FALL - 2024

1)

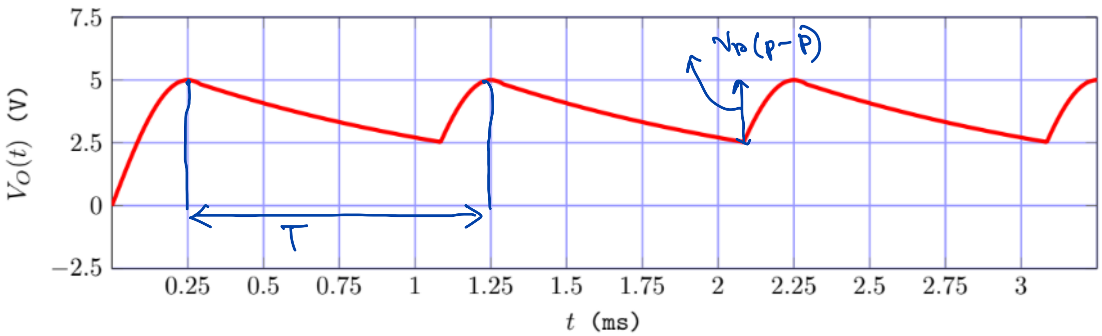


Figure-3

[2 marks] In *Figure-3*, you are given the output voltage waveform of an unknown rectifier circuit with an output load resistance, $R = 5k\Omega$, input frequency, $f_{in} = 0.5kHz$, and $V_{D0} = 0.55$V. **Analyze** the waveform in *Figure-3*, and **determine** the output voltage frequency, f_{out} and **draw** the rectifier circuit with proper labels.

Here, time period of the output voltage $T = 1.25 - 0.25 = 1$ ms

So, output voltage freq, $f_p = 1/T = 1kHz = f_{out}$

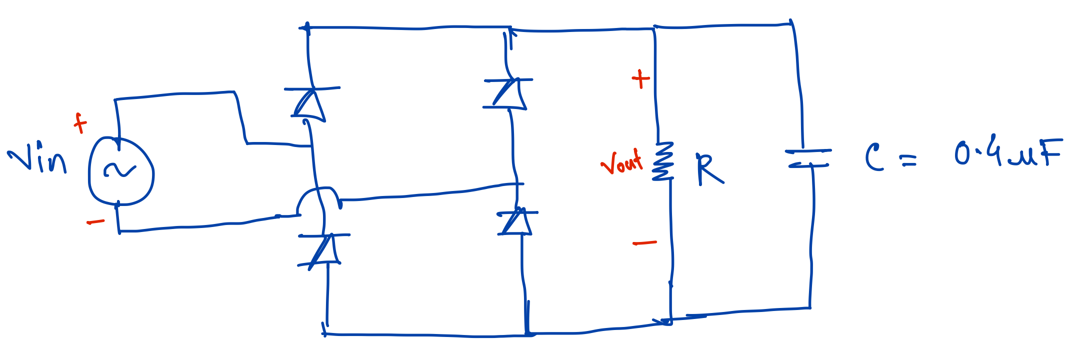
Given, input frequency, $f_{in} = 0.5kHz$; So, $\boxed{f_p = 2f_{in}}$

This is Full-wave Rectifier. If, $f_p = f_{in}$, $\boxed{\text{then Half-wave}}$

Given, $V_r(p-p) = 5 - 2.5 = 2.5V$

O/P peak, $V_p = 5V$ and $R = 5k\Omega$.

So, $V_r(p-p) = \dfrac{V_p}{f_p RC}$ or, $C = \dfrac{V_p}{f_p \, R \, V_r(p-p)} = 0.4 \mu F$



2) Analyze the circuit in Figure-4, and draw the output voltage waveform for Vin = 6sin(100πt) V

