North South University

Assignment 02

Power Systems

Course Code: EEE362

Section: 02

Course Instructor

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(1) Given that, $f = 60\,Hz$

rms value $= 100\,V$

$R = 15\,\Omega$

$L = 0.12\,H$

(a) we know that, $v = V_m \sin(\omega t + \alpha)$

for, $t = 0$,

$50 = \sqrt{2} \times 100 \sin\alpha$

$\Rightarrow \alpha = 20.70^\circ$

$\therefore Z = 15 + j2\pi \times 60 \times 0.12$

$= 47.66 \angle 71.66^\circ$

At, $t = 0$,

$i_{dc} = -\dfrac{100 \times \sqrt{2}}{47.66} \sin(20.7^\circ - 71.66^\circ)$

$= 2.305\,A$

(b) Maximum dc component occurs when

$\sin(\alpha - \theta) = \pm 1$

when, $(\alpha - \theta) = \pm 90^\circ$

$\alpha = 161.66^\circ$ or -18.34°

$v = 100\sqrt{2} \sin 161.66°$

$= 100\sqrt{2} \sin -18.34°$

$= \pm 44.5 V$

(c) No dc component will occur when $\alpha - \theta = 0$ or $\alpha - \theta = 180°$

when $\alpha = 71.66°$ or $251.66°$

$v = 100\sqrt{2} \sin 71.66°$

$= 100\sqrt{2} \sin 251.66°$

$= \pm 134.24 V$

(d) For $v = 0$ when $t = 0$ and $\alpha = 0$

0.5 cycles later $\omega t = \pi$ rad.

$t = \frac{\pi}{2\pi 60} = 0.00833 s$

$$i = \frac{100\sqrt{2}}{47.66}\left[\sin(180° - 71.66°) - e^{\frac{-15}{0.12}(0.00833)} \times \sin(-71.66°)\right]$$

$$= \frac{100\sqrt{2}}{47.66}\left(1 + e^{-1.0461}\right) \sin(-71.66°)$$

$= 3.810 A$

similarly

when, 1.5 cycles later : $\omega t = 3\pi$

$\therefore t = 0.025\,s$

$\therefore i = 2.940A$

and 5.5 cycles later : $\omega t = 11\pi$

$\therefore t = 0.09167\,s$

$\therefore i = 2.817\,A$

2) Given that:

transformer is rated 100 MVA, 18kV

reactance, $x_d'' = 10\,\%$

$x_d' = 26\,\%$

$x_d = 130\,\%$

base current : $\frac{100000}{\sqrt{3} \times 18} = 3207.5\,A$

a) The short circuit current :

$i = \frac{1}{\sqrt{1.3}} \times 3207.5$

$= 2467\,A$

(b) The symmetrical rms current:

$$i = \frac{1}{j0.10} \times 3207.5$$
$$= 16882\ A$$

(c) The max possible DC component short circuit current:

$$i = \sqrt{2} \times 16882$$
$$= 23874\ A$$

(3) ~~The initial symmetrical~~

(3) Given that, 100 MVA, 240Y / 18 ΔkV

$X = 10\%$

(a) The initial symmetrical rms current in high voltage side

$$I'' = \frac{1.0}{j(0.19+0.10)}$$
$$= -j3.448 \text{ per unit}$$

$$\text{Base } I_{HV} = \frac{100000}{\sqrt{3} \times 240} = 240.6A$$

$$\text{Base } I_{LV} = \frac{1000000}{\sqrt{3} \times 18} = 3207.5A$$

$$\therefore i = 3.448 \times 240.6$$
$$= 829.5A$$

(b) $i = 3.448 \times 3207.5$
$$= 11060A$$

(4) Given that, $f = 60Hz$; 500 MVA, $2kV$

$x_d'' = 0.20$ pu

resistive load $= 400$ MW at 20kV

Load current,

$$I_{Load} = \frac{400}{500} = 0.8 \text{ pu}$$

$$E_g'' = 1.0 + 0.8 \times j0.20$$
$$= 1.0 + j0.16 \text{ pu}$$

∴ The initial symmetrical rms current:

$$I_g'' = \frac{1 + j0.16}{j0.20} = 0.8 - j5.0 \text{ pu}$$
$$= 5.06 \text{ pu}$$

(5) Given that,

The pu reactance of the generator 0.15

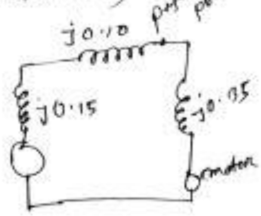
The p.u reactance of the ~~generator~~ motor 0.35

The leakage reactance of the transformer 0.10 pu

(a) when the generator is 0.9 pu and 0.8 pf leading.

