ELEC 344 - 101: Applied Electronics and Electromechanics

Instructor: Ignacio Galiano Zurbriggen

TAs:

Gabriel Ferreira (gabrielfs@ece.ubc.ca)
Jorge May (jorgemay@ece.ubc.ca)
Daniel Hsu (danielhsu@ece.ubc.ca)
Lucas Sinopoli (sinopoli@ece.ubc.ca)
Tania Mair (mairgarc@student.ubc.ca)

Assignment 1

Due February 12th, 11:59 pm.
Submit through Canvas
(Submit a typed report, include the procedure and steps followed to reach the results. Long derivations can be included in a non-typed appendix.)

1) Using the circuit in Fig. 1:
   a) Solve the circuit and find the voltage V_X.
   b) Add a capacitor of 100 μF in parallel with R3 and find the equivalent RC circuit (Thevenin).
   c) Find the expression for the capacitor voltage and calculate the time constant for charging the capacitor.
   d) Run the simulation in PSIM. Show the relevant waveforms during the capacitor charging transient.

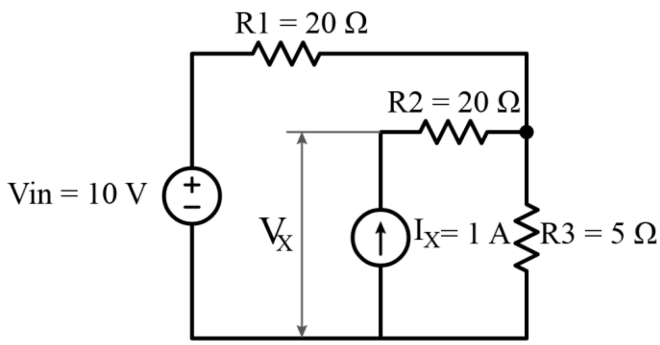

Fig. 1 – DC Circuit

2) Using the circuit in Fig. 2 with an input power supply $\boldsymbol{v_{in}} = \sqrt{\mathbf{2}}\ \mathbf{110}\,\mathbf{sin}(\boldsymbol{\omega t})$ V, and $\boldsymbol{f} = \mathbf{60}$ Hz

   a) Calculate magnitude and phase of the input current.

   b) Add a capacitor in parallel with the inductor. Calculate the value of the capacitor to obtain a 0 degree phase shift between input current and voltage.

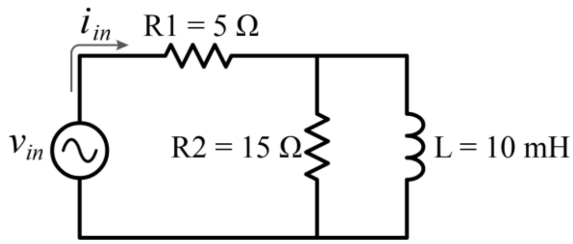

Fig. 2 – AC Circuit

3) Fig. 3 illustrates an ideal 3-Phase rectifier with the following parameters:

- $\boldsymbol{v_a} = \sqrt{\mathbf{2}}\ \mathbf{120}\,\mathbf{sin}(\boldsymbol{\omega t})$ V
- $\boldsymbol{v_b} = \sqrt{\mathbf{2}}\ \mathbf{120}\,\mathbf{sin}(\boldsymbol{\omega t} + \mathbf{120^o})$ V
- $\boldsymbol{v_b} = \sqrt{\mathbf{2}}\ \mathbf{120}\,\mathbf{sin}(\boldsymbol{\omega t} - \mathbf{120^o})$ V
- $\boldsymbol{\omega} = \mathbf{2}\boldsymbol{\pi f}; \boldsymbol{f} = \mathbf{60}$ Hz
- $\boldsymbol{R} = \mathbf{10\Omega}$

   a) Calculate the amplitude of the output voltage and current.

   b) Simulate the circuit in Fig. 2 using PSIM and plot the output voltage, output current and the current in each diode.

   c) Explain what you observe from the waveforms. What diodes are conducting at each portion of time? What is the conduction angle for the diodes? Explain why.

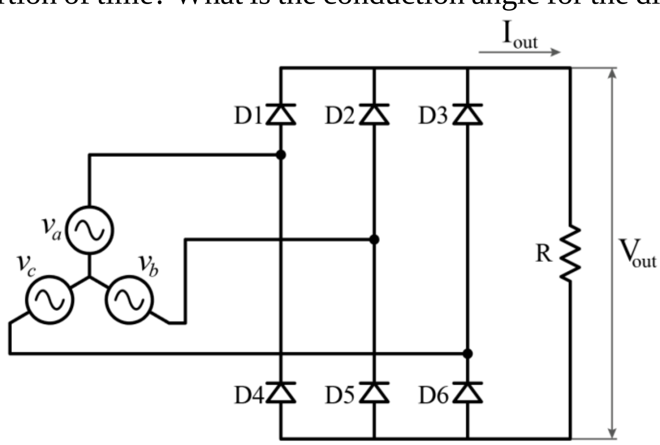

Fig 3 - Three Phase Rectifier

4) The circuit shown in Fig. 4 is often used to control the brightness of Light Emitting Diodes (LEDs) by using PWM modulation using a digital microcontroller. An LED works as a rectifier diode, and the LED brightness is proportional to the average current that passes through the diode (i_D).

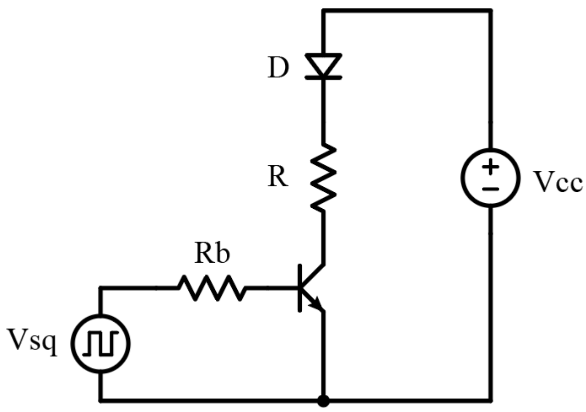

Fig 4 – LED driver circuit

LED (D):

$i_{D(max)} = 200mA$

$V_F = 2V$

$R_D = 1\Omega$

Transistor:

$v_{CE(sat)} = 2V$

$v_{BE(sat)} = 0.7V$

$i_b \geq \frac{i_c}{100}$

$R_C = 0.1\Omega$

Vsq is a square waveform (digital microcontroller output) that alternates between 0V and 5V, at a frequency of 1kHz. The proportion of time in which Vsq stays high can be adjusted to change the brightness.

a) For $Vcc = 5V$, calculate:
- The value of the resistor R necessary to achieve full brightness when the transistor stays ON continuously
- The maximum value of the resistor Rb that enables such condition
- The average diode power (P_D), resistor power (P_R), transistor power (P_T), and the source power (P_{Vcc}) for a brightness of 50%.

b) Repeat all calculations performed in a), in this case for $V_{cc} = 12V$