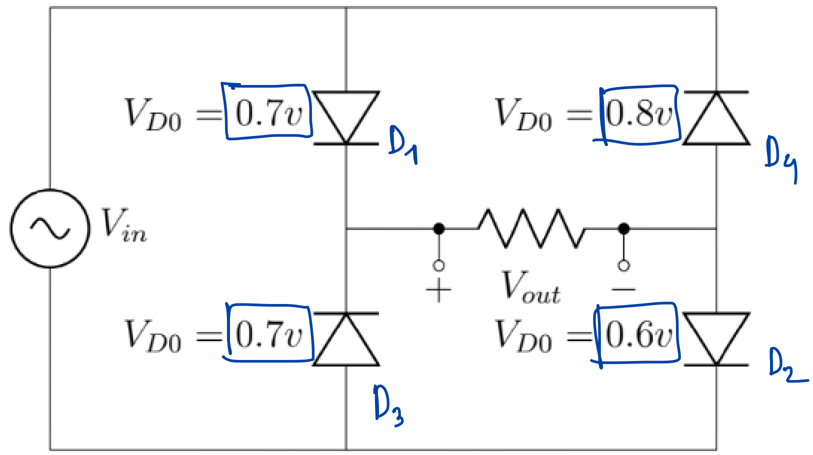
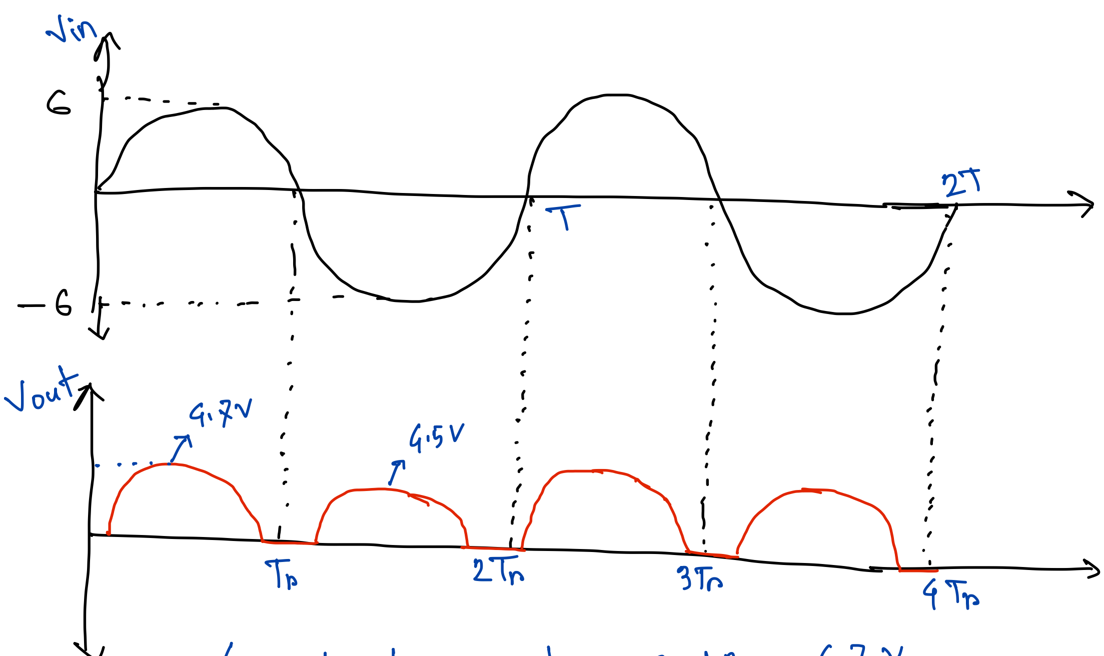


Figure-4

In the positive half cycle, D_1 and D_2 operates. D_3 and D_4 are off. So, Diode voltage drop $= (0.7 + 0.6)$
$= 1.3V$

Similarly, in the (−) half cycle, D_3 and D_4 operates, other two off. So, diode voltage drop in (−) half cycle $= (0.7 + 0.8) = 1.5V$.



O/P peak at (+) cycle $= 6 - 1.3 = 4.7V$

O/P peak at (−) cycle $= 6 - 1.5 = 4.5V$

3) Shadman has access to a sinusoidal voltage source of Vin = 12sin(500πt) V, and he needs a DC voltage source to run a DC motor. The DC motor requires a very good quality DC voltage source to run. While building a rectifier, Shadman realized that, to make the DC motor run smoothly, the ripple voltage of the rectifier should not exceed 3% of the peak input voltage. The DC motor has an internal resistance, $R_{DCmotor}$ = 50Ω. It is connected in series with a resistance, RS, to run smoothly, giving a total output load resistance, R = (R_S + 50) Ω for the rectifier circuit as shown in Figure 5. Additionally, Shadman is building the rectifier circuit with VD_0 = 0.7V. Analyze the diagram in Figure 5, and help Shadman design the rectifier circuit and determine the appropriate values of the rectifier components. Assume any value if necessary. Now, draw the designed circuit.