$$\therefore E_g'' = 0.9 + (0.8 + j0.6)(j0.15)$$
$$= 0.81 + j0.12 \text{ pu}$$

$$\therefore E_m'' = 0.9 + (0.8 + j0.6)(j0.45)$$
$$= 1.17 - j0.36 \text{ pu}$$



$$\therefore I_g'' = \frac{0.81 + j0.12}{j0.25}$$
$$= 0.48 - j3.24 \text{ pu}$$

$$\therefore I_m'' = \frac{1.17 - j0.36}{j0.35} = -1.03 - j3.34 \text{ p.u}$$

$$\therefore I_f'' = I_g'' + I_m''$$
$$= -0.55 - j6.58 \text{ pu}$$

(b) By using thevenin's theorem.

$$V_f = 0.9 - (0.8 + j0.6)(j0.1)$$
$$= 0.96 - j0.08 \text{ pu}$$

$$\therefore Z_{th} = \frac{j0.25 \times j0.35}{j0.60} = j0.146 \text{ pu}$$

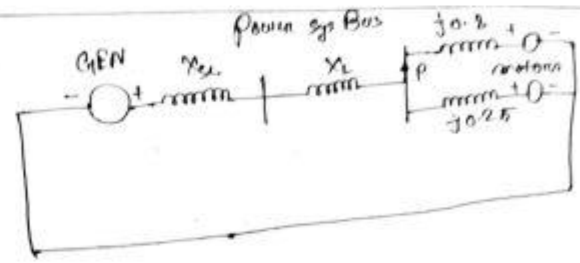
$$I_f'' = \frac{0.96 - j0.08}{j0.146} = -0.55 - j6.58 \text{ pu}$$

By replacing I_f'' by a current source and then applying the principle of superposition

$$I_g'' = 0.8 + j0.6 + \frac{j0.35}{j0.60}(-0.55 - j6.58)$$
$$= 0.48 - j3.24 \text{ pu}$$

$$I_m'' = -0.8 - j0.6 + \frac{j0.25}{j0.60}(-0.55 - j6.58)$$
$$= -1.03 - j3.34 \text{ pu}$$

(6)



$$\text{Base } Z = \frac{0.48^2}{2} = 0.1152\,\Omega$$

$$x_L = \frac{0.023}{0.1152} = 0.20 \text{ per unit}$$

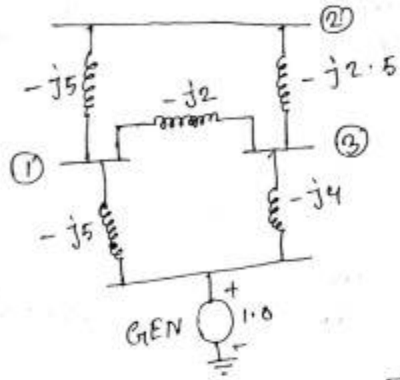
$$x_{se} = \frac{2}{96} = 0.208 \text{ per unit}$$

$$x_{th} = \frac{1}{\frac{1}{0.8} + \frac{1}{0.25} + \frac{1}{0.408}} = 0.130 \text{ per unit}$$

$$I_f^a = \frac{\frac{440}{480}}{-j1.30}$$

$$= 7.05 \text{ per unit}$$

(8) Given that, voltage bus (2) is $1.0\angle 0^\circ$ pu



$$Y_{bus} = \begin{bmatrix} -j12 & j5 & j2 \\ j5 & -j7.5 & j2.5 \\ j2 & j2.5 & -j8.5 \end{bmatrix}$$

$$\Delta = \frac{j}{-j}\Big\{12\,(7.5\times 8.5 - 2.5\times 2.5) + 5\,(-5\times 8.5 - 2\times 2.5) - 2\,[-5\,(-2.5) - (-2\times 7.5)]\Big\}$$

$$= j307.5$$

For the fault at bus ② the impedance needed are,

$$z_{12} = \frac{\Delta_{21}}{\Delta} = -\frac{j5(-j8.5) - j2.5\,(j2)}{j307.5}$$

$$= \frac{-42.5 - j5}{j307.5}$$

$$= j0.1195$$

$$Z_{22} = \frac{\Delta_{21}}{\Delta} = \frac{-j12(-j8.5) - j2(j2)}{j307.5}$$

$$= \frac{-102 + 4}{j307.5}$$

$$= j0.2465$$

$$Z_{32} = \frac{\Delta_{23}}{\Delta} = \frac{-j12(j2.5) - j5(j2)}{j307.5}$$

$$= \frac{-30-10}{j307.5}$$

$$= j0.1006$$

$$\therefore I_f'' = \frac{1.0}{j0.2465} = -j4.056 \text{ pu}$$

$$V_3 = 1 - \frac{j0.1006}{j0.2465} = 0.592 \text{ pu}$$

$$V_1 = 1 - \frac{j0.1195}{j0.2465} = 0.515 \text{ pu}$$

$$\therefore I_{12}'' = \frac{0.515}{j0.2} = -j2.58 \text{ pu}$$

From generator 1,

$$I_g'' = \frac{1 - 0.515}{j0.2} = -j2.42 \text{ pu}$$