

ATTENUATOR

Q: What is a Attenuator :

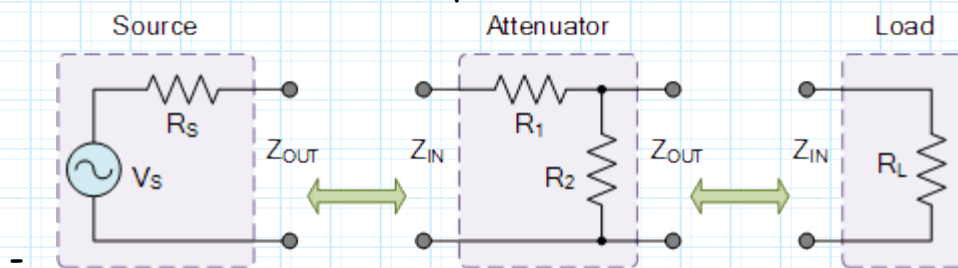
Ans : Attenuators are devices used to adjust

- signal levels,
- to control impedance mismatch and to
- isolate circuit stages.

An **Attenuator** is a special type of electrical or electronic bidirectional circuit. An attenuator is a two port resistive network designed to weaken or "attenuate" (hence their name) the power being supplied by a source to a level that is suitable for the connected load.

The *attenuator* reduces the amount of power being delivered to the connected load by either

- a single fixed amount,
- a variable amount
- in a series of known switchable steps.



Q: What are the basic types of Attenuators

The main formats for RF resistor attenuator pads are summarized below:

Pi attenuator pads: As the name indicates the pi attenuator pad has a topology similar in shape to the letter Pi.

It has a single series resistor in the signal line and at the input and output a resistor is taken to ground.

T attenuator pads: In terms of topology the T attenuator pad (or Tee attenuator pad) is the opposite of the Pi section resistive attenuator. It has a single resistor to ground and has series resistors on the input and output, forming a T section.

Bridged T attenuator pads: The bridged T attenuator can be thought of as a combination of the Pi and T attenuator pad topologies.

Q: Why we need to use , RF Attenuators

RF resistor attenuators or resistor attenuator pads are used in many RF circuit design applications. T

1. he RF attenuator pads reduce the level of the signal and this can be used to ensure that the correct radio signal level enters another circuit block such as mixer or amplifier so that it is not overloaded.
2. The RF resistive attenuator pads also enable the correct impedance levels to be seen in by

RF Resistor Attenuator Pad Design

RF attenuators can be categorised in a number of ways according to their capabilities and the technologies they use.

Fixed RF attenuator: As the name implies fixed attenuators have a specific value and this cannot be changed. They may come in a variety of formats from

small in-line items in a similar format to connector adaptors to those in small boxes with connectors on the ends to those incorporated within equipments.

Switched RF attenuators: Switched RF attenuators are widely used in test systems where levels may need to be changed. They are often seen as small boxes with a number of switches, typically with switches for 1, 2, 4, 8, etc dB changes. Switched attenuators may also be found in items of test equipment to change the levels, for example of a signal generator output.

Variable RF attenuators: variable RF attenuators are normally used in applications where it is necessary to continuously vary the level of a signal. Typically they provide a continuous level change by varying an analogue voltage on the input control line. They are normally used where accuracy is not a prime requirement.

How Attenuators Are Made

There are a number of ways in which attenuators can be designed and made. The two main types are given below.

Resistor RF attenuators: Resistor attenuators are used to provide fixed levels of attenuation. Levels may be varied by switching in different attenuator sections to provide the levels that are required.

PIN diode RF attenuators: PIN diode attenuators are normally used in attenuator designs where a continuously variable level is required.

FET RF attenuators: FET attenuators are normally used in attenuator designs where a continuously variable level is required. Like a PIN diode attenuator, FET attenuators use an analogue control voltage to control the level of attenuation.

ATTENUATOR WORK SHEET

Understanding db

Q: What does db means

Degrees of Attenuation

Decibel Attenuation

$$dB_v = 20 \log_{10} \frac{V_{out}}{V_{in}} \text{ (dB)}$$

Note that the decibel (dB) is a logarithmic ratio and therefore has no units. So a value of -140dB represents an attenuation of 1:10,000,000 units or a ratio of 10 million to 1!

