MADE EASY

ELECTRONICS ENGINEERING

Analog Electronics

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- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

* DEFINITION OF ANALOG CIRCUIT:-

* A ckt which consists of atleast one electronic device as the major components then that ckt will be Electronic circuit
  - i) Ampl^r.
  - ii) Rectifier.
  - iii) Oscillator.

* ckts can be of 3 types
  - i) Analog ckt (Input also analog and output also analog)
  - ii) Digital ckt (Input Digital + Output also digital)
  - iii) Mixed Electronic ckt (A to D Convertor, D to A Converter).

* ANALOG ELECTRONIC CKT:-

* An Electronic ckt which performs processing of Analog signals or a ckt in which Input and output are Analog signals. Such ckt are called Analog Electronic ckt.
  - i) Amplifier.
  - ii) Rectifier; etc

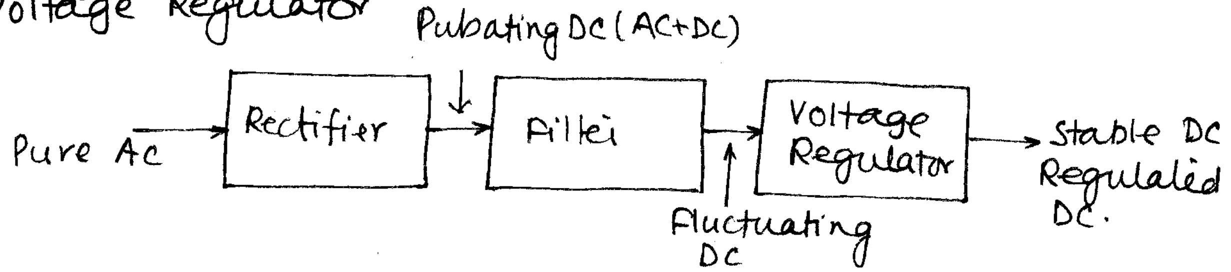
despite of Digital Era why use Analog ckts.

* Real time signals are Analog Signals; hence Analog ckts (usage)
* Advantages of Analog circuits are:-
  - i) Most of the Real time signals are Analog in nature + hence they can be directly processed in Analog circuit. But digital processing requires A to D + D to A Conversion which increases complexity and signal Accuracy is also lost; due to Quantisation Errors.
  - ii) Analog ckt can process signals having higher power level also. Digital ckts fails for processing high power supply. Digital ckts often work in mW range.

*Note:- IC's works on DC power supply. They won't work on AC power.

* DC POWER SUPPLY:-

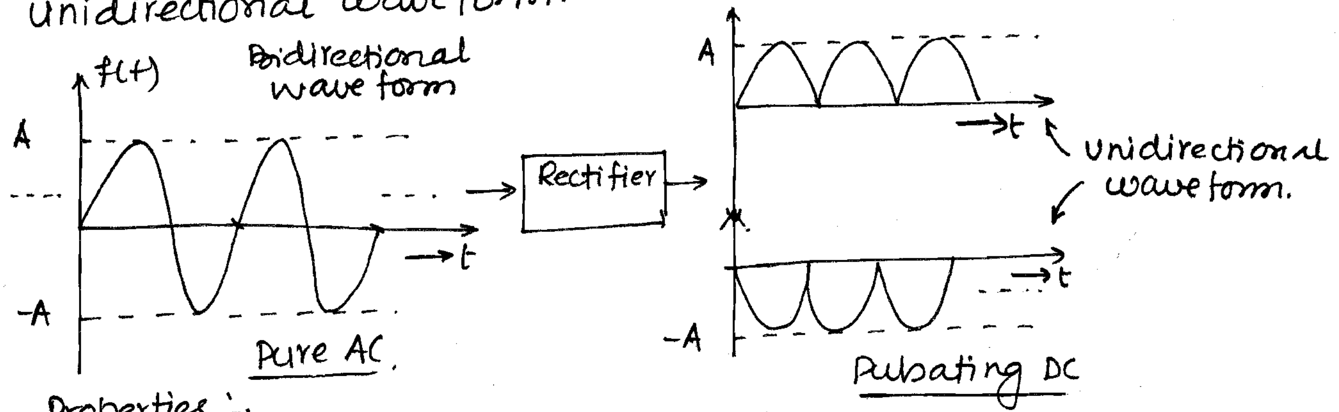
* It converts AC power into DC Power.
* A Regulated power supply consists of a Rectifier, Filter and a Voltage Regulator



