

Designing A Reactive Speaker Load Emulator

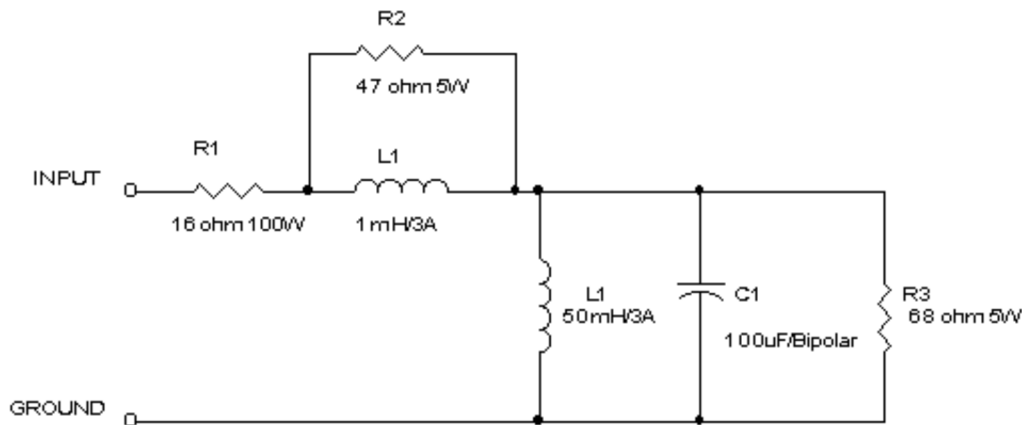
General

A speaker presents a varying impedance load to the amp. The stated impedance is usually measured at 400Hz, and can vary widely over the frequency range. Speakers generally have a large resonant peak that can be as much as 5 times the rated impedance, or even higher. The impedance also starts to rise upward following the trough impedance at 400Hz. This rise can occur at varying frequencies and have a varying rate, depending upon the speaker and its enclosure.

