APPLICATION NOTES

Internet Copy Rev 0

FIXED ATTENUATORS

Overview

Attenuators are passive elements that are used to reduce a microwave or RF signal strength without introducing much noise or distortion. They are realized mainly using non-inductive resistors. There are main categories of attenuator designs, tee, pi, bridged tee, reflection and balanced attenuators; with the former three being used the most (see figures below). This document explains some of the popular implementations and application considerations.

Figure 1: Broadwave Fixed Attenuators

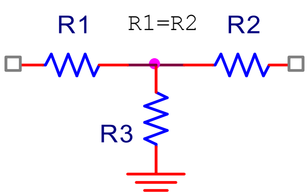

Figure 2: Tee Attenuator

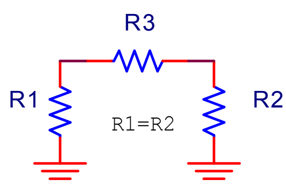

Figure 3: Pi Attenuator

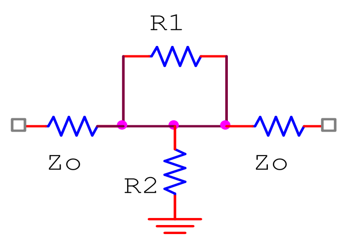

Figure 4: Bridged –Tee Attenuator

Application Considerations

Things to keep in mind when specifying attenuators are frequency range of operation, power handling capacity, and impedance matching.

Frequency of operation: Although most of these designs work without much problem at DC and low frequencies, things are not that simple at higher frequencies. For the resistive components inside the attenuators to retain their linearity, they have to be considered as a lumped element. One of the properties of lumped elements is that no geometry of the structure can exceed 1/10th of the wavelength of the maximum frequency of operation. That being said, as the frequency of operation goes higher, its wavelength gets smaller resulting in smaller and smaller component structure. So for a given package, (assuming only non-inductive resistors are being used) a tee might be more feasible to manufacture compared to a pi, or vice versa.

Power handling: Another key parameter to consider is the amount of power that will be dissipated by the attenuator. Going back to the concept of lumped elements and physical geometries, we know that generally as frequency of operation goes up, the smaller the components get, but we also know to handle power well, you need a larger area to dissipate power lost as heat. So you need to be aware of the power handling capacity as well as the physical geometry of the device, to choose the best device for your specific application

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Application Considerations (continued):

Impedance matching: One of the important things to consider when adding attenuators to your application is to make sure that the attenuator matches to the network its being added to. The same tee design will have different resistor values for one a 50 Ω network than one that is being matched to a 75 Ω network. Making sure that the attenuator is matched with the network its being placed into, reduces the errors caused by mismatch loss.

Terms and Definitions

Frequency Range (Hz): This is application specific.

VSWR: Voltage Standing Wave Ratio (VSWR) is the ratio of maximum and minimum voltage at a given point along a transmission line. VSWR is a good measure of power transfer efficiency. A low VSWR (i.e. closer to unity with little or no reflections) means more power is delivered from the source to the load, while a high VSWR (i.e. much greater than 1 with lots of reflection within unit) has less power delivered to the load.

Insertion Loss (dB): Insertion loss is defined as the decrease in the transmitted signal power due to the insertion of a device in a transmission line.

Octave Bands (Hz): A doubling in frequency is represented by an octave. 1-2 Ghz is an octave, while 8-12 Ghz is half an octave.

Input Power (W): Both average and peak power need to be taken into account when choosing an attenuator.

Flatness (dB) *: Flatness of an attenuator is the difference between the maximum and the minimum attenuation.

Normal Attenuation (dB) *: Normal attenuation is the average of maximum and minimum attenuation.

Attenuation Accuracy (dB) *: Attenuation accuracy is the difference between specified and normal attenuation. It is usually given as a range of plus or minus a value.

* These terms are described in detail on the next page.

