Ham 38 - Impedance, Attenuation & DC block

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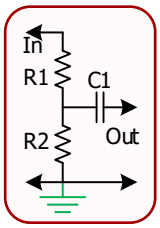
1. **Nerd Alert**:
   a. This is a topic that requires several calculations. The most difficult is multiply or divide.
   b. The design includes all the electrical topics encountered on the Technician exam.
   c. You passed that, so I know you can do this.

2. Audio has speaker or headphone output and microphone input. But then things get interesting.
   a. A typical speaker impedance (Z) operates at 8 Ω (Ohms). Headphone impedance is 30-60 Ω.
   b. Electret microphones are nominal 800 Ω. Other type mics operate with impedance for their purpose.
   c. Electret has a voltage applied to the mic to energize. Icom applies 8 Vdc with current of 10 ma.



3. Rules of thumb for connection.
   a. Amateur equipment is voice only with range of 300 – 3000 Hz.
   b. Music has a range of 20 – 20,000 Hz.
   c. The mics and speakers for music and voice are not interchangeable with equal performance.
   d. Output Z of the source must be lower than input Z of the equipment.
   e. If mic has low Z and equipment has high Z, the mic likely will have inadequate energy to drive the input.
   f. Maximum power transfer occurs with the source matches the load.
   g. If using other than electret, place a large disk capacitor in series with the mic input to remove the Vdc.
   h. Capacitance must be large enough to pass low frequency voice, (~1 µFd).
   i. Attenuation and impedance matching is easiest with a voltage divider, which is a 'T' network.

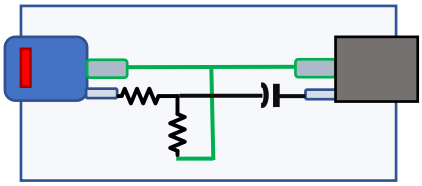
4. If creating a remote-control radio, connect the audio out from the radio to the computer.
   a. The attenuator resistor equals the impedance of the opposite port... $R_2 = Z_{in}$
   b. The sum of $R_1 + R_2 = Z_{out}$, so $R_1 = Z_{out} - R_2$.: $R_1 = Z_{out} - Z_{in}$
   c. The resistors create a voltage divider which attenuates V_{in}
   d. The series current depends on the voltage of audio in. $V_{in} = (R_1 + R_2)\, I_{in}$
   e. By substitution, the output voltage depends on the resistor ratio. $V_{out} = R_2 / (R_1 + R_2)\, V_{in}$
   f. Check that the output current is low enough to protect the circuit. $V_2 = R_2 * I_{out}$

5. Attenuation in decibels (dB) depends on the ratio of Vi_n / V_{out}.
   a. The input output voltage ratio depends on the same resistor ratio. $V_{in} / V_{out} = (R_1 + R_2) / R_2$
   b. The decibels are defined. $dB = 20 \log_{10} (V_{in} / V_{out})$

6. Consider an input from a speaker port (8 Ω) and an output to an electret port (800 Ω).
   a. Size resistor R_2 $R_2 = 8$
   b. Size resistor R_1 $R_1 = 800 - 8 = 792$
   c.
   d. Series current $V_{in} = 792\, I_{in}$
   e. Output voltage $V_{out} = 8 / 800\, V_{in} = 0.01\, V_{in}$
   f. Works even for a line voltage of 1 V, 1 ma $V_2 = 8 * I_{out}$

   Attenuation
   a. Voltage ratio $Vi_n / V_{out} = 800 / 8 = 100$
   b. dB $dB = 20 \log_{10} (100) = 40$

7. The diagram shows a connection interchange between the computer and radio.
   a. Preferably build on a circuit board, but the connections are simple enough to hand wire.



8. Consider constructing for a headphone as source feeding an electret mic input.
   a. R_2 is 45, R_1 = 800 – 45 = 755, V_{out} = .056 V_{in}, I_{out} = .056/45 = 1ma, dB = 25.
   b. To assure a lower impedance is feeding into a higher, use R for headphone.