* AC to DC conversion is needed because majority of Electronic Devices and appliances operate on DC power.

* RECTIFIER CIRCUIT :-

* An Electronic circuit which converts Pure AC into pulsating DC or a ckt which converts bidirectional waveform into a unidirectional waveform.



Properties :-

i) Periodic variation

ii) Bidirectional variation (both in +ve & -ve values)

iii) Avg. value = 0 (DC value).

iv) It has single frequency component. (Sinusoidal).

* Triangular & Square wave are also called as AC signals but not pure AC as they also have Harmonics. But AC (Pure AC) should have single freqn component.

Properties :-

i) Periodic variation.

ii) Unidirectional variation.

iii) Non Zero Avg, hence DC value will be present.

iv) It has Harmonics.

* Time varying signals have AC components.

Note :-

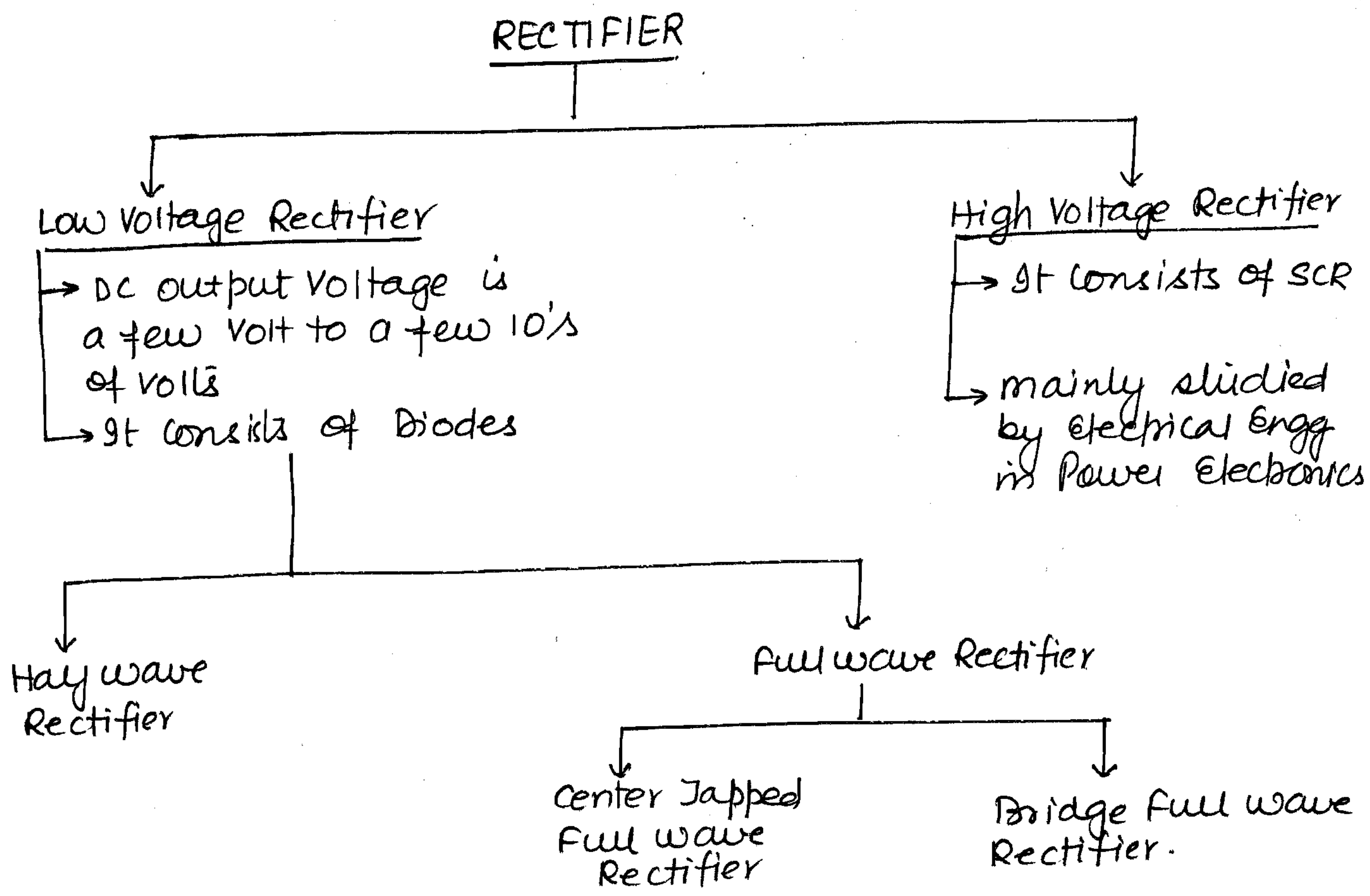
* Periodic variation indicates presence of AC component that varies with Time

