國立臺灣科技大學

114學年度碩士班招生

試題

系所組別：0710電機工程系碩士班甲組

科　　目：電力系統

<<507101>>

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(總分為 100 分；所有試題務必於答案卷內頁依序作答)

1. **(20%)** The three-phase power and line-line ratings of the electric power system shown in Fig. 1 are given below.

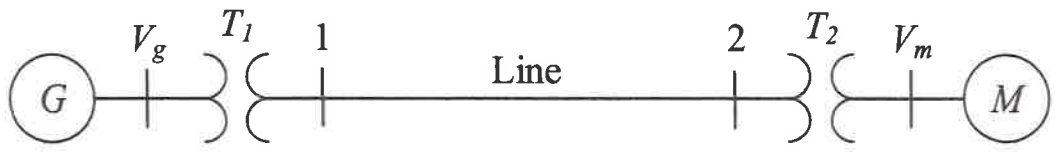

Fig. 1. One-line diagram for Problem 1.

G:	50 MVA	20 kV	$X = 8\%$
T_1:	60 MVA	20/200 kV	$X = 12\%$
T_2:	60 MVA	200/20 kV	$X = 12\%$
M:	50.77 MVA	19 kV	$X = 9\%$
Line:		200 kV	$Z = 100 + j150\ \Omega$

(1) (10%) Draw an impedance diagram showing all impedances in per-unit on a 100-MVA base. Choose 20 kV as the voltage base for generator.

(2) (10%) The motor is drawing 40 MVA, 0.80 power factor lagging at a line-to-line terminal voltage of 19 kV. Determine the internal emf of the generator in kV.

2. **(10%)** A 60-Hz, single phase power line and a telephone line are parallel to each other as shown in Fig. 2. The telephone line is symmetrically positioned directly below the middle of the power line. the power line carries a rms current of 300 A. Assume zero current flows in the ungrounded telephone wires. Find the magnitude of the voltage per km induced in the telephone line.

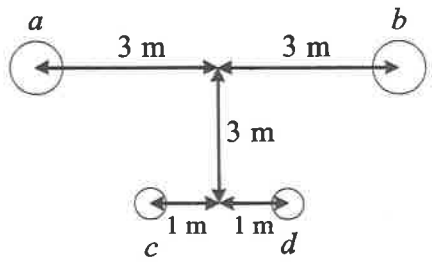

Fig. 2. One-line diagram for Problem 2.

3. **(20%)** A completely transposed 345-kV, three-phase transmission line is 200 km long. The series impedance is $z = 0.036 + j0.3\ \Omega/\text{km}$ per phase, and the shunt admittance is $y = j4.22 \times 10^{-6}$ S/km per phase. Full load at the receiving end of the line is 700 MW at 0.99 p.f. leading and at 95 % of rated voltage. Use the nominal π model to find:

(1) (10%) *ABCD* parameters of the nominal π model

(2) (6%) sending-end voltage $V_{S\ (line\ to\ neutral)}$, current I_S, real power P_S

(3) (4%) the voltage regulation

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4. **(12%)** The one-line diagram of a simple power system is shown in Fig. 3. The ratings and reactances of the generators and transformers are

   G_1 and G_2: 100 MVA, 20 kV　　$X''_d = X_1 = X_2 = 12\%$,　$X_0 = 5\%$,　$X_n = 5\%$

   T_1 and T_2: 150 MVA, 20/220 kV　　$X = 9\%$

   On a chosen base of 100MVA, 220kV in the transmission line circuit, the line reactances of L_{12} are $X_1 = X_2 = 13\%$ and $X_0 = 25\%$. The line reactances of L_{13} are $X_1 = X_2 = 13\%$ and $X_0 = 32\%$. The line reactances of L_{23} are $X_1 = X_2 = 20\%$ and $X_0 = 50\%$. The system is operating at nominal voltage without prefault currents.

   A single line-to-ground fault occurs at bus 2 with a fault impedance $Z_f = j0.2$ per unit. Determine the fault current.

