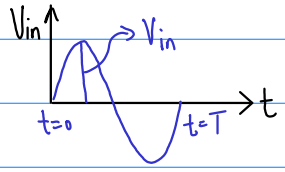
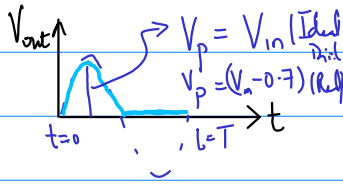
28.01.2022

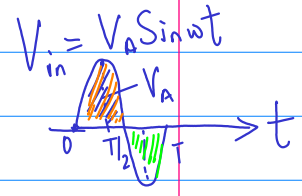
Rectifier and Filter Circuits

Recap: Half-wave rectifier circuit

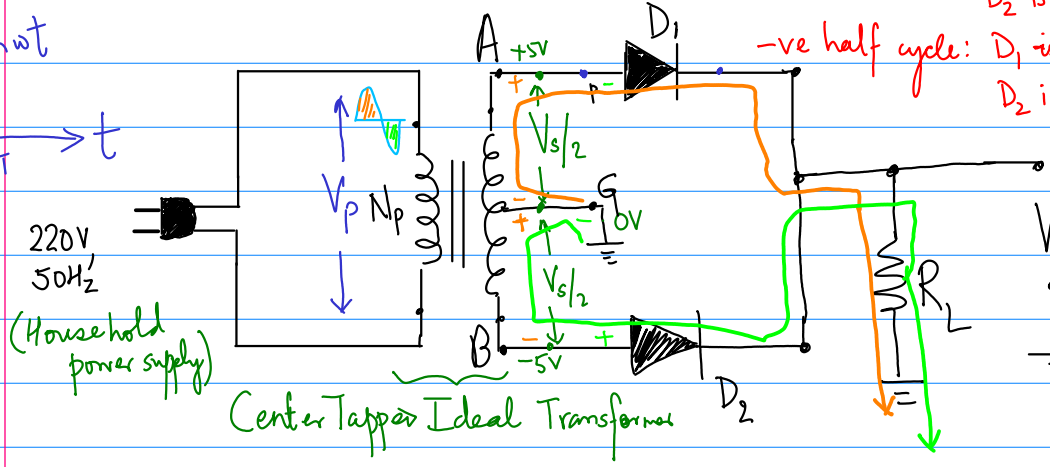


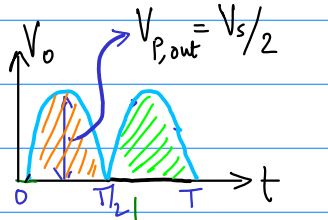


Full wave rectifier circuit:



220V 50Hz (Household power supply)





Observe in Scope / simulator

$$V_{p,out} = V_s/2 \quad ; \quad V_{ave.} = \frac{2V_{p,out}}{\pi} = \frac{2 \cdot V_s/2}{\pi}$$

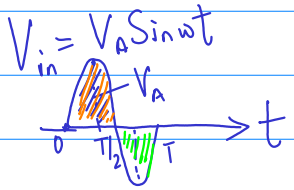
Ideal Diodes

For practical diode;

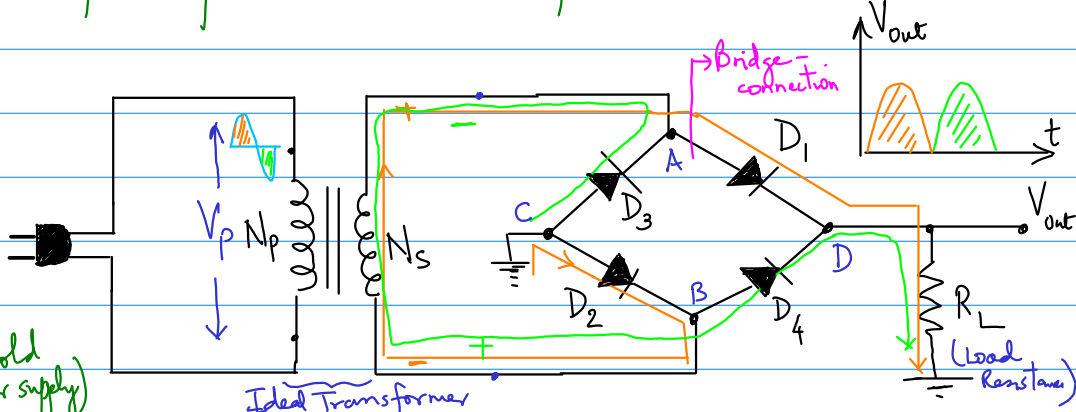
$$V_{p,out} = \left(\frac{V_s}{2} - 0.7V\right)$$

$$\Rightarrow V_{ave.} = \frac{2V_{p,out}}{\pi} = \frac{2}{\pi}\left(\frac{V_s}{2} - 0.7V\right)$$

