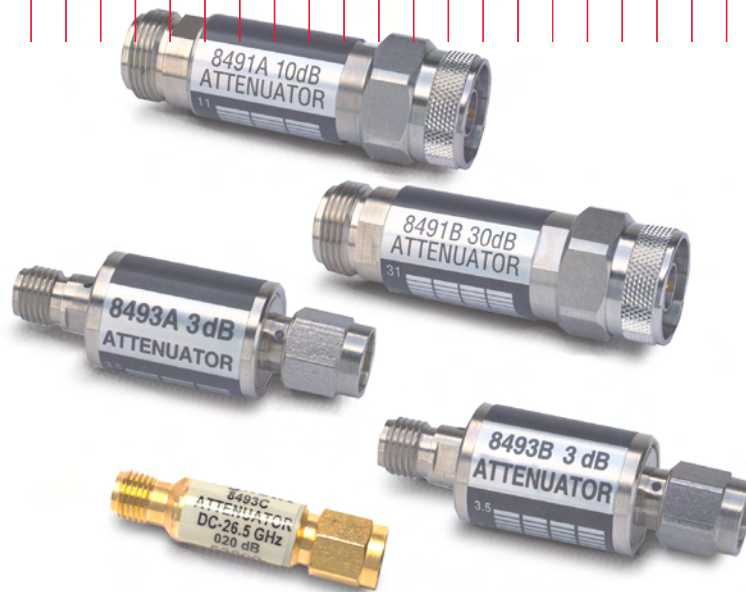


# Keysight 8491A/B, 8493A/B/C, 11581A, 11582A and 11583C Coaxial Attenuators

Technical Overview



- High accuracy
- Low SWR
- Broadband frequency coverage
- Small size

## Description

The Keysight Technologies's coaxial fixed attenuators provide precision attenuation, flat frequency response, and low SWR over broad frequency ranges (dc to 26.5 GHz) at low prices. Attenuators are available in eight attenuation values: 3, 6, 10, 20, 30, 40, 50, and 60 dB; with performances specified from dc to 26.5 GHz; and with choice of four connector types: Type-N, SMA<sup>1</sup>, and APC 3.5<sup>2</sup>.

These attenuators are all tested on a state-of-the-art precision analyzer to assure specifications over the full frequency ranges. Although the 8493C is not specified above 26.5 GHz, it performs resonance free to 34 GHz with only a small loss in performance.

## Precision construction

The attenuators employ a film on an attenuator card as the resistive element. The uniformity and repeatability of the film deposition process result in high accuracy and low SWR over very wide frequency ranges.

The 8493C features thin-film-tantalumnitride on a sapphire substrate for exceptional precision performance to 26.5 GHz. In fact, it performs resonance-free to 34 GHz, the top frequency limit of the APC-3.5 connector.

The choice of connector type and material also ensure accurate and repeatable attenuation. The 8491A/B attenuators are furnished with Type-N connectors whose dimensions are compatible with either MIL-C-71 or MIL-C-39012 connector specifications.

These connectors are stainless steel for long wear and high repeatability. The 8493A/B attenuators are furnished with SMA type connectors. The connectors are heat treated beryllium copper for greater strength and wear.

The 8493C is furnished with the APC 3.5 connector which is compatible with standard SMA connectors but is more rugged and offers improved repeatability over hundreds of connections.

## Quality assurance in testing

The flat frequency response and low SWR of the attenuators are assured over the entire frequency range by full frequency band testing on a state-of-the-art precision analyzer. Full frequency band testing ensures that narrow resonances in the frequency band are not over-looked. Actual attenuation values taken at dc, 4, 8, 12, 18, and 26.5GHz are stamped on the attenuator body for permanent and easy reference.

Testing each attenuator with a state-of-the-art precision analyzer brings standards lab accuracy to production testing because the system can determine its own measurement uncertainties and compensate for them in the testing process. System calibration is derived from precise physical standards which are directly traceable to the National Bureau of Standards. In addition, automatic testing eliminates the possibility of human error in setting instrument controls, taking data, or making calculations.

1. As per USASI Committee C83.2 compatible with OSM, ARM, WPM, BRM, NPM, etc.

2. Mate with MIL-C-71 or MIL-C-39012 connectors.

## Applications

Ruggedness, reliability and small size make these attenuators useful both on the bench and in systems applications. With their high accuracy and low SWR they are ideally suited for extending the range of sensitive power meters for higher power measurements and for “padding” poorly matched devices to improve system SWR.