* Non Zero Average indicates presence of DC component

* Hence Pulsating DC is a combination of AC & DC components.

* Rectifier converts Pure AC into Pulsating DC.

*Note:



RECTIFIER

Low Voltage Rectifier

- → DC output Voltage is a few Volt to a few 10's of volts
- → It consists of Diodes

High Voltage Rectifier

- → It consists of SCR
- → mainly studied by Electrical Engg in Power Electronics

Half wave Rectifier

Full wave Rectifier

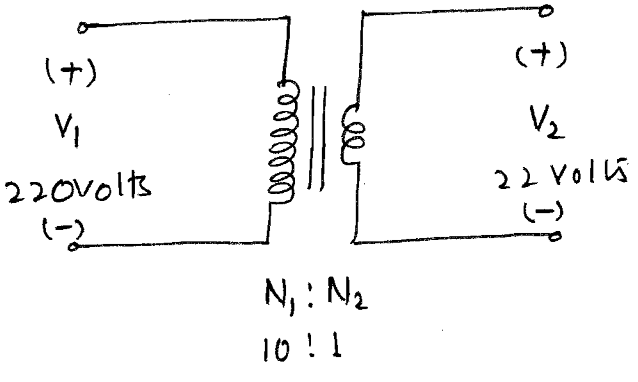
Center Tapped Full wave Rectifier

Bridge Full wave Rectifier.

*Note:

* In low voltage Rectifiers, step down Transformer is used to reduce the strength of AC voltage

$$\boxed{\frac{V_1}{V_2} = \frac{N_1}{N_2}}$$

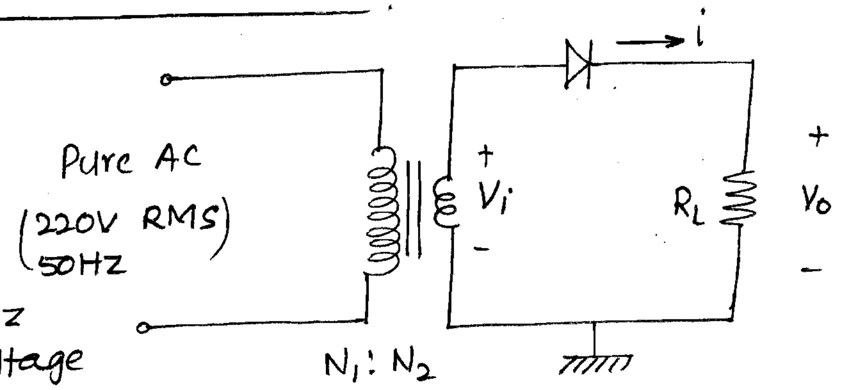


* Step Down Transformer is needed:

i) to get low DC Voltage from Rectifier.

ii) to protect Diodes which have smaller breakdown voltages.

