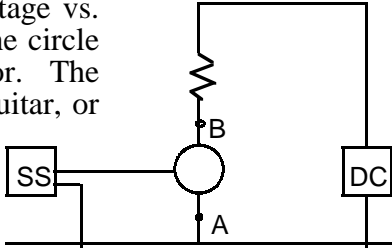


- A "woofer" is a large loudspeaker designed to produce low-frequency sounds. A small speaker called a "tweeter" is used to produce high-frequency sounds. A "two-way" stereo speaker contains one of each type enclosed in a box. Electrical signals go from an amplifier to the box, where the woofer and tweeter convert them into sounds. The problem is that the low-frequency ("bass") signals are powerful enough to damage the tweeter unless we protect it somehow. What familiar device studied in chapters X and XI can be connected in series with the tweeter to prevent low-frequency alternating current from passing through without interfering with the high frequency currents significantly? ____
- "Impedance" is voltage amplitude over current amplitude. (See page 11b) For a typical tweeter it's roughly eight ohms. What size capacitor would have the same impedance at a frequency of 5000 Hz? Please show how this and all other answers are calculated. Use #8 on RS XII. Remember that one Hz = one cycle per second. Also remember that one microfarad is 10^{-6} farad.
- If the current vs time graph is a cosine curve then the tweeter's voltage vs time graph will be a _____ curve and the capacitor's V-t graph will be a _____ curve. If the two impedances are equal, as in #2, then those two graphs will have equal _____. In that case:
 - The V-t graph for the series combination will be a sine curve with a ____-degree phase shift.
 - Its amplitude will be _____ times the original amplitude.
 - Show how the impedance of the combination at that frequency is calculated.
- Estimate the impedance of the same capacitor at 100 Hz. Round off *both* impedances properly.
- Roughly what fraction of the signal's current amplitude is "blocked" by the capacitor at 100 Hz? (In other words, what is the ratio of the change in current caused by the insertion of the capacitor to the current that would exist without the capacitor?) *Please show how this fraction is calculated.*
- In more expensive systems an "inductor" is connected in series with the woofer to prevent high-frequency signals from going through it. What shape must its reactance vs frequency graph have?
- The purpose of an "**amplifier**" is to increase the amplitude of a voltage vs. time graph without changing its shape. In the diagram at the right, the circle represents an electron "valve", such as a vacuum tube or a transistor. The "SS" box represents a signal source, such as a microphone, electric guitar, or anything else that generates a small, fluctuating emf. The "DC" box represents a DC power supply.
 
 - How are the resistor voltage, the AB voltage, and the power supply voltage related? _____ = _____
 - When the signal voltage increases slightly, it "opens the valve", causing the current between A and B to increase. According to Mr. Ohm, that causes the resistor voltage to ____crease.
 - According to 7a, the potential difference between points A and B must then ____crease.
- Is it possible to reverse the direction of the resistor current by adjusting the potential difference between B and C? _____ (That's like reversing the flow of water from a faucet by turning the knob.)
- Suppose the signal's voltage vs. time graph in #7 looks like a sine curve:
 - What must the resistor's current vs time graph look like?
Sketch the two graphs, one directly under the the other, using identical time scales.
 - Do your sketches contradict #8? _____
- If the amplitude of the signal voltage is great enough, the resistor current amplitude may be zero for certain parts of the cycle. Is that desirable, or will that produce distortion?_____
- What will the AB-voltage vs. time graph look like? Sketch it directly beneath the first two, using the same time scale. *Try not to contradict #7 or 8. Also try not to contradict Mr. Ohm.*
- The amplifier described above was suppose to increase the amplitude of a signal voltage vs. time graph. But it changed more than the amplitude. It also *added* a constant voltage to the alternating signal voltage. You saw earlier that capacitors have the ability to "conduct" AC, yet block DC. Show how a capacitor and load resistor can be added to the amplifier circuit in #7 to remove the DC part of the amplified signal.