These same characteristics lend themselves to applications as calibration standards in attenuation and RF substitution measurements. With their broad dc to 26.5 GHz frequency range and reasonable cost, general applications, such as the reduction of power level to sensitive components and instrumentation systems, are attractive and appropriate uses for these attenuators.

## Accuracy

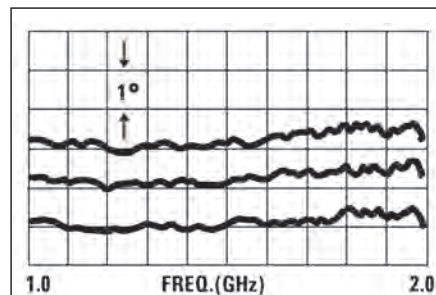
The accuracy of an attenuator directly affects the accuracy of the measurement where the attenuator is used. In fact, attenuators are used extensively as the standard against which other instruments or devices are calibrated.

Agilent’s fixed attenuators achieve flat frequency response (typically a few hundredths of a dB) and overall accuracy (typically  $\pm 2\%$  of value in dB at 26.5 GHz) through the use of thin-film attenuator cards. These cards are composed of high stability tantalum nitride resistive film deposited on a sapphire or alumina substrate.

## Quality assurance in specifications

The following examples demonstrate the reliability and comprehensiveness of specifications. Although the absolute accuracy for a 3 dB attenuator is specified as  $\pm 0.3$  dB, test data statistics indicate an expected value of 3 dB  $\pm 0.20$  dB from dc to 18 GHz. Similarly a 30 dB attenuator is specified as  $\pm 1.0$  dB, but typically is no worse than 30 dB  $\pm 0.75$  dB from dc to 18 GHz. The other attenuation values are also specified as conservatively.

In addition, Keysight precision attenuators meet more comprehensive performance standards. Linear phase response is an example. Not only is wide bandwidth significant, but also linear phase response is an important parameter for applications where pulse distortion must be kept to a minimum. The excellent linearity of the Agilent attenuators is typified in the accompanying illustration of an actual network analyzer measurement.



Center trace is phase response of 8491A -6 dB attenuator from 1.0 to 2.0 GHz taken with the 8410 network analyzer. Top and bottom traces are  $\pm 1^\circ$  calibration. Linear phase component has been compensated for with a line stretcher. Response, therefore, shows nonlinear phase deviation of  $< \pm 1/2^\circ$  over 1 to 2 GHz band.

## Economy

Automated procedures have resulted in economies of scale in production and testing. The automated resistive film deposition process permits high-volume manufacture with excellent yield. Furthermore, characteristics are consistently uniform; hand “touch-up” is not required to meet specifications. Automatic testing means exceptionally thorough, high-accuracy measurements can be performed in appreciably shorter time than could be done manually.

The overall result is outstanding attenuator performance at attractive prices.

## Calibration Data

### Optional calibration data

Use of calibration data has always been an effective means of reducing measurement uncertainty at RF and microwave frequencies. This data is available for Keysight’s fixed attenuators as Option 849xx- UK6. Data which is generated by an automatic network analyzer provides a tabulated list of attenuation and SWR’s at 26 to 67 frequencies (see table 2). Measurements to 60 dB are directly traceable to NBS standards and feature very low measurement uncertainties. Option 849xx-UK6 data is available when the attenuators are first purchased and recalibrations are available through Keysight Customer Service Centers around the world.

Table 1. SWR data uncertainties

| Connector type | Frequency range (GHz) | Measured SWR |              |
|----------------|-----------------------|--------------|--------------|
|                |                       | 1.0 to 1.35  | 1.35 to 1.86 |
| Male Type -N   | dc to 12.4            | ±0.025       | ±0.041       |
|                | 12.4 to 18.0          | ±0.031       | ±0.050       |
| Female Type -N | dc to 8.0             | ±0.025       | ±0.046       |
|                | 8.0 to 12.4           | ±0.031       | ±0.063       |
|                | 12.4 to 18.0          | ±0.042       | ±0.071       |
| Male SMA       | dc to 8.0             | ±0.031       | ±0.054       |
|                | 8.0 to 12.4           | ±0.045       | ±0.084       |
|                | 12.4 to 18.0          | ±0.077       | ±0.137       |
| Female SMA     | dc to 8.0             | ±0.054       | ±0.088       |
|                | 8.0 to 12.4           | ±0.077       | ±0.132       |
|                | 12.4 to 18.0          | ±0.122       | ±0.206       |
| Male APC-3.5   | dc to 8.0             | ±0.025       | ±0.041       |
|                | 8.0 to 12.4           | ±0.031       | ±0.050       |
|                | 12.4 to 18.0          | ±0.045       | ±0.067       |
| Female APC-3.5 | dc to 10              | ±0.020       | ±0.031       |
|                | 10 to 18              | ±0.025       | ±0.037       |
|                | 18 to 26.5            | ±0.035       | ±0.050       |