Alternate circuit for full-wave rectifier:



220V 50Hz (Household power supply)



for +ve half cycle: D_1 & D_2 – ON ; D_3, & D_4 – OFF

for -ve half cycle: D_3 & D_4 – ON ; D_1 & D_2 – OFF

As a result, we observed time-varying output voltage across the R_L.

$$V_S = n V_p = n V_A$$

$$V_{out} = V_S \quad \text{(Considering diodes to be Ideal)}$$

$$V_{ave.} = \frac{2 V_{out}}{\pi}$$

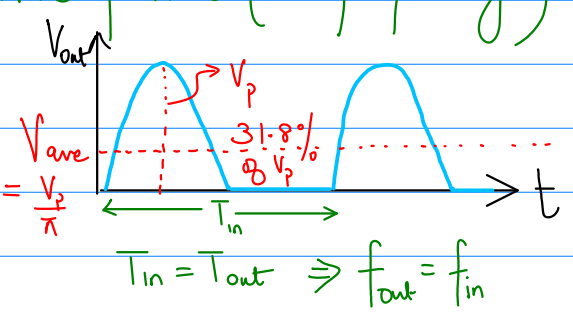
For practical circuit:

$$\boxed{V_{out} = V_S - 1.4\,V}$$

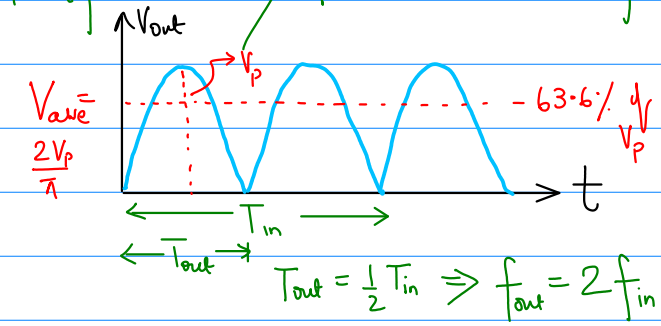
Since two diodes are replaced with two voltage sources of 0.7V each.

$$\boxed{V_{ave} = \frac{2}{\pi}\left(V_S - 1.4\,V\right)}$$

Time-period (or frequency) of Half-wave / Full-wave rectifier



$T_{in} = T_{out} \Rightarrow f_{out} = f_{in}$



$T_{out} = \frac{1}{2} T_{in} \Rightarrow f_{out} = 2 f_{in}$

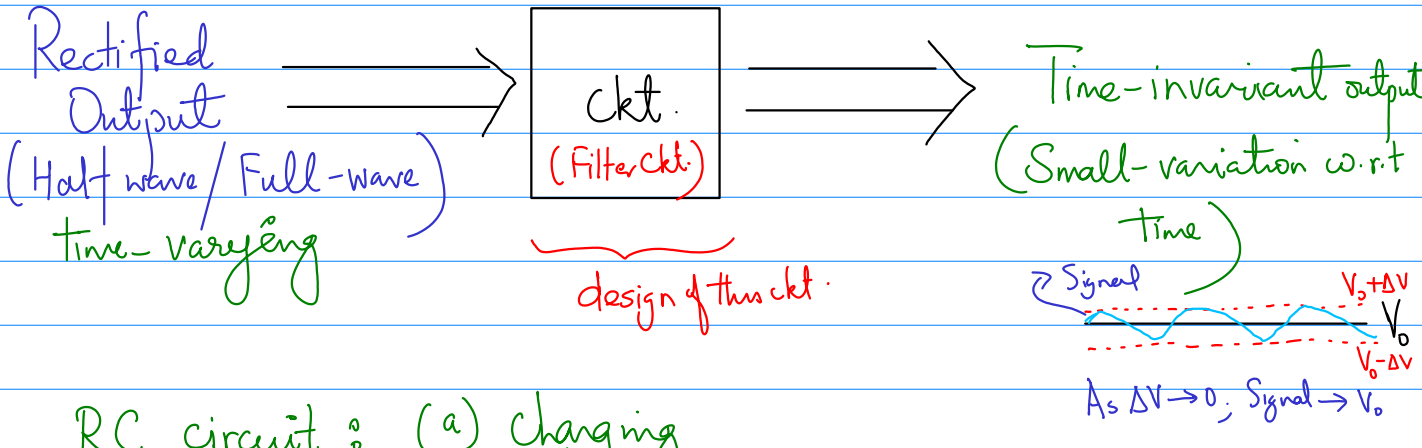
- For half-wave rectifier: Time-period of output voltage is same as

input voltage. That is, if input frequency is 50 Hz then output frequency is also 50 Hz.

