

**University of Saskatchewan
College of Engineering**

**EE 441: Power Systems II
Final Examination**

A one formula sheet is allowed

**Instructor: S.O. Faried
Duration: 3 hours**

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1- Consider the power system shown in Fig. 1. Use a power base of 500 MVA to calculate the fault current in amperes for a double line-to-ground fault at bus B.

G_1 : 500 MVA, 13.8 kv, $x_d'' = 0.2$ p.u., $x_2 = 0.2$ p.u. and $x_o = 0.1$ p.u.

G_2 : 600 MVA, 26 kv, $x_d'' = 0.15$ p.u., $x_2 = 0.15$ p.u. and $x_o = 0.1$ p.u.

G_3 : 400 MVA, 13.8 kv, $x_d'' = 0.2$ p.u., $x_2 = 0.2$ p.u. and $x_o = 0.1$ p.u.

T_1 : 500 MVA, 13.8 kv / 500 kv, $x = 0.1$ p.u.

T_2 : 600 MVA, 26 kv / 500 kv, $x = 0.1$ p.u.

T_3 : 500 MVA, 13.8 kv / 500 kv, $x = 0.1$ p.u.

Line $_{AB}$, $x_1 = 50 \Omega$

Line $_{BC}$, $x_1 = 80 \Omega$

For transmission lines: $x_0 = 3x_1$

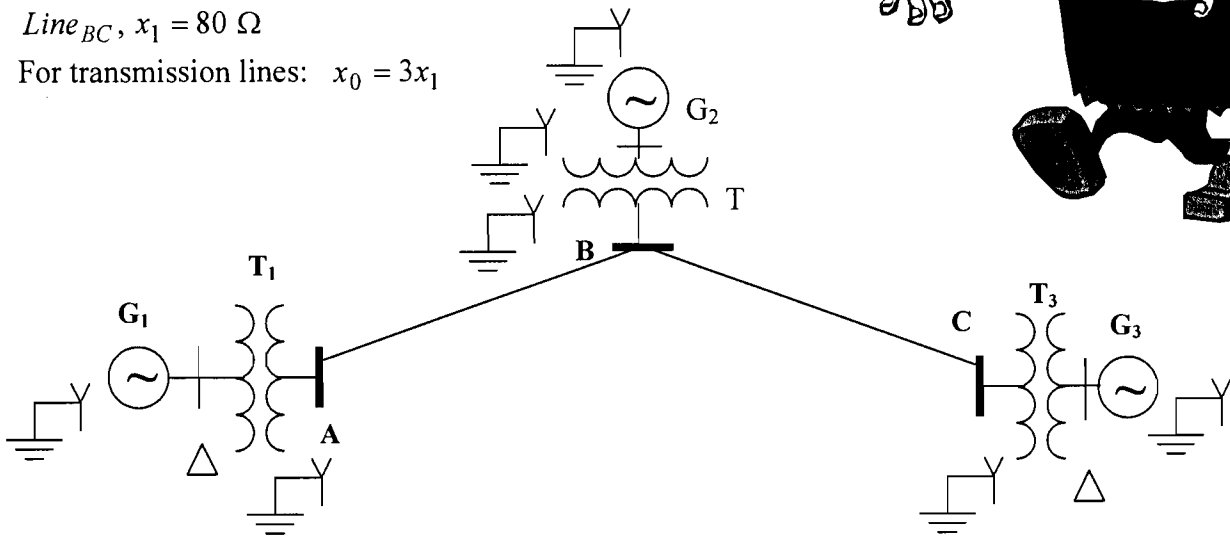


Fig. 1

2. The data of the sample power system shown in Figure 2 are given in Tables 1 and 2. These data were entered into a load flow program using a 100 MVA power base. Convergence was obtained and the program gave the following bus voltages:

$$V_1 = 1.04 \angle 0^\circ, \quad V_2 = 1.0 \angle -2.78806^\circ \text{ p.u.} \quad \text{and} \quad V_3 = 0.9161 \angle -6.99713^\circ \text{ p.u.}$$

Find:

- The real power flow in the three transmission lines (indicate the values on the diagram).
- The total real power losses.

