ATTENUATORS

narda
microwave-east

an L3 communications company

Find the following attenuator groups at the end of this introduction:
Attenuators Fixed
Attenuators Step
Attenuators Variable

Parameter	Specification
Operating Temperature	-54 to +105°C
Storage Temperature	-55 to +125°C
Humidity	Per MIL-STD-202F, Method 103B, Condition B (96 hours at 95% R.H.)
Shock	Per MIL-STD-202F, Method 213B, Condition J (30G, 11 msec)
Altitude	Per MIL-STD-202F, Method 105G, Condition B (50,000 ft)
Vibration	Per MIL-STD-202F, Method 204D, Condition B (.06" double amplitude or 15G, whichever is less)
Thermal Shock	Per MIL-STD-202F, Method 107D, Condition A (5 cycles)

***Applicable to: Stripline Directional Couplers, Attenuators, Power Dividers**

Note: This is an exclusive listing. Where otherwise noted in the catalog, the above environmental performance may not apply. Not applicable for those products designed for commercial applications. Many of our catalog off-the-shelf (COTS) products have the ability to withstand considerably more stringent environments. If you have special environmental requirements, please contact the Sales Department at Narda.

Coaxial attenuators are used in every type of equipment involving the transmission, control, or measurement of microwave energy. To meet the needs of system designers, original equipment manufacturers, and laboratory users, our variety of devices offers an almost limitless combination of physical and electrical performance characteristics.

Narda offers attenuators for frequency bands from DC to 40 GHz, with a choice of attenuation values from 0 to 69 dB, average power ratings from 0.5 to 150 watts, and flatness specifications to ±0.2 dB. Variable attenuators encompassing many combinations of bandwidth, attenuation range, accuracy, power handling capability, and physical dimensions are also available.

Attenuators for Systems Applications

The most common applications for coaxial attenuators in microwave systems are in transmitters and receivers. In these, and similar applications, the characteristics that are usually of principal concern are:

a. amount or range of attenuation
b. flatness with frequency
c. average and peak power-handling capability
d. temperature characteristics, and
e. size and weight

Fixed Attenuators

Fixed attenuators are used in systems for two broad classes of service. One is in a calibration channel to establish a known signal level; flatness over the required frequency range is important here. In the second type of service, the device is used for impedance matching or as a buffer to prevent interaction between two devices. For this type of service, low VSWR is the important factor.

The variety of fixed attenuators for these applications is shown in this catalog. Although these attenuators cover most requirements for frequency range and flatness, the practical rule, where cost is a factor, is to specify only the range and tolerances that are required. Since these attenuators are manufactured by thin-film deposition, savings resulting from unique specifications will not be significant for single units or small quantities, but should be considered for large quantities.

Variable Attenuators

Variable attenuators for systems applications (and some OEM and laboratory applications) fall into four general categories: lossy wall attenuators, low loss cutoff attenuators, step (or turret) attenuators and

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voltage-controllable attenuators. The general operating principles and characteristics of each of these types are described below.

Lossy Wall Attenuators

Figure 1 shows a section of the lossy wall attenuator. The construction is basically stripline with a section of the outer conducting wall replaced by a section of lossy material with high dielectric and magnetic dissipation factors. Microwave power flowing through this dielectric material is attenuated as a result of loss, allowing low variation of attenuation with frequency. Attenuation is varied by mechanically varying the location of the lossy material with respect to the fixed center conductor. In practice, the outer walls are displaced in such a way that the physical length of the transmission line is constant. Various coaxial line geometries are employed to provide gradual variation of attenuation with mechanical movement and to achieve the required flatness with frequency.

Limitations of available lossy materials restrict the usefulness of these attenuators to above 2 GHz, although they can be used with degraded performance to 1 GHz. Because the dissipation of energy in these lossy materials tends to be frequency sensitive, selection of a lossy wall attenuator usually involves a tradeoff of attenuation, bandwidth and flatness versus frequency range and size. For example, assuming one available model provides 90 dB of attenuation at 16 GHz, with a design center from 15.7 to 16.3 GHz. The same unit can be used in X-band, but with attenuation reduced to about 50 dB. These units have moderate power-handling capability since attenuation is achieved through dissipation of power as heat in the walls. Narda lossy-wall attenuators can easily handle an average power of as much as 10 watts and peak power to 5 kW.

