

# Use and Design of T-Attenuation Pads

## Application Note AN-00150



### Introduction

In discrete RF design, the output power of a transmitter is usually set specifically for the power output needed to meet operational and certification requirements. However, today many engineers prefer to use predesigned RF modules such as those manufactured by Linx in their designs. These RF modules provide a “black box” approach to RF design. An engineer simply places a module in circuit, provides an antenna, power, and a serial data stream and instantly has a wireless data link.

In order to provide the most useful design possible, manufacturers of RF modules will often build their transmitters with an output power level in excess of what is allowed by governing agencies for the customer’s final product. This is to ensure that engineers utilizing inefficient (high loss) antenna types, such as a loop-trace, will still have an adequate level of radiated power to achieve the maximum range. In cases where an engineer has chosen a particularly efficient antenna or where output power must be reduced to meet specific exemption provisions, an external method of power reduction is employed.

While there are numerous methods of achieving a reduction in output, one of the simplest is a T-pad attenuator formed from three resistors. The purpose of the attenuator is to give a fixed attenuation while maintaining a 50-ohm match between the antenna and the transmitter. Figure 1 shows a T-PAD style attenuator.

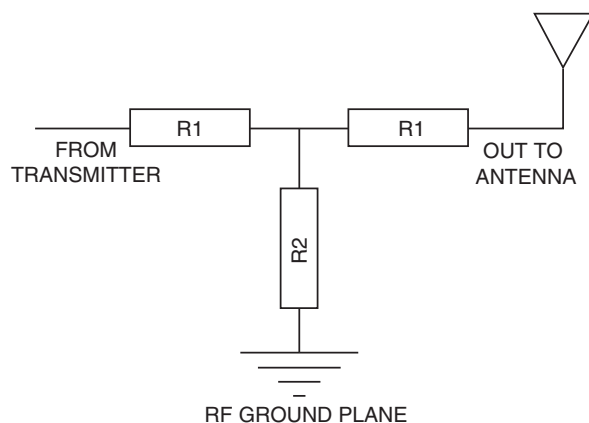


Figure 1: T-PAD Configuration

In this configuration the 50-ohm source (transmitter) and load (antenna) impedances form voltage dividers to reduce the output power level. The selection of resistors allows the input and output of the attenuator to be matched to the source and load impedances to prevent unwanted attenuation due to mismatch.

The resistor values can easily be calculated when the desired attenuation and input and output impedances are known. The chart on the following page can be used in place of these calculations to determine the values of R1 and R2.

The table in Figure 2 is normalized to 1-ohm input and output impedance and assumes that the attenuation pad is matching a source and load impedance that are equal. To understand how to use the table, let's use an example.

**Example 1:** A particular design requires the field strength of the fundamental frequency to be no higher than 250µVolts/meter at 3 meters. The transmitter generates a field strength of 11,500µVolts/meter at three meters. What values of R1 and R2 will attenuate the output power to provide a field strength of 250µVolts/meter?

**Solution:** First, we need to convert the field strength to power measured in dBm. To do this, we will use the following equation:

$$P = E^2/R$$

We know that R=377 ohms, which is the characteristic impedance of free space. So, let Pn equal the power in watts with a field strength of 11,500 µVolts/meter and let Pa equal the power with a field strength of 250µVolts/meter.

$$P_n = 0.0003507\text{mW}$$
$$P_a = 0.0000001658\text{mW}$$

Use the following formula to convert Pn and Pa to dBm:

$$\text{dBm} = 10 * \log(P_x \text{ in mW})$$
$$P_n = -35\text{dBm}$$

To determine the amount of attenuation needed, subtract Pn from Pa:

$$\text{Atten} = P_a - P_n = -33\text{dBm}$$

From the chart we can calculate R1 and R2 for an attenuation of 35dBm. R1 is 0.9650 and R2 is 0.0356.

The last step is to normalize R1 and R2 to the characteristic impedance of the line:

$$R_1 = 0.9650 * 50 \text{ ohms} = 48.25 \text{ ohms}$$
$$R_2 = 0.0356 * 50 \text{ ohms} = 1.78$$

T-PAD Resistor Combinations		
Attenuation	R1	R2
1	0.0575	8.668
2	0.1147	4.305
3	0.1708	2.838
4	0.2263	2.097
5	0.2800	1.645
6	0.3323	1.339
7	0.3823	1.117
8	0.4305	0.9458
9	0.4762	0.8118
10	0.5195	0.7032
11	0.5605	0.6120
12	0.5985	0.5362
13	0.6342	0.4712
14	0.6673	0.4155
15	0.6980	0.3668
16	0.7264	0.3238
18	0.7764	0.2559
20	0.8182	0.2020
25	0.8935	0.1127
30	0.9387	0.0633
35	0.9650	0.0356
40	0.9818	0.0200
45	0.9888	0.0112
50	0.9937	0.00633

Figure 2: T-PAD Resistor Combinations