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University of Saskatchewan
College of Engineering

EE 441: Power Systems II
Final Examination
A one formula sheet is allowed

Instructor: S.O. Faried **April 2007**
Duration: 3 hours

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: $x_0 = 3x_1$

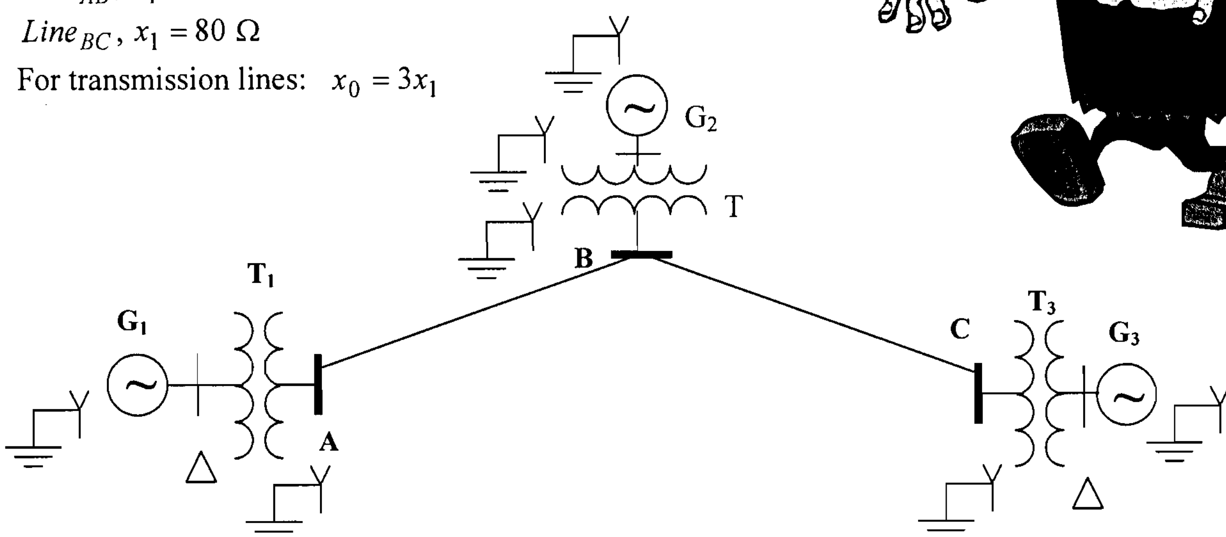


Fig. 1

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:

$V_1 = 1.04\angle 0^o$, $V_2 = 1.0\angle -2.78806^o$ p.u. and $V_3 = 0.9161\angle -6.99713^o$ p.u.

Find:

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

(b) The total real power losses.

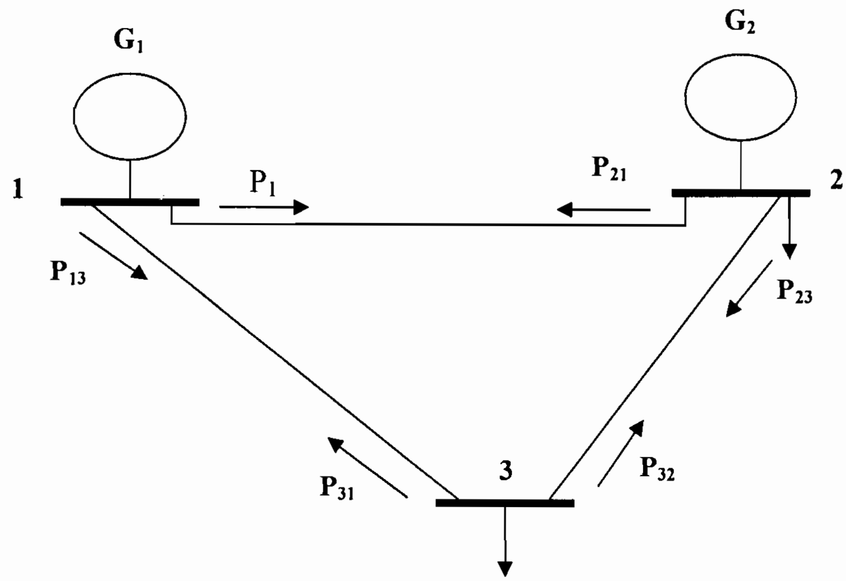


Fig. 2

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

3. 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:
   (a) The critical clearing angle in degrees.
   (b) The critical clearing time in seconds.
   (c) The generator speed at the instant of clearing in radians per second.

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

δ_c: 53.061°
t = 155 ms
ω: 382 rad/s

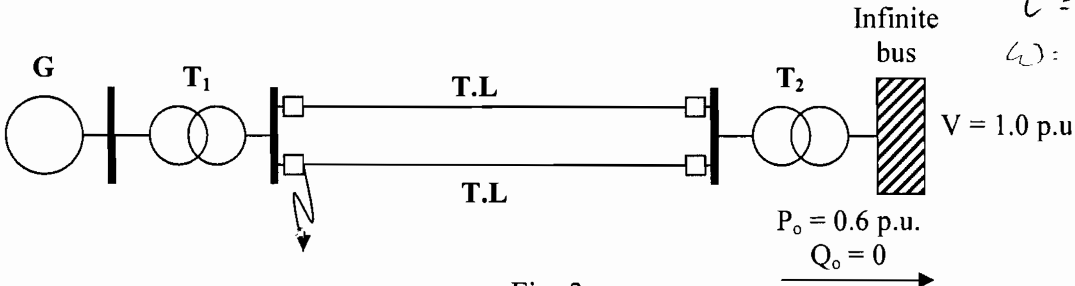


Fig. 3

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 $\delta = 40^o$. The fault is then cleared at $\delta = 45^o$. Using the equal area criterion, check the system stability.

Generator

$x_d' = x_2 = j0.4\ p.u.,\ x_o = j0.1\,p.u.,$

Transmission Lines

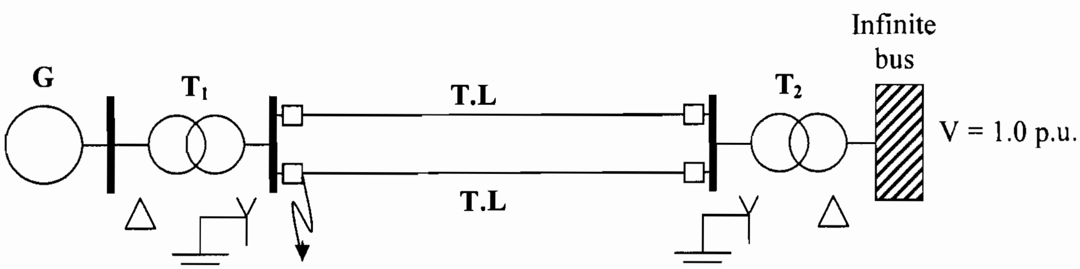
$x_{T.L1} = j0.8\ p.u.,\ x_{T.Lo} = 3x_{T.L1}$

Transformers

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

Initial power angle

$\delta_o = 30^o$



$X_{1eq} = X_{2eq} = 0.25j$
$X_{0eq} = 0.073j$
$X_{f_{LLG}} = 4.692j$

$A_{acc\ LL}$ - 0.066
$A_{acc\ 3\phi}$ - 0.041
A_{acc} 0.11
A_{dec} - 0.22

P_I - 1
$P_{II\ LG}$ = 0.213
$P_{II\ 3\phi}$ = 0
$P_{III} = \frac{1}{1.4} = 0.714$