Mansi Uniyal POWER.
19EE10039.

1

__/__/__

f.

Q1. 50Hz. 4 pole turbogenerator
Rated = 22MVA, 13.2KV = V
S
inertia constant = 9 sec = H

(i) Kinetic @ stored = ?
at rotor at sync speed.

(ii) acceleration = ?
if i/p < rotational loss.
24000 HP
electric power = 16MW.

{no acc^n torque before?}.

If acc^n generator is constant for period of 15 cycles
Δtorque angle = ?
rpm = ? at end

Ans. (i) Kinetic energy
Stored = H·S
= 9×22
= $\boxed{198 \text{ MJ}}$

(ii) acceleration power = mech. power i/p − elec. power o/p.

$P_a = P_i - P_g$.

rotational power loss. 24000.

$P_a = 24000 \text{ HP} - 16 \text{MW}$
$= 17896.797 - 16000 \text{ kW}$
$P_a = 1896.797 \text{ kW} \simeq 1.9 \text{ MW}$.

Mansi Uniyal
19EE10039.

(2)

$$\frac{d^2\delta}{dt^2} = \frac{Pa}{M} \qquad M = \frac{SH}{\pi f} = \frac{22\times 9}{\pi\times 50}$$

$$M = 1.2605 \text{ MFW/rad}.$$

$$\frac{d^2\delta}{dt^2} = \frac{1.9}{1.2605} = 1.507 \text{ rad/sec}^2$$

$$\boxed{\text{acceleration} = \frac{d^2\delta}{dt^2} = 1.507 \text{ rad/sec}^2}$$

(iii) 15 cycles = 0.3 sec.

change in torque angle $= \delta = \frac{1}{2}\frac{d^2\delta}{dt^2}t^2$

$$\delta = \frac{1}{2}\times 1.507 \times (0.3)^2.$$

$$\delta = 0.0678 \text{ rad}$$

$$= 3.8855133 \text{ electrical degree.}$$

$$\boxed{= 16.1896 \text{ rpm/s.}}$$

Speed in rpm $= \frac{120f}{P} + (0.3)\times\delta$

$$= 1500 + 4.8569$$

$$\boxed{= 1504.86 \text{ rpm.}}$$

Mansi Uniyal
19EE10039.

(3)

Q2. 50 Hz sync. generator + infinite bus via line
Reactances of generator = 0.35 pu.
— " — line = 0.15 pu
generator no load voltage = 1 pu
infinite bus = 1 pu. = G
inertia constant / generator = 3 sec = H

freq. of natural oscillation = ?
if generator @ 50% loaded
of max. power transfer capacity

Ans.

$\delta = \sin^{-1}(0.50) = 30^\circ$

$$\left.\frac{dP_e}{d\delta}\right|_{\delta=30^\circ} = P_{max} \cos(30^\circ) = \frac{\sqrt{3}}{2} P_{max}$$

$$= \frac{\sqrt{3}}{2} \times \frac{1}{0.35+0.15} = \frac{\sqrt{3}}{2 \times 0.5}$$

$$\left.\frac{dP_e}{d\delta}\right|_{\delta=30^\circ} = \sqrt{3} = 1.732$$

$$M = \frac{GH}{\pi f} = \frac{3 \times 1}{\pi \times 50} = 0.0191$$

$$\omega = \sqrt{\frac{dP_e/d\delta}{M}} = \sqrt{\frac{1.732}{0.0191}} = 9.523$$

$$f = \frac{\omega}{2\pi} = \boxed{1.5156\ Hz}$$

Mansi Uniyal
19EE10039.

(b) freq. of natural oscillation if 65% of max. power transfer capacity.