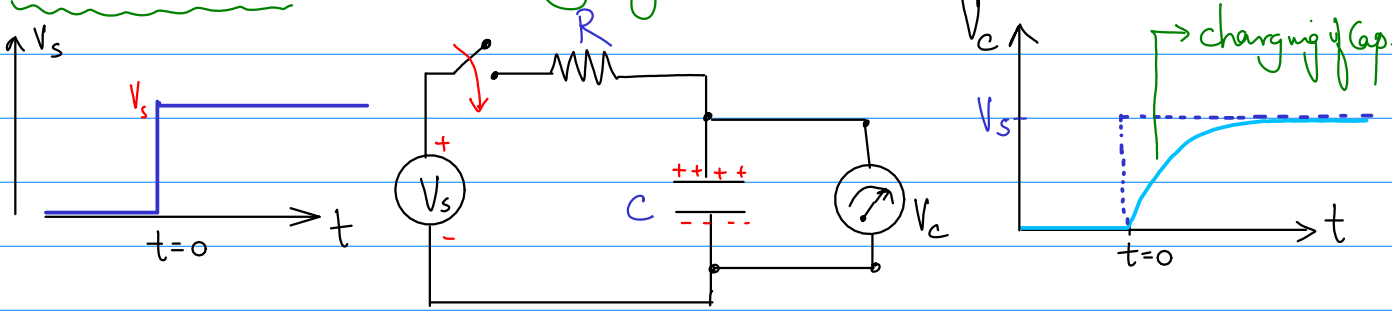
- For full-wave rectifier, the time-period of output voltage is half of the input voltage. That is, the frequency of output voltage will be 100 Hz for 50 Hz input frequency.

Remember: Output of the rectifier ckt. is time-varying

⇒ To get time-invariant output, we need another circuit
→ Filter circuit:



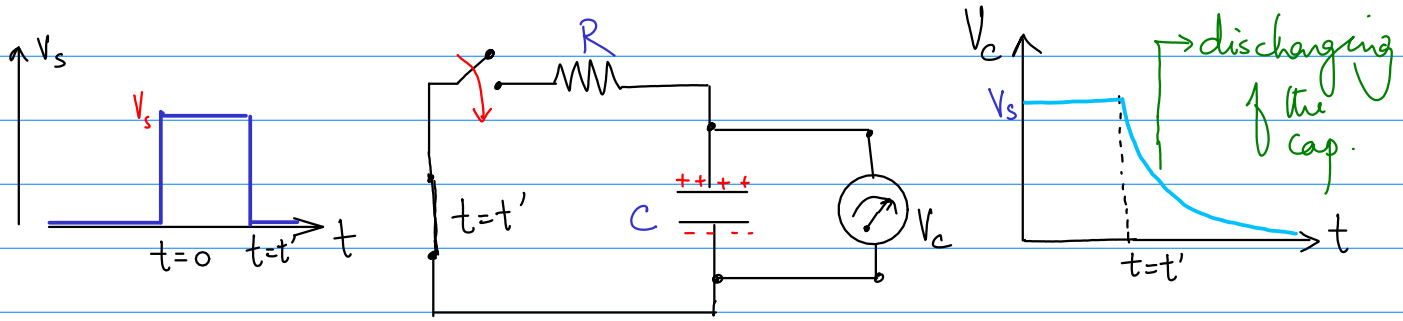
RC circuit: (a) charging



$$V_c(t) = V_s\left(1 - e^{-t/\tau}\right)$$

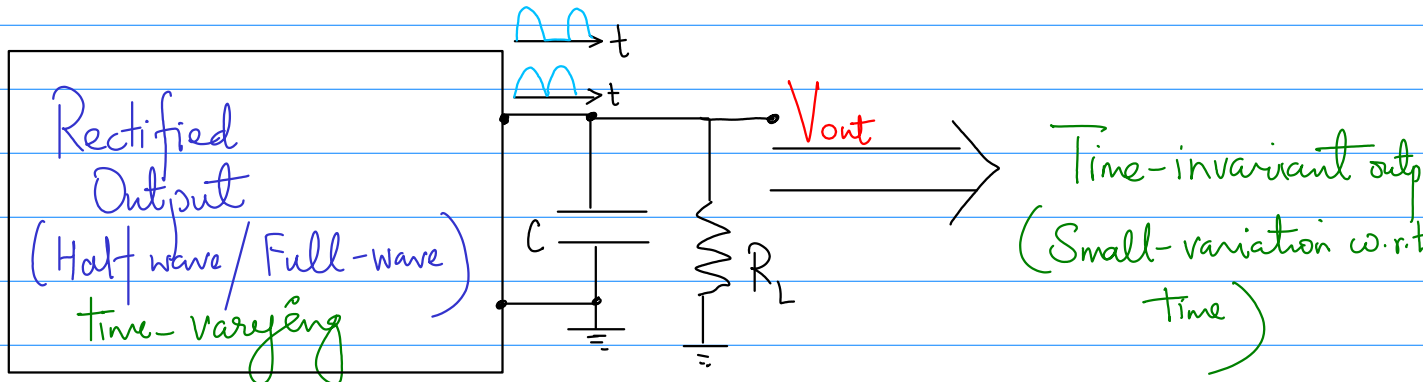
time constant: $\tau = RC$; $t = 5\tau$; $V_c(t) \approx V_s$

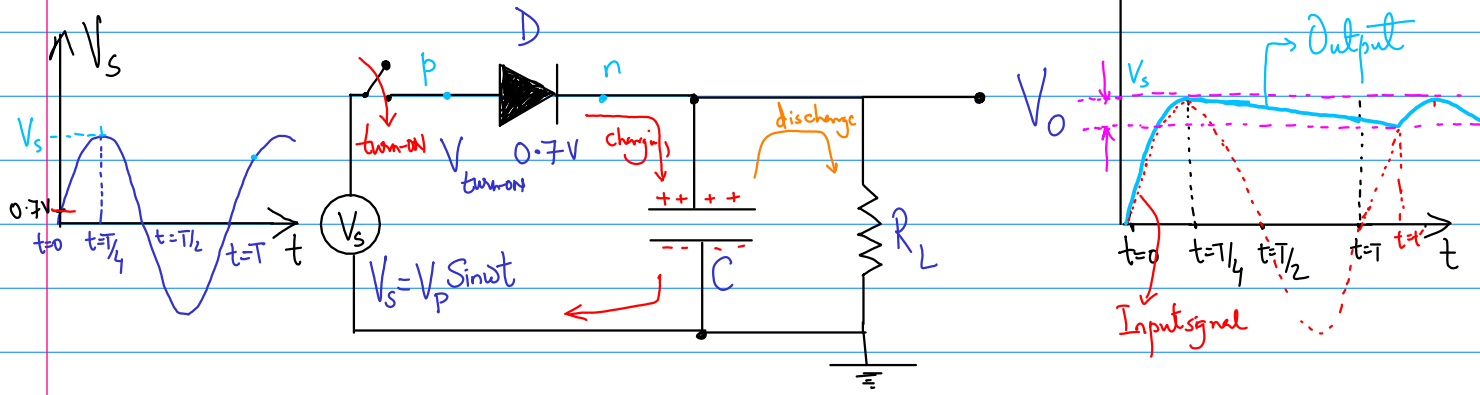
b) Discharging:



$$V_c(t) = V_s e^{-t/\tau} \qquad \tau = RC$$

when $t = 5\tau$, then $V_c \approx 0$

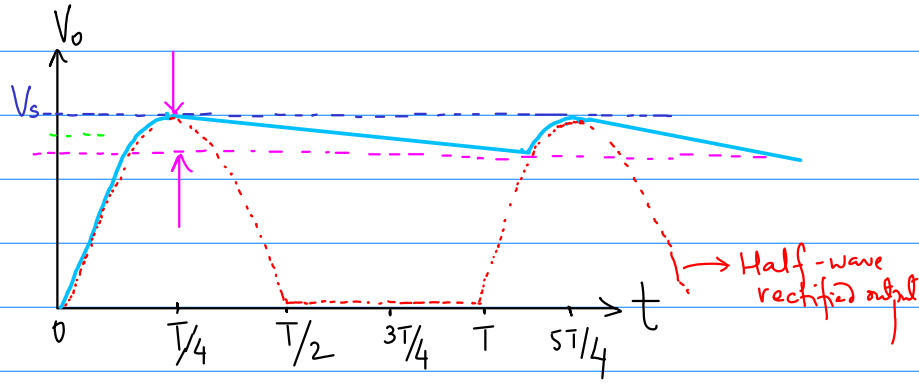




at $t = T/4$ and beyond: p-side becomes negative w.r.t n-side

$\Rightarrow$ the diode goes into the reverse bias cond^n.
ie, the input ckt. is "OPEN".

In half-wave rectifier with filter circuit, we get the following output :



In full-wave rectifier with filter circuit, we get the following output