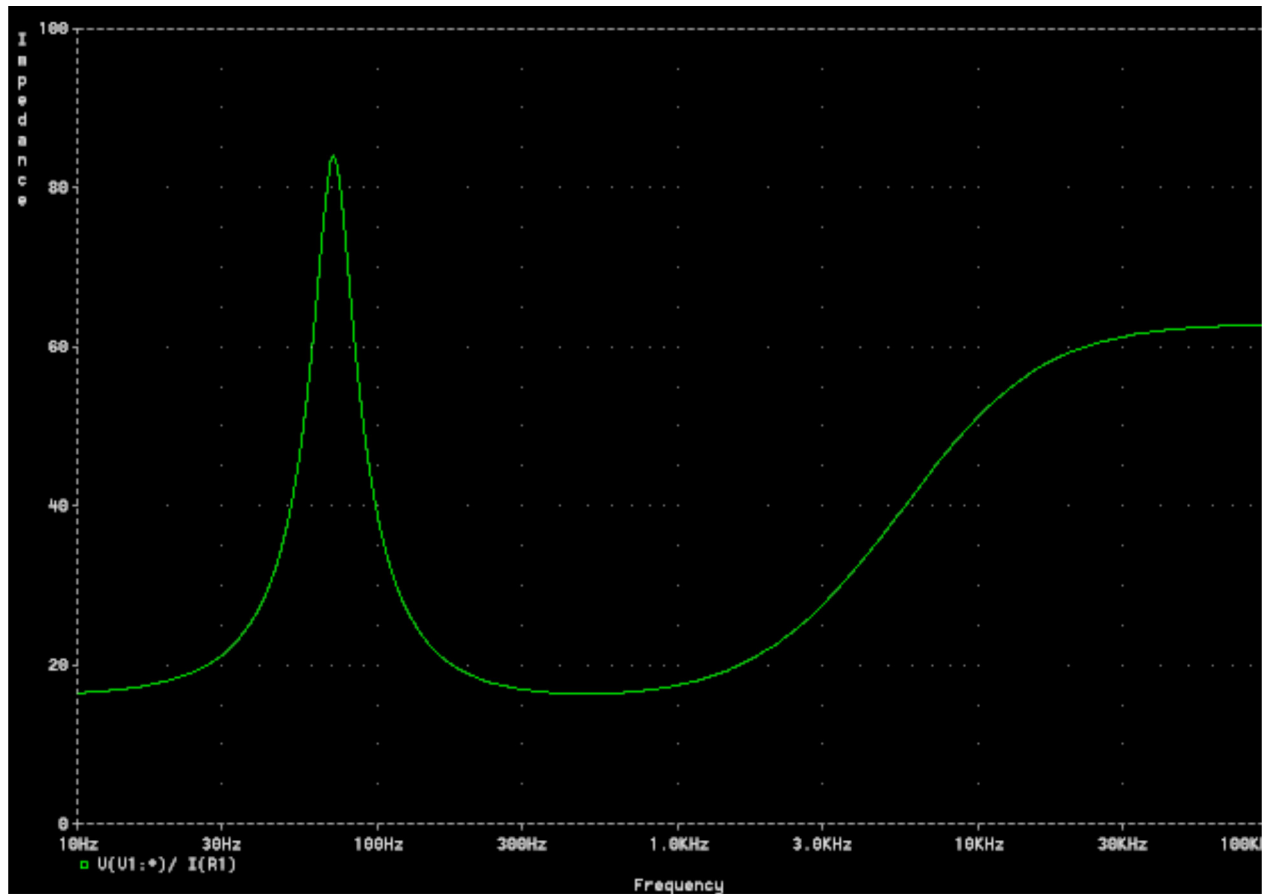
The design of a speaker emulator

Following is a design for a circuit that will simulate the impedance variations you get with a 16 ohm speaker cabinet. The real speaker will probably vary depending upon how hard it is driven, due to motional restrictions of the cone, which this circuit will not do.

This circuit will make the amp react to the load, unlike pure resistive dummy loads, but if you want to tap off the input and send the signal to a board, or other equipment, you will need to attenuate it with a voltage divider, and low-pass filter it to simulate the frequency response rolloff of the amp.

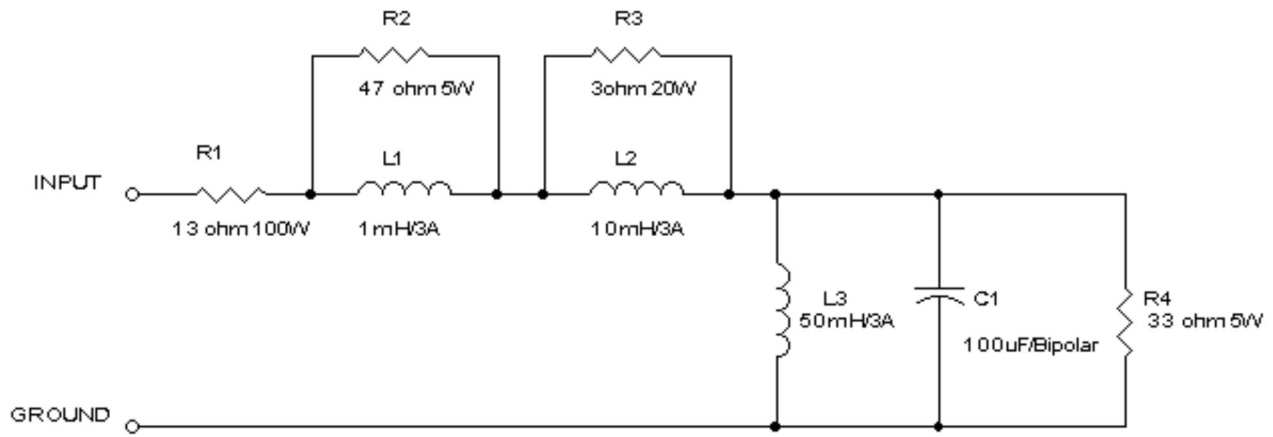


The impedance plot for this circuit looks like this:

