Assignment-2

Rectifiers

1. The input of a full-wave rectifier is a cosine voltage with peak V_M = 5 V and frequency 60 Hz, and output load resistance is R = 2 kΩ. Silicon diodes are used in this circuit for which the forward drop is V_{D0} = 0.7 V.

   (a) Briefly explain the purpose of a rectifier and describe its operation. [1]
   (b) Show the input and output waveforms. [2]
   (c) Calculate the DC value of the output voltage. [1]
   Now after connecting a capacitor in parallel with the load, the output becomes a ripple voltage **Vout =** V_{DC} **±0.2 V**
   (d) Calculate the **peak-to-peak ripple voltage**, and from that, the value of the capacitor. [2]
   (e) Calculate the average of the output voltage V_{DC} after connecting the capacitor. Compare this with the DC value determined in 'c' and comment on the difference between these two. [2]

2. The input of a **Half-wave rectifie**r is a sine voltage with peak VM = 10 V and frequency 55 Hz, and output load resistance is R = 2.5 kΩ. Silicon diodes are used in this circuit for which the forward drop is V_{D0} = 0.4 V.

   (a) Calculate the DC value of the output voltage. [1]
   Now after connecting a capacitor in parallel with the load, the output becomes a ripple voltage **Vout =** V_{DC} **±0.3 V.**
   (b) Calculate the **peak-to-peak ripple voltage**, and from that, the value of the capacitor. [2]
   (c) Draw the **Voltage Transfer Characteristic (VTC) curve [2]**

3. The input of a full-wave rectifier is expressed by, Vs(t)= 7sin(400πt), and output load resistance is R = 5 kΩ. Silicon diodes are used in this circuit for which the forward drop is V_{D0} = 0.3 V.

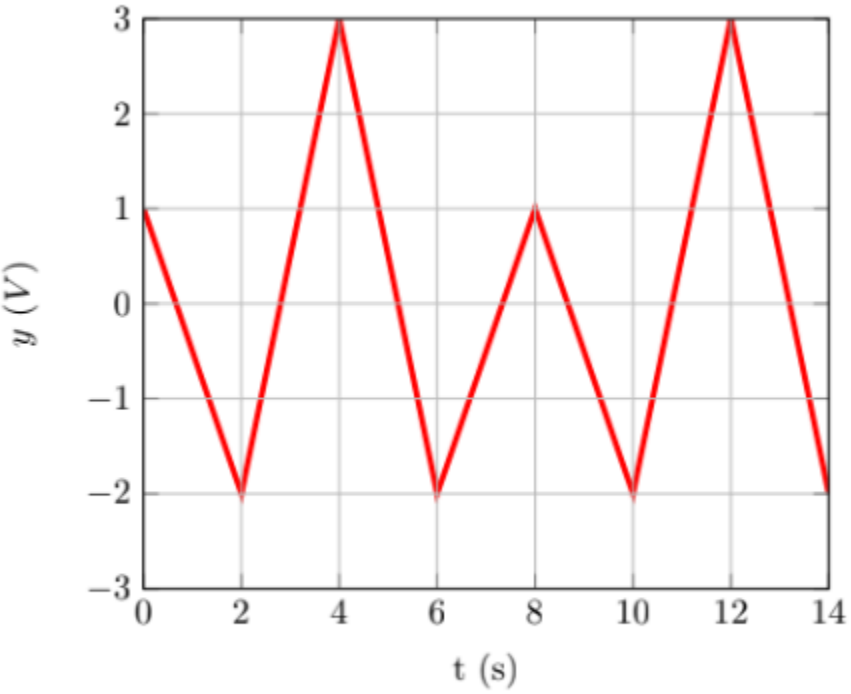
   (a) Calculate the input and output wave frequency. [2]
   (b) Show the input and output waveforms.

   Now after connecting a capacitor, C= 100 μF in parallel with the load.
   (c) Calculate the peak-to-peak ripple voltage,
   (d) How can you provide better filtering for the output waves?
   (e) What is the frequency of the Ripple voltage?

4. The input of a **Half-wave rectifier** is a **Square** wave voltage with peak V_M= 15 V and frequency 0.5 Hz, and output load resistance is R = 5 kΩ. Silicon diodes are used in this circuit for which the forward drop is V_{D0} = 0.7 V.
   i. Show the input and output waveforms. [4]
   ii. Draw the VTC curve [2]

5. The input of a **full-wave rectifier** is a **Square** wave voltage with peak V_M= 15 V and frequency 0.5 Hz, and output load resistance is R = 5 kΩ. Silicon diodes are used in this circuit for which the forward drop is V_{D0} = 0.7 V.
   i. Show the input and output waveforms. [4]

ii. Draw the VTC curve [2]



(b) Input of the FW rectifier

6.