Table 2. Coaxial attenuator calibration frequencies\* (MHz)

|      |      |       |       |               |  |
|------|------|-------|-------|---------------|--|
| 100  | 4500 | 9000  | 13000 | 16750         |  |
| 500  | 5000 | 9500  | 13500 | 17000         |  |
| 1000 | 5500 | 10000 | 14000 | 17250         |  |
| 1500 | 6000 | 10500 | 14500 | 17500         |  |
| 2000 | 6500 | 11000 | 15000 | 17750         |  |
| 2500 | 7000 | 11500 | 15500 | 18000         |  |
| 3000 | 7500 | 12000 | 16000 | (each 250 MHz |  |
| 3500 | 8000 | 12400 | 16250 | to 26.5 GHz   | *dc to 12.4 GHz models include 26        |
| 4000 | 8500 | 12500 | 16500 |               | frequencies, dc to 18 GHz models include |
|      |      |       |       |               | 42 frequencies, dc to 26.5 GHz models    |
|      |      |       |       |               | include 67 frequencies (2 to 26.5 GHz).  |

Table 3. Attenuation data uncertainties

| Attenuation (dB) | 8491, 8492 and 8493 Attenuation data uncertainty (dB) |            |               |                  |                  |
|------------------|---|------------|---------------|------------------|------------------|
|                  | 0.1 to 2.0 GHz  | 2 to 6 GHz | 6 to 12.4 GHz | 12.4 to 18.0 GHz | 18.0 to 26.5 GHz |
| 3                | ±0.07   | ±0.06      | ±0.07         | ±0.11            | ±.15             |
| 6                | ±0.07   | ±0.07      | ±0.07         | ±0.11            | ±.15             |
| 10               | ±0.08   | ±0.07      | ±0.08         | ±0.12            | ±.15             |
| 20               | ±0.09   | ±0.08      | ±0.09         | ±0.13            | ±.15             |
| 30               | ±0.12   | ±0.11      | ±0.12         | ±0.15            | ±0.18            |
| 40               | ±0.15   | ±0.14      | ±0.15         | ±0.21            | ±0.25            |
| 50               | ±0.23   | ±0.23      | ±0.23         | ±0.34            | n/a              |
| 60               | ±0.50*  | ±0.48*     | ±0.90*        | ±0.90*           | n/a              |

\*The uncertainties noted represent 99.7% probability values.

Specifications:

Specifications describe the instruments warranted performance. Supplemental characteristics (shown in italics) are intended to provide information useful in applying the instrument by giving typical, but non-warranted, performance parameters.

Frequency Range:

8491A and 8493A, dc to 12.4 GHz  
 8491B, 8493B, dc to 18 GHz  
 8493C, dc to 26.5 GHz

Attenuation Accuracy:

|       | <b>8491A/93A</b>      | <b>8491B/93B</b>                   | <b>8493C</b>                     |
|-------|-----------------------|------------------------------------|----------------------------------|
|       | <i>dc to 12.4 GHz</i> | <i>dc to 12.4 / 12.4 to 18 GHz</i> | <i>dc to 18 / 18 to 26.5 GHz</i> |
| 3 db  | ±0.3 dB               | ±0.3 dB                            | ±0.5 dB / ±1.0 dB                |
| 6 dB  | ±0.3 dB               | ±0.3 dB / ±0.4 dB                  | ±0.6 dB                          |
| 10 dB | ±0.5 dB               | ±0.6 dB                            | ±0.3 dB / ±0.5 dB                |
| 20 dB | ±0.5 dB               | ±0.6 dB / ±1.0 dB                  | ±0.5 dB / ±0.6 dB                |
| 30 dB | ±1.0 dB               | ±1.0 dB                            | ±0.7 dB / ±1.0 dB                |
|       | 8491A only            | 8491B/92A only                     |                                  |
| 40 dB | ±1.5 dB               | ±1.5 dB                            | ±1.0 dB / ±1.3 dB                |
| 50 dB | ±1.5 dB               | ±1.5 dB                            | N/A                              |
| 60 dB | ±2.0 dB               | ±2.0 dB                            | N/A                              |

