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18-37400-1

1.

$X_{eq} = \frac{11^2}{150} = 0.806$

$Z_s = 0.806 \Omega$

$Z_{12} = 0.7 \Omega$

$Z_{23} = 0.4 \Omega$

$I_{f3} = \frac{\frac{11}{\sqrt{3}} \times 10^3}{0.806 + 0.7 + 0.4} = 3165.92 A$

$I_{f2} = \frac{\frac{11}{\sqrt{3}} \times 10^3}{Z_s + Z_{12}} = \frac{\frac{11}{\sqrt{3}} \times 10^3}{0.806 + 0.7} = 4217.03 A$

$I_{f1} = \frac{\frac{11}{\sqrt{3}} \times 10^3}{0.806} = 7879.47 A$

Relay C

if fault occurs at Bus 3, fault current = 3165 A

Nominal current 110 A

load margin = 25%.

over load current = $110 \times 1.25 = 137.5 A$

ration 200/5 A

Ps should be choosen such as pick up current must be greater than over load rating, 137.5 A

PS = 75%.

I pickup primary = $200 \times 0.75 = 150 A$

PSM = $\frac{3165}{150}$ = 21.1 > 20

t_{cc} = 2.25 BM = 0.15 Assumed

Actual operating tim of relay C fault at Bus 3

$t_{cc} = 2.25 \times 0.15 = 0.33$

Relay B

Actual operating time of relay B for fault at Bus $t_{ab} = (0.33 + 0.5)$ s

= 0.74 s

Nominal current = 150 A

load margin = 25%

O/L rating = 150×1.25 = 187.5 A

CT rating = 200/5

PS should be choosen as I pick up must be greaten than O/L rating

PS = 100 %.

I pick up primary = 200×100 %.

Psm = $\frac{3165}{200}$ = 15.825 < 20

$$t_{cB} = \frac{0.14}{(psm)^{0.02} - 1} = 2.465$$

$$TSM_B = \frac{t_{aB}}{t_{cB}} = \frac{0.74}{2.465} = 0.300$$

TSM should be within 0-1 with step of 0.05

TSM = 0.30

fault is at Bus B

$$PSM = \frac{4217}{200} = 21.085 > 20$$

t_{cB} = 2.2 sec

$t_{aB} = 2.2 \times 0.30 = 0.675$

Relay A

Fault Bus 2, ~~relay 35~~.

Actualy operating time of relay for fault at Bus

$t_{aA} = 0.675 + 0.5 = 1.17$ sec

Nominal current = 300 A

Load Mangin = 25 %.

O/L rating = $300 \times 1.25 = 375$

Assumed CT rating = 400/5

ps should be choosen as Ipick up is greater

then 375 A

PS = 100 %.

I pick up primary = 400 × 100 % = 400 A

$PSM = \frac{4217}{400} = 10.5425 \angle 20$

$t_{cr.} = \frac{0.19}{(10.59)^{0.02} - 1} = 2.90$ sec

$I_{SMA} = \frac{1.17}{2.09} = 0.403$

As TSM should be within spe 0-1

TSM = 04

if fault at Bus A

$PSM = \frac{7879}{400} = 14.69 \angle 20$

$t_c = \frac{0.14}{(14.69)^{0.02} - 1} = 2.279$

$t_{GA} = t_c \times TSMA$

$= 2.274 \times 0.4 = 0.911$ S.

2.

(b)

Current

Pick up

316.5 . 31

3000

0.215 sec

$PSM = \frac{3000}{200} = 10 : t_c = 1.8$ sec

$t_a = 1.8 \times 0.25$

$= 15 \times c$

$2500 - PSM = \frac{2500}{200} = 12.5 : t_c = \frac{1.4}{(12.5)^{0.02}_{-1}}$

$= 2.7$

$t_a = 2.7 \times 0.25$

$= 0.67$ sec

$1500 - PSM = \frac{1500}{200} = 7.5$ $t_c = 3.40$

$t_a = 0.85$

$1000 - PSM = \frac{1000}{200} = 5$; $t_c = 4.27$

$t_a = 1.06$ sec

$500 - PSM = \frac{500}{200} = 2.5$ $t_c = 7.5$

$t_a = 1.39$ sec

(b)

For operating relay

Operating force $\geq$ restaining force

Here,

$I_1 = 300\,A$

$I_2 = 290\,A$

$k = 0.1$

$I_{pick\ up} = 2.5\,A$

$\frac{N_r}{N_o} = 0.05$

$$\text{Operating force} = \left| \frac{I_1 - I_2}{k} \right|$$

$$= \left| \frac{300 - 290}{0.1} \right|$$

$$= \left| \frac{10}{0.1} \right|$$

$$= 100$$

$$\text{Restaining force} = \left| \frac{I_1 + I_2}{2k} \right| \times \frac{N_r}{N_o} + I_{pick\ up}$$

$$= \left| \frac{300 + 290}{2 \times 0.1} \right| \times 0.5 + 2.5$$

$$= 1477.5$$

So operating force is less than the restaining force. So the relay will not operate.