$\delta = \sin^{-1}(0.65) = 40.5416^\circ$

$$\left.\frac{\partial P_e}{\partial \delta}\right|_{\delta = 40.54^\circ} = 2 \times \cos 40.54^\circ = 1.52$$

$$M = \frac{GH}{\pi f} = 0.0191$$

$$\omega = \sqrt{\frac{1.52}{0.0191}} = 8.92 \text{ rad/s}$$

$$f = \frac{\omega}{2\pi} = \boxed{1.42 \text{ Hz}}$$

Mansi Uniyal.
19EE10039.

Q3. 22MVA, 10.2kV alternator
+ve reactance = 0.25 pu.
-ve seq. = 0.25 pu
0 seq. = 0.1 pu. $Z_f = 0$.

line to ground fault occurs at terminal
fault current = ?
line to line voltage = ?

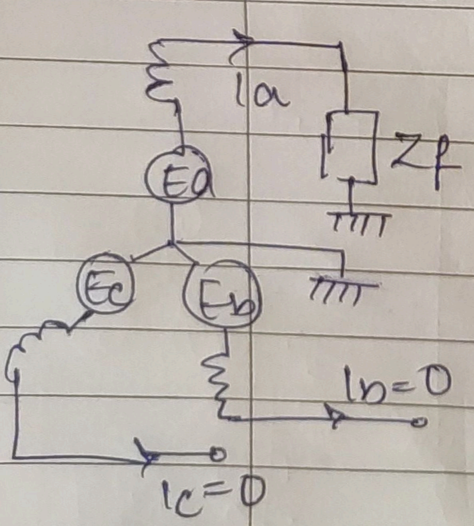
Ans. $I_a = \dfrac{3E_a}{Z_1 + Z_2 + Z_0 + 3Z_f} = I_{a_1} + I_{a_2} + I_{a_0}$, where $E_a \to 1$ pu.

where $I_{a_1} = I_{a_2} = I_{a_0} = \dfrac{E_a}{Z_1 + Z_2 + Z_0 + 3Z_f}$.

$I_a = \dfrac{3}{0.25 + 0.25 + 0.1} = 5$ pu.

$I_a = \dfrac{5 \times 22}{10.2\sqrt{3}}$ kA $= \dfrac{10.784}{\sqrt{3}}$ kA.

$= \boxed{6.23\text{ kA}}$ Ans.



Mansi Uniyal
19EE10039.

6

if $Z_f = 0$
$V_{af} = 0$
for line to ground fault

$V_b = \beta^2 V_{a1} + \beta V_{a2} + V_{a0}$
$= \beta^2 \left(E_a - Z_1 \frac{I_a}{3}\right) + \beta\left(-Z_2 \frac{I_a}{3}\right) - Z_0 \frac{I_a}{3}$

$V_b = 0.583\angle 240° - 0.416\angle 120° - 0.16$ pu
$V_b = 0.898\angle -105.71$ pu.

Similarly, $V_c = \beta V_{a1} + \beta^2 V_{a2} + V_{a0}$
$= 0.583\angle 120° - 0.416\angle 240° - 0.16$

$V_c = 0.898\ \angle 105.719°$ pu.

line to line voltages:-
$V_{ab} = V_a - V_b = \boxed{0.898\angle 74.29°\text{ pu.}}$

$V_{bc} = V_b - V_c = \boxed{0\text{ pu}}$
$V_{ca} = V_c - V_a = \boxed{0.898\angle 105.719°\text{ pu}}$

Ans.

$V_{bc} = 0V$
$V_{ab} = -V_{ca} = 0.898\angle 74.29°$ pu
$= 9.1596\angle 74.29$ kV.

Mansi Uniyal
19EE10039.

Qu. fault current = ?
line to line voltage = ?

when line to line fault at ends of alternator.
in phase B & C.

Ans.