Very good quality DC = $\boxed{\text{Full wave}}$

I/P peak, $V_M = 12\text{ V}$

I/P freq, $f_{in} = 250\text{ Hz}$

For full wave, output ripple freq, $f_r = 2f_{in} = 500\text{ Hz}$.

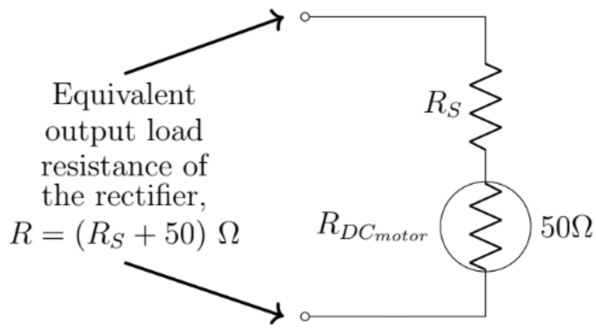


Figure-5

Given condition, $V_{r(p-p)} \leq 3\%$ of V_M

$\leq 12 \times 0.03$

$\leq 0.36\text{V}$

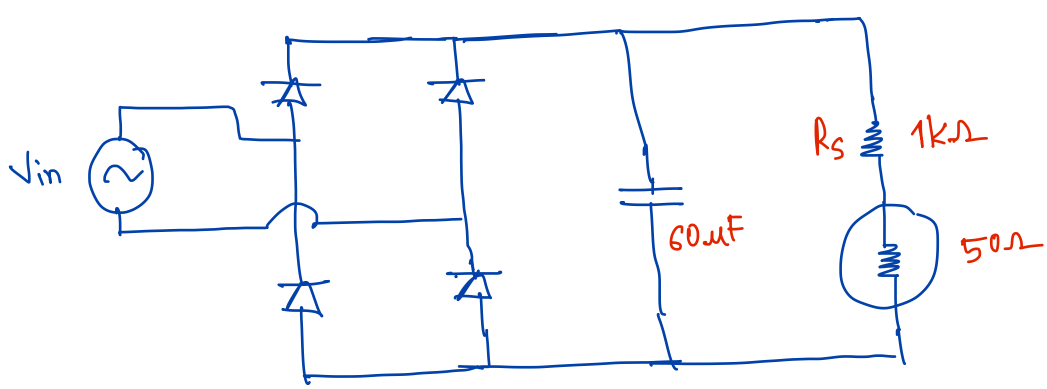
For full wave, o/p peak, $V_p = V_M - 2V_{D0} = 12 - 2 \times 0.7 = 10.6\text{ V}$

For full wave, $V_{r(p-p)} = \dfrac{V_p}{f_r RC} \leq 0.36$ or, $RC \geq \dfrac{V_p}{0.36 f_r}$

or, $RC \geq \dfrac{10.6}{0.36 \times 500} = 0.05889$.

Assuming $R_S = 1\text{k}\Omega$, $R = R_s + 50 = 1050\ \Omega$

So, $C \geq \dfrac{0.05889}{1050}$ or, $C \geq 56\ \mu\text{F}$; Let $C = 60\ \mu\text{F}$



FALL - 2022

A voltage waveform vi = 8 sin(100πt) V is is fed into a rectifier with a load resistance R = 10 kΩ. Silicon diodes are used in this circuit, for which the forward drop is VD_0 = 0.8 V. The output frequency of the rectifier is 100 Hz.

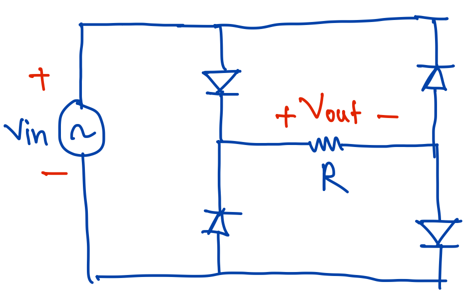
(a) Identify the type of rectifier used (full-wave or half-wave). Give proper reasoning.
(b) Show the circuit with proper input and output labels.
(c) Illustrate the input and output waveforms in separate graphs. Label the graph and indicate the voltage levels properly.
(d) Calculate the DC value of the output.

