IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Charging Infrastructure

Lecture-6

Revisiting Diode Bridge rectifier-II

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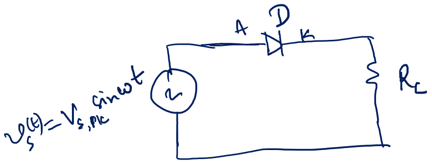
1-ϕ input, 1-ϕ AC-DC Converter
3-ϕ input, 3-ϕ AC-DC Converter

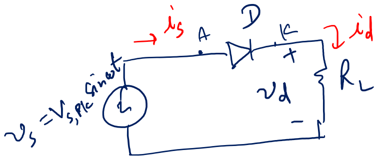
1-ϕ Diode Bridge Rectifier (uncontrolled Rectifier)

(i) Half-bridge Rectifier (ii) full-bridge Rectifier

$\boxed{\text{1-}\phi\text{ Half-bridge rectifier with Resistive load}}$



'D' turns on when the 'v_s' is in the positive half; it is reverse biased when 'v_s' is in the negative half cycle.

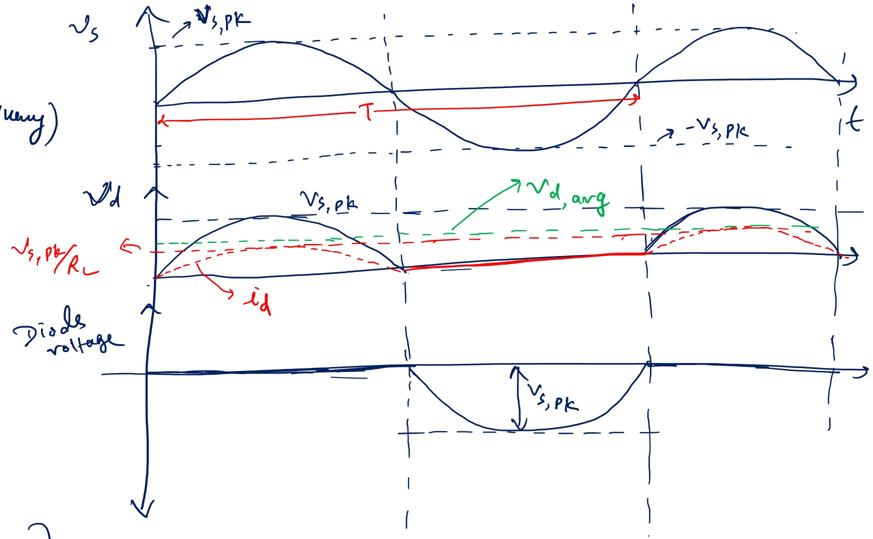


$$v_d = \begin{cases} v_s, & v_s > 0 \\ 0, & v_s < 0 \end{cases}$$

$$\omega = 2\pi f_s \quad (f_s = \text{supply frequency})$$

$$\Rightarrow T = 1/f_s$$

$$\Rightarrow \omega T = 2\pi$$



average value of v_d, $V_{d,avg} = \dfrac{1}{T}\displaystyle\int_0^{T/2} (V_{s,pk} \sin \omega t)\cdot dt$

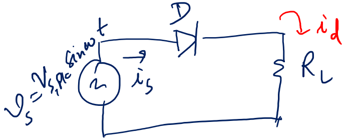
$$= \frac{V_{s,pk}}{\omega T}\left(\Big[-\cos \omega t \Big]_0^{T/2} \right)$$

$$= \frac{V_{s,pk}}{\omega T}\left[-\left(\cos \frac{\omega T}{2} - \cos 0 \right) \right]$$

$$= \frac{V_{s,pk}}{2\pi}\left[-\left(\cos \pi - \cos 0 \right) \right]$$

$$= \frac{V_{s,pk}}{2\pi}\left[-(-1-1) \right]$$

$$\boxed{V_{d,avg} = \frac{V_{s,pk}}{\pi}}$$

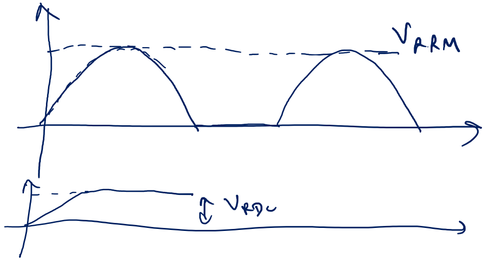


$$i_s = \begin{cases} i_d & ; v_s > 0 \\ 0 & ; v_s < 0 \end{cases}$$

Diode selection

v/g ratings

- → Peak repetitive reverse voltage (V_{RRM})
- → Peak reverse voltage
- → Reverse voltage or DC Blocking voltage