In general, lossy-wall attenuators have low insertion loss (usually less than 1 dB), low VSWR, and relatively flat attenuation characteristics over the design band. Attenuation is directly proportional to the length of the center conductor between the lossy material. Consequently, the designer concerned about space limitations can safely estimate that a 40 dB unit will be approximately twice the size of 20 dB unit.

Lossy wall attenuators are ideally suited for use as buffers in front of a local oscillator or power source, where the requirement is for a minimum of 10 dB of attenuation with capability for precise tuning. Common applications are in surveillance, and in radar reflection augmenters, where each of many local oscillators must be trimmed a few dB.

For these and similar applications, the lossy wall attenuator offers cost and size advantages over other types of variable attenuators.

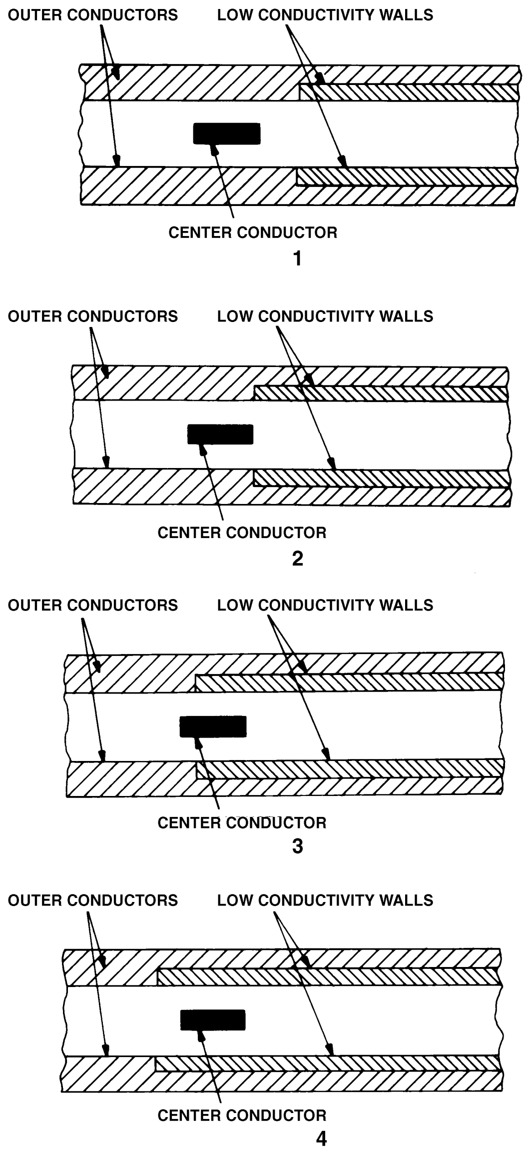

Figure 1. Transverse section of lossy wall attenuator at various stages of attenuation: (1) minimum attenuation; (2) small attenuation; (3) high attenuation; (4) maximum attenuation.

Step (Or Turret) Attenuators

For applications demanding both broadband flatness and adjustability over ranges from 0 to 69 dB, Narda has a number of stepping-type attenuators that utilize the flatness characteristics of thin-film fixed attenuators. The turret attenuator, Narda Model 745/ 4745 Series, is a typical example, using fixed attenuators mechanically arranged to permit successive stepping in discrete increments. Typically, these units are offered with switching in 10 or 1 dB increments and may be cascaded to provide the desired attenuation range with resettability of better than 0.05 dB. Because of the inherent broadband characteristics of the thin-film, step attenuators afford excellent flatness from DC to above 18 GHz.

Narda turret attenuators have a specified repeatability of 0.05 dB; in practice this figure is usually better than 0.02 dB. Life of the Narda turret attenuators can be expected to be in excess of one million steps.

Comparison Of Variable Attenuators

The suitability of several types of variable attenuators can be evaluated from Figure 2 . The performance characteristics given are for Narda attenuators.

