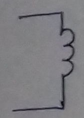
ELECTRICAL MACHINES.

* winding.



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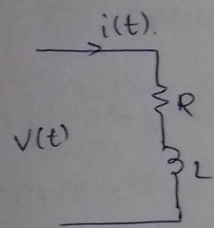
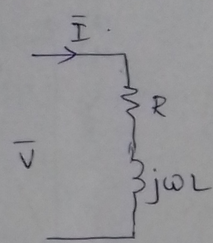


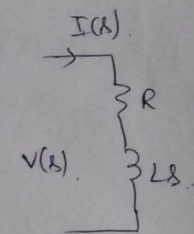
$V(t) = Ri(t) + L\frac{di(t)}{dt}$.

TIME-DOMAIN ANALYSIS.



$\bar{V} = \bar{I}(R + j\omega L)$.

PHASOR-ANALYSIS.



$V(s) = (R + Ls)I(s)$.

LAPLACE TRANSFORM.

* Speed of the fan with time.

Time constant $= \tau = 2s$.

Time by which the output will be 66% of steady state value.

$N = N_0\left(1 - e^{-t/\tau_0}\right)$.

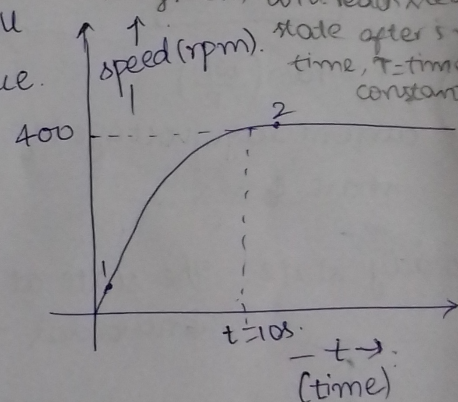
N = speed,

N_0 = final speed.

$t = 5\tau$.

$N = N_0\left(1 - e^{-t/\tau_0}\right)$, $\tau_0 = \frac{L}{R}$.

The system will reach steady state after 5τ time, τ = time constant



$I_1 > I_2$.

$e^{-1} = 36.5\%$

$e^{-2} = 13.5\%$

$e^{-3} = 5\%$

$e^{-4} = 2\%$

$e^{-5} = 1\%$.

$\tau = \frac{J}{B}$.

J = Moment of Inertia (kgm^2),

B = Friction coefficient.

Torque(τ) $= \frac{J}{B}$.

Torque(τ) $= \frac{J}{B}$.

$\tau \rightarrow N.m.$

$\tau = B.\omega$.

$N.m. = B.\frac{rad}{s}$.

