Loud Speaker Crossover Networks

The Design Challenge:

Loudspeakers and amplifiers (amps) are manufactured by numerous companies building one or both of the systems. Different design parameters cause impedance mis-matching which can be damaging to speakers. Overcurrent situations caused by overdriving power amps can damage the wirewound coils, causing shorts or opens in the copper windings of speaker components. Low power amps may act as clippers, causing a frequency shift or high frequency signals which can damage speakers, tweeters and constant directivity horns. Another common failure mode is caused by taking a speaker from a zero state to a highly excited state in extremely short amounts of time. The design of crossover networks concerns itself with the load seen from the amplifier. The initial internal resistance of the device is extremely small compared to the total impedance of a cross-over circuit such as Zobel network or conjugate impedance network.

The obvious solution is circuit protection using overcurrent protection devices. Two choices are fuses and circuit breakers. Circuit breakers can add undesirable distortion as the metal contacts separate. The electric field generated by the current flow resists the change in current, resulting in arcing and electrical white noise. Fuses must be accessible and manually replaced. The cost of the fuse, fuse holder and access panel to the fuse makes typical fusing economically unattractive. Also, there is the possibility of mistakenly or intentionally over-rating the fuse, setting the system up for damage and violating agency safety certifications. In crossover networks, a minimal number of components are used to protect the tweeter. The obvious solution is to use an inexpensive resettable fuse that can be buried in the cabinet without needing maintenance or replacement.

The Application:

A MULTIFUSE PPTC is frequently used in a parallel circuit with a large resistor (typically 10k ohms) and this circuit is placed in series upstream of the speaker. (See Figure 1.) During normal operation within the parameters of the tweeter, the MULTIFUSE PPTC acts as a conductor for the speaker. When an overcurrent situation such as an overdriven amp occurs, the polymer within the PPTC will expand and the carbon chains will disengage. This shunts all of the current into the shunt resistor, dropping the voltage across the resistor and protecting the speaker. Once the signal changes to a low value, the PPTC will begin to reset and the circuit will react as designed.

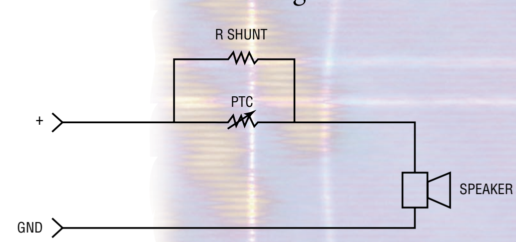

Figure 1

Another application is to use the PPTC without a shunt resistor (see Figure 2). As the PPTC's resistance increases exponentially, the speaker, horn or other delicate instrument will see little to no current flow.

The choice of MULTIFUSE PPTC used depends upon the current demanded by the parameters of the speaker which the PPTC protects during normal operation. The Ihold of the PPTC is the amount of operational current desired in the design. The Itrip is the value at which you wish to begin protecting the circuit, keeping in mind that the ambient temperature is an integral part of the circuit design when selecting the correct device.

A typical crossover network design is drawn below (Figure 2), with typical values.

C_1 = Ranges from 10 to 2uF
R_1 = Ranges from 2.7 to 22 ohms
C_2 = Ranges from 4uF to 2.2uF
L_1 = Ranges from 450uH to 300uH
L_2 = Ranges from .7uH to 2.5mH
C_3 = Ranges from 4.7uH to 33uH

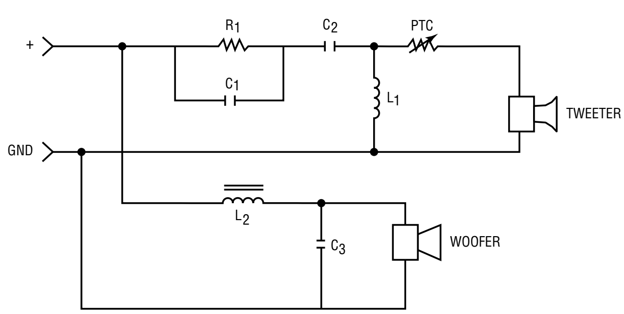

Figure 2

The input voltage can range up to 60 volts continuous for newer speaker systems and about 53 volts on older systems. Typical music peaks are a minimum of 12db and normally 15db. New woofers can handle 500 watts while older styles are limited to 350 watts. Tweeters fall into values of 60 watts for new speakers, and 40 watts for older speakers.

Typical MULTIFUSE component values for the PPTC would be the MF-R040 for the 60-volt system and MF-R030 for the 53-volt system.

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