3.

(i)

Corresponding current in CT primary $= \frac{1.8 \times 1000}{5}$

$= 360$ A

Here,
$V_1 = 11$ kV
$V_{LN} = 11/\sqrt{3}$ kV
$R = 15\ \Omega$
Transformation ratio = 1800/5 A

% of winding unprotected $= \frac{15 \times 360 \times 100}{11/\sqrt{3} \times 10^3}$

$= 85.02$ %

% of winding protected $= (100 - 85.02)$

$= 14.97$ %

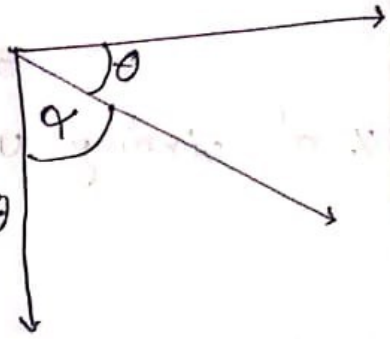
(ii) If 95% of winding is protected that means 5% winding is unprotected

$$5 = \frac{R \times 360 \times 100}{\frac{11}{\sqrt{3}} \times 10^3}$$

$R = 0.882\ \Omega$

(b)
The driving torque of an induction type directional relay change in proportional to the instantaneous active power value

$T \propto \phi_1 \phi_2 \sin\alpha$



Here,
$\phi_1 \propto V_1$, $\phi_2 \propto I$ and ~~$\phi\phi\phi\theta$~~

$\alpha = 90 - \theta$

$T \propto VI \sin(90 - \theta)$

$T \propto VI \cos\theta$

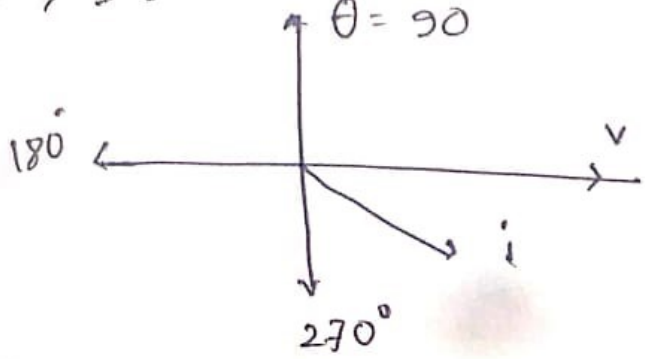
$\Rightarrow T \propto$ power in the circuit

Active power flowing through a part of electronic circuit is $P = VI\cos\theta$ where θ is the angle between V and I

i) For $\theta < 190^\circ$, real power is positive

ii) For $\theta = 190^\circ$, real power 0

For $\theta > 190^\circ$, real power negative



4.

a) Assume, line current on 0.44 kV side = 800A

Phase current of delta connected CTs for 0.44 kV sidd = 5 A

line current of delta connected CTs on 0.44 kV side = $\sqrt{3} \times 5 = 8.66$ A

If I is the line current on 11 kV side then, Primary apparent power = Secondary apparent power

$$\Rightarrow \sqrt{3} \times 0.44 \times 10^3 \times 800 = \sqrt{3} \times 11 \times 10^3 \times I$$

$$I = \frac{\sqrt{3} \times 0.44 \times 10^3 \times 800}{\sqrt{3} \times 11 \times 10^3} = 32 \text{ A}$$

Turn ratio of CTs on 11kV side

$$= 32 : 8.66$$

$$= 3.696 : 1$$

(b) The distance relay is a distance protection element designed to measure the faulty point. The operation of this relay depends on the value of the impedence. It gets starts operating only when the voltage and current ratio which means impedence is less then the predetermined impedence value of the relay as the impedence of the transmission line is directly proportional to its length, then the relay starts operating if any fault occures within the length of the transmission line or predetermined distance.