Original Equipment Applications

For the original equipment designer, the ideal attenuator is likely to be a panel-mountable unit continuously variable from 0 to 69 dB, with maximum flatness over a wide frequency range. Since the present state-of-the-art is unable to provide devices with this combination of characteristics, equipment designers must choose a practical alternative. A step attenuator with a continuously variable attenuator to serve as a fill-in vernier between incremental steps over restricted frequency ranges will usually suffice.

Laboratory Applications

The selection of attenuators for use in the development laboratory is generally the easiest of the specification tasks. Because bench testing requirements may vary considerably from project to project, the objective in specifying attenuators for these applications will normally be to provide for the broadest possible range of project requirements. Characteristics involved in this concept of versatility will be:

a. broad bandwidth
b. large attenuation range
c. high accuracy
d. longevity of connectors

Variable Attenuators for the Laboratory

The wide range of testing requirements usually dictates a selection of variable attenuators that remain flat over at least an octave, and frequently over several octaves. For this reason, the step attenuator represents a more practical choice than the low-loss, continuously-variable attenuator. Typical of step attenuators designed for bench test applications are the Narda Models 700/4700 Series. This series provides 0 to 60 dB attenuation in 10 dB steps; 0 to 9 and 0 to 69 dB attenuation in 1 dB steps. The series also includes effective zero-loss positions to permit full signal input to the load, providing convenient reference levels without removing the units from the setup. These units are usable as freestanding models, or in panel-mount configurations with behind-the-panel connectors.(Panel- mounting hardware is supplied as an accessory where applicable.)

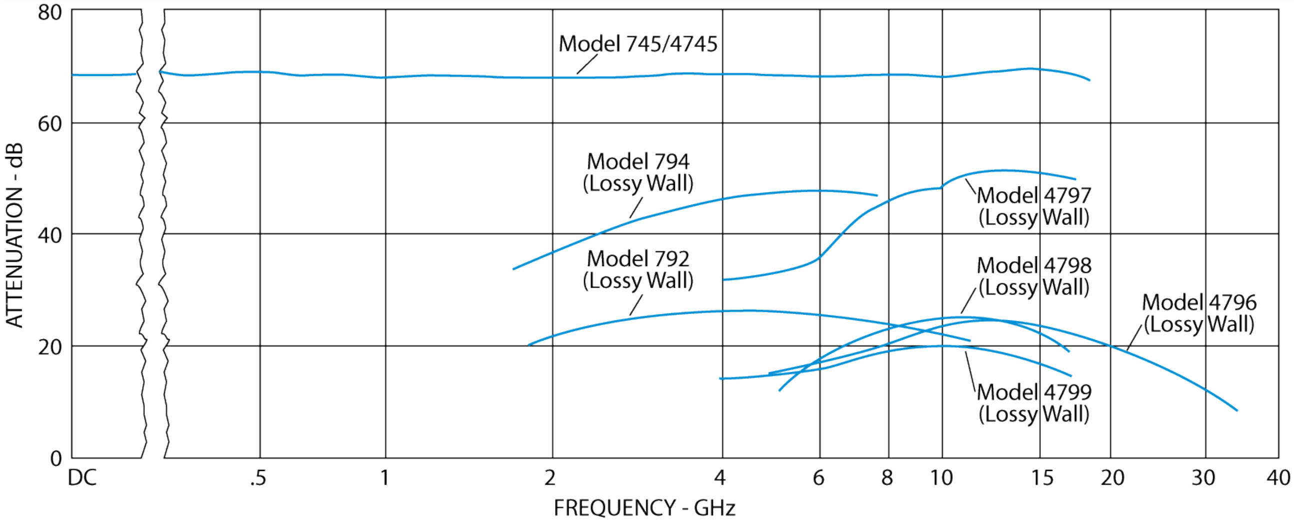

Figure 2. Attenuation vs. Frequency of Variable Attenuators

Fixed Attenuators for Laboratory Setups

Fixed attenuators for laboratory service are available with various levels of calibration accuracy.

The Attenuator Series, Model 777C for example, is available in eight standard attenuation values from 3 to 60 dB and is calibrated at DC, 4, 8, 10 and 12.4 GHz. Model 779 is available in 15 (standard) attenuation values from 1 to 60 dB and is calibrated at DC, 4, 8, 12.4 and 18 GHz. Attenuation certification for this series of attenuators is recorded at each frequency to the nearest .05 dB.

