STEP ATTENUATOR

Step Attenuator suitable for 0 - 30MHz.

Useful for receiver sensitivity evaluations this Step Attenuator is a series of switchable Pi attenuation pads as shown in Fig 1 schematic below. The resistance values required were derived from paralleled on hand resistors in stock. All resistors are of a 5% tolerance however should be adequate for the intended purpose. The combination of step values were chosen as they represent values that are easily for mental arithmetic however are not necessarily the most efficient combination of values.

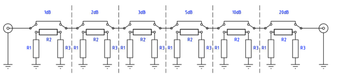

Fig 1 Step Attenuator schematic. The broken lines represent PCB pad shielding.

ATTENUATION dB	R1	R2	R3
1	869.55	5.7692	869.55
2	436.21	11.615	436.21
3	292.4	17.615	292.4
5	178.49	30.398	178.49
10	96.248	71.151	96.248
20	61.111	247.5	61.111

Fig 2 Attenuation pad resistor values.

ATTENUATION dB	Resistors	REQUIRED R	Ra	Rb	PARALLEL VALUE	ERROR
1	R1 & 3	869.55	1000	6800	871.795	-0.26%
	R2	5.7692	6.8	39	5.790	-0.37%
2	R1 & 3	436.21	680	1200	434.043	0.50%
	R2	11.615	12	390	11.642	-0.23%
3	R1 & 3	292.4	2700	330	294.059	-0.57%
	R2	17.615	18	820	17.613	0.01%
5	R1 & 3	178.49	180	22000	178.539	-0.03%
	R2	30.398	33	390	30.426	-0.09%
10	R1 & 3	96.248	150	270	96.429	-0.19%
	R2	71.151	82	560	71.526	-0.53%
20	R1 & 3	61.111	91	180	60.443	1.09%
	R2	247.5	3300	270	249.580	-0.84%

Fig 3 Resistor combinations to achieve required attenuation pad resistor values.

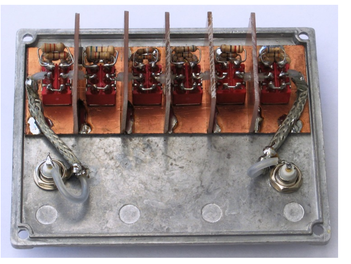

Photo 1 Bottom rear view of the assembled Step Attenuator.

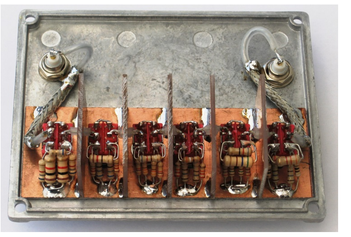

Photo 2 Top rear view of the assembled Step Attenuator.

Photo 3 Front view of the assembled Step Attenuator.

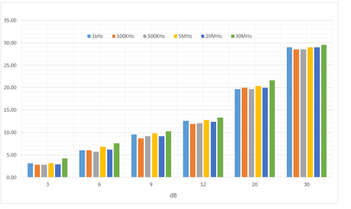

Fig 4 graph shows attenuation achieved at various frequencies.

The graph in Fig 4 was derived from measuring the voltage applied to the input against the voltage presented at the output at selected frequencies. The results are applied to the below formula to calculate the dB attenuation.

$$dB = 20 \times log10\left(\frac{\text{VoltageIn}}{\text{VoltageOut}}\right)$$
$$= 20 \times log10\left(\frac{3.16}{1.08}\right) = 3.1dB$$

The practical use of the step attenuator is to present a precise voltage reference based on a known source voltage from a signal generator for example to measure receiver sensitivity or calibrate receiver 'S' meter. The below formula shown how to determine the output voltage from the step attenuator with an input of 10mV with the attenuator set to -6dB resulting in an output of 5.012mV.

$$V = \frac{Vin}{10^{\frac{dB}{20}}} = \frac{10mV}{10^{\frac{6dB}{20}}} = 5.12mV$$

V = Voltage out
Vin = Voltage input

The below table gives a multiplier to apply to the input voltage and derive the output for given dB attenuation. The formula and the table are for voltage only and not power.

dB Attenuation	Attenuation Multiplier
0	1
1	0.891250938
2	0.794328235
3	0.707945784
4	0.630957344
5	0.562341325
6	0.501187234
7	0.446683592
8	0.398107171
9	0.354813389
10	0.316227766
11	0.281838293
12	0.251188643
13	0.223872114
14	0.199526231
15	0.177827941
16	0.158489319
17	0.141253754
18	0.125892541
19	0.112201845
20	0.1
21	0.089125094
22	0.079432823
23	0.070794578
24	0.063095734
25	0.056234133
26	0.050118723
27	0.044668359
28	0.039810717
29	0.035481339
30	0.031622777
31	0.028183829
32	0.025118864
33	0.022387211
34	0.019952623
35	0.017782794
36	0.015848932
37	0.014125375
38	0.012589254
39	0.011220185
40	0.01
41	0.008912509

Fig 5 dB voltage multiplier table.

Related projects:

Also see step attenuator project: 40dB Standard Attenuator

References:

Pi & Tee Network Resistive Attenuation Calculator
http://n5tia.arrsc.org/att_pad.cgi

PI Attenuator Calculator
http://www.random-science-tools.com/electronics/PI_attenuator.html

The Pi-pad Attenuator - Equations
http://www.electronics-tutorials.ws/attenuators/pi-pad-attenuator.htm

Fixed Pi and Tee Attenuators – Equations
http://www.rfcafe.com/references/electrical/attenuators.htm

TOP OF PAGE

Page last revised 05 December 2015