HALF WAVE RECTIFIER :.



20V; 50Hz
→ Line Voltage
→ line frequency

* V_i : Pure AC Voltage having smaller RMS value.

Mathematically,

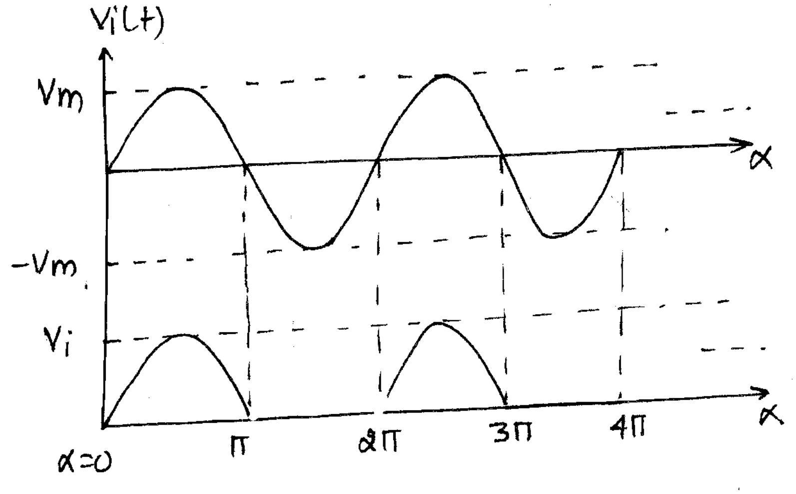
$$\boxed{v_i(t) = V_m \sin\omega_0 t = V_m \sin\alpha}$$

V_m: Peak value.

$\frac{V_m}{\sqrt{2}}$: RMS value.

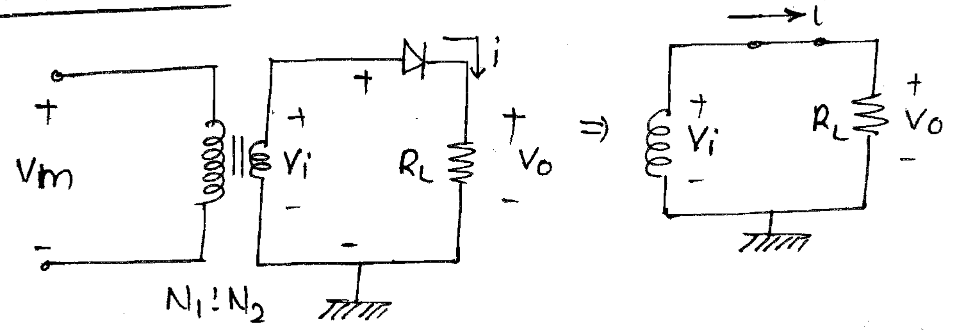
$$\boxed{314 \text{ rad/sec} = \omega_0 = 2\pi f_0}$$

$\boxed{50\text{Hz} = f_0}$: line frequency ie freqⁿ of AC supply (50Hz).



Analysis :.

CASE 1 $(0 < \alpha < \pi)$:.

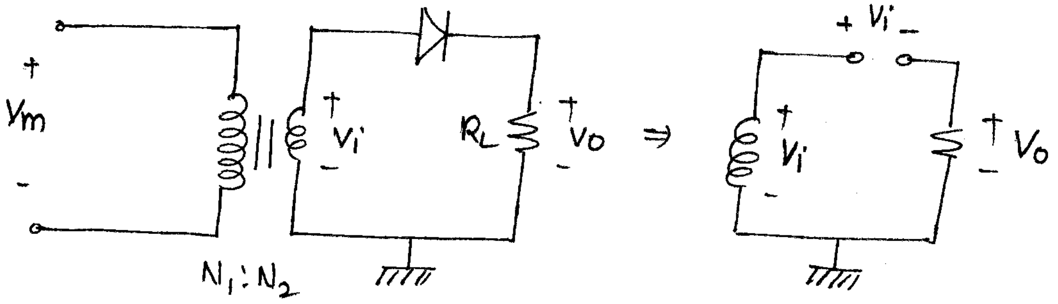


i) V_i is +ve

ii) Diode is in Forward Bias ⇒ Short ckt

iii) $\boxed{V_0 \cong V_i}$

CASE ($\pi < \alpha < 2\pi$):.



