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EE1101: Circuits and Network Analysis

Lecture 16: Periodic Signals

September 2, 2025

Topics :

1. Average and RMS Values
2. Sinusoidal Signals and Phasor Representation

Periodic Signals - Average and RMS Values

Def:- Signal $v(t)$ is periodic with period T if

$$v(t+T) = v(t) \quad \forall \quad 0 \le t \le T.$$

Ex:- a) $\sin(\omega t)$: period $T = 2\pi/\omega$.

b) $\sin(n\omega t)$ where n is an integer : period $(T) = 2\pi/n\omega$ ← fundamental Period

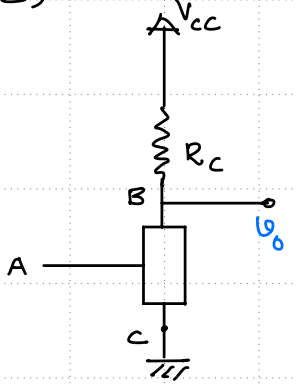
↓ is also periodic with period $2\pi/\omega$

c) $\sum_{n=1}^{m} V_n \sin(n\omega t)$ → also periodic with period $2\pi/\omega$.

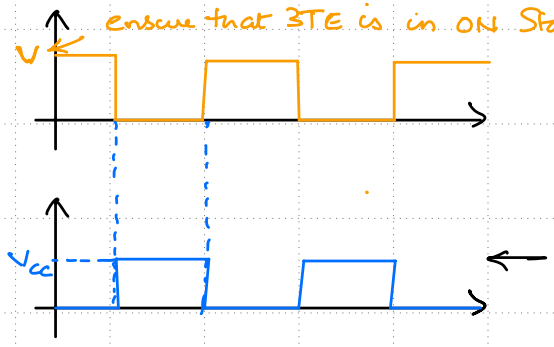
$n=1$ fundamental Component

$n>1$ harmonic Components

d)



v_{AC} is chosen such that the BJT operates as a Switch.



← Periodic if v_{AC} is Periodic

Period is same as Period of v_{AC}

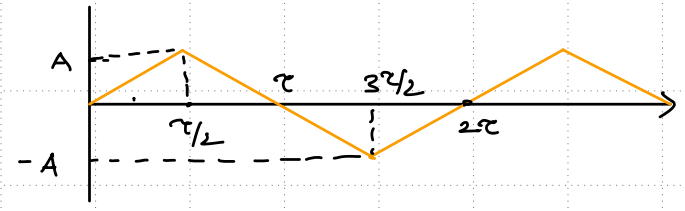
Periodic Signals - Average and RMS Values

Average Value: For a periodic signal $v(t)$ with period T, the average value is defined as

↓ DC value or DC Component

$$\bar{V} \text{ or } V_{avg} = \frac{1}{T}\int_0^T v(t)\,dt = \frac{1}{T}\int_\tau^{\tau+T} v(t)\,dt$$

$$= \frac{\text{Area under } v(t) \text{ over a Period}}{T}$$

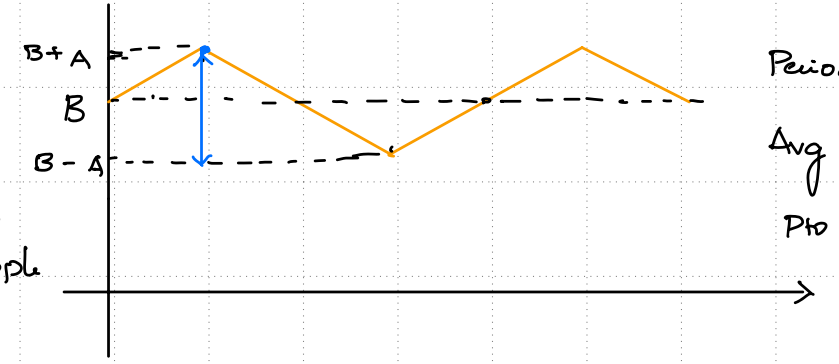


Period 2τ.

Avg value $= 0$.

Peak to Peak ripple $= 2A$

Peak to peak ripple = deviation from the avg value



Period 2τ.

Avg value $= B$.

Pto p ripple $= 2A$.

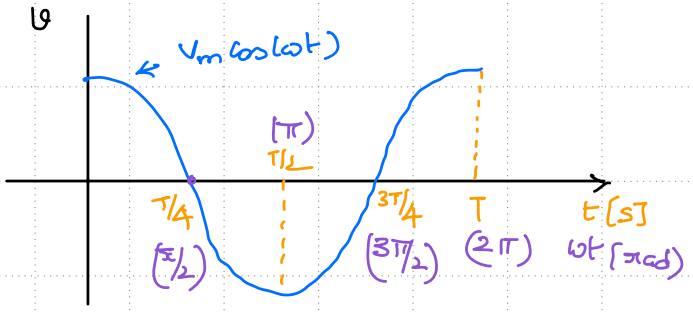
In practice: DC signal: Avg value >> Peak to Peak ripple

RMS (Root Mean Square) Value: For a periodic signal $v(t)$ with period T, the RMS value is defined as

$$V \text{ or } V_{rms} = \sqrt{\frac{1}{T}\int_\tau^{\tau+T} v^2(t)\,dt}$$

Sinusoidal Signal

for this Course : a signal of the form $V_m \cos(\omega t + \phi)$



$V_m \rightarrow$ Peak value | max. value

$\omega \rightarrow$ angular freq (rad/s)

$f \rightarrow$ frequency (Hz) : $\omega = 2\pi f$.

$\phi \rightarrow$ Phase (rad/deg)

① Volts $= V_m \cos(\omega t + \phi)$ $\phi = 0$

Avg value = 0.

RMS value = $\frac{V_m}{\sqrt{2}}$

Avg value (over $T/2$) = 0 to $T/2$: $\overline{V} = 0$

$T/4$ to $3T/4$: $-\frac{2V_m}{\pi}$

useful indicator when

Studying rectifiers

Avg value on ωt Scale:-

$$V = \frac{1}{2\pi} \int_0^{2\pi} V_m \cos \omega t \, d(\omega t)$$