جامعة الفرات الاوسط التقنية
المعهد التقني سماوة
قسم التقنيات الكهربائية

المحاضرة الثانية

POWER ELECTRONICS

المرحلة الثانية

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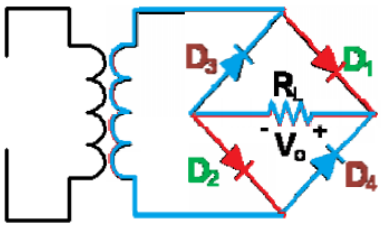
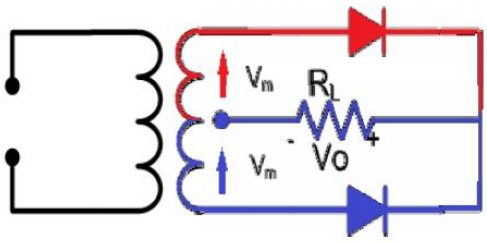
الاختبار القبلي

- *Fill the following blanks with the appropriate words:-*
  - *A. The half wave rectifier used ……. Diode while full wave used ……. diodes.*
  - *B. The output frequency from single phase full wave is …….. From input frequency.*
  - *C. The ripple factor for full wave rectifier is ……..*

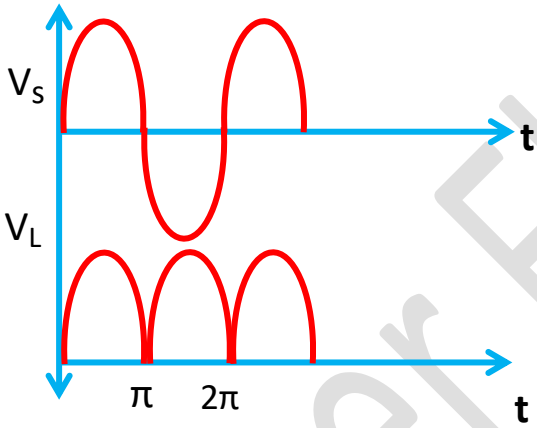
B-Full Wave



Bridge rectifier (BR)



center tap transformer



Where V_s: the voltage on the secondary
V_{in} : the voltage on the primary
V_o or V_L : the voltage on the load

$T=\pi$

 # D.C Component Calculation For The Rectifier

$$I_{dc} = \frac{1}{T}\int_0^T I(\theta)\, d\theta$$

$$I_{dc} = \frac{1}{\pi}\left[\int_0^{\pi} I(\theta)\, d\theta\right]$$

$$= \frac{1}{\pi}\left[\int_0^{\pi} I_m \sin\theta\, d\theta\right]$$

$$= \frac{I_m}{\pi}\left[\int_0^{\pi} \sin\theta\, d\theta\right]$$

$$= \frac{I_m}{\pi}\left[-\cos\theta\right]$$

$$= \frac{I_m}{\pi}\left[-\cos\pi - (-\cos 0)\right]$$

$$= \frac{I_m}{\pi} * 2$$

$$\boxed{I_{dc} = 2\frac{I_m}{\pi}}$$ ……. ***Equ. (3)***

R.M.S Component of Rectifier

$$I_{RMS} = \left[\frac{1}{\pi}\int_0^{\pi}(I_m \sin\theta)^2\, d\theta\right]^{\frac{1}{2}}$$

$$= \left[\frac{I_m{}^2}{\pi}\int_0^{\pi} \sin\theta^2\, d\theta\right]^{\frac{1}{2}}$$

$$= \left[\frac{I_m{}^2}{\pi}\int_0^{\pi} \frac{1-\cos 2\theta}{2}\, d\theta\right]^{\frac{1}{2}}$$

$$= \left[\frac{I_m{}^2}{2\pi}\int_0^{\pi} (1-\cos 2\theta)\, d\theta\right]^{\frac{1}{2}}$$

$$= \left[\frac{I_m{}^2}{2\pi}\left\{\theta - \frac{\sin 2\theta}{2}\right\}\right]^{\frac{1}{2}}$$

$$= \left[\frac{I_m{}^2}{2\pi}\left\{(\pi - 0) - \frac{\sin 2\pi - \sin 0}{2}\right\}\right]^{\frac{1}{2}} = \left[\frac{I_m{}^2}{2}\right]^{\frac{1}{2}}$$

$$\boxed{I_{rms} = \frac{I_m}{\sqrt{2}}}$$ ..... Equ. (4)

