ELECTRICAL ENGINEERING
Short Notes

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

POWER SYSTEM

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Distribution Systems

Objectives:- a) Uniform voltage distribution to all customers.
b) Reactive p/w supply.

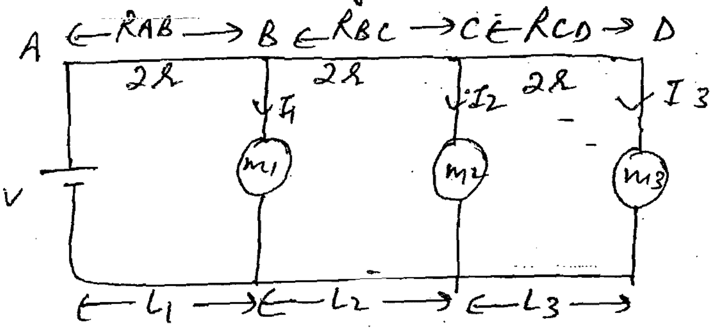
Methods:-
→ Source from one end.
→ Source fed at both the ends.
→ Ring Distribution.

Types of Distribution S/ys.

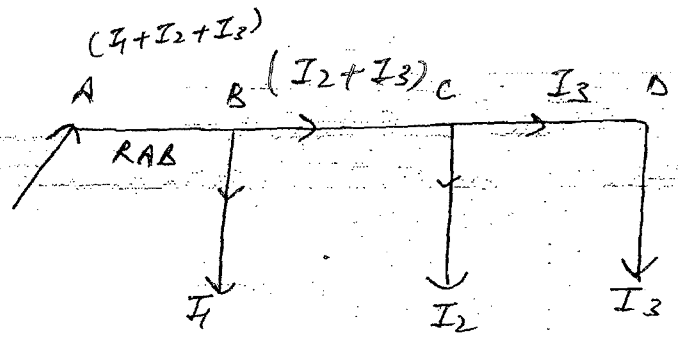
a) DC distribution:- Used in sub stations & generating station for equipment protection
b) AC distribution:- used in public utility.

Source fed from one end

1) DC Distribution System



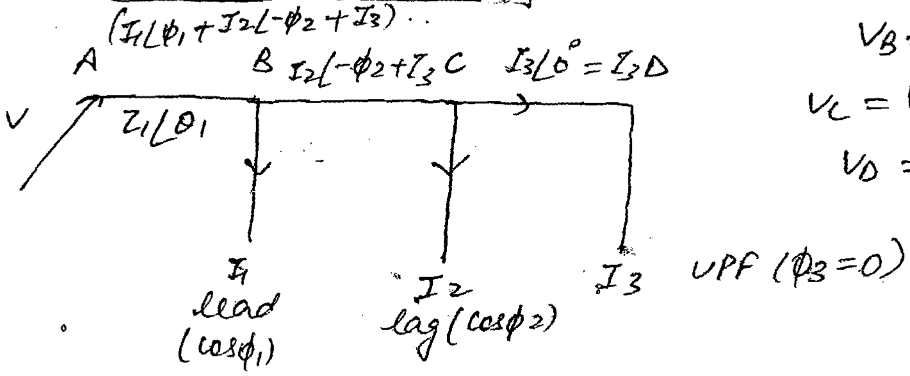
r = resistance of cond. /m
2r = " " distributor /m
$R_{AB} = 2rL_1$, $R_{BC} = 2rL_2$
$R_{CD} = 2rL_3$



$V_A = V$
$V_B = V_A - (I_1+I_2+I_3)R_{AB}$
$V_C = V_B - (I_2+I_3)R_{BC}$
$V_D = V_C - I_3 R_{CD}$

Voltage drop of distributor $= V_{AD} = V_A - V_D$

(b) AC Distribution S/y.



