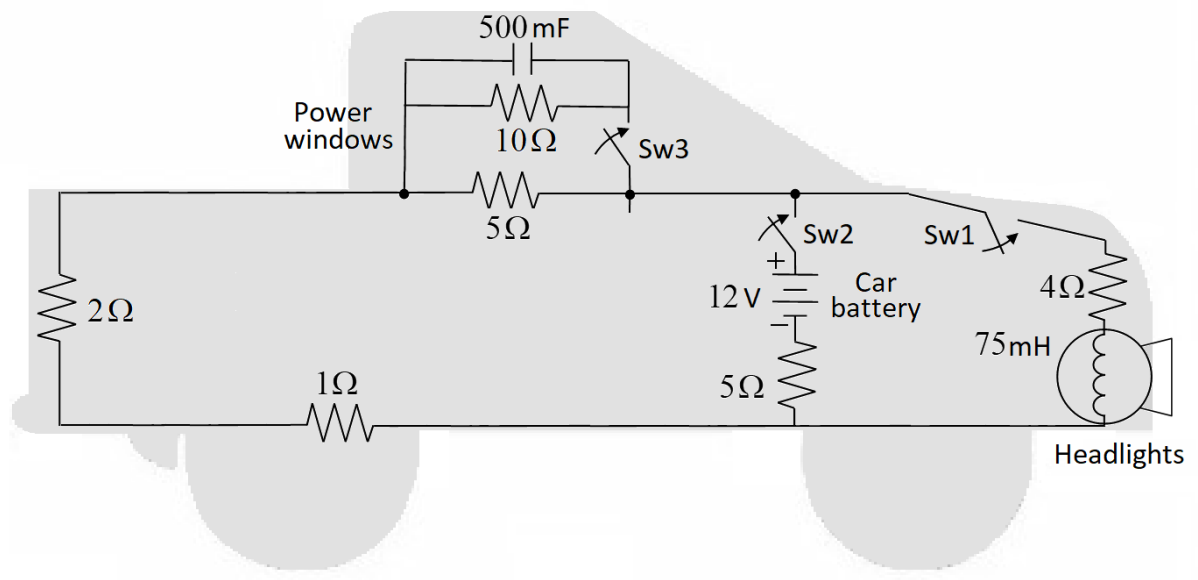
School of Electrical Engineering & Telecommunications

ELEC1111 Tutorial 5

Analysis of the headlights and power windows of a car

The circuit below shows the wiring of the headlights and power windows of a car. The power window system has an internal capacitance of 500mF in parallel with a 10 Ω resistor and the headlamp bulb has an internal resistance of 4 Ω with an inductance of 75 mH in series. The car also features a 12V car battery which can power the system when the car engine is turned off. Due to poor wiring, there are 5 Ω, 2 Ω and 1 Ω resistances connected to the power windows circuit.



Q1. You want to test the headlights using the car battery when the power windows are not in use. Under these conditions switch Sw3 is open, and switches Sw1 and Sw2 are closed. Find the power dissipated by the headlights (both resistor and inductor) in DC steady state conditions.

Answer: $P_{headlights}$ = 4.34 W

Q2. Taking t = 0 as the time when you first connect the headlights (i.e. Sw1 and Sw2 close and Sw3 remains open), calculate and plot the current across the inductor. Ensure your plot is to scale and has at least three labelled values. Consider that the headlights have not been used for a long time and the inductor is initially discharged.

Answer: $i(t) = 1.04(1 - e^{-t/0.01059)}\ A$

Q3. If you disconnect the battery from the headlights (i.e. Sw2 opens), how long will it take for the inductor to completely discharge?

Answer: t = 31.25 ms

Q4. You note that the power windows are working slower than usual. You suspect that the response of the power windows is slow due to their internal capacitance. To test them, you open all the switches for a sufficient amount of time, and then close the car battery switch (Sw2) and power windows switch (Sw3). The headlight switch (Sw1) is open during this test. Calculate and plot the voltage across the capacitor. Ensure your plot is to scale and has at least three labelled values.

Answer: $v(t) = 3.53(1 - e^{-t/1.176})\ V$

Q5. Using the response in Q4, find how long it takes for the power windows to reach maximum speed if the speed is proportional to the voltage across the 10 Ω internal capacitor.

Answer: t = 5.88 s

Q6. (Design and simulation question) *Within your group*, discuss how you could speed up the response of the power windows by inserting a component into the power window circuit. Select and calculate the value of a suitable component that would improve the response of the power windows by three times. Use circuit simulation software to verify your design and calculations.

Answer: There are different correct designs possible, which can be verified using simulation. If you are still unsure after simulating your design, contact your lecturer to organise an appointment.