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POWER SYSTEM

Distribution Systems

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

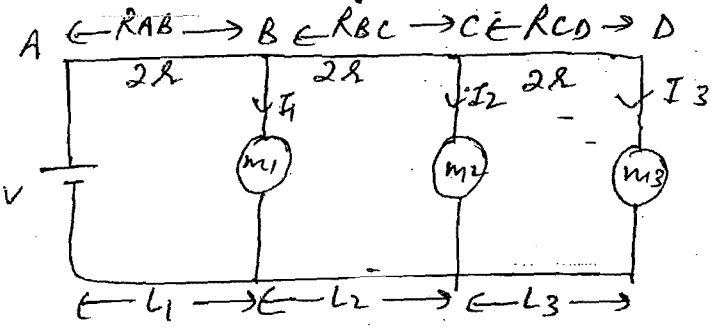
Methods:-
→ Source from one end.
→ Source fed at both the ends
→ Ring Distribution.

Types of Distribution S/ys.

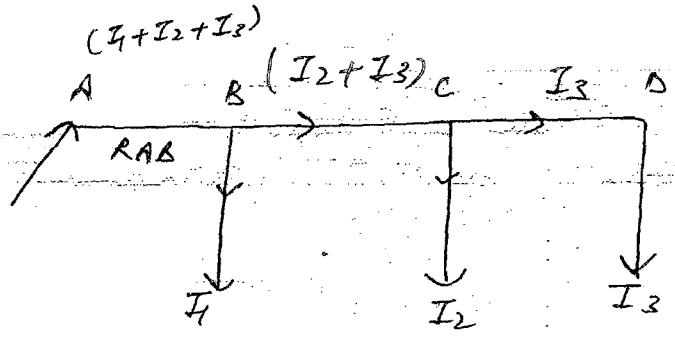
a) DC distribution:- Used in sub stations & generating station for equipment protection
b) AC distribution:- used in public utility.

Source fed from one end

1) DC Distribution System



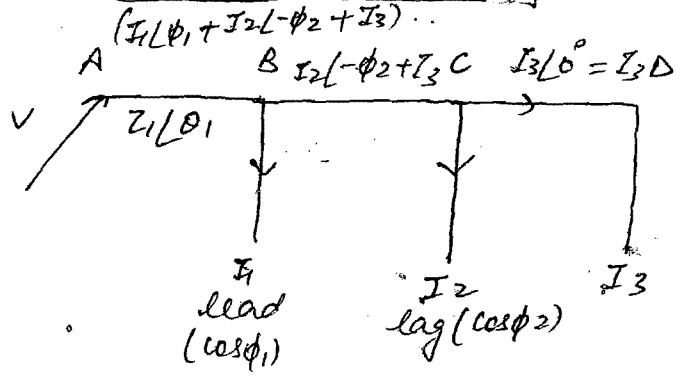
r = resistance of cond. m/m
2r = " " distributor m/m
$R_{AB} = 2rL_1$, $R_{BC} = 2rL_2$
$R_{CD} = 2rL_3$



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

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

(6) AC Distribution S/y.



$V_A = V$

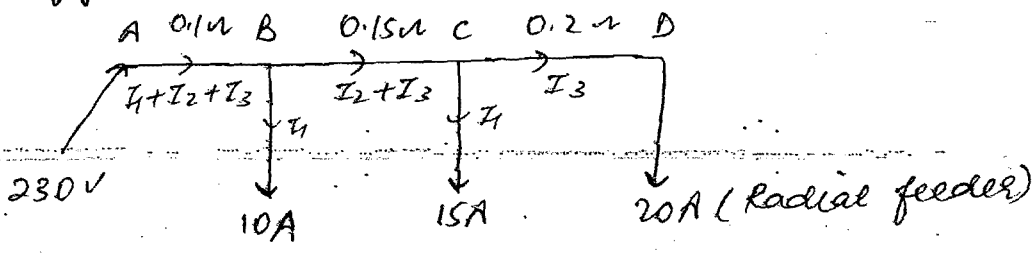
$V_B = (V_A - I_1\angle(\phi_1 + I_2\angle(-\phi_2+I_3)Z_1\angle\theta_1$

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

$V_D = V_C - I_3\angle\theta_3$

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

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



$V_A = 230V$,

$V_B = 230 - (I_1+I_2+I_3)R_{AB}$

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

$V_B = 225.5\,V$

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

$= 225.5 - (35)0.15$

$= 220.25V$

$V_D = V_C - I_3R_{CD}$

$= 220.25 - 20\times 0.2$

$= 216.25\,V$

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

$= 230 - 216.25$

$= 13.75V$

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

Source feeding from both the ends.

