MADE EASY

Electrical Engineering

Toppers Handwritten Notes

Power System-1

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Standard voltages used in India :-

HVAC RMS line to line voltage / line voltage (kV) :

Transmission Network voltage (kV) -

- 1200 kV (maximum in india) Maharashtra
- 765, 400
- 220, 132
- 66

Distribution Network voltages (kV) -

- 33 kV, 11 kV

Industrials uses - 6.6 kV, 3.3 kV, 1.1 kV, 400 V

Houses uses - 230 V (phase voltage)

Frequency $f = 50\,Hz$

HVDC ± 500 kV, ± 800 kV, $f = 0\,Hz$

Q.N:- The rated voltage of a 3-phase power system is -
- RMS line to line voltage

All India Installed capacity sector : 382.730 GW

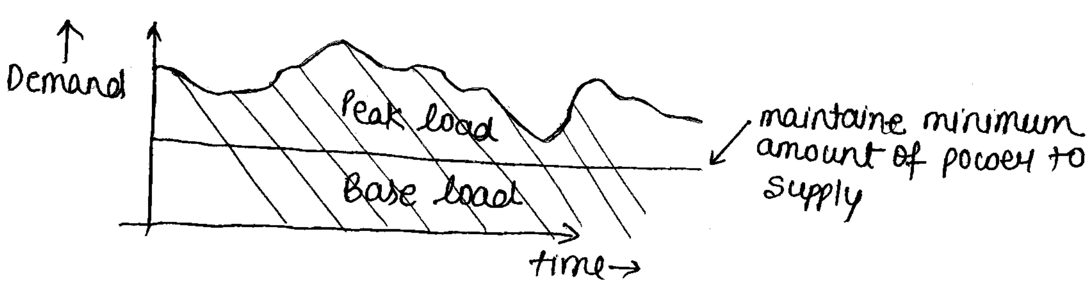
Coal : 209294.5 MW	Gas : 24924 MW	Nuclear : 6780 MW
Hydro : 46209.22 MW	Diesel : 509.71 MW	Renewable Energy source : 95012.59 MW

WR : 74320 MW by coal largest power utilisation
NER : 770 MW by coal smallest

Thermal : Coal + Lignite + Gas + Diesel

30th June 2021 → maximum power consumed by 193 GW at 12:46 pm

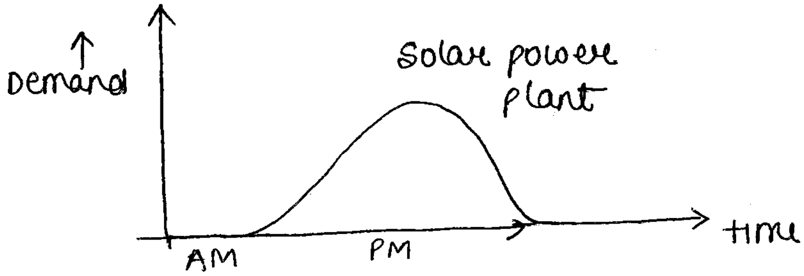
variable load curve : All india Demand (GW) v/s time



Base load –: Thermal plant

Peak load –: Hydro plant

Next to peak load : Gas, wind, solar



1 Kwhr = 1 unit

2019-20 1208 kwh per capita consumption

Objectives of Power system :-

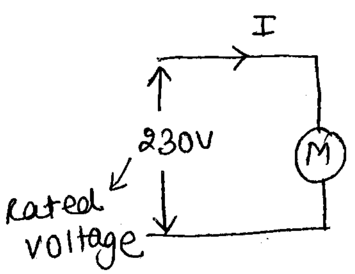
(i) Cost of electric energy must be low.

- Economic factors
- Economic load dispatch

(ii) Reliable power supply i.e; no interruption of power supply

- power generation methods
- Transmission
- Distribution
- Load flow studies

(iii) Maintaine constant voltage i.e; supply rated voltage to consumer



$P = 230W$

$\cos\varphi = 0.8$

$P = VI\cos\varphi$

$$I = \frac{P}{V\cos\varphi} = \frac{230}{230 \times 0.8} = 1.25A$$

suppose supply voltage get reduce to $V = 200$ volts then current drawn by motor will be

$$I = \frac{230}{200 \times 0.8} = 1.4375A.$$

$$\% \text{ increase in current} = \frac{1.4375 - 1.25}{1.25} \times 100 = 15\%$$

