Indian Institute of Technology Patna
Department of Electrical Engineering
EE381 - Power Systems
Autumn - 2023
Quiz - II − Solution.
November 24, 2023

There are 5 problems. They carry equal marks.

$(5 \times 2 = 10)$

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1. Consider the following equations.

$$10x_1 \sin x_2 - 0.8 = 0$$
$$10x_1^2 - 10x_1 \cos x_2 - 0.6 = 0$$

Suppose the solution of the variables x_1 and x_2 is obtained by employing Newton-Raphson method, find x_1 and x_2 after first iteration. Assume $x_1^0 = 1$ and $x_2^0 = 0$.

$J = \begin{bmatrix} 10\sin x_2 & 10x_1 \cos x_2 \\ 20x_1 - 10\cos x_2 & 10x_1 \sin x_2 \end{bmatrix}$ $\quad J^0 = \begin{bmatrix} 0 & 10 \\ 10 & 0 \end{bmatrix}$ $\quad \Delta f^0 = \begin{bmatrix} 0.8 \\ 0.6 \end{bmatrix}$

$\Delta x^0 = (J^0)^{-1} \Delta f^0 = \begin{bmatrix} 0.06 \\ 0.08 \end{bmatrix}$

$x_1^1 = 1.06$

$x_2^1 = 0.08$

2. The fuel cost functions in rupees/hour for two 600 MW thermal power plants are given bleow.

$$\text{Plant 1} \;:\; C_1 = 350 + bP_1 + 0.004P_1^2$$
$$\text{Plant 2} \;:\; C_2 = 450 + 6.2P_2 + 0.003P_2^2$$

where P_1 and P_2 are power generated by plant 1 and plant 2, respectively in MW and b is a constant. The incremental cost of power (λ) is 8 rupees per MWh. The two thermal power plants together meet a total power demand of 550 MW. Find the optimal generation of plant 1 and plant 2 in MW.

For optimal dispatch, $\frac{dC_1}{dP_1} = \frac{dC_2}{dP_2} = \lambda$

$0.006P_2 + 6.2 = 8$

$P_2 = 300$ MW

$P_1 = P_D - P_2 = 250$ MW

3. In an unbalanced three phase system, phase currents $I_a = 1.1\angle 0°$ p.u. and $I_c = 1\angle 120° +$ 0.1 p.u. If $I_{b0} = 0.1\angle 0°$ p.u., find the phase current I_b in p.u.

$I_a = 1.1\angle 0°$; $I_c = 1\angle 120° + 0.1 = 0.954\angle 114.79°$;

$I_{b0} = 0.1\angle 0° = I_{a0} = I_{c0}$

$I_{a0} = \frac{1}{3}(I_a + I_b + I_c)$

$I_b = 3I_{a0} - I_a - I_c = -0.4 - j0.866$

$I_b = 0.954\angle -114.79°$

4. A 5 kVA, 415 V, 50 Hz, generator has the positive, negative, and zero sequence reactances of 0.25 p.u., 0.15 p.u., and 0.05 p.u., respectively. The neutral of the generator is grounded with a resistance so that the fault current for a bolted (solid) line to ground fault and that of a bolted (solid) three-phase fault at the generator terminal are equal. Find the value of grounding resistance in ohms.

L-L-L

$|I_f| = \frac{1}{0.25} = 4$ p.u — ①

L-G

$|I_f| = 3 \times \frac{1}{\sqrt{(3R_N)^2 + (0.45)^2}}$ — ②

By equation ① and ②,

$R_N = 0.2$ p.u

$R_N = 6.69\ \Omega$

5. A 20 MVA, 11.2 kV, 4-pole, 50 Hz alternator has an inertia constant of 15 MJ/MVA. If the input and output powers of the alternator are 15 MW and 10 MW, respectively, find the angular acceleration in mechanical degree/s^2.

$$\frac{2H}{\omega_{sm}} \frac{d^2\delta_m}{dt^2} = P_m - P_e$$

$\omega_{sm} = \frac{\omega_s}{P/2} = \frac{2 \times 180 \times 50}{2}$ mech. deg/sec ; $P_m = \frac{15}{20}$; $P_e = \frac{10}{20}$;

$$\frac{d^2\delta_m}{dt^2} = \frac{0.25}{2 \times 15} \times \left(\frac{2 \times 180 \times 50}{2}\right) = 75 \text{ mech. deg}/s^2$$