$\Rightarrow B = \frac{N.m.s}{rad}$

*

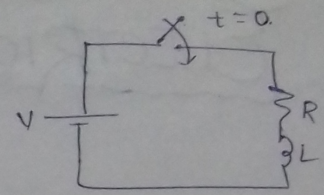
$$V = iR + L\frac{di}{dt}$$

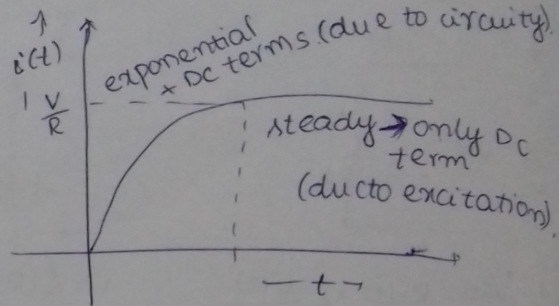
$$V - iR = L\frac{di}{dt}$$

$$\frac{1}{V-iR}\,di = \frac{1}{L}\,dt$$

$$\frac{-1}{R}\left\{\ln(V-iR)\right\}_0^i = \frac{1}{L}t$$

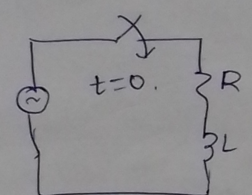
$$i = V\left(1 - e^{-R/L\,t}\right)$$





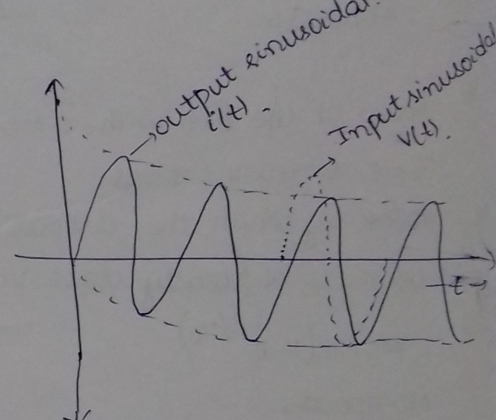
Input → $\boxed{\text{system}}$ → output

*

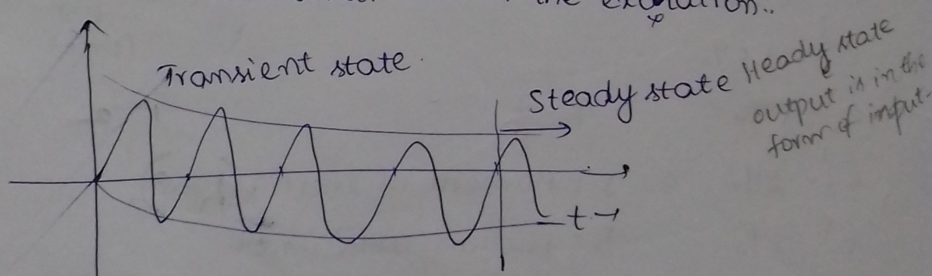


$$\phi = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

current lags voltage by phase ϕ.



Steady state:- The state at which the final response is sinusoidal that of the excitation.



$\tau = L/R$. $f = 50\,Hz$

$$\therefore 5 \times \frac{L}{R} = 4 \times \frac{1}{50}$$ Four×time period (∵ Four cycles) $R = 10\,\Omega$.

$$\frac{5}{10} \times L = \frac{4}{50} \Rightarrow L = \frac{4}{25} = 160\,mH = 0.16\,H$$

Electrical Time constant = 16ms. [∵ $t = 80/5 = 16ms$].
Mechanical Time constant = 2s.

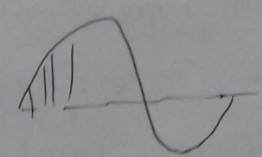
Phase Analysis is applied for

1. Sinusoidal excitation.
2. Steady-state analysis.

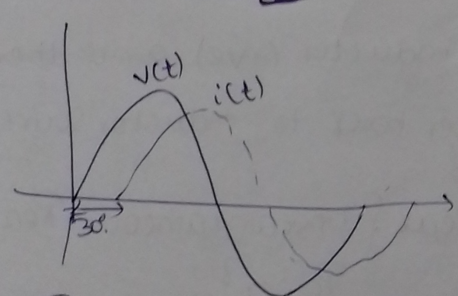
It provides mathe-matical simplification.

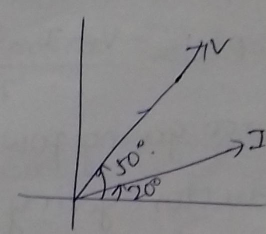
$$\frac{di}{dt} \to j\omega \bar{I} \qquad \int v(t)dt \to \frac{\bar{V}}{j\omega}$$

t	$i(t)$	$\frac{di}{dt}$
t_1	I_1	
t_2	I_2	$\frac{I_2 - I_1}{t_2 - t_1}$
⋮	⋮	⋮
t_n	I_n	$\frac{I_n - I_{n-1}}{t_n - t_{n-1}}$



* $\bar{I} = I\angle\theta_i = 5\angle 20^\circ$, $\bar{V} = V\angle\theta_v = 10\angle 50^\circ$. $f = 50Hz$.