* Input voltage appears fully accross diode which is acting as open ckt

i) Vi become -ve

ii) Diode is in Reverse Biased ⇒ open circuit

iii) $\boxed{V_0 = 0}$

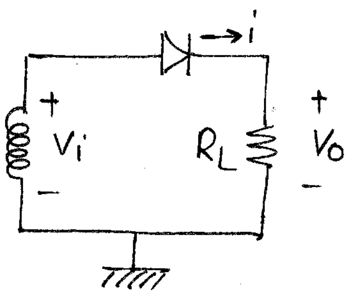
* Analysis of Half wave Rectifier:.

i) Instantaneous output current(i):-

a) $0 < \alpha < \pi$ [Diode is in FB ≡ R_F (few Ω)] :-

R_F = Bulk Resistance of Diode
(Internal Resistance of Diode).

* R_F : Internal Resistance of Diode; we name technically as Bulk Resistance.



* KVL in Secondary ckt:.

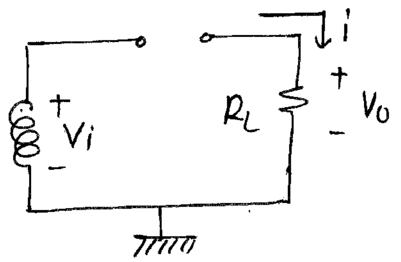
$$-V_i + i \cdot R_F + i R_L = 0$$

$$\boxed{i = \frac{V_i}{R_F + R_L} = \frac{V_m \sin\alpha}{R_F + R_L}}$$

$\boxed{i = I_m \sin\alpha.}$; $\boxed{I_m = \frac{V_m}{R_F + R_L}}$

) $\pi < \alpha < 2\pi$ (Diode is in RB) :.

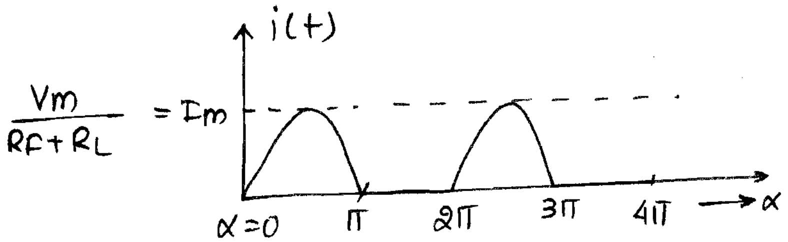
* If a diode is in RB, it passes a negligible current equal to Reverse saturation current.
* Reverse saturation current = nA (Si)
  µA (Ge).



$\boxed{i \cong 0}$

Hence

$$\boxed{\begin{aligned} i &= I_m \sin\alpha \quad ; \quad 0<\alpha<\pi \\ &\cong 0 \quad ; \quad \pi<\alpha<2\pi \end{aligned}}$$



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ii) DC output current (I_{DC}) :.

I_{DC} = Average value of Instantaneous current "i".

Mathematically

$$I_{DC} = \frac{\text{Area}}{\text{Time Period}}$$

$$I_{DC} = \frac{1}{2\pi}\int_0^{2\pi} i \, d\alpha. = \frac{1}{2\pi}\int_0^{\pi} I_m \sin\alpha \, d\alpha + 0.$$

$$= \frac{I_m}{2\pi}\left[-\cos\alpha\right]_0^{\pi} = \frac{-I_m}{2\pi}\left[-1-1\right]$$

$$I_{DC} = \frac{+I_m}{2\pi}\left[1+1\right]$$

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$$\boxed{I_{DC} = \frac{I_m}{\pi} \text{ A}}$$

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iii) RMS output current (I_{RMS}):-

I_{RMS} = RMS value of instantaneous current "i".