Current ratings

- → Average forward current, $I_{F(av)}$
- → Average rectified forward current
- → Repetitive peak forward current, I_{FRM}
- → Non-Repetitive peak forward current, I_{FSM}
- → $\boxed{I^2 t \text{ rating}}$

I → Rms value of forward current

t → the time period of the pulse

Diode selection

voltage rating

→ $\boxed{\text{Peak repetitive reverse voltage } (V_{RRM}) = V_{s,pk}}$

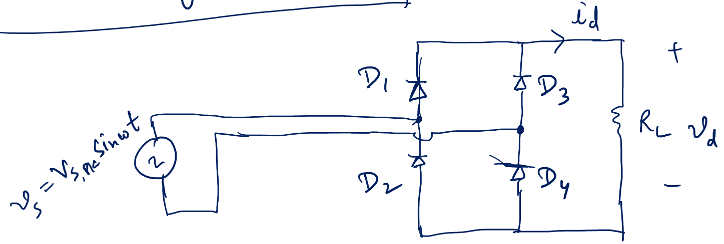
→ $\boxed{I_{F,avg} = \dfrac{V_{s,pk}}{\pi R_L}}$

→ $I_{F,rms} = \sqrt{\dfrac{1}{T}\int_0^{T/2} \left(\dfrac{V_{s,pk}\sin\omega t}{R_L}\right)^2 \cdot dt}$

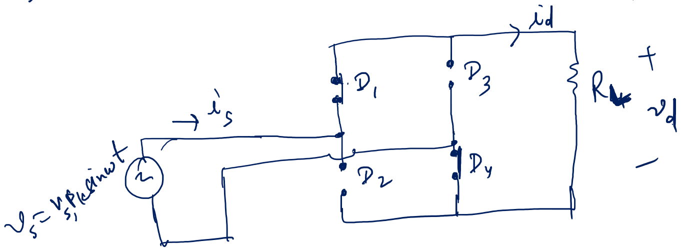
$\boxed{I_{F,rms} = \dfrac{V_{s,pk}}{2R_L}}$

- The power is being delivered to the resistive load only in positive half cycle
- The output is pulsating in nature
- Average Output voltage is proportional to $V_{s,pk}$ (which is peak of the Applied voltage)
- The current drawn is not continuous

$\boxed{1-\phi \text{ full-bridge Rectifier}}$



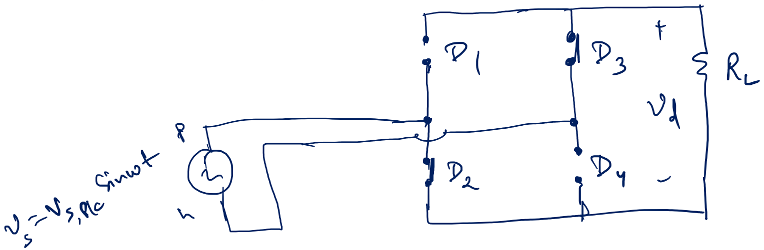
When v_s is in positive half cycle $(v_s > 0)$, D_1 & D_4 gets forward biased, D_2 & D_3 get reverse biased



$\Rightarrow \quad i_s = i_d$

$\Rightarrow \quad v_d = v_s$

When v_s is in negative half cycle $(v_s < 0)$, D_2 & D_3 is forward biased, D_1 & D_4 is reverse biased