SWR:

|       | <b>8491B/8493B</b>    |                        |                         | <b>8493C</b>   |                  |                     |
|-------|-----------------------|------------------------|-------------------------|----------------|------------------|---------------------|
|       | <b>8491A/8493A</b>    |                        |                         |                |                  |                     |
|       | <i>dc to 8 (GHz)</i>  | <i>8 to 12.4 (GHz)</i> | <i>12.4 to 18 (GHz)</i> | <i>dc to 8</i> | <i>8 to 12.4</i> | <i>12.4 to 26.5</i> |
| 3 db  | 1.25                  | 1.35                   | 1.5                     | 1.10           | 1.15             | 1.25                |
| 6 dB  | 1.2                   | 1.3                    | 1.5                     | 1.10           | 1.15             | 1.27                |
| 10 dB | 1.2                   | 1.3                    | 1.5                     | 1.10           | 1.15             | 1.25                |
| 20 dB | 1.2                   | 1.3                    | 1.5                     | 1.10           | 1.15             | 1.25                |
| 30 dB | 1.2                   | 1.3                    | 1.5                     | 1.10           | 1.15             | 1.25                |
|       | 8491A/B on 8491B only |                        |                         |                |                  |                     |
| 40 dB | 1.2                   | 1.3                    | 1.5                     | 1.10           | 1.15             | 1.25                |
| 50 dB | 1.2                   | 1.3                    | 1.5                     | N/A            | N/A              | N/A                 |
| 60 dB | 1.2                   | 1.3                    | 1.5                     | N/A            | N/A              | N/A                 |

## Environmental:

Temperature: Operating 0°C to +55°C  
Storage -55°C to +85°C  
Humidity: Operating <95% relative at 40°C  
Storage <95% relative at 40°C  
Altitude: Operating <4,600 meters (15,000 feet)  
Storage <15,300 meters (50,000 feet)  
EMC Radiated interference is within the requirements of MIL STD 461 method RE02, VDE 0871 EN55011 and FCC part 18

|                   |             | 8491 A           | 8493A          | 8491B            | 8493B          | 8493C                    |                      |
|-------------------|-------------|------------------|----------------|------------------|----------------|--------------------------|----------------------|
| Connectors (50 Ω) |             | Type-N2          | SMA1           | Type-N2          | SMA1           | APC-3.5                  |                      |
| Dimensions        | Millimeters | 67 X 21          | 40 X 13        | 67 X 21          | 40 X 13        | 3,6,10,20 dB<br>33.8 X 8 | 30,40 dB<br>36.8 X 8 |
|                   | Inches      | 2 7/16 X 13/16 D | 1 9/16 X 1/2 D | 2 7/16 X 13/16 D | 1 9/16 X 1/2 D | 1 5/16 X 5/16 D          | 1 7/16 X 5/16 D      |
| Weight            | Net         | 110 g (4 oz)     | 30 g (1 oz)    | 110 g (4 oz)     | 30 g (1 oz)    | 8.5 g (0.3 oz)           | 9.4 g (0.33 oz)      |
|                   | Shipping    | 220 g (8 oz)     | 220 g (8 oz)   | 220 g (8 oz)     | 220 g (8 oz)   | 45 kg (1 lb)             |                      |

## Supplemental Characteristics:

Temperature stability:  
0.0001 dB/dB/°C (all except 8493C)  
0.0002 dB/dB/°C (8493C)  
Maximum input power: 2 W avg., 100 W peak<sup>3</sup>  
Power sensitivity: 0.001 dB/dB/W (all except 8943) 0.001 dB/W (8493C)

## Attenuator Sets

11581A/11582A/11583C

A calibrated set of four fixed coaxial attenuators (3, 6, 10, and 20 dB) is available. Each set includes a calibration report certified traceable to the National Bureau of Standards. The reports included with the 11581A, 11582A, and 11583C indicate the accuracy of measurement and list the attenuation and reflection coefficient at each port of the attenuator.

The set of four attenuators is furnished in a handsome walnut accessory case. In addition to protecting the units when not in use, the case is also a convenient storage place for the attenuators and the calibration reports. Calibration data as described on page 4 is included with rack attenuator set.