Part 2: A voltage waveform $V_i = 15\sin(2000\pi t)$ V is fed into a Half-wave rectifier with a load resistance $R = 5$ kΩ. Silicon diodes are used in this circuit for which the forward drop is $V_{D_0} = 0.7$ V.

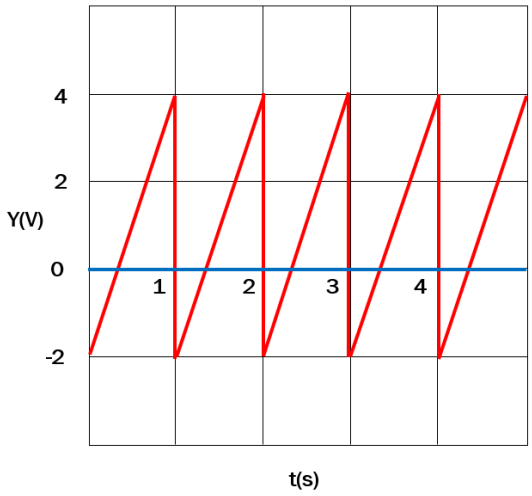
(a) **Illustrate** the input and output waveforms in separate graphs. Label the graph and **indicate** the voltage levels properly. [2]

(b) **Calculate** the DC/Average value of the output. [1]

(c) A capacitor is now added to reduce the fluctuation of the output voltage, which makes the peak to peak ripple voltage **4%** of the maximum output voltage V_P. **Deduce** is the value of the capacitor from the given data.[2]

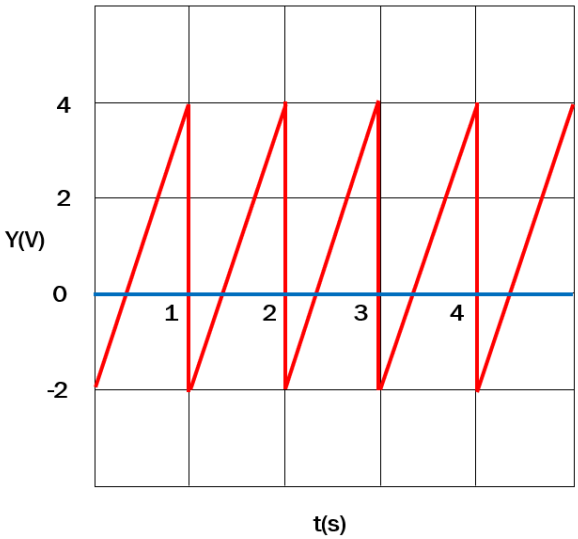
(d) The input of a Full-wave rectifier is shown in Figure 1(b) above and output load resistance is $R = 10$ kΩ. Germanium diodes are used in this circuit for which the forward drop is $V_{D_0} = 0.3$ V. **Show** the input and output waveforms [1]

7.



The input of a **Half-wave rectifier** is exhibited in the Figure above and output load resistance is R = 5 kΩ. Silicon diodes are used in this circuit for which the forward drop is V_{D0} = 0.7 V.

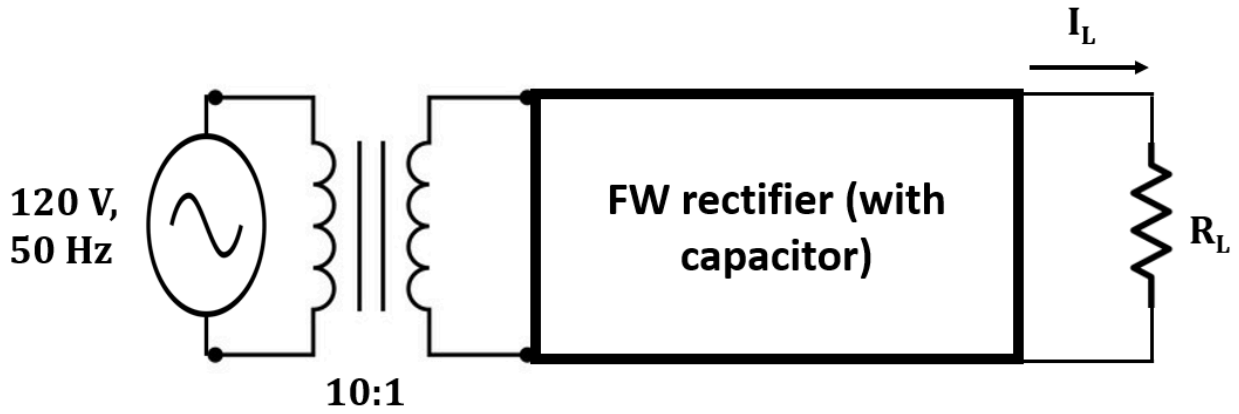
i. Show the input and output waveforms. [3]
ii. Draw the VTC curve [2]
Iii. Calculate input and output frequency [3]