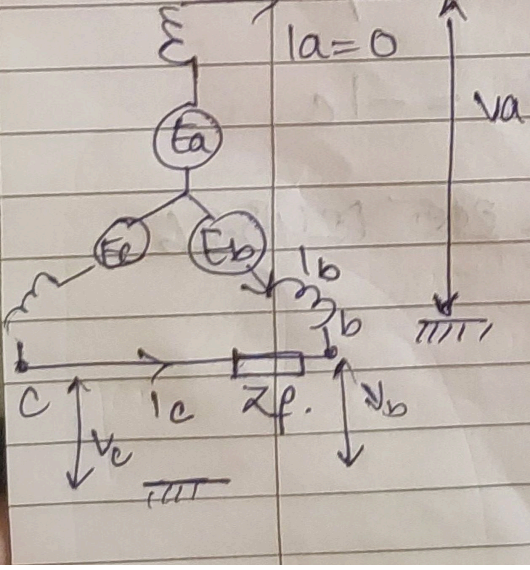
$$I_b = -I_c = \frac{-j\sqrt{3}\,E_a}{Z_1 + Z_2 + Z_f}$$

$$I_b = -I_c = \frac{-j\sqrt{3} \times 1}{0.25 + 0.25}$$

$$= 3.464 \angle -90^\circ \text{ pu.}$$

$$|I_b| = |I_c| = 3.464 \text{ pu} = \frac{7.471}{\sqrt{3}} \text{ kA.}$$

$$= 4.313 \text{ kA.}$$



Supposing line to line fault occure betn phase b & c.

Mansi Uniyal
19EE10039.

8

$$\begin{cases} V_b - V_c = Z_f I_b = 0 = V_{bc} \quad \text{as } Z_f = 0. \\ I_b + I_c = 0 \\ I_a = 0 \longrightarrow V_a = E_a = 1 \text{ pu}. \end{cases}$$

$V_b = E_b - I_b Z_s.$

$= 1\angle -120° - 3.464 \times 0.25\angle -90°$ pu

$V_b = 0.5\angle -180°$ pu

Similarly, $V_c = E_c - I_c Z_s$

$= 1\angle 120° - 3.464 \times 0.25\angle 90°$ pu

$V_c = 0.5\angle 180°$ pu

line to line voltages:-

$V_{ab} = V_a - V_b = 1\angle 0° - 0.5\angle -180°$ pu

$V_{ab} = \boxed{1.5\angle 0° \text{ pu}}$

$V_{bc} = V_b - V_c = \boxed{0 \text{ pu}}$

$V_{ca} = V_c - V_a = \boxed{-1.5 \text{ pu}}$

Ans.

$V_{bc} = 0$ V

$V_{ab} = -V_{ca} = 1.5$ pu

$= 15.3$ kV.

Mansi Uniyal
19EE10039.

9

Q5. Motor: 26% power ~~from~~ recieve from infinite bus
If load on motor is x2
max of δ = ?
during swinging of rotor around equilibrium.

Ans. $P_{i0} = 0.26\ P_{max}$.

$\delta_0 = \sin^{-1}\left(\frac{P_{i0}}{P_{max}}\right) = \sin^{-1}(0.26)$.

$\delta_0 = 15.07° = 0.26302$ rad.

$P_i = 2 \times 0.26 P_{max} = 0.52 P_{max}$.

$\delta_1 = \sin^{-1}\left(\frac{P_i}{P_{max}}\right) = \sin^{-1}(0.52)$

$\delta_1 = 31.33° = 0.54685$ rad.

let $\delta_2 \rightarrow$ max value.

$(\delta_2 - \delta_0)\sin\delta_1 + \cos\delta_2 - \cos\delta_0 = 0$

$0.52(\delta_2 - 0.263) + \cos\delta_2 - 0.9656 = 0$

$\cos\delta_2 + 0.52\,\delta_2 = 0.13676 + 0.9656$
$= 1.1023$

$\therefore \delta_2 = 0.849$ rad ?

$\boxed{\delta_2 = 48.64°}$

Ans max.

$\delta_2 = \begin{cases} 0.263 \\ 0.849 \\ 3.725 \end{cases}$ rad