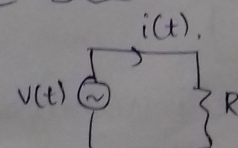
Active Power and Reactive Power..

$P(t) = v(t) . i(t)$.

$v(t)$ - sinusoidal.

$i(t) = \frac{V(t)}{R}$

Sinusoidal.

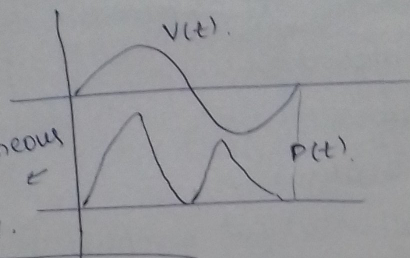


Active Power = $V(t).i(t)$

Reactive Power?

$$P(t) = v(t).i(t) = \frac{A^2 \sin^2 \omega t}{R} = \frac{A^2}{2R}(1 - \cos 2\omega t)$$

when voltage covers 1 cycle, power covers 2 cycles.



$\boxed{\text{Active Power} = VI\cos\phi}$ ∴ Active Power = $VI\cos\phi$, Reactive Power = $VI\sin\phi$.

Average power → commonly used.

Active Power = Avg {Instantaneous Active Power}.

Uni-directional → Active Power.

Active Power = Avg{Instantaneous Active Power} ← P(t)

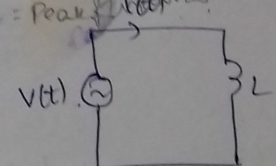
Reactive Power = Peak{Instantaneous Reactive Power}

* $P(t) = V(t) \cdot i(t)$.

$V(t) = V_m \sin\omega t$,

$i(t) = I_m \sin(\omega t - \pi/2)$

$P(t) = \frac{-V_m I_m \sin 2\omega t}{2}$..



Source giving power to inductor (+ve). and then inductor giving power back to ~~inductor~~ source (-ve)

Reactive Power = {Peak {Instantaneous Reactive Power}.

bi-directional

$\boxed{R.P = VI\sin\phi}$

* For RL, state the instantaneous power, instantaneous A.P, instantaneous R.P, A.P, R.P.

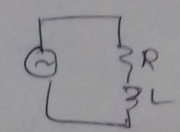
* In steady state, capacitor acts as open circuit (after a long time after the switch is closed).

* Steady state response – forced response.

* Steady state response – forced response.
  Transcient response – normal response.

* A) $i(t) = i_n(t) + i_f(t) = \frac{V}{R} e^{-t/\tau} + \frac{V}{R}$ — ⓐ

$$= \frac{-V}{R} e^{-t/\tau} + \frac{V}{R} \quad \text{— ⓑ}$$

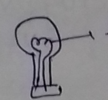


B) $v(t) = V_m \sin\omega t$,

$$i(t) = \frac{V_m}{|Z|} \sin\phi \, e^{-t/\tau} + \frac{V_m}{|Z|} \sin(\omega t - \phi).$$

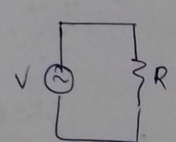
* In bulbs, we indicate power by average value.
* In a bulb, electrical bulb is filled with inert gas.
  temperature of the filament = 4500°C.
* Tip of the cigarette, temperature = 2500°C

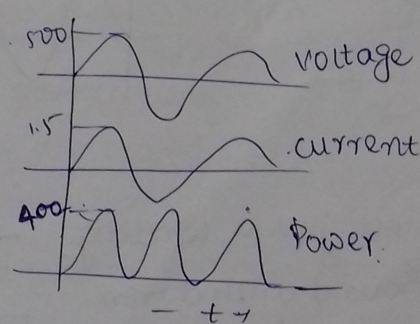
* $\Delta R = \alpha \, \Delta T \, R_0$
  Temperature coefficient:



(made of tungsten acts as resistance).

