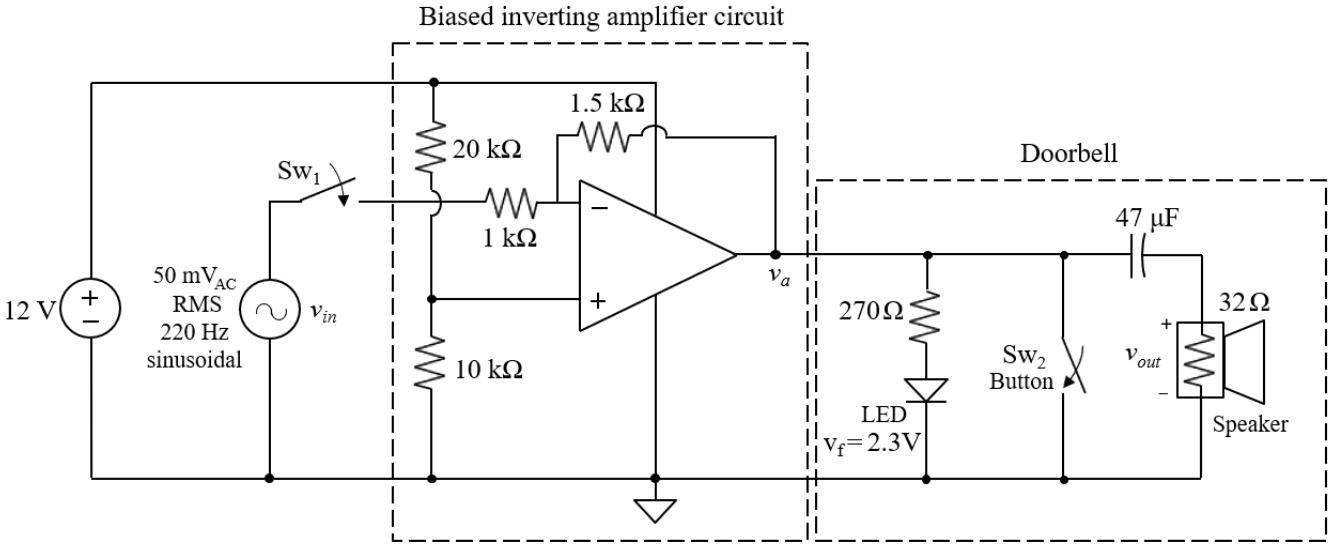
School of Electrical Engineering & Telecommunications

ELEC1111 Tutorial 7

1. Analysis of a doorbell circuit

In this tutorial we will analyse a circuit which allows us to light a doorbell button with an LED and speak to the visitor at the door, all using the original two wires to the doorbell button. To test the speaker functionality, we use a sinusoidal waveform. The circuit is shown below.



Q1. Calculate the voltage v_a when Sw1 and Sw2 are open.

Answer: $v_a = 4$ V

Q2. Using the value of v_a from Q1, calculate the current (i_{LED}) and power (P_{LED}) in the LED light, where the LED light is modelled as a voltage source of value v_f = 2.3V. Calculate the current (i_{out}) and power (P_{out}) in the speaker. Note that switches Sw1 and Sw2 are still open.

Answer: i_{LED} = 6.3 mA; P_{LED} = 14.49 mW; i_{out} = 0 A; P_{out} = 0 W

Q3. You push and hold the doorbell button Sw2 (switch Sw1 remains open). If the button is pushed at time t = 0 seconds, calculate and plot the voltage across the speaker, v_{out}, for the first 10 milliseconds. Ensure your drawing has at least three key values labelled.

Answer: $v_{out} = -4\mathrm{e}^{-\frac{\mathrm{t}}{0.001504}}\ V$

Q4. You push the doorbell button Sw1 to speak. Express the voltages at the amplifier input, v_{in}, and output, v_a, as a function of time and then as a phasor.

Answer: $v_{in}(t) = 0.0707\cos(440\pi t)\ V \ \rightarrow \ \mathbb{V}_{in} = 0.0707\angle 0°\ V$

Analyse Op Amp circuit to calculate v_a: $v_a = 10 - 1.5\ v_{in}$

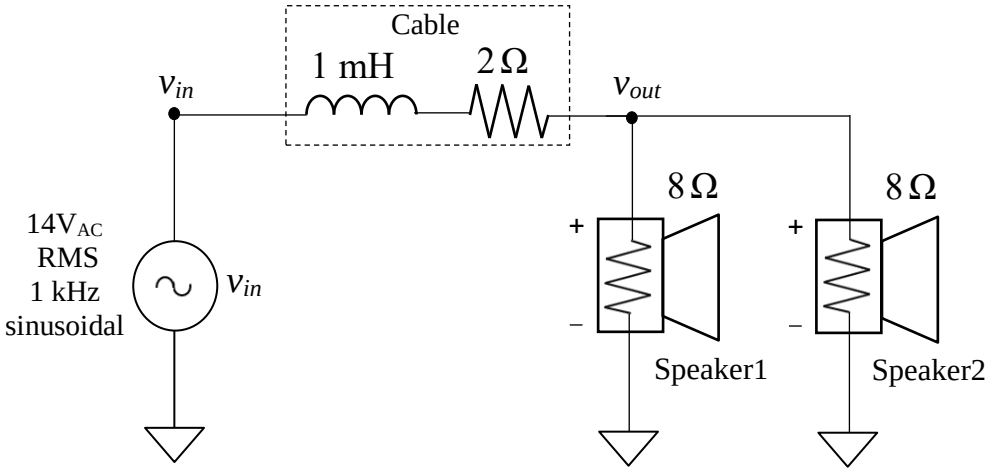
$v_a(t) = 10 - 0.106\cos(440\pi t)\ V \ \rightarrow \ \mathbb{V}_a = 0.106\angle -180°\ V$

Q5. Find the voltage v_{out} across the speaker as a phasor. Note that the DC voltages in the circuit and the LED will have no effect on v_{out} and you may ignore them during this analysis. Note that switch Sw1 is still closed and Sw2 is open.

Answer: $\mathbb{V}_{out} = 0.095\angle -154.31° \, V$

2. Analysis of a fire alarm system[1]

The circuit shown below is a simple fire alarm system. When the alarm is triggered, 1 kHz sinusoidal "beeps" are sent to the speakers.



Q6. Express the voltage at the amplifier input v_{in} as a function of time and as a phasor.

Answer: $v_{in}(t) = 14\sqrt{2}\cos(2000\pi t)\ V \ \rightarrow \ \mathbb{V}_{in} = 14\sqrt{2}\angle 0° \, V$

Q7. Find the voltage v_{out} across each speaker as a phasor.

Answer: $\mathbb{V}_{out} = 9.115\angle -46.32° \, V$

[1] This problem is from the final exam in Semester 2, 2018 (full solution will be provided under Final exam -> Supplementary material in Moodle)