$V_A = V$

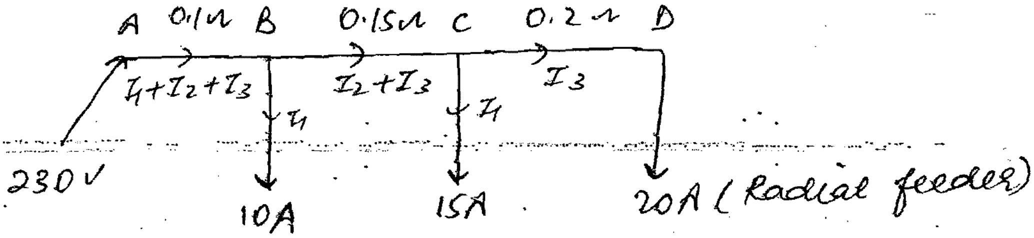
$V_B = (V_A - (I_1\angle\phi_1 + I_2\angle-\phi_2 + I_3) Z_1\angle\theta_1$

$V_C = V_B - (I_2\angle-\phi_2 + I_3) Z_2\angle\theta_2$

$V_D = V_C - I_3\angle\theta_3$

voltage of distributor $= V_{AD} = V_A - V_D$

Example Find voltage at each node for ckt shown in the figure.



$V_A = 230V,$ $\quad V_B = 230 - (I_1 + I_2 + I_3) R_{AB}$

$= 230 - (10 + 15 + 20) \times 0.1$

$V_B = 225.5V$

$V_C = V_B - (I_2 + I_3) R_{BC}$

$= 225.5 - (35) 0.15$

$= 220.25V$

$V_D = V_C - I_3 R_{CD}$

$= 220.25 - 20 \times 0.2$

$= 216.25V$

$\Rightarrow V_{AD} = V_A - V_D$

$= 230 - 216.25$

$= 13.75V$

In this method consumer at far end from source experiences low voltage and reliable p/w supply not possible

<u>Source feeding from both the ends.</u>

Step 1 Assume I_A from V_A.

Step 2 Calculate I_A using

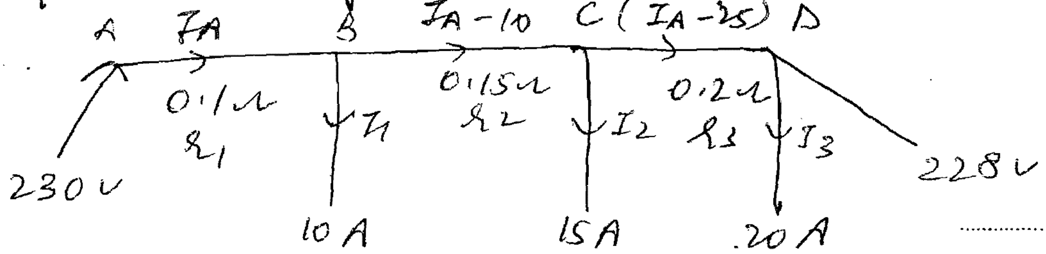
$V_A - V_D = I_A r_1 + (I_A - I_1) r_2 + (I_A - I_1 - I_2) r_3$

step-3 Substitute I_A in $(I_A - I_1)$ and $(I_A - I_1 - I_2)$ and check for sign change.

step 4 Node of first sign change is node of min. potential

step 5 Calculate min. potential using KVL.

Example Find voltages at each node shown in figure.



① $V_A - V_D = I_A R_1 + (I_A - R_1) R_2 + (I_A - I_1 - I_2) R_3$

$230 - 228 = 0.1 I_A + 0.15 (I_A - 10) + 0.2 (I_A - 25)$

$2 = 0.1 I_A + 0.15 I_A - 1.5 + 0.2 I_A - 5$

$\Rightarrow \boxed{I_A = 18.9 A}$

② $I_A - 10 = 18.9 - 10 = +8.9$ Node B

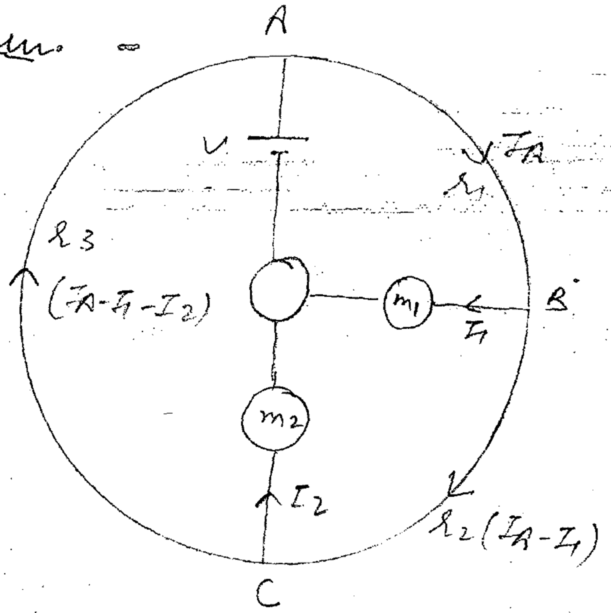
$I_A - 25 = 18.9 - 25 = -6.1$ node C

sign change so C at min potential

③ $V_C = 230 - (0.1 \times 18.9 + 8.9 \times 0.15) = 226.775$

$V_B = 230 - 18.9 \times 0.1 = 228.1 V$

Ring distribution System.