Power conversion efficiency: P.C.E = $\frac{Pdc}{Prms} = \frac{Idc^2 * Rl}{Irms^2 * Rl} = \frac{\left[\frac{2Im}{\pi}\right]^2}{\left[\frac{Im}{\sqrt{2}}\right]^2} = \frac{\frac{4}{\pi^2}}{\frac{1}{2}} = \frac{4}{\pi^2} * 2 = 81.13\%$

Output frequency $(f_o) = 2 * \text{input frequency}\ (f_{in})$

Ripple factor $(r) = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$

$$(r) = \sqrt{\left(\frac{\frac{I_m}{\sqrt{2}}}{2\frac{I_m}{\pi}}\right)^2 - 1}$$

$$(r) = \sqrt{\left(\frac{\frac{1}{\sqrt{2}}}{\frac{2}{\pi}}\right)^2 - 1}$$

$$= 0.48 = 48\%$$

For F.W Rectifier

$$I_{dc} = 2\frac{I_m}{\pi}$$

$$I_{rms} = \frac{I_m}{\sqrt{2}}$$

$$P.I.V = Vm \ldots\ldots\ldots\ldots for\ BR$$

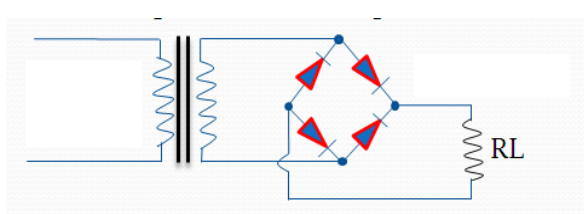
$$P.I.V = 2Vm \ldots\ldots\ldots\ldots for\ C.T.T$$

$$\zeta = 40.5\%$$

$$r = 0.48 = 48\%$$

$$f_{out} = 100\ Hz$$

Ex: *A bridge rectifier is used to supply a 500 ohm load resistor , transformer with turn ratio N2/N1 = 2/5 is used to couple the bridge to the main supply find the D.C current in the load if the maximum voltage across the transformer secondary is 68v , also find the RMS voltage of the main supply . What is the PIV on the diode?*



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Solution:- $I_{dc}=\frac{Vdc}{RL}$ $\quad Vdc = 2\frac{Vm}{\pi} = 2\frac{68}{\pi} = 43.3V$

$\therefore Idc = \frac{43.3}{500} = 86.66mA$

$\frac{n1}{n2} = \frac{v1}{v2}$ $\quad \frac{5}{2} = \frac{v1}{68}$ $\quad \therefore v1 = \frac{5*68}{2} = 170V$ .....Maximum

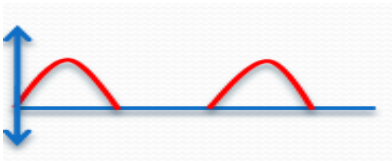
$Vrms = \frac{V_m}{\sqrt{2}} = \frac{170}{\sqrt{2}} = 120.56\ V$ $\quad$ PIV = 68 V $\quad$ $f_o = 2*f_{in} = 100HZ$

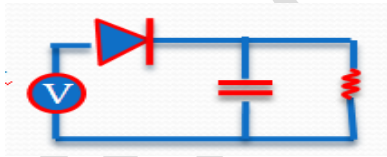
2- The Filters

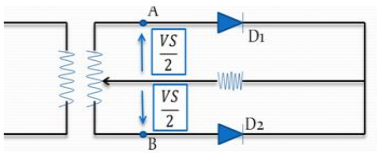
The output waveform of Half–wave and full-wave rectifiers contains ripple . Filter must be used to get smooth D.C output

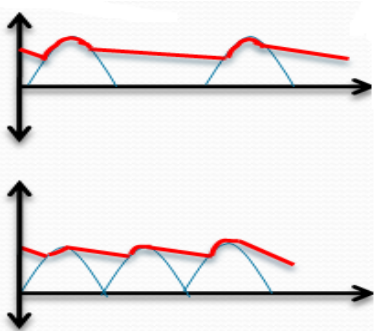
Filters type :

