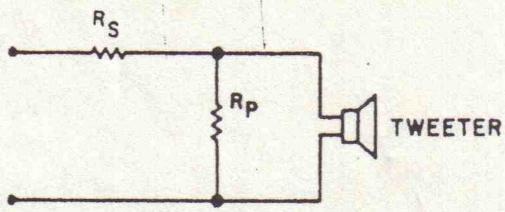
IMPEDANCE CORRECTED ATTENUATION

Given a too efficient driver, it has previously been a matter of trial and error in trying to find the proper series resistor to match the driver to the system. Once the series resistor was found, most individuals stop; not realizing the major impedance change now in the system. Not only would the change effect passive crossovers, it also effects the transient response of the amplifier. Trying to find both series and pass resistor through trial and error methods would cause anyone hair loss.

Fortunately, there are two simple equations that allow calculation of the proper pass (Rp) and series (Rs) resistors. Given driver impedance (ZD) and attenuation in negative decibels (A), the circuit and formulas are defined as follows:



$$R_P = \frac{10^{[A/20]} Z_D}{1 - 10^{[A/20]}}$$

$$R_S = Z_D - \frac{1}{(1/R_P) + (1/Z_D)}$$

A form of these formulas can be used to find the system equivalent impedance (Zeq) and attenuation (A) if they are the unknowns. The equations are as follows:

$$Z_{eq} = \frac{1}{(1/R_P) + (1/Z_D)} + R_S$$

$$A = 20\log\left[\frac{\frac{1}{(1/R_P) + (1/Z_D)}}{Z_{eq}}\right]$$

Recently, a speaker manufacturer published an attenuation system that was incorrect. The circuit given would drop the driver impedance from 4 ohms to less than 1.5 ohms. Obviously, it could cause drastic problems with regard to both crossover frequency as well as amplifier reliability. This kind of misinformation seems to be an all too common problem. Therefore, please check all published attenuation network values with the previous formulas before using them in systems. It will save us all a lot of headaches!

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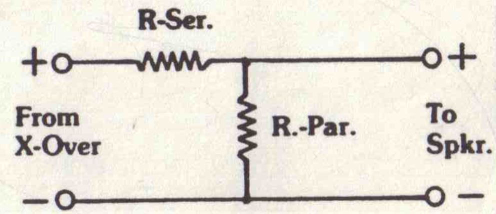
Resistor Attenuators

Speaker Impedance	Attenuation	R Parallel	R Series	Resultant Impedance
8	1.02 dB	—	1	9.00
8	1.16 dB	56	1	8.00
8	1.94 dB	—	2	10.00
8	2.48 dB	25	2	8.02
8	2.61 dB	20	2	7.71
8	2.82 dB	15	2	7.22
8	3.23 dB	10	2	6.44
8	3.67 dB	20	3	8.71
8	3.95 dB	15	3	8.22
8	4.48 dB	10	3	7.44
8	5.58 dB	10	4	8.44
8	6.16 dB	7.5	4	7.87
8	7.25 dB	5	4	7.07
8	8.39 dB	5	5	8.07
8	9.17 dB	4	5	7.67
8	12.31 dB	2	5	6.60
8	15.10 dB	2	7.5	9.10
8	16.42 dB	1	5	5.89
8	19.50 dB	1	7.5	8.39



Capacitor Crossover Points

Eight Ohm Capacitor	3dB point	6dB point	12dB point	Crossover (4.5dB)
2.2 uf	9043 Hz	4522 Hz	2261	6400 Hz
3.3 uf	6029 Hz	3014 Hz	1507	4300 Hz
4.7 uf	4233 Hz	2116 Hz	1058	3000 Hz
6.8 uf	2926 Hz	1464 Hz	732	2100 Hz
10 uf	1989 Hz	995 Hz	497	1400 Hz
15 uf	1326 Hz	663 Hz	332	940 Hz
22 uf	904 Hz	452 Hz	226	640 Hz
33 uf	603 Hz	301 Hz	151	430 Hz
47 uf	423 Hz	212 Hz	106	300 Hz
100 uf	199 Hz	100 Hz	50	140 Hz