Node of min potential

① Assume I_A from V_A.

② Calculate I_A using

$0 = I_A R_1 + (I_A - I_1) R_2 + (I_A - I_1 - I_2) R_3$

③ Substitute I_A in $I_A - I_1$ and in $(I_A - I_1 - I_2)$ and check for sign change

④ Node of 1st sign change = Node of min. potential.

Advantages of Ring dist s/y

a) Reliable p/w supply possible
b) uniform voltage to all customers possible

Disadvantage

→ No of lines are more so p/w loss is more

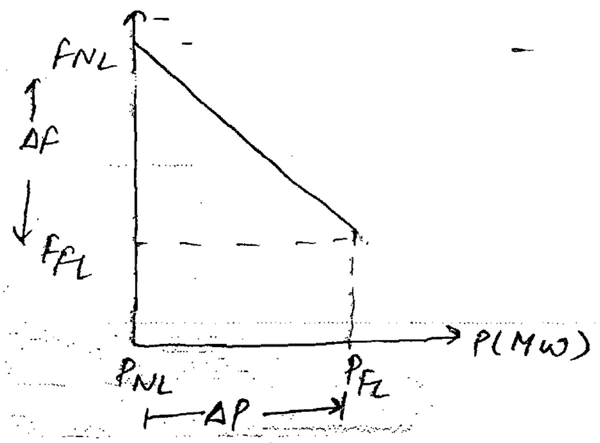
Advantages of Radial Dist s/y

→ ~~No of~~ lines are less so p/w loss is min
→ used as load regulation unit for freq control using current carrier protection.

Disadvantages of Radial s/y

→ Reliable p/w supply not possible
→ Remote consumer experiences low voltage.

② LOAD FREQUENCY CONTROL



Speed Regulation Parameter(R):-

$$R = \frac{-\Delta f}{\Delta P} \quad Hz/MW$$

also

$$R = \frac{\Delta f_2}{\Delta P_2} = \frac{\Delta f_1}{\Delta P_1}$$

Speed Regulation Constant

$$\frac{F_{NL} - F_{FL}}{F_{FL}} \times 100$$

Steady state freq drop / deviation (ΔF)

$$KE = HS = \frac{1}{2} I\omega^2$$
$$= \frac{1}{2} I(2\pi F)^2$$

$$F_i^{\circ} \propto (H \cdot S)^{\frac{1}{2}}$$

$$\boxed{\Delta F = (F_n - F_i^{\circ})\ Hz}$$

a) loss of load / Trip of trans. line

$$F_n \propto (HS + (\Delta P_D)T_d)^{1/2}$$

$$\boxed{F_n = F_i^{\circ}\left(\frac{HS + (\Delta P_D)T_d}{HS}\right)^{\frac{1}{2}}}$$

b) Additional load Demand

$$\boxed{F_n = F_i^{\circ}\left(\frac{HS - (\Delta P_D)T_d}{HS}\right)^{\frac{1}{2}}}$$