Example No1

A passive attenuator circuit has an insertion loss of -32dB and an output voltage of 50mV. What will be the value of the input voltage.

$$dB_v = 20 \log_{10} \frac{V_{out}}{V_{in}} \text{ (dB)}$$

$$-32 = 20 \log_{10} \frac{V_{out}}{V_{in}}$$

$$\therefore -1.6 = \log_{10} \frac{V_{out}}{V_{in}}$$

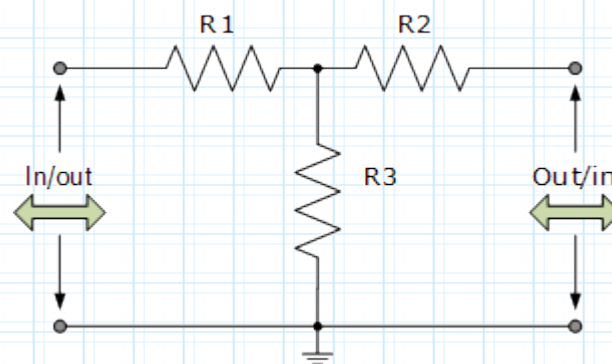
$$\frac{V_{out}}{V_{in}} = 0.025$$

$$\therefore V_{in} = \frac{V_{out}}{0.025} = \frac{50\text{mV}}{0.025} = 2 \text{ volts}$$

Then if the output voltage produced with 32 decibels of attenuation, an input voltage of 2.0 volts is required.

The T-pad Attenuator

A **T-pad attenuator** is an unbalanced attenuator network consisting of three non-inductive resistive elements connected together to form a "T" configuration, (hence its name). Basic T-pad Attenuator Circuit



Formulas for Tee Attenuator Balanced

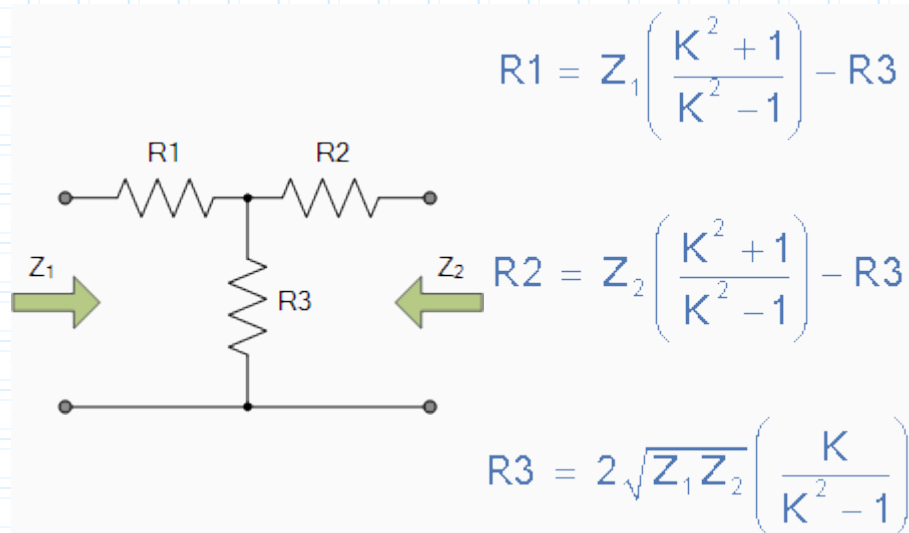
$$R1 = R2 = Z \left(\frac{K-1}{K+1} \right)$$

$$R3 = 2Z \left(\frac{K}{K^2-1} \right)$$

When impedance of both connecting network is same

The "K" value for a voltage attenuation of 6dB will be $10^{(6/20)} = 1.9953$, and an attenuation of 18dB will be $10^{(18/20)} = 7.9433$,

Taper Pad Attenuator Equations for Unequal Impedances

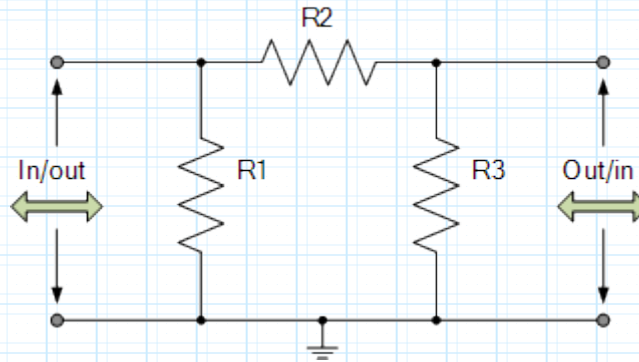


where: K is the impedance factor from the table above, and **Z1 is the larger of the source/load impedances** and **Z2 is the smaller of the source/load impedances**.

The Pi-pad Attenuator

As well as the T-pad attenuator we looked at previously, there is another type of voltage controlled attenuator design commonly used in radio frequency and microwave transmission lines called the **Pi-pad Attenuator**, or **π -pad attenuator**.

The *Pi-pad attenuator* is so called because its design resembles that of the Greek letter pi (π) meaning that it has one series resistor and two parallel shunt resistors to ground at the input and the output.



Generally, resistors R1 and R3 are of the same value but when designed to operate between circuits of unequal impedance these two resistor can be of different values.