1. ***capacitive filter :***
   - *This type is simple and used when ripple is small.*
   - *When D ON, C charges to V_m , when D off ,C discharges through (RL) .*
   - *Time constant $\tau=R_LC$, τ must be >> T to minimize loss of charge in C*





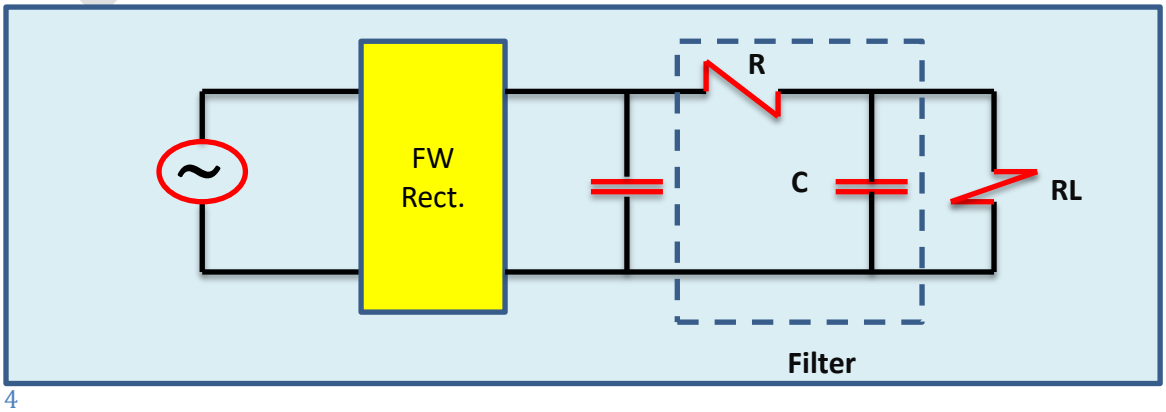




2. ***R – C filter:***

This type is used with the low load current circuits

- *Adding R will limit the charging current drawn by (C).*
- *But this will cause voltage drop .*
- *By using large R we get better filtering but this results in large loss of D.C voltage that is why this type is used only when load current is small .*



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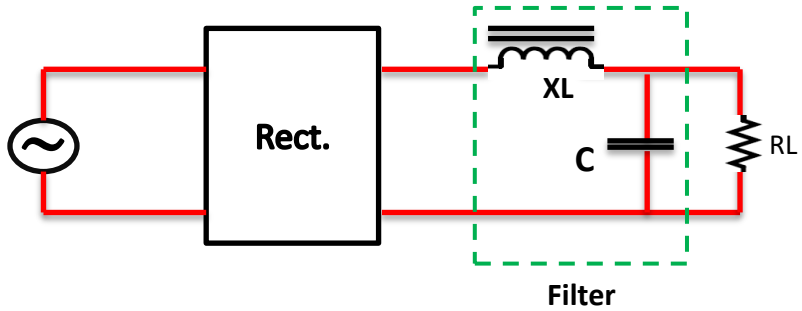
3. L - C Filter:



∵ the output of rectifier contain D.C component (wanted) and A.C component (unwanted)

* The coil will pass D.C component easily to load

X_L Hi for A.C $\quad X_L = 2\pi f L$

X_L Lo for D.C

X_c Lo for A.C $\quad X_C = \frac{1}{2\pi f C}$

Xc Hi for D.C

∴ coil pass D.C and imped A.C Capacitor imped D.C and pass A.C

D.C component on load may be calculated from

$$V_{DC} = V_{dc} * \frac{R_{load}}{(R+R_{load})}$$

(V_{DC}) - D.C voltage across R_{load}

(V_{dc}) - D.C voltage output from rectifier

(R) - coil resistance .

(R_{load}) – load resistance .

* When frequency is zero then R and RL become in series forming potential divider.

* R usually much less than RL , therefor most the D.C component appears on load .