* $V = V_m \sin\omega t$.





Power – Instantaneous power (unidirectional, +ve).
* Active Power. – Avg{Instantaneous Active Power}.
  unidirectional.
  Reactive Power. – ~~Avg~~ Peak {Instantaneous Reactive Power}
  bidirectional.

* In R-L circuit,

$P = V_m I_m \sin\omega t \sin(\omega t - \phi)$.

$= V_m I_m \{\sin^2\omega t \cos\phi - \sin\omega t \cos\omega t \sin\phi\}$.

$= V_m I_m \left[\left(\frac{1-\cos 2\omega t}{2}\right)\cos\phi - \frac{\sin\phi}{2}\sin 2\omega t \right]$

$= \underbrace{V_m I_m \cos\phi \frac{(1-\cos 2\omega t)}{2}}_{\text{Active Power term}} - \frac{V_m I_m}{2} \sin 2\omega t \sin\phi$.

$V_m = V/\sqrt{2}$, $I_m = I/\sqrt{2}$.

$\therefore P = VI\cos\phi(1-\cos 2\omega t) - VI\sin 2\omega t \sin\phi$.

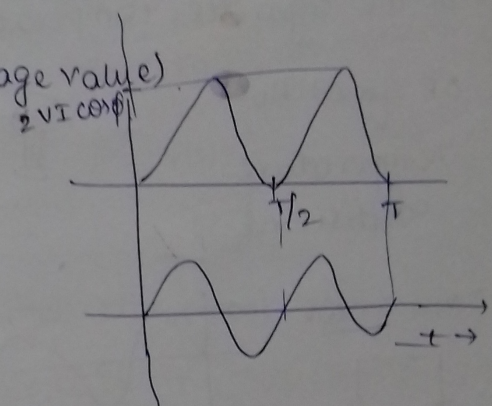
Instantaneous Power wave form.

$P_a = VI\cos\phi$.

Instantaneous Active Power (Average value)

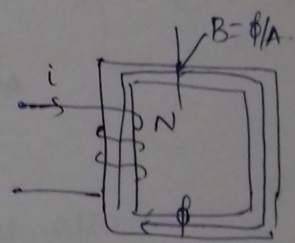
$P_r(t) = VI\sin\phi$.

Instantaneous Reactive Power. (Peak Value).



* Inductor.

Inductor is not just a winding, but a coil wound around iron core.



Iron core is used because flux will be more.

Magneto Motive Force (MMF) = No. of turns × current.

$F = Ni$.

MMF.

$F = \phi \times R$ → reluctance.

Flux.

Magnetic field Intensity (H) $= \frac{MMF}{length} = \frac{F}{L} = \frac{Ni}{L}$.

$H \rightarrow \frac{\text{Amp turns}}{\text{meter}}$.

Electric field Intensity $= \frac{EMF}{length}$

l = length of the core.

[∵ Along the core, flux has to be distributed].

In case of permanent magnet,

units of $H \rightarrow \frac{\text{Amp}}{\text{meter}}$ [∵ No. of turns are not considered].

* Electromagnetic → Permanent magnet.

$\frac{B}{H}$ = Permeability.

$= \mu$.

$= \mu_0 \mu_r$.

where,

μ_0 = permeability of free space,

$= 4\pi \times 10^{-7}$.

μ_r = relative permeability.

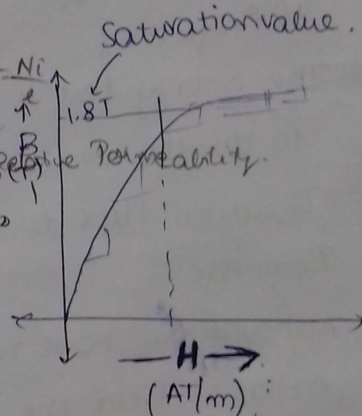
* $H = \frac{MMF}{l} = \frac{Ni}{l}$

$B = \mu H$,

$\mu = \mu_0 \mu_r$ → Relative Permeability.

