Name: _____

Resistive Network Design

Objective

The focus of this exercise is to review Ohm's Law and Kirchhoff's Voltage and Current Laws (KVL & KCL) and their applications to resistive circuits. This exercise also reinforces some of circuit design practices that have been covered in the lessons.

Theory Overview

Designing a circuit, in broad terms, involves applying laws of electricity to set up the proper equations to solve for design requirements. The general steps can be summarized as shown below.

1. Compile a list of design requirements
    - Design requirements, of course, vary from circuit to circuit. For one design, the requirement might be to limit certain current for a particular voltage setting (e.g. an LED circuit); and in another, the requirement might be to apply a particular voltage to an input.
    - Whatever the requirements, having a clear list of design requirements (or goals) is of vital importance. Without a good understanding of the design requirements, one might design the circuit for the wrong set of voltages and currents.
    - Compiling a list of requirements, most times, requires looking through specification sheets for the active devices to extract "device specifications". These can include
        i. Max or min input/output voltage
        ii. Max or min input/output current
        iii. Required supply voltage to turn the device on…

2. Compile a list of known values. These include values such as
    - Supply voltage
    - Component values if given as part of the design problem
    - Component power rating…

3. Determine what type of circuit (series, parallel or a combination of the two) can achieve your design requirements
    - For example, for a circuit that requires to limit the amount of current through an active device (e.g. LED), you will need a single resistor in series with your active device.

- At this point, one will draw a schematic for the candidate circuit and lists the unknown design values (resistance, current, voltage) that one needs to solve for.

4. Use the laws of electricity (Ohm's, KCL, KVL…) to set up the equations based on your requirements (e.g. amount of current) and known values (e.g. battery voltage) to solve for the unknown values (e.g. resistance)
    - Sometimes, the circuit requires a single equation to solve for the unknown values, and other times, one might need to write down a system of equations for multiple unknowns to solve.

5. Solve the equations for the unknown values
    - Usually, steps 4 & 5 are part of an iterative process where one writes one equation and solves for one value (e.g. current) and then writes another equation and solves for another value (e.g. resistance).
    - This iterative process is repeated until all unknown values have been solved for.

Next, we will work through some design examples.

Design Challenge 1

Given a battery of V_B volts and an LED, design a circuit to turn the LED on with half its maximum brightness.

Given values:
V_B = 9V
LED max turn-on voltage = V_{LED_on} = 2V
LED max current = I_{LED_max} = 100ma

Step 1) List of requirements

Step 2) List of known values

Step 3) Type of circuit to use

Step 4 & 5) Write down the equations and solve for the unknowns

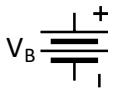
At this point, you might want to simulate your design in SPICE to make sure your design has achieved the desired requirements (goals).

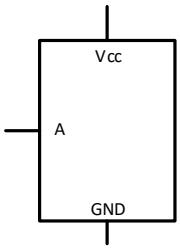
Q) What would you do differently if the design had asked to turn on two identical LEDs at the same brightness?

Design Challenge 2

Given a battery of V_B volts and an active circuit with an input A, design a circuit to apply a voltage of V_A to the input.

Given values:
V_B = 9V
V_{A_min} = 2.5V
V_{A_max} = 3.5V
Input A on current = I_{A_on} = 1ma





Step 1) List of requirements

Step 2) List of known values

Step 3) Type of circuit to use

Step 4 & 5) Write down the equations and solve for the unknowns

At this point, you might want to simulate your design in SPICE to make sure your design has achieved the desired requirements (goals).

Q) What would you do differently if I_{A_on} was 1μa instead of 1ma?

Design Challenge 3

Given a battery of V_B volts, design a circuit to determine the internal series resistance of the battery.

Given values:
$V_B = 9V$

Step 1) List of requirements

Step 2) List of known values

Step 3) Type of circuit to use

Step 4 & 5) Write down the equations and solve for the unknowns

Q) Can this circuit be simulated? If no, why not? If yes, how would you set up the simulation?