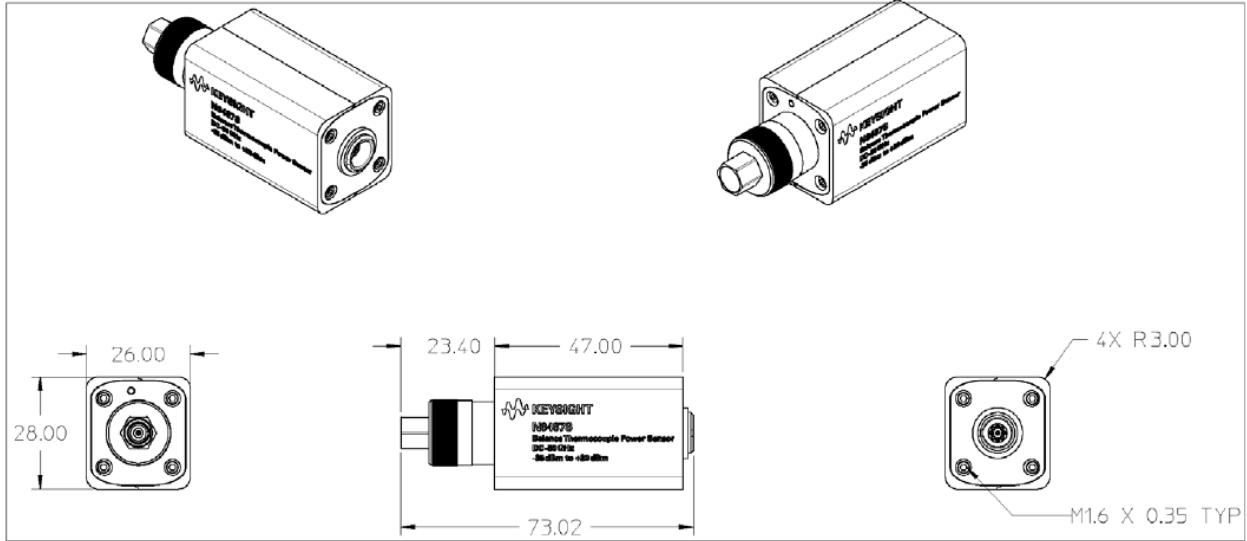
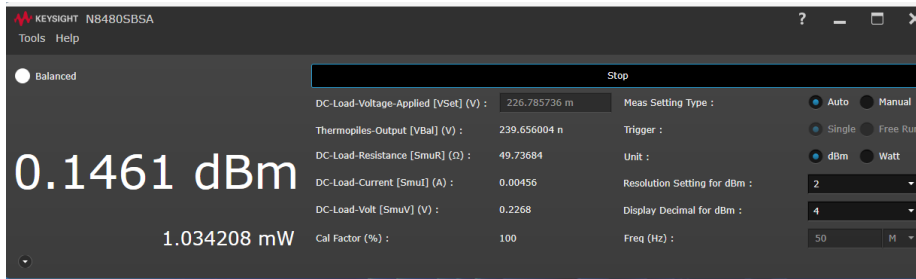


Figure 5. N8487S power sensor dimension

Mechanical Characteristic

Mechanical characteristics such as center conductor protrusion and pin depth are not performance specifications. They are, however, important supplemental characteristics related to electrical performance. At no time should the pin depth of the connector be protruding.



System and Installation Requirements

PC operating system

Windows 10	Windows 10 64-bit (Home, Professional, Enterprise or Educational versions)
Computer hardware	Processor: 1 GHz or faster (2 GHz or greater recommended)
	RAM: minimum 8 GB
Interfaces	USB, GPIB, LAN, RS-232
Display resolution	1920 x 1200 with scaling set to 100% (recommended)

Ordering Information

Model	Description	Frequency Range	Power Range
N8481S-100	DC to 18 GHz Balance Thermocouple Power Sensor	DC to 18 GHz	-35 to +20 dBm
N8487S-100	DC to 50 GHz Balance Thermocouple Power Sensor	DC to 50 GHz	-35 to +20 dBm

Standard shipped items

Power sensor cable 5 ft (1.5m), default cable length

Option	Description
Cables (selectable during sensor purchase)	
U2071A	Power sensor cable 5 ft (1.5m)
U2071B	Power sensor cable 10 ft (3m)

Software	Description
N8480SBSA	N8480SBSA Balance Thermocouple Power Sensor Software Application license

Calibration	Description
N848xS-1A7	Calibration + Uncertainties + Guardbanding
N848xS-A6J	ANSI Z540-1-1994 Calibration

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