1. Use an oscilloscope and a sine generator to make a graph of capacitor voltage vs current as you did on page 109 & 110. Then disconnect the oscilloscope's vertical input wire from the capacitor. Connect it instead to the resistor terminal where the "H" wire is already connected.
 - a. Now the voltage between the V and G terminals must be identical to the voltage between ___ and G, so the pattern on the screen must be a _____al line. -Is it? ____ (If not, try lower frequency.)
 - b. Adjust the vertical and horizontal gains on the oscilloscope until that line has a 45-degree inclination angle and does not go off-screen.
 - c. Recall that the oscilloscope is really two voltmeters. The spot's vertical displacement is proportional to one voltage and its horizontal displacement is proportional to another. In 1b we adjusted the sensitivities of those two voltmeters to make them _____.
2. Now re-connect the "V" wire to the capacitor, as it was in #1. Do NOT adjust the oscilloscope in any way. Adjust the *generator* frequency until you can see that the reactance of the capacitor is equal to the resistance of the resistor. *Clue: The ratio of a RESISTOR'S voltage amplitude to its current amplitude is called "_____". For CAPACITORS the ratio is called "_____".*
 - a. The pattern on the screen is then a _____. The special frequency measured in #2 is between _____ and _____. The resistance used in this experiment was _____ \pm ____ %, as determined by the color code or with an ohm-meter.
 - b. We conclude that the capacitive reactance must have been _____ \pm ____ %.
 - c. We conclude that the capacitance must have been _____ and _____.
On the back of this paper please show how that range was calculated. Start with #8 on RS XII.
 - d. It would take about ____ minutes to check that result by the method on page 110.
If you care enough to do so, please show how you did it and what result you obtained.
3. Suppose we exchange the wires connected to the "G" and "H" terminals on the oscilloscope:
 - a. Draw a diagram showing how the oscilloscope is now connected to the circuit.
 - b. According to that diagram, the spot's vertical displacement must now be proportional to the _____ of the resistor and capacitor voltages, while the horizontal displacement is still proportional to the _____ through the combination.
 - c. Sketch graphs of capacitor voltage vs time and resistor voltage vs. time. In #2 we made sure that those voltages had _____ amplitudes.
 - d. Sketch a third graph showing how the sum of those two voltages fluctuates as time goes on.
 - e. Describe that graph. (What kind of curve is it, and how does it differ from the ones sketched in 3c?)
 - f. If we understand this correctly, the amplitude of that third graph must be _____ times the amplitude of the first or second graph.
 - g. Sketch the pattern that you expect to see on the oscilloscope, and show it to your teacher. Then find out if your predictions are correct.
4. Definition: The *impedance* of an electrical device is the quotient obtained when you divide the amplitude of the voltage across the device by the amplitude of the current through it.
 - a. The impedance of a capacitor is the same as its _____ance, by definition.
 - b. The impedance of a resistor is the same as its _____ance.
 - c. The impedance of the combination in #3 turned out to be _____ times greater than the impedance of either part. That's the result which we would get if we added them using _____ addition, pretending that the angle between them is _____ degrees.
- * 5. An "inductor" is a device for which voltage is proportional to the RATE at which current changes.
 - a. If an inductor carries sinusoidally alternating current, how must its voltage vs. time graph differ from its current vs. time graph? Explain, mentioning both shape and phase. (See #4 on RS VIII.)
 - b. Suppose the frequency is doubled without changing the voltage amplitude. Using 109 and 110 as a model, *explain* exactly how the current amplitude will be affected. (Use #3 or #4 on RS VIII.)
 - c. How would you define "inductive reactance"? -How must it depend on frequency? (Explain)
 - d. Do a simple experiment to test that theory. Explain what you see and what you conclude.
- * 6. An inductor is connected in parallel with a light bulb to a DC power supply.
 - What happens when the power supply is removed from the circuit, and why does that happen?
 - How is this trick utilized in automobiles?
7. Can an inductor store energy? -In what form is the energy stored?