## Ordering Information

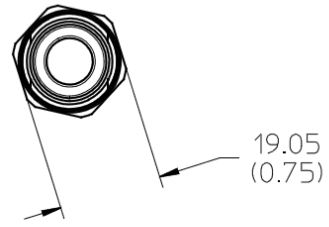
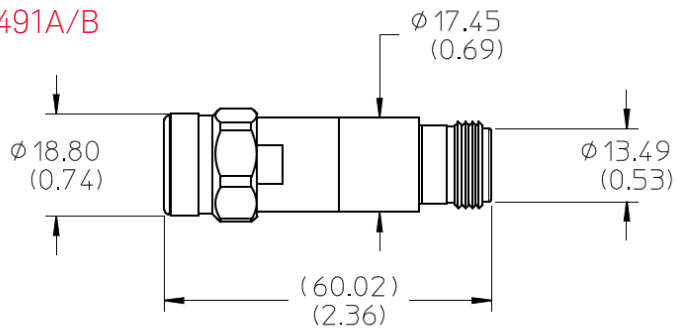
To order, basic model number and option (specifies attenuation value) must be specified. Option 849xx-UK6 calibration data can also be ordered with the basic model number and attenuation value option. Please note, Option 849xx-UK6 is not available with 1158½A nor 11583C.

| Attenuation options |       |                 |                 |                 |
|---------------------|-------|-----------------|-----------------|-----------------|
|                     | Atten | 8491A/B options | 8491A/B options | 8491A/B options |
| Option 003          | 3 dB  | 8491x-003       | 8493x-003       | 8493C-003       |
| Option 006          | 6 dB  | 8491x-006       | 8493x-006       | 8493C-006       |
| Option 010          | 10 dB | 8491x-010       | 8493x-010       | 8493C-010       |
| Option 020          | 20 dB | 8491x-020       | 8493x-020       | 8493C-020       |
| Option 030          | 30 dB | 8491x-030       | 8493x-030       | 8493C-030       |
| Option 040          | 40 dB | 8491x-040       |                 | 8493C-040       |
| Option 050          | 50 dB | 8491x-050       |                 |                 |
| Option 060          | 60 dB | 8491x-060       |                 |                 |

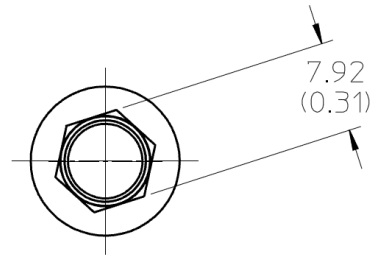
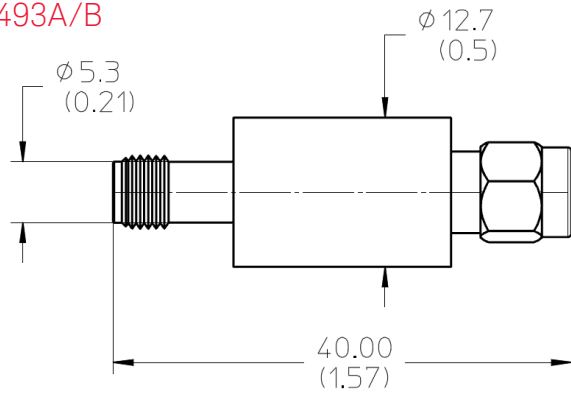
Note: x = A or B

1. As per USASI Committee C83.2 compatible with OSM, ARM, WPM, BRM, NPM, etc.
2. Mate with MIL-C-71 or MIL-C-39012 connectors
3. At 20°C derated to 1.3 W avg. at 55°C.

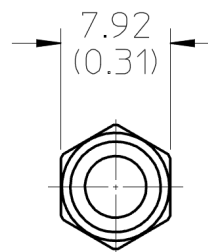
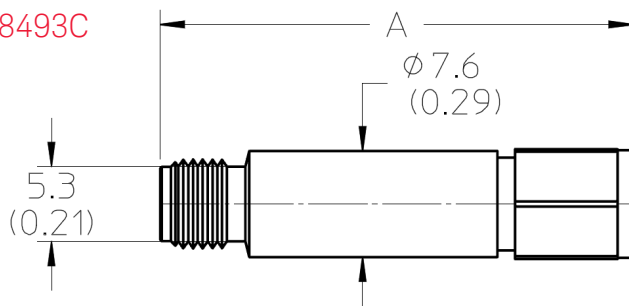
8491A/B



8493A/B



8493C



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