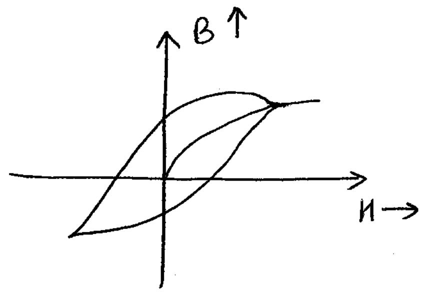
current drawn by motor is high value. this will cause overheating

To get constant voltage — voltage/Reactive power control

(iv) **Maintaine Rated frequency**

$f = 50Hz \pm 1\%$ (49.5 to 50.5) Hz (ideal case)

$= 50Hz \pm 3\%$ (48.5 to 51.3) Hz (practical case)



power T/F : $V = 4.44 f \phi_m N$

$\frac{V}{f\downarrow} \propto \phi\uparrow$ → causes core saturation

For this → load frequency control

(v) **Faster fault identification** and **clearance of fault** in **minimum time**

— Fault Analysis

— Protection

(vi) Stable Generator has to be maintained

— stability

(viii) **Flexible power transfer**

— Power cable

Panther	- 132 kV
Zebra	- 220 kV
Moose	- 400 kV

Transmission line Parameters & Performance :-

By using transmission line, electric power is transfer from the remote generating station to the load centre (electric power utilised).

Material of Transmission line :-

ACSR – Aluminium conductor steel Reinforced

steel is used at the centre because it has higher mechanical strength to withstand and carry large weight of ACSR conductor.

4 layer ACSR (37 – 30 | 7) → 37: strands, 30: Al, 7: steel

5 layer ACSR (61 – 54 | 7) → 61: strands, 54: Al, 7: steel

No. of strands : $N = (3x^2 - 3x + 1)$

Total Dia $D = (2x - 1)d$

x = layer number

d = Dia of each strands

Technical name of ACSR :- Animal like, Zebra, Panther, Moose, Dog etc is used for Aluminium for european standard and bird name like swan, sparrow, Raven, Pigeon etc is used as for US standard.

Power carrying capacities at 65°C :-

At 132 KV with 'Panther' ACSR = 75 MVA

At 220 KV with 'Zebra' ACSR = 200 MVA

At 400 KV with 'Moose' ACSR = 500 MVA .

3ϕ T/L $\Rightarrow \sqrt{3}\, V \cdot I \cos\phi = P_{3\phi}$

$\sqrt{3} \times 400 \times 10^3 \times I \times 0.95 = 500 \times 10^6$

$I = 759.67\,A$ carrying current by Moose

Tower configuration :-

3 bundle conductor not practically used due to mechanical strength.

Classification of Transmission line :-

(i) Short line – $l < 80km$, $lf < 4000$

(ii) Medium line – $80 \le l \le 200$ km, $4000 \le lf \le 10000$

(iii) Long line – $l > 200$ km, $lf > 10000$

where l = length of Tr. line f = supply frequency = 50Hz

Ex-: Short line $l \times f = 80 \times 50 = 4000$

NOTE-: communication line operating at MHz range hence considered as long transmission line because $lf > 10{,}000$ for any length of line

QN:- A T/L is excited by the frequency of

(i) 300Hz (ii) 50Hz (iii) 600Hz

Find the type of T/L if its physical length is 20km?

Solution :-

(i) 300Hz $lf = 20km \times 300Hz = 6000$ (lf)

→ $4000 \le lf \le 1000$ → Medium

(ii) 50Hz $lf = 20km \times 50Hz = 1000$ ⟶ short line ($lf < 4000$)

(iii) 600Hz $lf = 20km \times 600Hz = 12{,}000$ ⟶ long line $lf > 10000$

Transmission line Parameters :-

(i) Inductance (L)

(ii) capacitance (C)

(iii) Resistance (R)

(iv) conductance (G)

Inductance :-

current ⟶ produce flux ⟶ link with other 2 phase also i.e; due to flux (self + Mutual) produces inductance in it.

Capacitance :-

Two metal is separated by some distance & operating at some voltage produce capacitance in it & ground capacitance also exists.

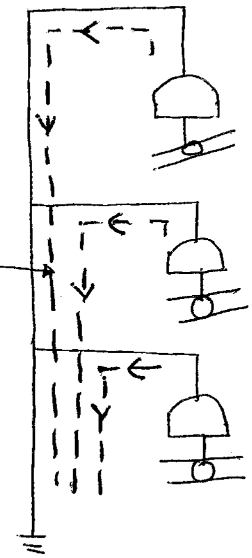
Resistance :-

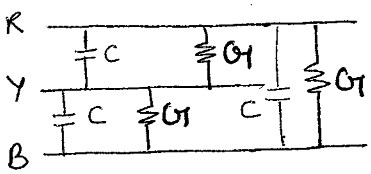
ACSR has certain cross section area & length which will produce resistance.