Step 1 Assume I_A from V_A.

Step 2 calculate I_A using

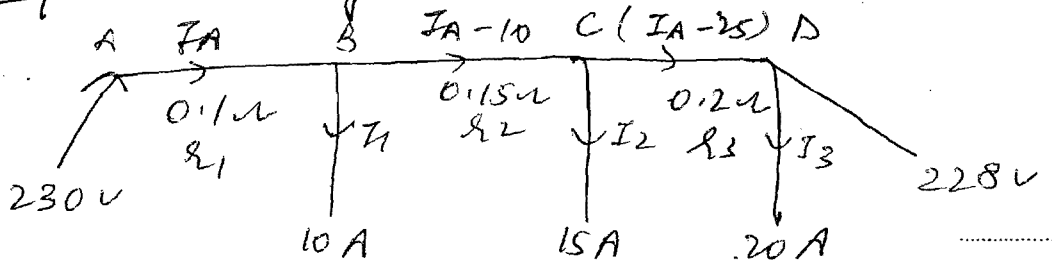
$V_A - V_D = I_A R_1 + (I_A - I_1)R_2 + (I_A - I_1 - I_2)R_3$

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

Step4 Node of first sign change is node of min. potential

Step5 Calculate min. potential using KVL.

Example Find voltages at each node shown in figure.



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

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

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

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

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

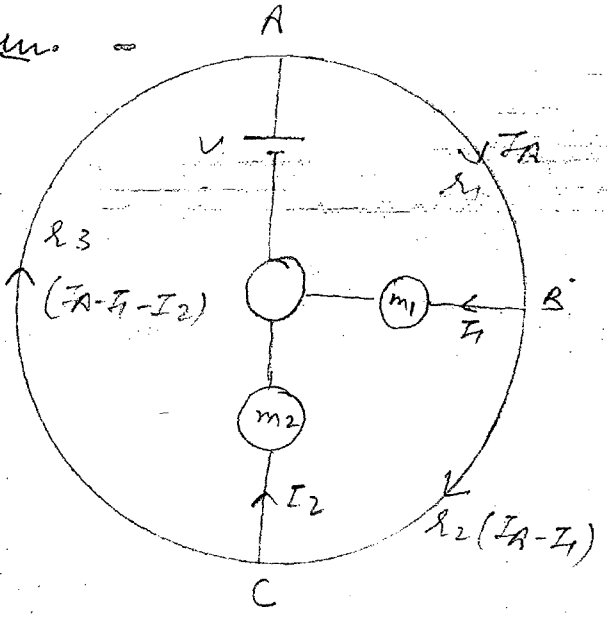
$I_A - 25 = 18.9 - 25 = -6.1$ node C

↙ sign change so C at min potential

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

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

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 Ist 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

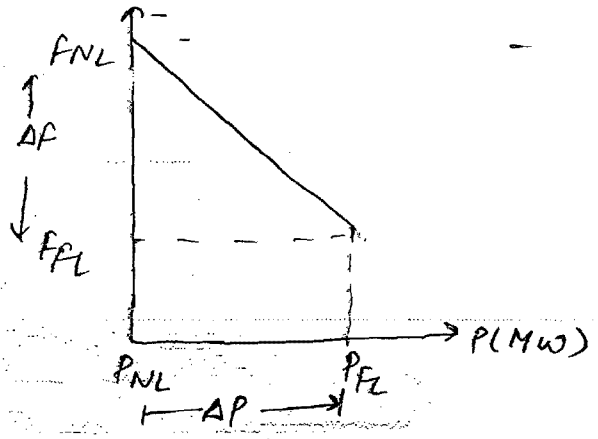
Advantages of Radial Dist s/y

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

Speed Regulation Constant

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

Steady state freq drop / deviation (ΔF)

