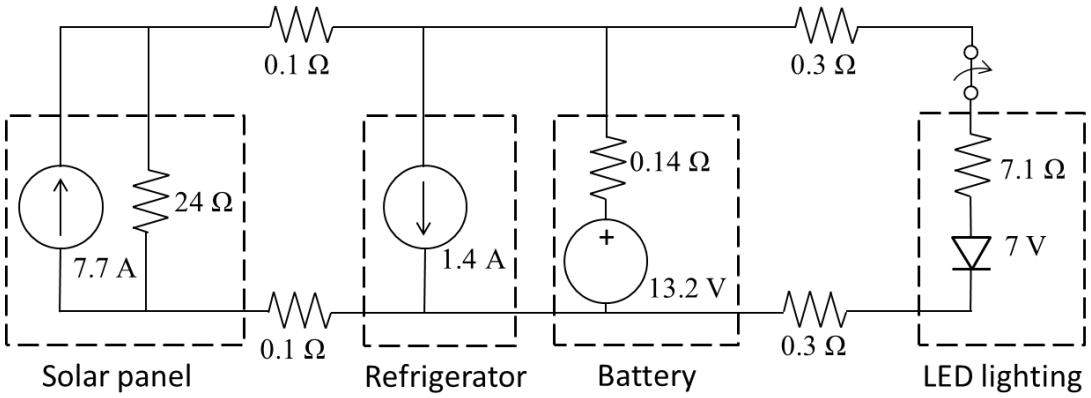
School of Electrical Engineering & Telecommunications

ELEC1111 Tutorial 2

Analysis of a solar powered caravan

In this tutorial we will analyse a solar powered caravan. The caravan has a solar panel on the roof to power an LED light on the ceiling and a refrigerator. A battery charged during the day keeps things running at night. The solar panel and LED light are mounted on the roof, while the battery and refrigerator are at ground level next to each other. Two different cables connect the solar panel and the LED light to the battery (resistances marked on the diagram).

The solar panel can be modelled as a current source with a shunt resistance in parallel, while the LED light and battery can be modelled as voltage sources with an internal resistance in series[1]. The refrigerator draws a constant current regardless of voltage (i.e. it acts as a current source).



Q1. Using nodal analysis, calculate the power balance of the system when the LED light is on (i.e. switch is closed). Calculate the power transferred from the solar panels to the refrigerator, battery, and LED light (i.e., power absorbed by each element over power supplied by the solar panel) and the efficiency[2] of the system.

Within your group, comment on the efficiency of the system.

Answer:
Check that $\sum P = 0$. If this is the case, it means your analysis is correct.
Power transferred from solar panel to refrigerator = 18%.
Power transferred from solar panel to battery = 61%.
Power transferred from solar panel to LED = 11%.
Efficiency of the system = 90%.

[1] Note: Solar panels and batteries are more complex than this but assume that they behave this way for this tutorial.

[2] Efficiency η is defined as the ratio of the total useful power consumed by a system (to perform a task) to the total power supplied to it. Efficiency is an indication of how much of the supplied power is being lost (e.g. heat dissipation by wires resistances).

Q2. During a sunny day, the solar panel delivers its rated current for 8 hours. How many Amp-hours are stored in the battery? (assume that the battery is discharged enough overnight to accept all the next day's charging).

When the sun is not shining for the other 16 hours, the solar panel produces no current, but its shunt resistance remains connected. How many Amp-hours are drawn from the battery during this time? Use mesh analysis to calculate any relevant information.

Within your group, and based on these results, discuss whether it is possible to leave the LED light turned on day and night.

Answer:
Amp-hours stored in the battery during the day = 38.16 Ah.
Amp-hours stored in the battery when sun is not shining = 42.88 Ah.

Q3. (Design question) During the day the LED light is very hot and you know this will significantly shorten its lifetime. You suggest changing the resistor in the LED light to limit the current to 0.5 A during the day. Using a circuit analysis technique of your choosing, calculate the new value of the 7.1 Ω resistor.

Answer: 13.24 Ω

Q4. (Design question) A diode can be used to improve the efficiency of the system during the night. *Within your group*, discuss where you would place the diode to achieve this.

Answer:
This is a design question which can have multiple answers. If you have a design in mind and you want to know whether it is correct out of tutorial hours, you can simulate it using Falstad (http://www.falstad.com/circuit/) or other simulator of electric circuits. Otherwise, please contact your lecturer to organise an appointment.