Power System Test

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Pratyush Jaiswal
18EE30021

Q 1. (a) Demand factor $= \dfrac{\text{Maximum Demand}}{\text{Total connected Load}}$

$= \dfrac{126 \times 10^6}{220 \times 10^6} = 0.5727$

(b) load factor $= \dfrac{\text{Total annual energy}}{\text{Annual peak load} \times 8760}$

$= \dfrac{38 \times 10^4 \times 10^6}{\cancel{220}\,126 \times 10^6 \times 8760} = 0.344$

Q 2. $G = 20\ \text{MVA}$, $H = 9\ \text{sec} = 9\ \text{MJ/MVA}$

$\therefore$ Stored kinetic energy $= GH = 20 \times 9\ \text{MVA}\cdot\text{MJ/MVA}$
$= 180\ \text{MVA}\cdot\text{MJ/MVA}$
$= \boxed{180\ \text{MJ}}$

$f = 50\ \text{Hz}$

we know that, $M = \dfrac{GH}{180 f} = \dfrac{180 \times 10^6}{180 \times 50}$ J sec/elect. deg

$= \dfrac{1}{50}$ MJ sec/elect. deg.

$M \dfrac{d^2\delta}{dt^2} = P_a = (18375 - 15000)\ \text{kW}$

$\Rightarrow \dfrac{1}{50}\ \text{MJ sec/elect. deg} \times \dfrac{d^2\delta}{dt^2} = 3.375\ \text{MW}$

$\Rightarrow \dfrac{d^2\delta}{dt^2} = 3.375 \times 50$ elect. deg/sec²

$= 168.75$ elect. deg/sec²

acceleration $= \boxed{168.75\ \text{elect. deg/sec}^2}$

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$1\,5 \text{ cycles} = \frac{15}{50} = 0.3 \text{ sec}$

Change in torque angle $= \delta = \frac{1}{2} \times \alpha (\Delta t)^2$

$= \frac{1}{2} \times 168.75 \times (0.3)^2$ elect-deg

$= \boxed{7.59 \text{ elect-degree}}$

Now,

$\alpha = 168.75$ elect-deg/sec^2

$= 168.75 \times \frac{50}{360^\circ}$ rpm/sec $= 23.4375$ rpm/sec

$\therefore$ Rotor' Speed at the end of 15 cycles

$= \frac{120f}{P} + \alpha(\Delta t)$

$= \left(\frac{120 \times 50}{4} + 23.4375 \times 0.3\right)$ rpm

$= \boxed{1507.03125 \text{ rpm.}}$

Q4.

$k_1 = \frac{P_{max} \text{ during the fault}}{P_{max} \text{ before the fault}}$

$k_2 = \frac{P_{max} \text{ after the fault}}{P_{max} \text{ before the fault}}$.

P_{max} during the fault $= 0.4$ pu

P_{max} after the fault $= 1.25$ pu

P_{max} before the fault $= 1.7$ pu

$k_1 = \frac{0.4}{1.7} = 0.2353$

$k_2 = \frac{1.25}{1.7} = 0.7353$

then, $P_i = 1.25 \sin \delta_m' = 1$

$$\delta_m' = 53.13^\circ \simeq 0.927 \text{ rad.}$$

$$\delta_m = (\pi - 0.927) \text{ rad} = 2.214 \text{ rad} = 126.887^\circ$$

$$\delta_0 = \sin^{-1}\left(\frac{1}{1.7}\right) = 36.03^\circ \text{ or } 0.6288 \text{ rad}$$