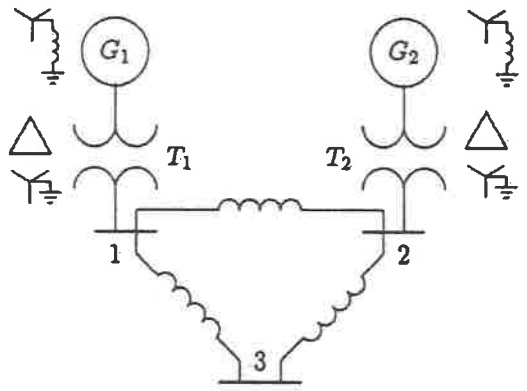

Fig. 3. The one-line diagram for Q4

5. **(20%)** A two-area power gird with only primary FLC control loop connected by a tie-line has following characteristics.

Area	1	2
Speed regulation	$R_1 = 0.06$	$R_2 = 0.0625$
Frequency-sen. Load coeff.	$D_1 = 0.6$	$D_2 = 0.9$
Inertia constant	$H_1 = 5$	$H_2 = 4$
Base power	600 MVA	500 MVA
generation range	250~500 MW	200~450 MW
Governor time constant	$\tau_{g1} = 0.2$ sec	$\tau_{g2} = 0.3$ sec
Turbine time constant	$\tau_{T1} = 0.5$ sec	$\tau_{T2} = 0.6$ sec

(1) (8%) The areas are sharing 600 MW at the nominal frequency. Transmission losses are neglected. The incremental costs of units in $/MWh are given by

$IC_1 = 5.2 + 0.006P_1$　　$IC_2 = 5.0 + 0.004P_2$

Determine the optimal scheduling of generation in area 1 and 2.

(2) (12%) Suppose generation of area 1 and 2 are 260MW and 440MW respectively and operate at 60-Hz. A load change of -100 MW occurs in area 2. Determine the new steady-state frequency and the new generations for each area.

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6. **(18%)** A 60-Hz synchronous generator having inertia constant H= 5.5 MJ/MVA and a direct axis transient reactance $X'_d = 0.32$ per unit is connected to infinite bus through a purely reactive circuit as shown in Fig. 4. Reactances are marked on the diagram on a common system base. The generator is delivering real power $P_e = 0.8$ per unit, 0.8 power factor lagging, to the infinite bus at a voltage of $V = 1$ per unit. The per unit damping power coefficient is $D = 0.12$.

(1) (10%) A temporary three-phase fault occurs at the sending end of the line at point F. When the fault is cleared, both lines are intact. Find the critical clearing power angle.

(2) (8%) Consider a small disturbance of $\Delta\delta = 20°$. For example, the breaker open and then quickly close. Obtain and plot the equation describing the motion of the generator frequency (Hz) during swinging.

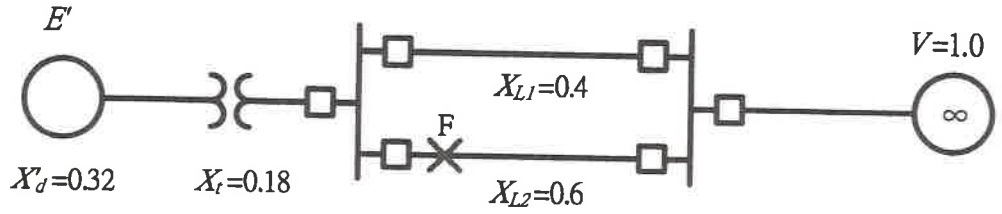

Fig. 4. The one-line diagram for Q6

Hint:

Natural frequency (rad/s)	$\omega_n = \sqrt{\frac{\pi f_0}{H} P_s}$	eq(1)
Synchronizing power coefficient	$P_s = \left.\frac{dP}{d\delta}\right\|_{\delta_0}$	eq(2)
Damped frequency	$\omega_d = \omega_n\sqrt{1-\zeta^2}$	eq(3)
Dimensionless damping ratio	$\zeta = \frac{D}{2}\sqrt{\frac{\pi f_0}{HP_s}}$	eq(4)
Deviation of frequency	$\Delta\omega = -\frac{\omega_n \Delta\delta_o}{\sqrt{1-\zeta^2}} e^{-\zeta\omega_n t}\sin\ \omega_d t$	eq(5)