Pi-pad Attenuator with Equal Impedances

We have said previously, that the Pi-pad attenuator is a symmetrical attenuator design consisting solely of passive resistor elements making it linear in its design allowing for its input and output terminals to be transposed with each other. This makes the Pi-pad attenuator ideal for insertion between two equal impedances ($Z_S = Z_L$) to reduce signal levels.

In this case the three resistive elements are chosen to ensure that the input impedance and output impedance match the load impedance which forms part of the attenuator network. As the Pi-pad's input and output impedances are designed to perfectly match the load, this value is called the "**characteristic impedance**" of the symmetrical Pi-pad network.

Then the equations given to calculate the resistor values of a Pi-pad attenuator circuit used for impedance matching at any desired attenuation are given as:

Pi-pad Attenuator Equations

$$Z_S = Z_L = Z$$

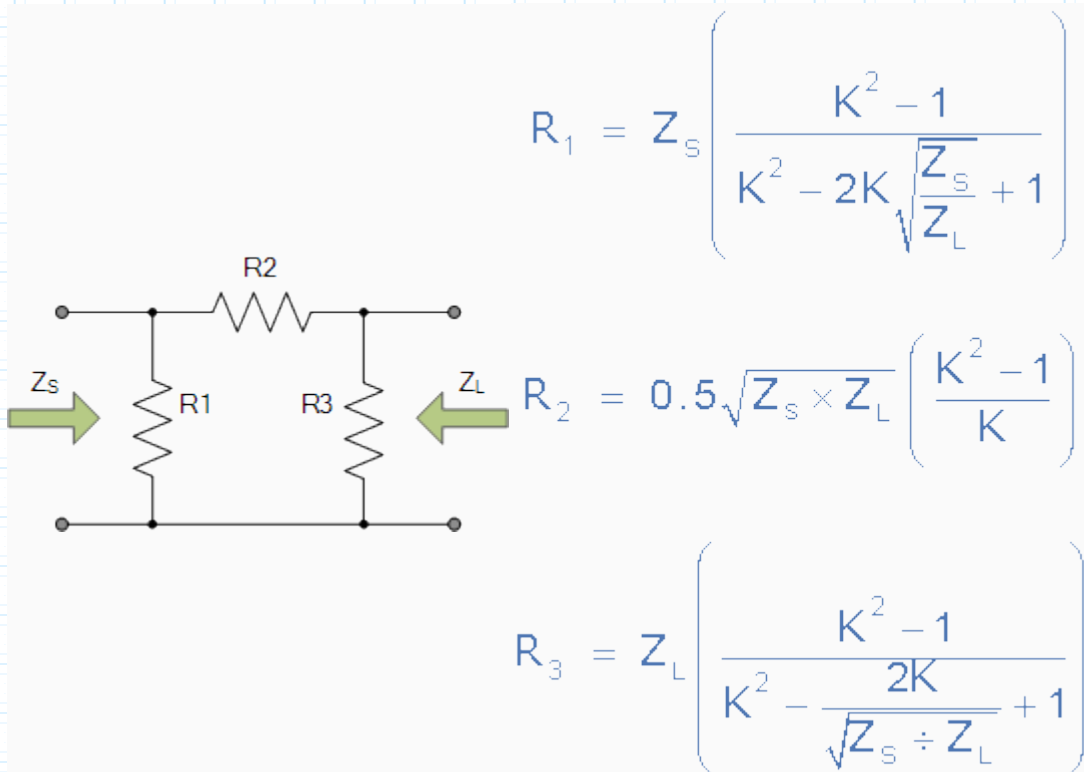
$$R1 = R3 = Z \left(\frac{K+1}{K-1} \right)$$

$$R2 = Z \left(\frac{K^2 - 1}{2K} \right)$$

where: K is the impedance factor and Z is the source/load impedance.

Pi-pad Attenuator with Unequal Impedances

As well as using the Pi-pad attenuator to reduce signal levels in a circuit with equal impedances, ($Z_S = Z_L$) we can also use it for impedance matching of unequal source and load impedances ($Z_S \neq Z_L$). Pi-pad Attenuator Equations for Unequal Impedances



where: K is the impedance factor, Z_S is the larger of the source impedance and Z_L is the smaller of the load impedances.

1. A T-pad attenuator connected to a load impedance of 50Ω is required to reduce the level of an audio signal by 18dB from an impedance source of 75Ω . Calculate the values of the three resistors required.
2. A Pi-pad attenuator circuit is required to reduce the level of an audio signal by 10dB while matching the impedance of a 75Ω network. Calculate the values of the three resistors required.
3. A T-pad attenuator is required to reduce the level of an audio signal by 18dB while matching the impedance of the 600Ω network. Calculate the values of the three resistors required.
4. **Pi-pad attenuator** circuit is required to attenuate a signal between a radio transmitter with an output impedance of 75Ω and a power signal strength meter of impedance 50Ω by 6dB. Calculate the values of the required resistors.