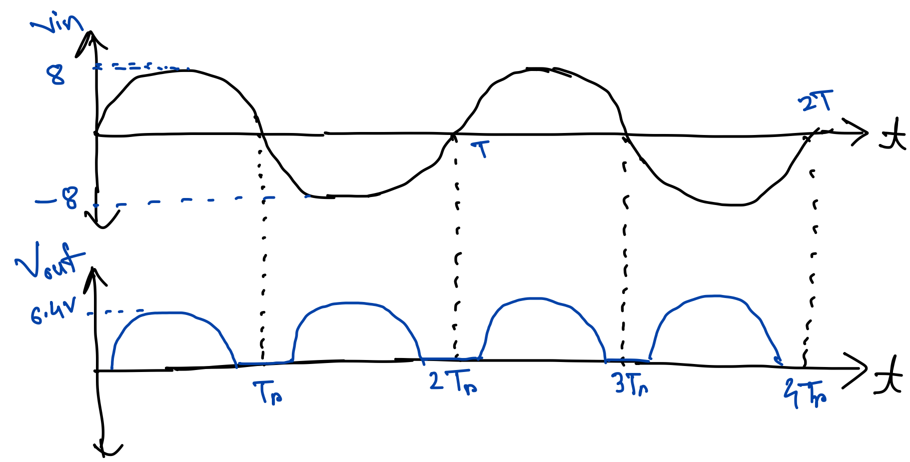
A capacitor is now added to reduce the fluctuation of the output voltage, which makes the peak-to-peak ripple voltage 5% of the maximum output voltage V_P..

(e) Deduce the value of the capacitor from the given data.
(f) Calculate the DC value of the output after adding the capacitor and compare the result with that found in part (d).

Input freq $f_{in} = 50\text{Hz}$; output freq $f_r = 100\text{Hz} = 2f_{in}$

So, full-wave Rectifier. Because, output freq doubled.





O/P peak, $V_p = V_M - 2V_{D0}$
$= 8 - 2\times 0.8$
$= 6.4\text{V}$

O/P DC Value, $V_{DC} = \frac{2}{\pi}V_M - 2V_{D0} = \frac{2}{\pi}\times 8 - 2\times 0.8 = 3.5\text{V}$

$V_r(p-p) = 5\%$ of $V_p = 6.4\times 0.05 = 0.32\text{V}$

We know, $V_r(p-p) = \frac{V_p}{f_r RC}$ or, $C = \frac{V_p}{V_r(p-p)\, f_r R} = 20\mu F$

DC value after adding capacitor $= V_p - \frac{V_r(p-p)}{2} = 6.24\text{V}$

$\boxed{\text{DC value improved}}$.

SUMMER - 2022

The input of a half-wave rectifier is a sinusoidal voltage with peak VM = 10 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 $VD_0 = 0.7$ V.

(a) Briefly explain the purpose of a rectifier and describe its operation.

(b) Show the input and output waveforms.

(c) Calculate the DC value of the output voltage.

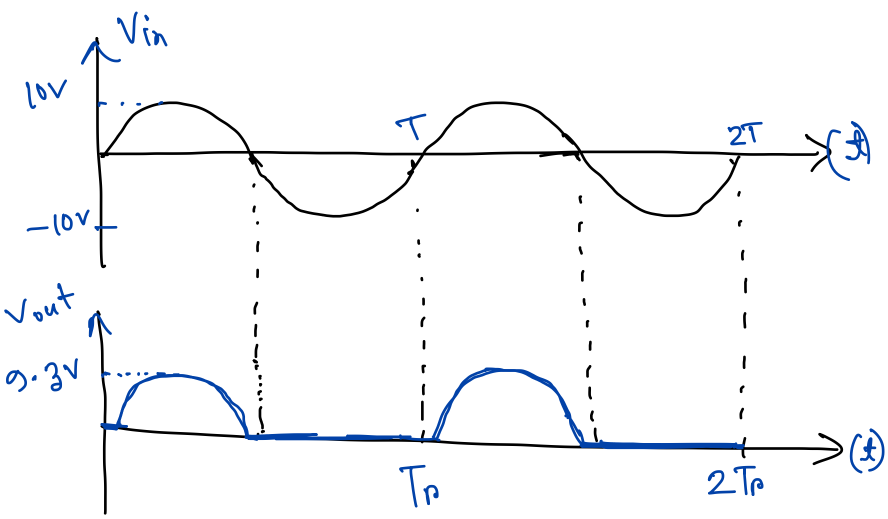
Now, after connecting a capacitor in parallel with the load, the output becomes a ripple voltage Vout = V_{DC} ±0.2 V.