Calculations

Below are some calculation for the resistor values of a tee and pi attenuator. The network is assumed to have the same characteristic impedance of the network

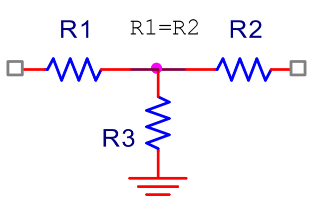

Figure 5: Tee attenuator resistor value calculations

Zo = Characteristic Impedance of the network

A = Attenuation desired in decibels (dB)

R1=R2= Z0 ((10$^{(A / 20)}$-1) / (10$^{(A / 20)}$+1)) W

R3=2Zo((10$^{(A / 20)}$ / (10$^{(A / 20)}$ + 1)) W

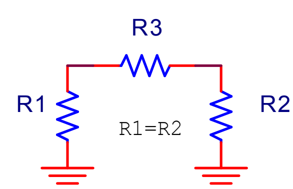

Figure 6: Pi attenuator resistor value calculations

Zo = Characteristic Impedance of the network

A = Attenuation desired in decibels (dB)

R1=R2= Zo((10$^{(A / 20)}$ + 1) / (10$^{(A / 20)}$ - 1) W

R3= 2Zo(10 $^{(A / 10)}$ - 1) / (10 $^{(A / 20)}$) W

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Terms Explained

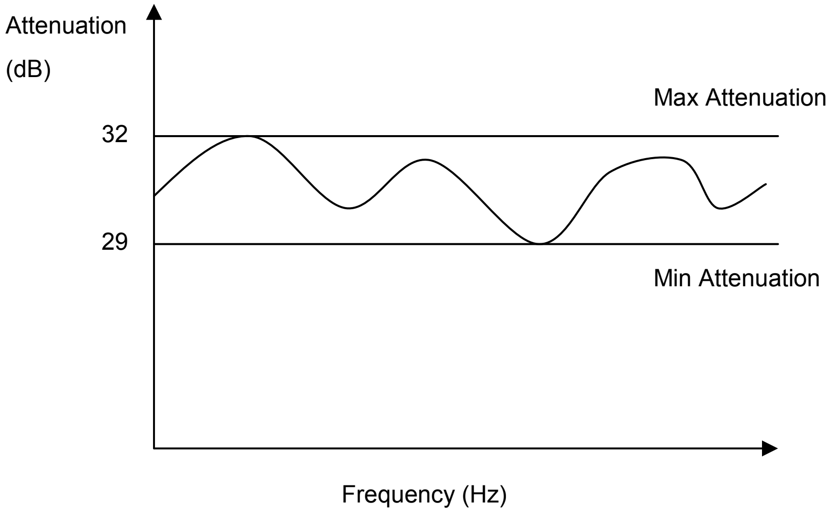

Figure 7: Attenuation Vs Frequency for a 30dB attenuator

Some Calculations Explained (Refer to figure above):

Flatness = Maximum attenuation - Minimum attenuation = 32 - 29 = 3 dB

Normal Attenuation = (Maximum attenuation + Minimum attenuation) / 2 = (32+29)/2 = 30.5 dB

Attenuation Accuracy = Specified attenuation - Normal attenuation = 30-30.5 = -0.5 dB

Applications

- Test equipment.
- Telecommunication systems.
- Base stations.
- Radar applications.
- High precision applications (military, defense, etc).

FIXED ATTENUATORS

Broadwave Technologies Fixed Attenuators

Given below are some of the general specifications of Broadwaves's fixed attenuators. For more detailed information, specifications or to view entire catalog, please visit our website. If you are unable to find a product that meets your specifications, feel free to contact us.

Fixed Attenuators (Part no: 35X-XXX-XXX)	
Connector Types	**2.9mm,F,SMA, N, TNC, BNC**
Impedance	**50 W & 75 W**
Input Power (Average)	**Up to 1000W**
Attenuation *	**1 to 40 dB**
Frequency Range	**DC to 40 Ghz**
Operating Temperature * *	**- 65 °C to +125 °C**

Note: * Higher attenuation values are available.

** Weather resistant models are available on request.

For more details, visit our website or contact us.

Broadwave Technologies, Inc.

500 Polk Street, Suite 25

Greenwood, IN 46143

Phone; 317-888-8316

Email: sales@broadwavetechnologies.com

Website: http://www.broadwavetechnologies.com