The accuracy characteristics of these units are best suited to the standards laboratory, where they can be used under controlled conditions, rather than on the bench where other factors may cancel out the advantages to be gained from precise calibration and accuracy. For bench service, a more practical choice is the Narda 757C which covers the DC to 12.4 GHz band, has an average power capacity of 2 watts and is accurate to 0.3 dB; or the Narda 779 for DC to 18 GHz.

The design and performance of Narda attenuators are suited to many high-reliability applications. In such cases, economical selection of attenuators can be achieved with Narda's assistance when the customer defines the requirement and application. Application-specific qualification inspections can be performed. This applies to both fixed and variable attenuators.

Connector Longevity

This is especially important in laboratory use, as worn or damaged connectors cause errors in attenuation and high VSWR. While many manufacturers supply stainless steel connectors on their better quality attenuators to provide longer life, all Narda standard line attenuators have stainless steel connectors.

User-Manufacturer Consultation

Manufacturers of microwave components are often in a position to make recommendations regarding the selection of attenuators for particular applications. Narda offers consultation on any systems, original equipment or laboratory requirements and is prepared to assist in evaluating or specifying either catalog-listed or custom-designed attenuators for all application requirements.

Theory and Practice of Attenuation Measurements

In the use and design of microwave components it is often necessary to consider their insertion loss or attenuation characteristics. Insertion loss is the ratio of the power delivered to a matched load by a matched generator before and after the insertion of a component into the line. Insertion loss is actually a combination of two losses: mismatch loss (reflective) and attenuation (dissipative).

Mismatch loss is the ratio of power that would be absorbed by the device if it were perfectly matched to the actual power absorbed by the device with its mismatch in impedance. Attenuation is the ratio of power into a component to the power out under matched conditions, and represents the actual power dissipated within the component. Where a component is perfectly matched to the line and load, the mismatch loss is zero and insertion loss is the same as attenuation.

The expression is the same for all three losses but the variables have different significance for each case. For insertion loss, P1 is the power at the load before insertion of the component in the line and P2 is the power after insertion. In the case of attenuation, P1 is the power into the component and P2 is the power out.

In practice, the insertion loss is usually of primary interest. It is good practice to provide a well matched generator and load. An attenuator with low VSWR is commonly used to obtain good source and load match.

Methods Of Measurement

Modern technique for measuring loss and return loss (or VSWR) on microwave attenuators utilizes two classes of network analyzers, scalar and vector. The choice depends upon the application and the form of data desired. Both are in use at Narda. Features of each are summarized:

Scalar Network Analyzer

- **Provides magnitude, in dB, for example**
- **Interval microprocessor quickly plots graphs, automatically compensating for instrumentation frequency response.**
- **Frequency range presently to 60 GHz**

Vector Network Analyzer (Also called Automatic Network Analyzer, or ANA)

- **Provides magnitude and angle of all S-parameters**
- **Plots graphs or prints tabular data under software control**
- **High-resolution error-corrected measurements, against attenuation standards traceable to NIST.**
- **Frequency range to 60 GHz.**

Data on individual attenuators can be supplied (for a nominal fee) upon request. For fixed attenuators, this is normally in tabular form as attenuation and two-ended VSWR vs. frequency, taken with an ANA. Resolution is 0.01 dB, and in hundredths for VSWR.

In addition to microwave measurement, insertion loss can be measured at DC. The attenuator under test is placed between precise resistive terminations, and the dB value calculated from the drop-in load voltage read on a high-resolution digital voltmeter. Accuracy of DC attenuation is as follows:

Attenuation	Maximum Error
to 10 dB	0.009 dB
to 40 dB	0.015 dB
50 dB	0.035 dB
60 dB	0.090 dB

The DC attenuator measurement can be used as a check on ANA data; correlation with results at 45 MHz is typically within 0.03 dB.

Software utilized for tabulated data on the ANA extends dynamic range at high frequency through multiple measurement averaging. As a result, typical day to day repeatability of SMA-type attenuators up to 18 GHz is:

Attenuation Value	Repeatability
to 50 dB	0.05 dB
60 dB	0.33 dB

NOTE: For all applicable Narda Attenuators, Narda can supply **standard** test data for a nominal fee.

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