(d) Calculate the peak-to-peak ripple voltage, and from that, the value of the capacitor.

(e) Calculate the average of the output voltage V_{DC} after connecting the capacitor.

Purpose of Rectifier = To produce DC signal from AC

Operation describe with circuit diagram [self]



O/P peak, $V_p = V_M - V_{D0}$

$= 10 - 0.7$

$= 9.3V$

O/P DC, $V_{DC} = \frac{V_M}{\pi} - \frac{V_{D0}}{2}$

$= \frac{10}{\pi} - \frac{0.7}{2}$

$= 2.833V$

Given, $V_{r(p-p)} = (V_{DC} + 0.2) - (V_{DC} - 0.2) = 0.4V$

Now, $V_{r(p-p)} = \frac{V_p}{f_r RC}$ or, $C = \frac{V_p}{f_r R V_{r(p-p)}} = \frac{9.3}{60 \times 2K \times 0.4} = 193 \mu F$

After connecting capacitor, $V_{DC} = V_p - \frac{V_{r(p-p)}}{2} = 9.3 - \frac{0.4}{2}$

$= 9.1$ V

SPRING-2023

A voltage waveform $v_i = 10\sin(1000\pi t)$ V is fed into a full-wave (FW) rectifier with a load resistance $R = 10$ kΩ. A capacitor is also connected in parallel with the load to reduce the fluctuation of the output voltage. It produces a peak-to-peak ripple voltage which is **3%** of the peak output voltage. The diodes have a forward voltage drop of $V_{D_0} = 0.8$ V.

(d) **Deduce** the peak output voltage, V_p, and the peak-to-peak ripple voltage, $v_{r(p-p)}$. [2]

(e) **Calculate** the average (DC) value of the output voltage. [1]

(f) **Estimate** the value of the capacitor from the given data. [2]

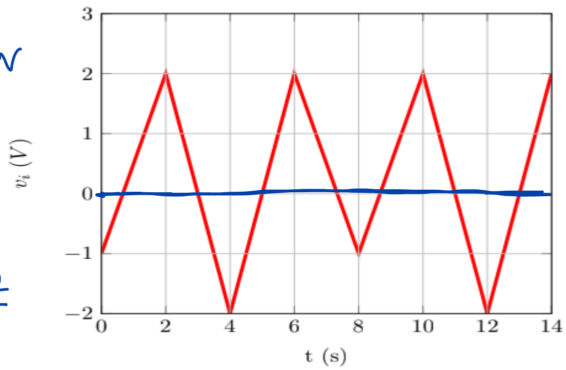
Now the input voltage v_i is changed to the one shown in Figure (ii) and the **capacitor is removed**.

(g) **Show** the output waveform and **indicate** the voltage levels properly. [2]

$$V_p = V_M - 2V_{D0} = 10 - 2\times 0.8 = 8.4V$$

$$V_{r(p-p)} = 3\% \text{ of } V_p = 0.03 \times 8.4 = 0.252\ V$$

$$V_{DC} = V_p - \frac{V_{r(p-p)}}{2} = 8.4 - \frac{0.252}{2} = 8.274V$$



(ii) Input of the FW rectifier

We know, $V_{r(p-p)} = \dfrac{V_p}{f_p R C}$

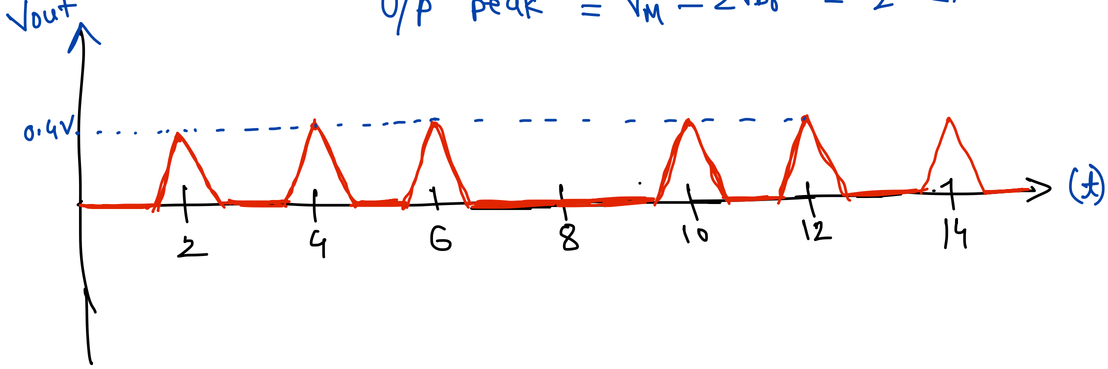
For full-wave, $f_p = 2\times f_{in} = 2\times 500 = 1000$ Hz

