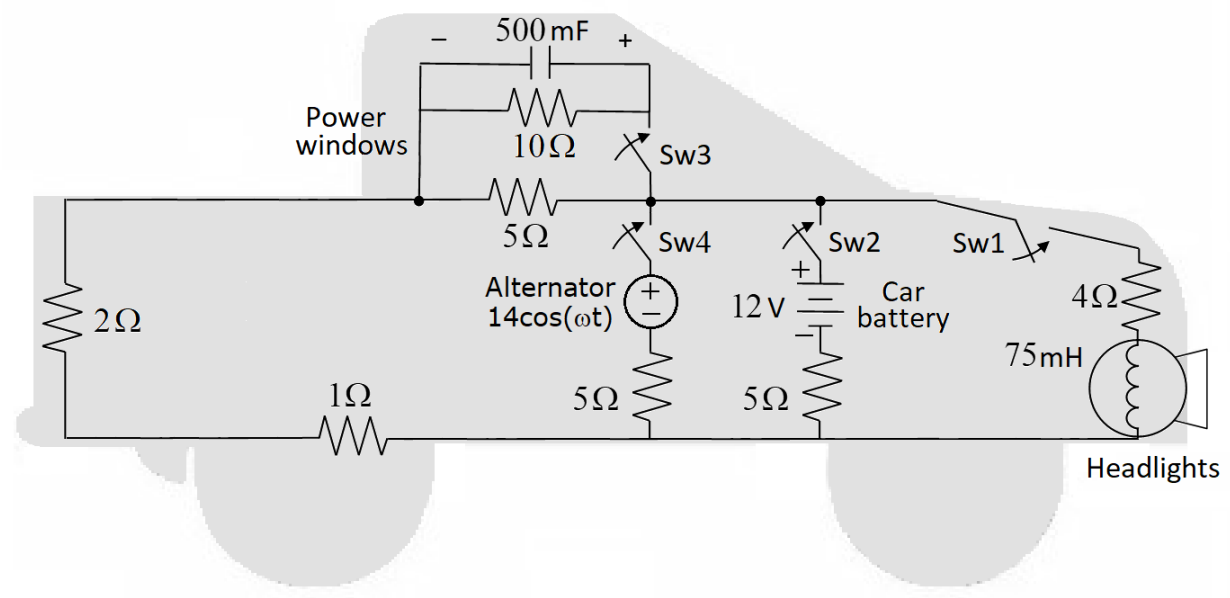
School of Electrical Engineering & Telecommunications

ELEC1111 Tutorial 9

1. 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 (alternator) is turned off. When the alternator is on, it produces AC power with an amplitude of 14V. The frequency of the AC signal is directly tied to the speed of the car. Due to poor wiring, there are 5 Ω, 2 Ω and 1 Ω resistances connected to the power windows circuit.



Consider that the car battery is disconnected (i.e. Sw2 is open), but the headlights, power windows and alternator are connected (i.e. Sw1, Sw3 and Sw4 are closed). Also, consider that you are driving at 10 km/h, and the frequency of the alternator is 50Hz at this speed.

Q1. Calculate the average power dissipated by the power windows (capacitance and 10 Ω resistor) and the headlights (inductance and 4 Ω resistor).

Answer: $P_{avg_{windows}} = 6.05\ \mu W$, $P_{avg_{headlights}} = 93.53\ mW$

Q2. Calculate the power windows' impedance that will ensure maximum transfer of power from the car to the power windows.

What will the maximum average power be? Compare this value with the average power calculated in Q1 for the current power windows.

Answer: $\mathbb{Z}_{L_{windows}} = 3.04 - j0.14\ \Omega$, $P_{avg\_max_{windows}} = 1.125\ W$

Q3. Calculate the headlights' impedance that will ensure maximum transfer of power from the car to the headlights. Recalculate the values of inductance and resistance to achieve this impedance.

What will the maximum average power be? Compare this value with the average power calculated in Q1 for the current headlights.

Answer: $\mathbb{Z}_{L_{headlights}} = 1.875 + j0.0024\ \Omega,\ R_{new} = 1.875\ \Omega,\ L_{new} = 7.64\ \mu\text{H},$
$P_{avg\_max_{headlights}} = 1.84\ W$