8. The input of a **full-wave rectifier** is exhibited in the Figure above and output load resistance is R = 5 kΩ. Silicon diodes are used in this circuit for which the forward drop is V_{D0} = 0.7 V.

   i. Show the input and output waveforms. [3]
   ii. Draw the VTC curve [2]
   Iii. Calculate input and output frequency [3]

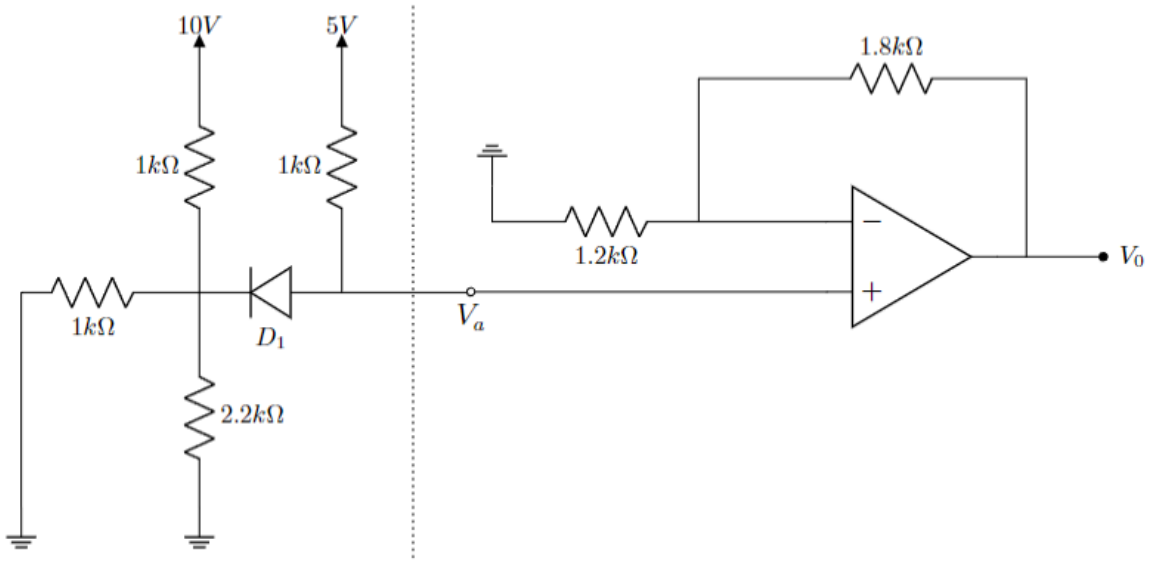
9. A full-wave rectifier is designed to deliver a maximum current I_L = 120 mA to the load. The rectifier produces an output with a ripple of 5% of the peak output voltage. An input line voltage of 120 V (peak), 50 Hz is available. A 10:1 step-down transformer is used to transform the supply voltage to 12 V (peak).



(a) **Draw** the Voltage Transfer Characteristics of the full-wave rectifier. [2]
(b) **Calculate** the peak output voltage. [1]
(c) **Determine** the value of the Load Resistor to deliver a maximum load current of 120mA. [2]
(d) **Deduce** the value of the Capacitor and the DC average value. [1]
(e) Assume the transformer is removed and the rectifier is directly connected to the AC power supply line. **Discuss** the state of the diodes. [Hint: use the Peak Input Value of the rectifier input] [3]

Hybrid Problems

1.