Examples :-

Ex1: H.W rectifier is fed from 24 V/50 Hz. A load of 100Ω resistance is connected on the rectifier output after using a filtering capacitor of (100μF). Calculate:-

1- Time constant during charging assuming that forward resistance of diode is (30Ω).

2- Time constant during discharge.

Solution :

$$\tau = C.R$$

$$\tau_{ch} = r_D.C = 30 * 100 * 10^{-6} = 3\ ms$$

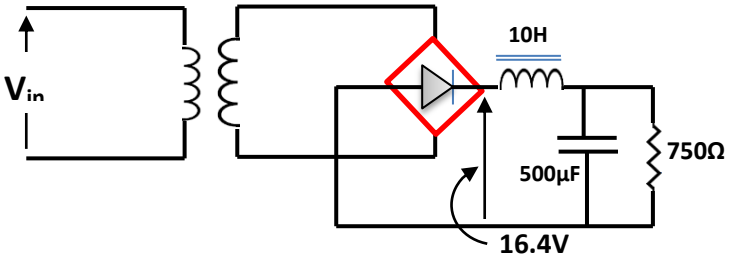
$$\tau_{disch} = R_L.C = 100 * 100 * 10^{-6} = 10\ ms$$

Ex2:- For the circuit shown: Calculate the D.C load voltage if V_{dc} output from rectifier is 16.4 V and R=25 Ω (coil resistance).

Solution:

$$V_{DC} = V_{dc}\frac{R_L}{R_L+R}$$

$$= 16.4\frac{750}{750+25} = 15.9\ V$$



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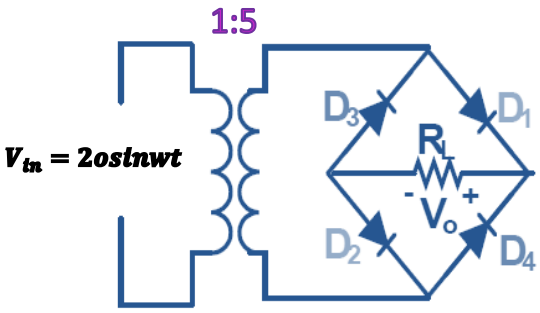
Home work



For the bridge rectifier shown calculate :-

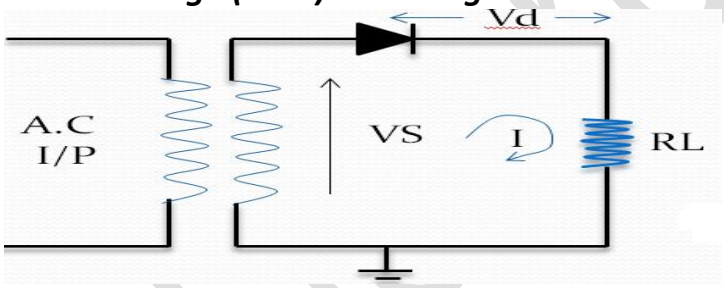
1- D.c output voltage .

2- Peak inverse voltage.

3- Output frequency

الاختبار البعدي

Q1:In the circuit show below if the transformer turns ratio N2:N1 = 1:4 , find the D.C load voltage and the peak inverse voltage (P.I.V) assuming ideal diode . Take V_{in} =220 V.

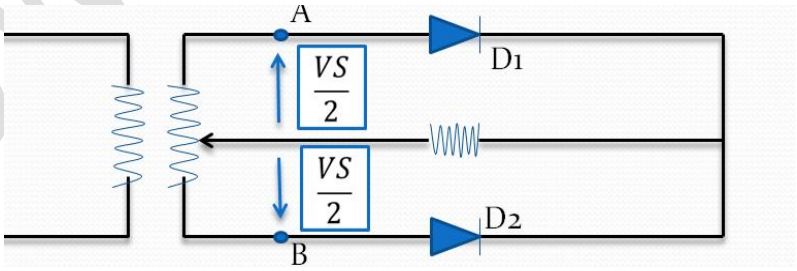


Q2 : the circuit shown below is that of a full wave rectifier. if the potential difference between the center tap and terminal A on the transformers is 28.3 V (maximum) . take RL=100Ω .calculate :

1- dc load voltage.

2- rms load current .

3- PIV on the diode .



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