Permeability of free space

Permeability of medium

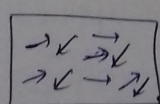


For a material, μ_r changes.

$V = iR + L\frac{di}{dt}$.

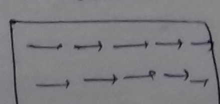
Inductance goes on changes [Non-linearity = Saturation].

* Initially, in ~~iron core~~ iron core...



magnetic domain.
(randomly alligned].

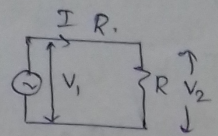
~~After~~ * Increase the current slowly, after sometime,



Aligned in one direction.

After reaching the above condition, if we furthur increase the current, there will not be any change in magnetic domain, $L = \frac{N^2 \mu A}{l}$.

* $\text{Loss} = \frac{(V_1 - V_2)^2}{R}$.



* AC Voltage.

Magnetic systems store power.

Area under graph is loss of energy. → Hysteresis loss.

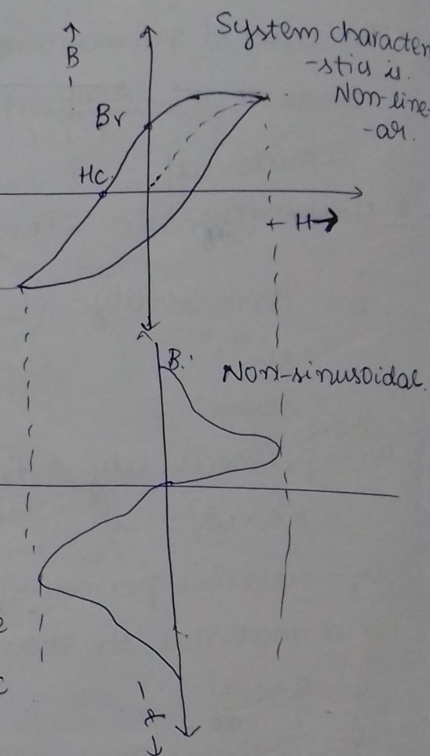
~~If frequency~~.

The energy lost is used to do the mechanical work

Residual flux density.

Remenac.

Although you ~~have~~ remove the external field, the magnetic material retains some magnetism.



Coercive force:

Amount of reverse field to be applied so that the magnetic field will loose its magnetism.

Energy lost during 1 cycle of magnetism. → Hysteresis loss.

H_c = Coersive force,

B_r = Residual flux density.

B → input

If B and H are sinusoidal, then, the resulting plot/graph has to a straight line passing through origin.

Input will be voltage (for the transformer).

$$H = \frac{ni}{l}$$

where, i will be decided by the transformer.

If input is sinusoidal, B is sinusoidal.

Why??

$$v(t) = N\frac{d\phi}{dt}$$

$$= V_m \sin \omega t$$

$$\therefore \phi(t) = \frac{1}{N}\int v(t)\,dt$$

$\phi(t)$ → Sinusoidal,

$B(t)$ → Sinusoidal then,

$H(t)$ → Non-Sinusoidal.

Magnetic Field Intensity

$H = \frac{ni}{l}$

$v = N\frac{d\phi}{dt}$

* To establish sinusoidal flux in the core, the source has to inject non-sinusoidal input.

Friday.
26-01-18.

$\vec{F} = i(\vec{l} \times \vec{B})$

Motor :-

Machine which converts electrical to mechanical energy.

* Machines which provide Mechanical energy are.
  Turbine, Engine.

~~Mo~~ Current carrying conductor placed in a magnetic field, ~~it~~ experiences some force.

$$\vec{F} = i\vec{l} \times \vec{B} \longrightarrow \text{lorentz force}$$

$\vec{l}$ → length of the conductor in the direction of current.