Mathematically,

$$I_{RMS} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} i^2 \, d\alpha}.$$

$$I_{RMS} = \sqrt{\frac{1}{2\pi}\int_0^{\pi} I_m^2 \sin^2\alpha \, d\alpha}.$$

$$= \sqrt{\frac{1}{2\pi} \times \frac{I_m^2}{2}\left[\int_0^{\pi} d\alpha - \int_0^{\pi} \cos \cancelto{0}{2}\alpha \, d\alpha\right.}.$$

$$= \sqrt{\frac{I_m^2}{2\pi \times 2}\left[\pi\right]}$$

$$= \sqrt{\frac{I_m^2}{4}}$$

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$$\boxed{I_{RMS} = \frac{I_m}{2} \, A.}$$

iv) RMS value of AC component (I'_{RMS}):-

*output current of Rectifier is a pulsating DC ie (AC+DC).

$$\boxed{i = \text{AC Component} + \text{DC Component}}$$

$$i = i' + I_{DC}$$

$$\boxed{i' = i - I_{DC}} \leftarrow \text{AC component.}$$

I'_{RMS} = RMS value of i'.

$$= \sqrt{\frac{1}{2\pi}\int_0^{2\pi} (i')^2 \, d\alpha}$$

$$(I'_{RMS})^2 = \frac{1}{2\pi}\int_0^{2\pi} (i - I_{DC})^2 \, d\alpha = \frac{1}{2\pi}\int_0^{2\pi} i^2 \, d\alpha + \frac{1}{2\pi}\int_0^{2\pi} I_{DC}^2 \, d\alpha - \frac{1 \times 2}{2\pi}\int_0^{2\pi} I_{DC} \cdot i \, d\alpha$$

$$(I'_{RMS})^2 = \frac{1}{2\pi}\int_0^{2\pi} i^2 d\alpha + \frac{1}{2\pi}\int_0^{2\pi} I_{DC}^2 d\alpha - \frac{2}{2\pi}\int_0^{2\pi} I_{DC}\cdot i\, d\alpha$$

$$= \underbrace{\frac{1}{2\pi}\int_0^{2\pi} i^2 d\alpha}_{I'_{RMS}} + \frac{1}{2\pi}\cdot I_{DC}^2 (2\pi) - \underbrace{\frac{2I_{DC}}{2\pi}\int_0^{2\pi} i\cdot d\alpha}_{I_{DC}}$$

$$(I'_{RMS})^2 = I_{RMS}^2 + I_{DC}^2 - 2I_{DC}^2$$

$$\boxed{(I'_{RMS}) = \sqrt{I_{RMS}^2 - I_{DC}^2}}$$

← An AC Ammeter Connected in series with R_L will record I'_{RMS}. Therefore I'_{RMS} is also Known as Reading of AC Ammeter.

Note :-

* I_{DC} is reading of DC Ammeter.

) RIPPLE FACTOR (r) :-

* The unwanted AC component which is present in the O/P of the Rectifier is Known as Ripple.

* Ripple Factor is a measure of the amount of AC component

Mathematically,

$$\boxed{r = \frac{\text{RMS value of AC component}}{\text{DC component}}}$$

$$\boxed{r = \frac{I'_{RMS}}{I_{DC}} = \frac{V'_{RMS}}{V_{DC}}}$$

As AC component is unwanted, Ripple Factor should be smaller, and Ideally should be zero.

* Analysis :-

$$\boxed{r = \frac{I'_{RMS}}{I_{DC}} = \frac{\sqrt{I_{RMS}^2 - I_{DC}^2}}{I_{DC}} = \sqrt{\left(\frac{I_{RMS}}{I_{DC}}\right)^2 - 1}}$$