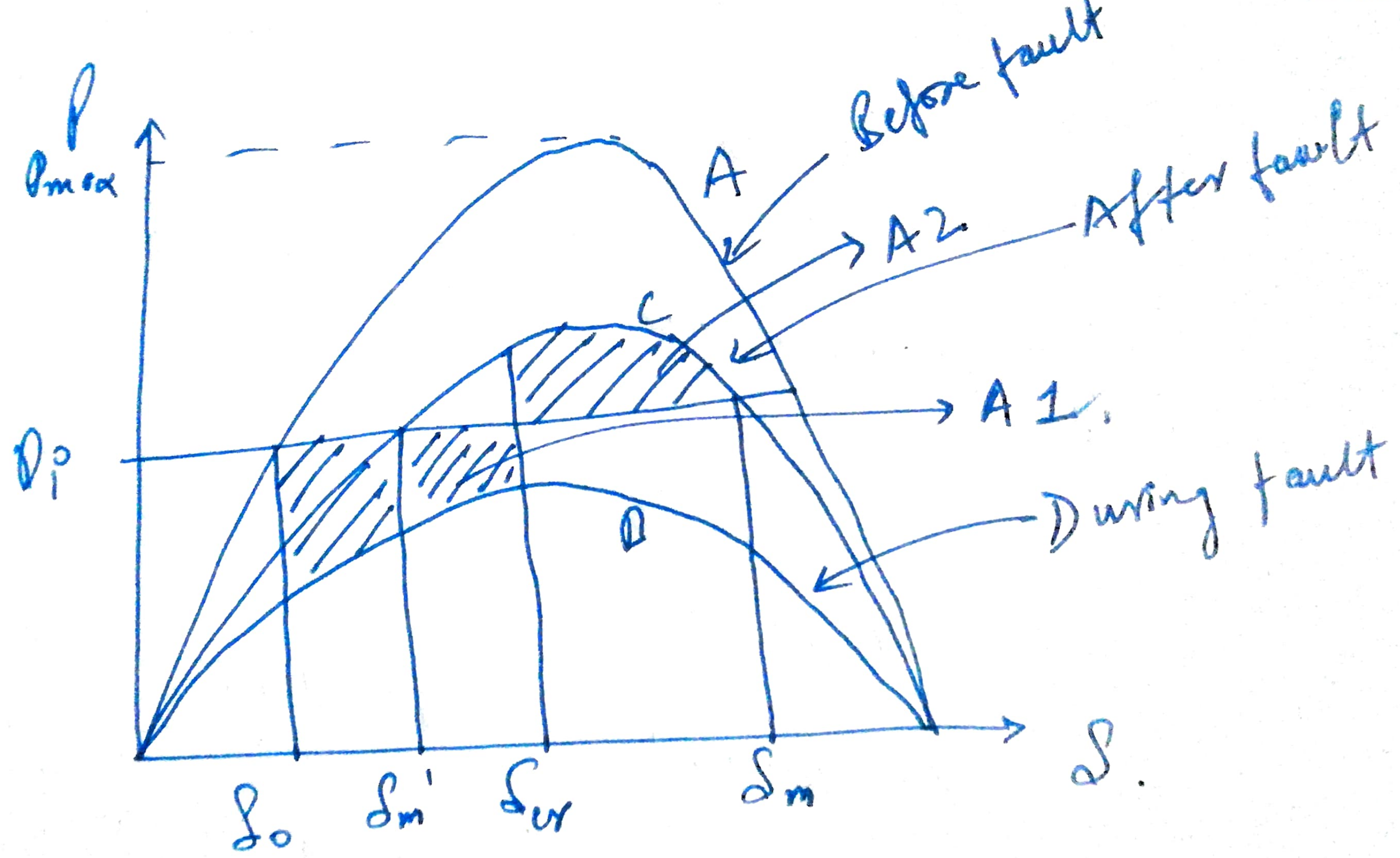
then,
$$\cos \delta_{cr} = \left(\frac{1}{b_2 - b_1}\right)\left[(\delta_m - \delta_0)\sin \delta_0 + b_2 \cos \delta_m - b_1 \cos \delta_0\right]$$

$$= \left(\frac{1}{0.7353 - 0.2353}\right)\left[(2.214 - 0.6288)\sin(0.6288) + 0.7353 \cos(2.214) - 0.2353 \cos 0.6288\right]$$

$$= 0.6021$$

$$\therefore \delta_{cr} = \cos^{-1}(0.6021) = 52.979^\circ \text{ or } 0.9246 \text{ rad.}$$

$\therefore$ Critical clearing angle $= \boxed{52.979^\circ \text{ or } 0.9246 \text{ rad}}$



P
Pmax
Pi
δ.
δo
δm'
δcr
δm
A
B
C
A2
A1.
Before fault
After fault
During fault

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Q3.

Stored kinetic Energy = $100 \times 10^6 \times 4.5$ W-sec

$= 450 \times 10^6$ W-sec

Decreased power input to generator before the steam valve begins to close = 25 MW.

Decreased energy power to rotating parts in 0.6 sec

$= 25 \times 10^6 \times 0.6$ W-sec

$= 15 \times 10^6$ W-sec

∴ frequency at the end of 0.6 sec

$$= 50 \times \left(\frac{450 \times 10^6 - 15 \times 10^6}{450 \times 10^6} \right)^{1/2} \text{ Hz}$$

$= 49.159$ Hz.