$v_d = -v_s \quad ; \quad i_s = -i_d$

v_s is +ve,

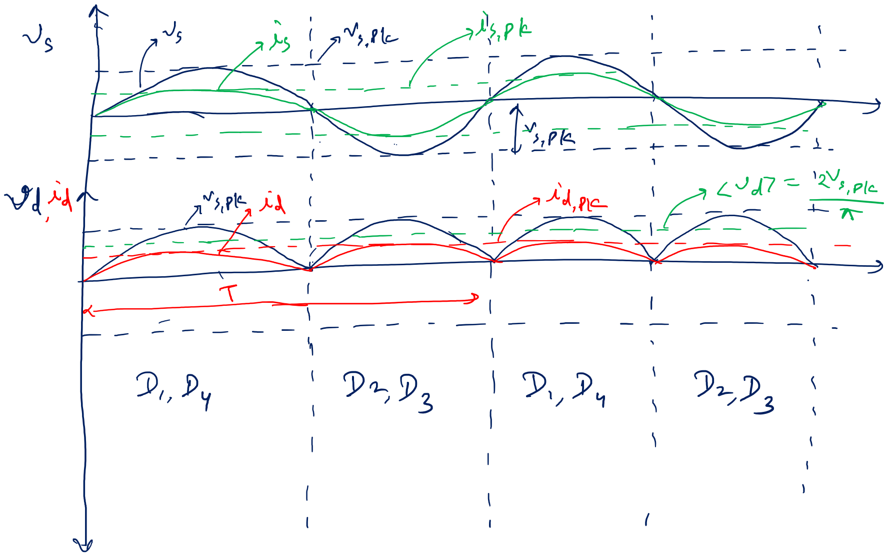
$v_d = v_s$

$i_s = i_d$

v_s is −ve,

$v_d = -v_s$

$i_s = -i_d$



$$i_{d,pk} = \frac{V_{s,pk}}{R_L}$$

$$i_{s,pk} = \frac{V_{s,pk}}{R_L}$$

$f_s = 50\,Hz$

$\Rightarrow T = \frac{1}{f_s} = 20\,ms$

$\omega = 2\pi f_s$

$\Rightarrow \omega T = 2\pi$

average voltage of v_d, $\langle v_d \rangle = \frac{1}{T/2} \int_0^{T/2} v_{s,pk} \sin\omega t \cdot dt$

$$= \frac{2}{\omega T}\left[\left[-v_{s,pk}\cos\omega t\right]_0^{T/2}\right]$$

$$= \frac{2v_{s,pk}}{\omega T}\left[-\left[\cos\frac{\omega T}{2} - \cos 0\right]\right]$$

$$= \frac{2v_{s,pk}}{2\pi}\left[-\left[-1-1\right]\right]$$

$$\boxed{\langle v_d \rangle = \frac{2v_{s,pk}}{\pi}}$$

Diode Selection

$$V_{RRM} = V_{d,pk} = V_{s,pk}$$

Average current, $I_{F(avg)\,(D_1,D_4)} = \frac{1}{T}\int_0^{T/2} \frac{V_{s,pk}\sin\omega t}{R_L}\,.dt$

$$= \frac{V_{s,pk}}{\pi R_L}$$

$$I_{F(avg)\,(D_2,D_3)} = \frac{1}{T}\int_{T/2}^{T} -\frac{V_{s,pk}\sin\omega t}{R_L}\,.dt$$

$$= \frac{V_{s,pk}}{\pi R_L}$$

$$I_{F(avg)\,(D_1,D_2,D_3,D_4)} = \frac{V_{s\,pk}}{\pi R_L}$$

$$I_{rms} = \sqrt{\frac{1}{T}\int_0^{T/2} \left(\frac{V_{s,pk} \sin\omega t}{R_L}\right)^2 \cdot dt}$$

$$I_{rms} = \frac{V_{s,pk}}{2R_L}$$

$\Rightarrow$ I^2t rating using I_{rms} value
$t = 10ms$

Inference

→ The output voltage is uncontrolled, it only depends on input AC voltage ($V_{s,pk}$)

→ The input current is sinusoidal in natural

→ Power is delivered in both the cycle (+ve & -ve) to R_L.

→ The output voltage is not constant, it is rectified DC voltage

$\Rightarrow$ $v_d(t) = |v_s(t)|$

it is continuously varying

Thank You