Four Ohm Capacitor	3dB point	6dB point	12dB point	*Crossover (4.5dB)
2.2 uf	18085 Hz	9043 Hz	4522	12800 Hz
3.3 uf	12058 Hz	6029 Hz	3014	8600 Hz
4.7 uf	8466 Hz	4233 Hz	2166	6000 Hz
6.8 uf	5852 Hz	2926 Hz	1463	4200 Hz
10 uf	3978 Hz	1989 Hz	995	2800 Hz
15 uf	2652 Hz	1326 Hz	663	1880 Hz
22 uf	1808 Hz	904 Hz	452	1280 Hz
33 uf	1206 Hz	603 Hz	301	860 Hz
47 uf	846 Hz	423 Hz	212	600 Hz
100 uf	399 Hz	199 Hz	100	280 Hz

THE BUSINESS OF MOBILE AUDIO

By John Patterson, President of PAC

Editor's Note: PAC may be contacted at (800) 854-3133 for assistance with crossovers or a catalog.

Resistors in a speaker circuit are useful to reduce the amount of power a speaker receives. If a speaker or speakers are to be used for rear fill, the power going to that circuit may be desired at a reduced level. In some instances, a particular speaker may be too loud and create an unbalanced system.

Tweeters and other small speakers may need protection and usually can afford a reduced amount of power. A single speaker used for center imaging may have both the right and left channel input to it and, in most instances, resistors are necessary to stabilize the load an amplifier sees in that section.

If a passive crossover is made for a particular ohm load which is not the same as the speaker, a resistor can be used to change the ohm load seen by the crossover. Resistors may be used in series or in parallel with a speaker.

What happens to the amount of power which ends up driving the speaker when a resistor is used is similar to what happens when two speakers are put in series or in parallel. The essential difference between a speaker and resistor is a resistor turns its power into heat rather than music.

SERIES RESISTORS

Series resistors will always reduce the power which reaches the speaker. The amount of power ending up at the speaker is dependent on two factors:

1) The change in amplifier load, and

2) The distribution of power between the resistor and the speaker.

As an example, a 4 ohm resistor in series with a 4 ohm speaker will double the amplifier load and in theory reduce amplifier output by 50 %. In practice, most amplifier circuits will respond with a slightly increased output into this increased load. As a general rule, the amplifier output will be 60% rather than 50 %.

The reduced amplifier output is then split evenly between the speaker and resistor. Therefore the speaker receives 1/2 of the 60 % of power or 30 % of the original amplifier power. The 30 % powering the resistor helps heat the car.

To figure various resistor and speaker value combinations use the formula or chart shown below.

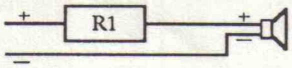
When a resistor is used in a passive crossover circuit, the value of coils and/or capacitors need to be chosen based on the ohm load of the speaker and resistor combination. Two 4 ohm speakers in series would require an 8 ohm crossover. A 4 ohm resistor in series with a 4 ohm speaker would also require an 8 ohm crossover. More on resistors in March.

FORMULA AND CHART
RESISTOR AND SPEAKER IN SERIES

$$1 / \left(\frac{R1 + R2}{R2}\right) \times \left(\frac{R2}{R1 + R2}\right) = \text{POWER TO SPEAKER}$$

Not adjusted for the small increase in power from the amplifier circuitry.

SERIES RESISTOR



% OF POWER RECEIVED BY SPEAKER WITH RESISTOR IN SERIES

RESISTOR OHMS	SPEAKER OHMS 3	4	6	8
1	56	64	73	79
2	36	44	56	64
3	25	33	44	53
4	18	25	36	44
6	11	16	25	33
8	7	11	18	25