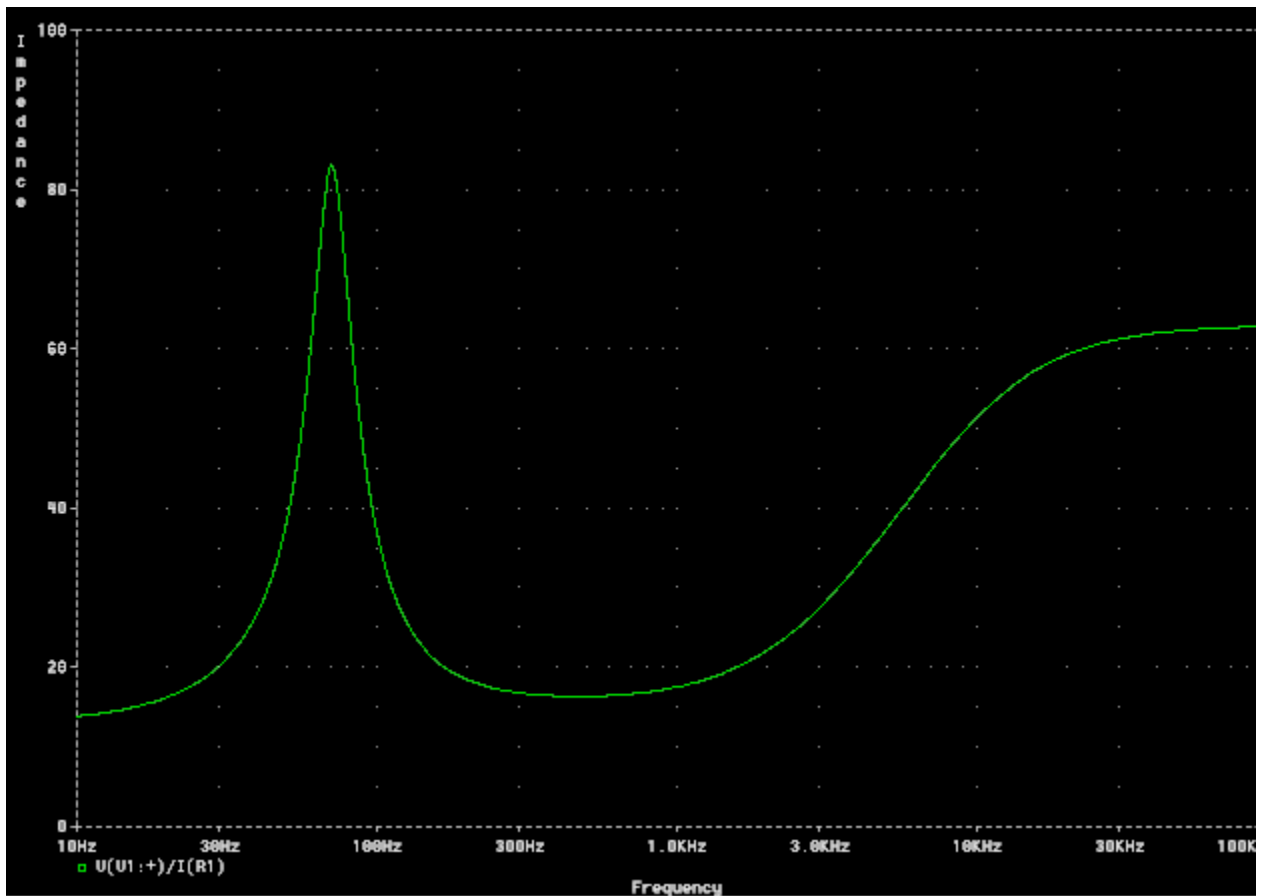


A more accurate speaker emulator

A true speaker impedance is somewhat lower at DC than its nominal rated impedance. If you want to make a closer approximation of the impedance curve, you could add more reactive elements to make the impedance look like 16 ohms only at the trough, and make it lower between DC and the resonant peak. The circuit would look like this:



The impedance plot for this circuit looks like this:



These circuits are designed to present a 16 ohm nominal load to the amp; if you want a different impedance, you will have to scale the resistive and reactive elements accordingly. The impedance scaling factor will be $Z = Z_{new} / Z_{old}$, and the new element values will be as follows:

$$R' = Z \times R$$

$$L' = Z \times L$$

$$C' = C / Z$$

The primed elements indicate the values after scaling. Be sure to take into account the higher currents at the lower impedance levels and adjust the inductor current values and resistor power levels accordingly.

If you want to add a line out feature for recording, tap off the input of the circuit; that is, at the junction of the amplifier output and R1. Use a resistive divider to lower the signal level (make sure the divider resistance is much larger than the output or load impedance). Note that this circuit provides a load impedance that approximates a speaker, but it does not provide a frequency response that approximates a speaker. If you want to use such a device as a silent load for recording, you will have to add further lowpass and highpass filtering, along with amplitude equalizers which approximate a speaker frequency response. Otherwise, the frequency response will be far too bright and buzzy sounding.

In addition, you can adjust the resonant circuit values ($L3/C1$) to change the location of the resonant peak to closer match the speaker/cabinet of your choice. The formula for the frequency of the resonant impedance peak is as follows:

$$f = 1/(2*PI*SQRT(L3*C1))$$

R4 limits the amplitude of the resonant peak and can be adjusted as well if desired. The peak impedance limit is equal to $R1+R2+R4$.

The high frequency impedance limit is primarily set by R2 and is equal to $R1+R2+R3$.

<>Note that the large value bipolar caps can be converted to smaller film (or other type) caps if you use a capacitance transformer (if you don't know what this is, you shouldn't be messing around with this circuit!). In fact, you might be able to replace the parallel inductor with the primary inductance of the transformer, or at least transform the entire RLC network.

Note that this design is for informational purposes only - you are on your own if you choose to build and use these circuits and we will take no responsibility if you blow up your amp! Also, we unfortunately do not have the time to assist builders in component selection, layout, modification, or questions regarding the use of these circuits - the info is offered free of charge and is worth every penny.

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