H = Inertia constant MW sec/MVA

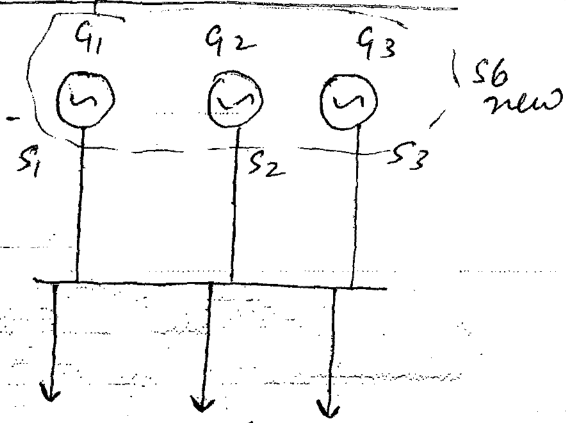
S = Rating of Generator MVA

T_d = Governor s/y time delay in sec

ΔP_D = load loss / loss Demand MW

F_i° = Initial freq Hz , F_n = New freq Hz

Multiple Generator case



$P_D \rightarrow (P_D \pm \Delta P_D)$

① R_1, R_2, R_3 --- Hz/MW

S_1, S_2, S_3 --- MVA or MW

ΔP_D = MW

$$R = -\frac{\Delta F}{\Delta P_D} \text{ --- Hz/MW}$$

② R_1, R_2, R_3 --- pu

corresponding to S_1, S_2, S_3

$$R_{pu\,new} = R_{pu\,old} \times \frac{S_{b\,new}}{S_{b\,old}}$$

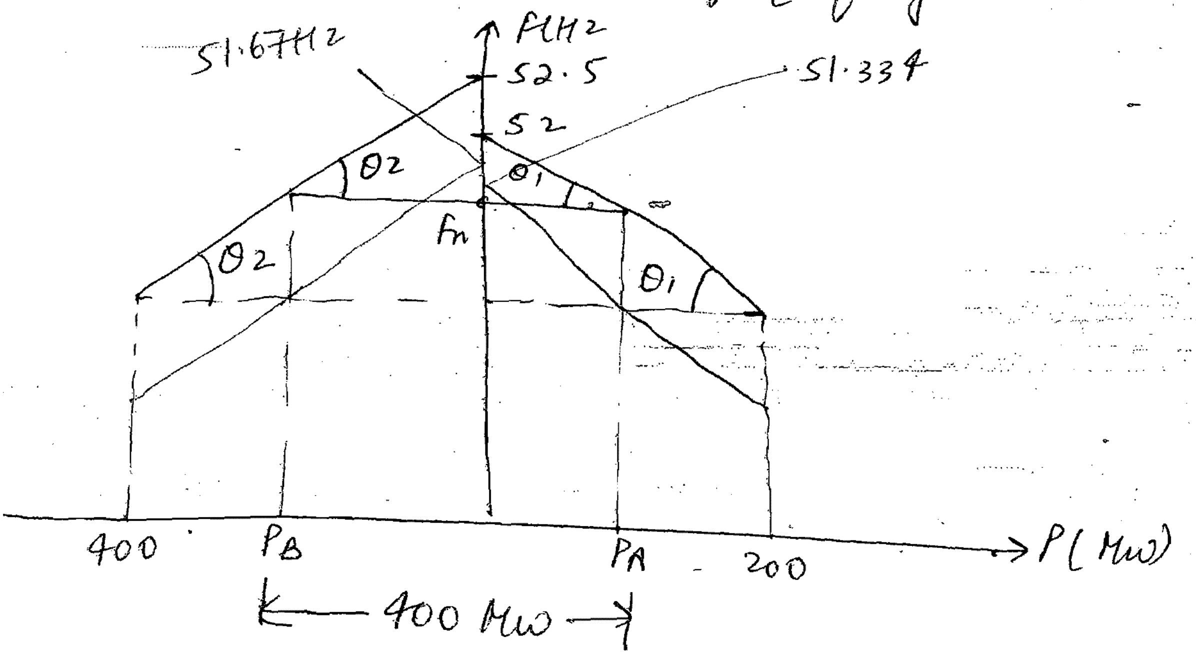
→ In case of parallel operation of generators which have same no-load freq, the generator which has lowest drooping character will share the max load.

→ If a 0% drooping character generator is connected in parallel to other generators which have 2, 4, 6% droop character, then 0% generator will supply entire load change w/o loading other parallel generators, assuming it has ∞ capacity.

Q Two generators delivering 200 MW & ~~400 MW~~ at 50 Hz and drooping characteristics of generator is 4% & 5% respectively from no load to full load.

1) If load is dropped to 400 MW. Find load sharing of g_1, g_2 and corresponding operating freq assuming free governing action.

2) By adjusting speed changer freq is set to 50 Hz for a load of 400 MW, the generators are sharing in the ratio of their rating. Calculate no load freq of generator.



$$\tan\theta_1 = \frac{52 - F_n}{P_A} = \frac{52 - 50}{200} \quad \text{—} (1)$$