So, $C = \dfrac{V_p}{V_{r(p-p)} f_p R} = \dfrac{8.4}{0.252\times 1000 \times 10K} = 3.33\,\mu F.$

The output waveform: Positive parts → $2V_{D_0}$ less

Negative parts → positive → $2V_{D0}$ less.

O/p peak $= V_M - 2V_{D_0} = 2 - 2\times 0.8 = 0.4V$



SUMMER - 2023

A voltage waveform, vi = 5sin(200πt) V, is fed into a Full-wave rectifier with a load resistor, R = 5 kΩ. Silicon diodes are used in this circuit where VD_0 = 0.6 V.

(a) Draw the rectifier circuit. Label the input and output voltages properly. Briefly explain the application of the circuit.

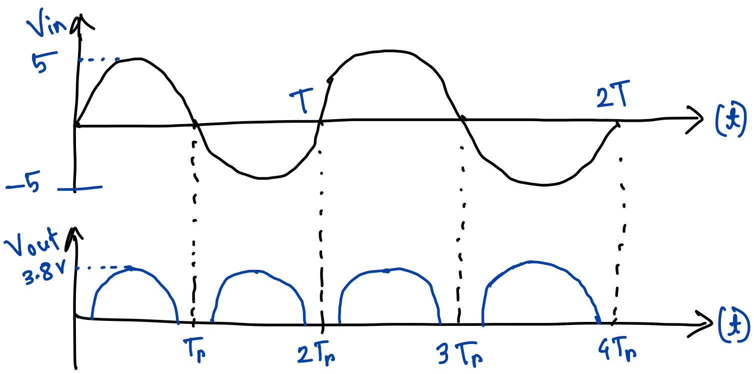
(b) Calculate the DC value of the output voltage, V_{dc} and the output frequency, f_o.

(c) Draw the Voltage Transfer Characteristics (VTC) of the Full-wave rectifier and label it properly.

(d) Now, you have to connect a capacitor in parallel with the load resistor. You have two capacitors of 5 μF and 1 μF at your disposal. Which capacitor will you use? Explain briefly with necessary calculations.

(e) [Bonus] A different input waveform is fed into the Full-wave rectifier. The new peak-to-peak ripple voltage is 50% of the previous one calculated from (d) with the 5 μF capacitor. The new output frequency is 300 Hz. Determine the equation of the input waveform.

Draw full wave rectifier [see previous answers]



O/P peak, $V_p = V_M - 2V_{D0}$

$= 5 - 2\times 0.6$

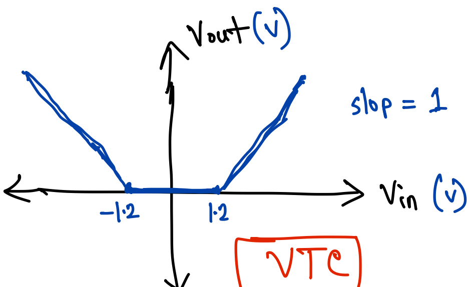
$= 3.8\,V$

O/P DC, $V_{DC} = \frac{2}{\pi}V_M - 2V_{D0}$

$= 1.983\,V$

O/P freq, $f_r = 2f_{in} = 2\times 100$

$= 200\,Hz$



if 1μF used, $V_{r(p-p)} = \frac{3.8}{200\times 5k\times 1\mu} = 3.8\,V$

if 5μF used, $V_{r(p-p)} = \frac{3.8}{200\times 5k\times 5\mu} = 0.76\,V$

Less ripple for 5μF,

I will use 5μF.