$KE = HS = \frac{1}{2} I\omega^2$

$= \frac{1}{2} I(2\pi f)^2$

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

$$\boxed{\Delta f = (f_n - f^\circ)\ Hz}$$

a) loss of load / Trip of trans. line

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

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

b) Additional load Demand

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

H = Inertia constant MW sec/MVA

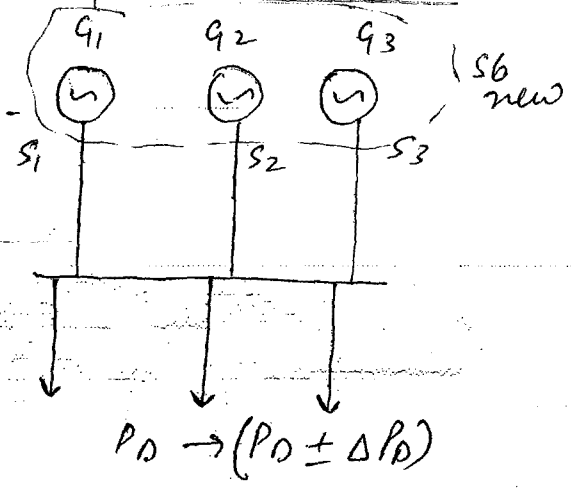
S = Rating of Generator MVA

T_d = Governor g/y time delay in sec

ΔP_D = load loss / loss demand MW

f° = Initial freq Hz , f_n = New freq Hz

Multiple Generator case



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

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

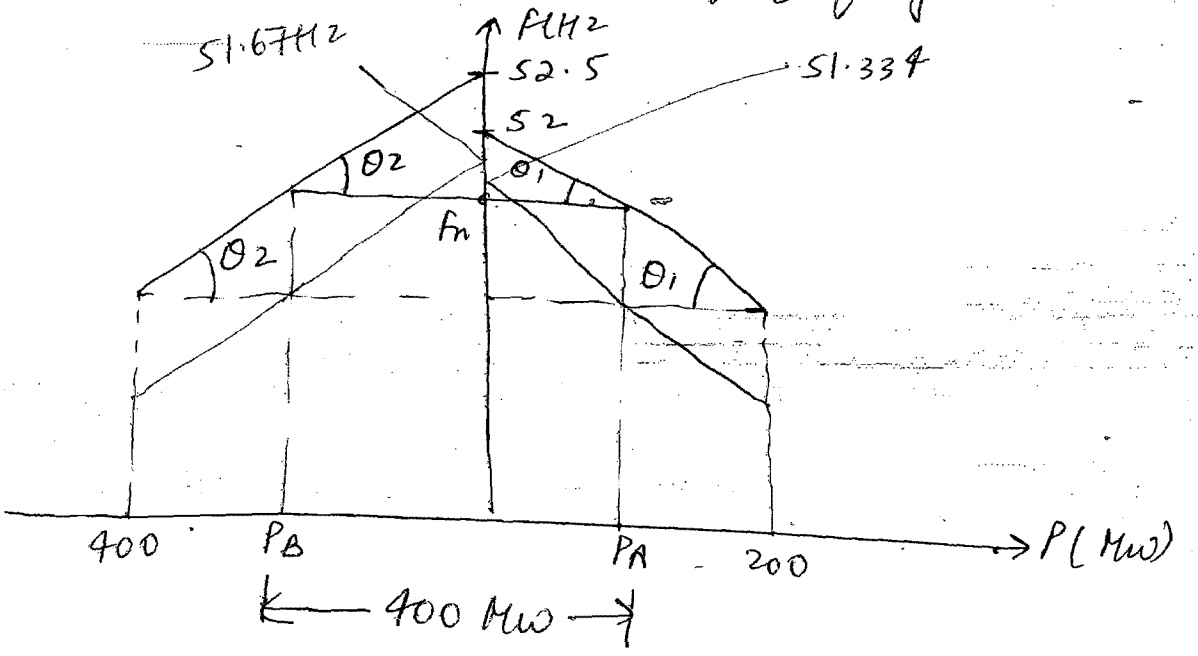
→ In case of parallel operation of generators which have same no-load freq, the generator which has lowest drooping character will share the max load.

→ 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 generators 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.



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