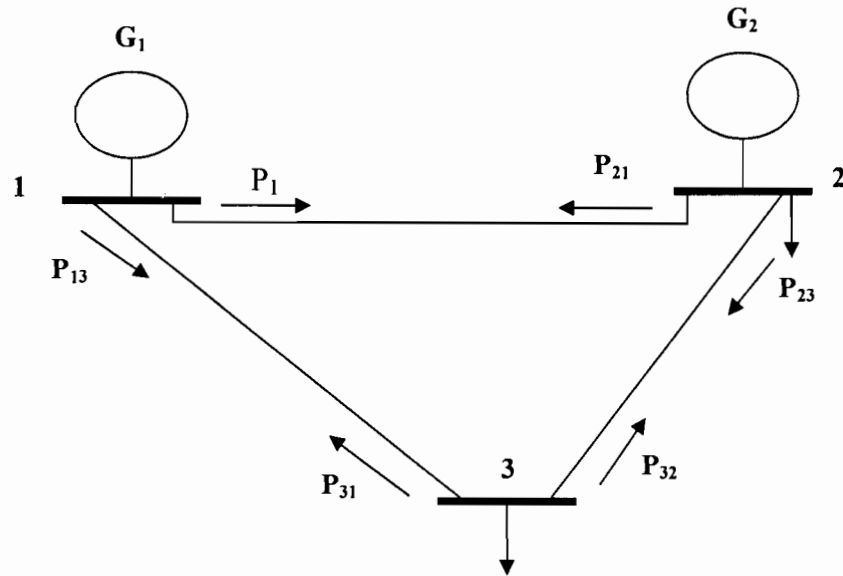


Fig. 2

Table 1: Impedances of the sample power system in p.u. on a 100 MVA base

Bus Code: p - q	Impedance Z_{pq}	Line charging $0.5Y_{pq}$
1-2	$0.04 + j0.16$	$j0.15$
1-3	$0.02 + j0.08$	$j0.07$
2-3	$0.03 + j0.1$	$j0.04$

Table 2: Scheduled generation and loads and magnitudes of bus voltages for the sample power system.

Bus code p	Bus voltage	Generation		Load	
		MW	MVAR	MW	MVAR
1	1.04	?	?	0	0
2	1.0	100	?	50	20
3	?	0	0	250	150

- In the system shown in Figure 3, a three-phase fault occurred on one of the transmission lines just after the circuit breaker. Find the following:
 - The critical clearing angle in degrees.
 - The critical clearing time in seconds.
 - The generator speed at the instant of clearing in radians per second.

$$x'_d = j0.4 \text{ p.u.}, \quad x_{T.L} = j0.8 \text{ p.u.}, \quad x_{T_1} = x_{T_2} = j0.1 \text{ p.u.}, \quad M = 7 \text{ sec}$$

$$\delta_c = 53.061^\circ$$

$$t = 155 \text{ ms}$$

$$\omega = 382 \text{ rad/s}$$

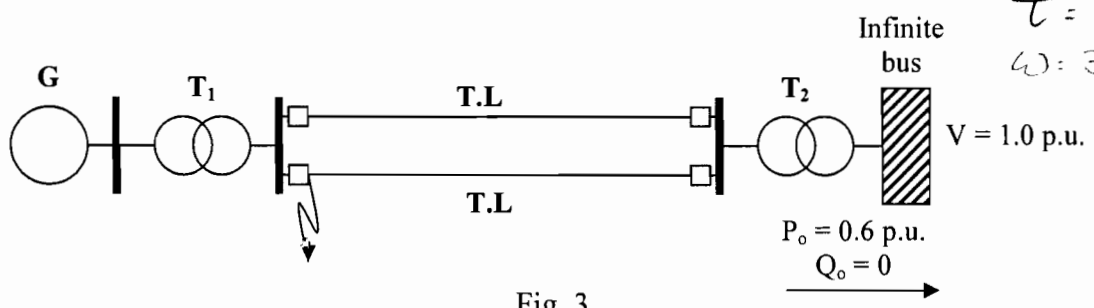


Fig. 3

4. For the system of Fig. 4, a double line-to-ground fault occurred just after the beginning of one of the two transmission lines. After a short interval, the fault became a three-phase fault at a time corresponding to $\delta = 40^\circ$. The fault is then cleared at $\delta = 45^\circ$. Using the equal area criterion, check the system stability.

Generator

$$x'_d = x_2 = j0.4 \text{ p.u.}, \quad x_o = j0.1 \text{ p.u.},$$

Transmission Lines

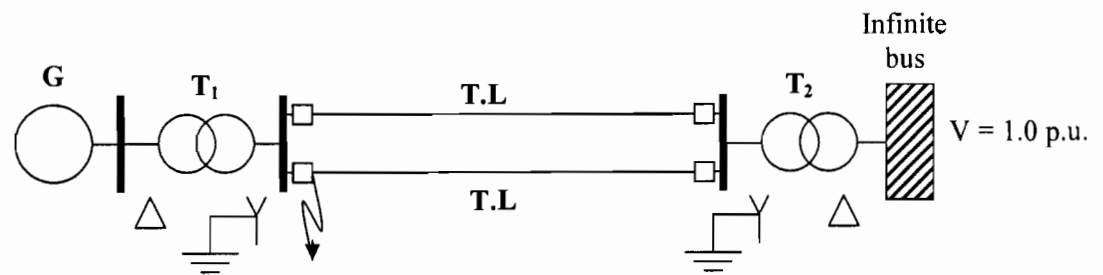
$$x_{T.L1} = j0.8 \text{ p.u.}, \quad x_{T.L0} = 3x_{T.L1}$$

Transformers

$$x_{T_1} = x_{T_2} = j0.1 \text{ p.u.},$$

Initial power angle

$$\delta_o = 30^\circ$$



$$X_{1eq} = X_{2eq} = 0.25j$$

$$X_{0eq} = 0.073j$$

$$X_{f1eq} = 4.692j$$

$$A_{accL} = 0.066$$

$$A_{acc3\phi} = 0.041$$

$$A_{acc} = \frac{0.066}{0.110}$$

$$A_{dec} = 0.225$$

$$P_T = 1$$

$$P_{acc} = 0.213$$

$$P_{3\phi} = 0$$

$$P_T = \frac{1}{1.4} = 0.714$$