Conductance (G) :- The leakage current flowing through the supporting insulator is represented by the conductance parameter. It's value is very small and hence neglected in case of short & medium line and consider in the long transmission.

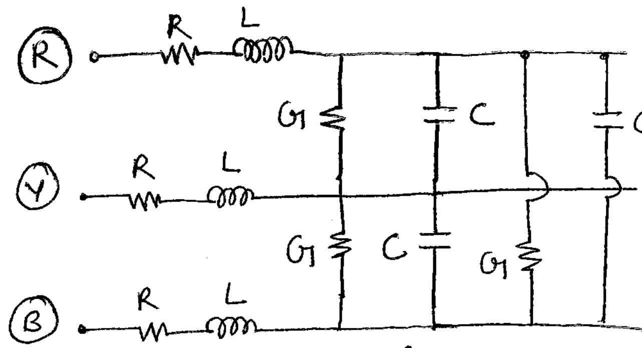
Electrical equivalent of leakage current $\Rightarrow$ conductance (G)

leakage current due to small value of resistance in insulator (Negl.)





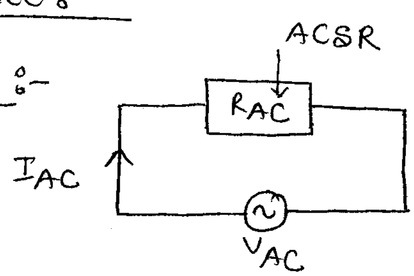
series element $\Rightarrow$ R & L
shunt element $\Rightarrow$ C & G



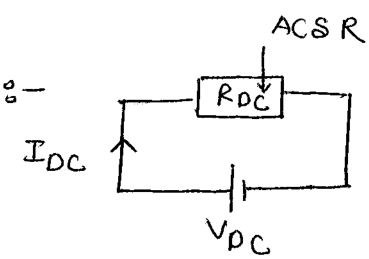
:- Electrical eq^t of x-mission line :-

Resistance :-

HVAC :-

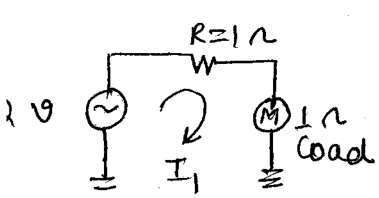


HVDC :-

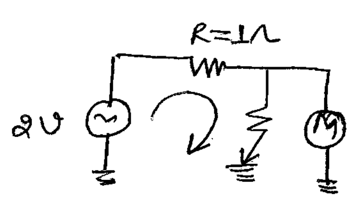


$R_{AC} > R_{DC}$ Due to (i) skin effect (ii) proximity effect

$R_{AC} = 1.5\, R_{DC}$



$I_1 = \frac{2}{1+1} = \frac{2}{2} = 1A$



$I_2 = \frac{2}{1} = 2A$

$I_2 = 2I_1$ during short ckt condition

Short ckt rating : KA/S [maximum current able to withstand during fault]

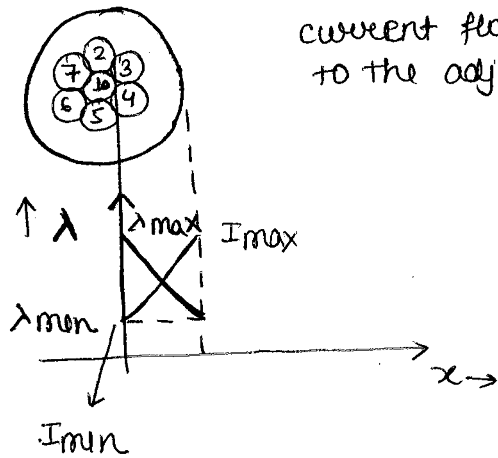
RTS : KN

(i) Skin effect :-

(a) Accumulation of the current on the surface of conductor is called skin effect

⊙ outwards current

current flowing in the conductor producing flux to the adjacent of conductor



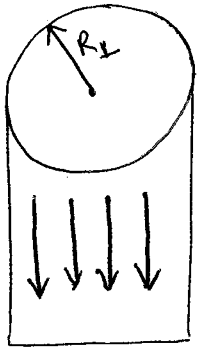
λ_{max} i.e; L_{max} then $X_L \uparrow$