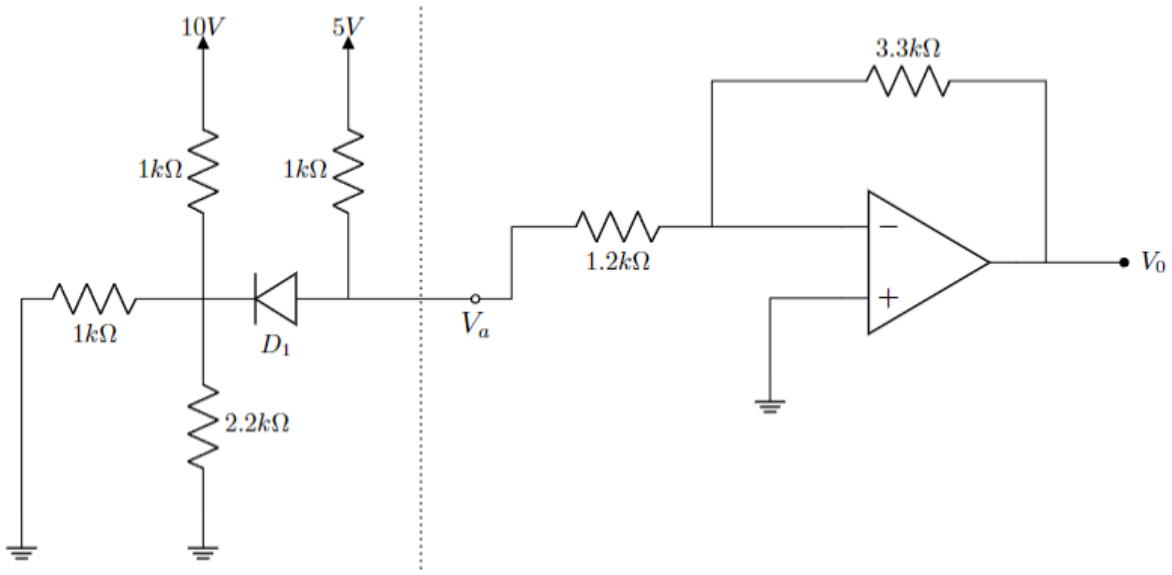
The saturation voltages of the Op-Amp are given as- $V_{sat}^{+} = +\ 10V$ and $V_{sat}^{-} = -\ 10V$. The forward voltage drop of the diode, V_D is $0.7V$.

(a) **Determine** the operating mode diode, D_1. Verify your assumption with necessary calculations.

(b) **Calculate** the voltage at - (i) node 'Va', (ii) non-inverting terminal of the Op-Amp, (iii) inverting terminal of the Op-Amp.

(c) Find out the output voltage, Vo of the Op-Amp.

2.



The saturation voltages of the Op-Amp are given as- $V_{sat}^{+} = +\ 10V$ and $V_{sat}^{-} = -\ 10V$. The forward voltage drop of the diode, V_D is $0.7V$.

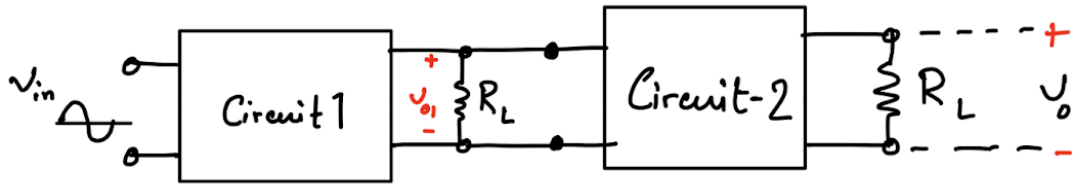
(a) **Determine** the operating mode diode, D_1. Verify your assumption with necessary calculations.

(b) **Calculate** the voltage at - (i) node 'Va', (ii) non-inverting terminal of the Op-Amp, (iii) inverting terminal of the Op-Amp.

(c) Find out the output voltage, Vo of the Op-Amp.

3.

You are provided with the diagram below as a starting point for designing an AC to DC converter. Input voltage source is an sinusoidal voltage source (V_{in}), with 2V peak to peak voltage (i.e. 1 V amplitude) and the DC voltage is around 10 V (with ripple) at the output terminals (v_o).



So, in order to solve this problem, you are provided with a single diode (with $V_{D0} = 0.7$ V), two resistors (R_1 and R_2, excluding the load resistors R_L) and an UA741 op-amp.

(a) Design **circuit-1** with the single diode and $R_L = 10\ k\Omega$ (R_L is already provided in the diagram as output terminals of **circuit-1**) to get a rectified voltage and determine the DC value of the output voltage (v_{o1}) of the circuit. [1+2]

(b) Determine the ripple voltage of v_{o1}. [Ripple voltage is defined as the difference between the maximum and minimum value of a DC voltage.] [2]

(c) What should be the value of a capacitor used at the output end of **circuit-1** with R_L to reduce the ripple voltage of v_{o1} to 1 V. How should the capacitor be connected with R_L in the diagram? [4+1]

(d) Design an amplifier using an operational amplifier as **circuit-2** to increase the DC voltage level of the output voltage of the circuit designed in (c) to 10 V. Find the ripple voltage of the amplified voltage signal. [4+1]