New, $V_{r(p-p)} = 0.5\times 0.76$ [5μF]

$= 0.38\,V$

So, $V_p = V_{r(p-p)}\, f_r RC$

$= 0.38\times 300\times 5k\times 5\mu$

$= 2.85\,V$

$V_M = V_p + 2V_{D0} = 4.05\,V$

$f_{in} = f_r/2 = 150\,Hz$

So, input wave; $\omega = 2\pi f_{in} = 300\pi$

$\boxed{V_{in} = 4.05\sin(300\pi t)\ V}$

SPRING-2024

The input voltage of a half-wave rectifier is a **Sine** wave with amplitude $V_M = 10$ V and 40 Hz frequency. The output load resistance is $R = 50\ \text{k}\Omega$. A silicon diode is used in this circuit whose forward voltage drop is $V_{D_0} = 0.6$ V.

(a) [**4 marks**] Briefly **explain** the purpose of a rectifier. **Draw** the input and output waveforms of the mentioned rectifier with proper labeling. **Draw** the Voltage Transfer Characteristic (VTC) curve of the rectifier.

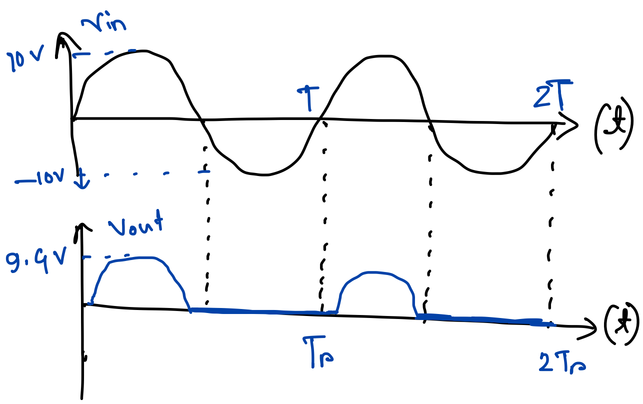
(b) [**1 mark**] **Calculate** the DC value of the output voltage, V_{DC}.

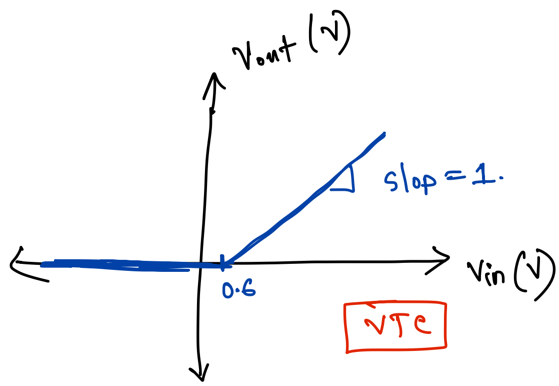
(c) [**3 marks**] After connecting a capacitor parallel to the load, V_{DC} changes to $V_{DC(Cap)}$ and the new output voltage can be expressed as $V_{out} = V_{DC(Cap)} \pm 0.5$ V. **Calculate** the peak-to-peak ripple voltage $V_{r(p-p)}$, and **determine** the ripple frequency, f_r. Now, **calculate** the value of the capacitor, C.

(d) [**1 mark**] **Calculate** the DC value of the output voltage after connecting the capacitor, $V_{DC(Cap)}$.

(e) [**1 mark**] **Compare** $V_{DC(Cap)}$ with V_{DC} determined in part-(b) and briefly **explain** their difference.

O/P peak, $V_p = V_M - V_{D0} = 10 - 0.6 = 9.4$ V





$$V_{DC} = \frac{V_M}{\pi} - \frac{V_{D0}}{2} = 2.883\ \text{V}$$

According to new output after connecting capacitor

$V_{r(p-p)} = 0.5 \times 2 = 1$ V

O/P $f_r = 2 f_{in} = 2 \times 40 = 80$ Hz.

$$V_{r(p-p)} = \frac{V_p}{f_r R C} \quad \text{or,} \quad C = \frac{V_p}{V_{r(p-p)} f_r R} = \frac{9.4}{1 \times 80 \times 50\text{K}} = 2.35\ \mu\text{F}$$

After connecting capacitor, $V_{DC(cap)} = V_p - \dfrac{V_{r(p-p)}}{2} = 9.4 - \dfrac{1}{2} = 8.9$ V

V_{DC} significantly improved after connecting a capacitor.