$\downarrow I = \frac{V}{X_L \uparrow}$

λ_{min} i.e; L_{min} then $X_L \downarrow$

$\uparrow I = \frac{V}{X_L \downarrow}$

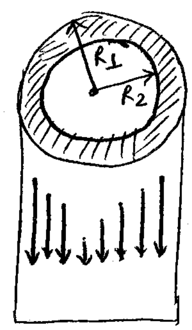
HVDC :



uniform current is flowing because there is no rate of change of flux.

$$R_{DC} = \frac{\rho l}{\pi R_1^2}$$

HVAC :



$$R_{AC} = \frac{\rho l}{\pi (R_1^2 - R_2^2)}$$

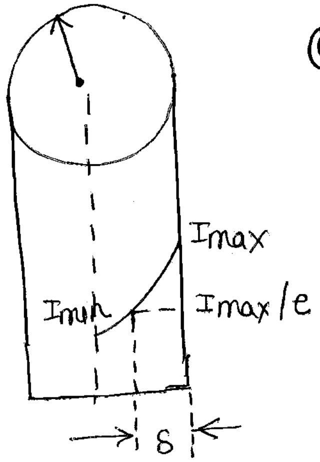
(b) Due to skin effect, effective area of current flowing path is reduced which causes $R_{AC} > R_{DC}$. in HVAC system.

(c) Skin effect depends on f, σ, μ_r and size of the conductor.

(d) Skin effect is more in communication line because frequency is in MHZ range and this effect is neglected in power lines because the frequency is less (50HZ) only.

f = supply frequency , μ_r = Relative Permeability   σ = conductivity

Skin depth (δ) :-



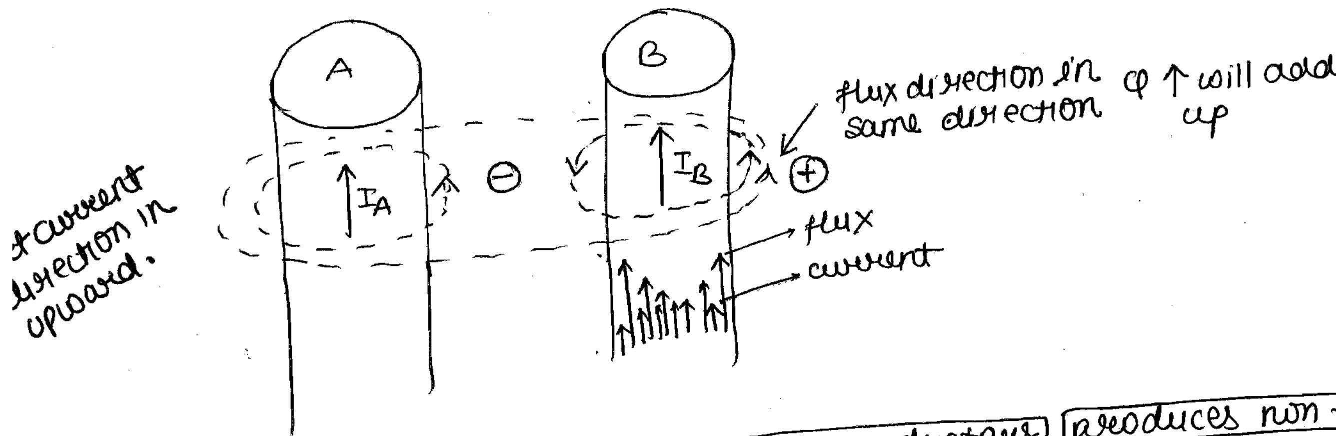
(a) The depth of the conductor at which the current is drop to (1/e) time of the maximum current & that depth is called as skin depth.

$$\delta = \frac{1}{\sqrt{\pi f \mu_0 \mu_r \sigma}} \propto \frac{1}{\text{skin effect}}$$

(b) when skin depth is less then more accumulation of current on the surface of conductor, then skin effect will be more

(c) In HVDC, no skin effect because f = 0

Proximity effect :-



(a) The current flowing in the adjacent conductors produces non-uniform flux linkage which will cause non-uniform current flow so, that the effective area of current flowing path is reduce which causes $R_{AC} > R_{DC}$ (we are not able to utilise whole area)

(b) Proximity effect depends on f, μ_r, σ & distance between the conductor

(c) this effect is more in power cable and less in overhead transmission line because .