Mansoura University
Faculty of Engineering
Dept. of Electrical Engineering

M.Sc Exam (8/9/ 2013)
Full Mark : 100
Time allowed: 3 Hours

Analysis of Electrical Power Networks

Please Answer The Following Questions:

Question # 1: (30 Mark)

a- Explain briefly the active power-frequency interaction and reactive power-voltage interaction in power system.

b- Consider a three-bus power system where a shunt capacitor bank is switched at bus 2 to regulate the voltage magnitude of this bus to 1.02 p.u. A regulating transformer (RT) is introduced between buses (2-3) to regulate the voltage of bus 3. Consider RT is a magnitude regulator with off-nominal turns ratio a = 1.03. The input data of line and RT are given in tables 1 & 2. The system bus data is given in table 3. Carry out one iteration of load flow solution by Gauss-Seidel iterative method to find the following:

(i) Voltage of buses 2&3.
(ii) Reactive power generated by a shunt capacitor at bus 2.
(iii) Active and reactive power generated at bus 1.
(iv) Active and reactive power flow in line 2-3.
(v) Discuss the effect of shunt capacitor at bus 2 and RT on the system operation.

Table 1: Line Input Data (MVAbase =100)

Branch	Bus to Bus	Series impedance (Z p.u)	Ysh/2
Line	1-2	0.005+ j0.04	j0.02

Table 2: Regulating Transformer (RT) Data (MVAbase =100)

Branch	Bus to Bus	Leakage impedance (Z p.u)	Tap setting (a)
RT	2-3	j0.08	1.03

Table 3: System Bus Data (MVAbase =100)

Bus #	Voltage (p.u)	Generation (p.u)		Load demand (p.u)	
		P_G	Q_G	P_D	Q_D
1	1.03+j0.0	---	---	0.0	0.0
2	1.02+j0.0	0.0	---	0.5	0.3
3	1.0 + j0.0	0.0	0.0	0.3	0.2

Question # 2: (30 Mark)

a- What are the different causes of shunt faults and their consequences on power system components?

b- Derive the necessary equations for calculating the fault current and bus voltages for a double-line to ground fault using bus impedance matrix method.

c- The reactance data for the three-phase power system of Fig.1 on a common base is:

G: X_1=X_2= 0.1, X_0 = 0.05 and X_n= 0.02 p.u. (Connection Y and earthed through X_n).

T: X= 0.1p.u (connected Δ/ Y solid earthed).

Line: X_1=X_2=0.2, X_0=0.5 p.u

Bus 2 (Infinite Bus): X_1=X_2=0.15, X_0= 0.05 p.u (connection Y isolated).

(i) Using step by step method to formulate Z_{Bus} for positive, negative and zero sequence networks.

(ii) With both generator and infinite bus operating at 1.0 p.u voltage on no load, a solid double-line to ground fault occurs at bus 1, calculate:

- Fault current.
- Voltage at bus 2 (a, b, c).

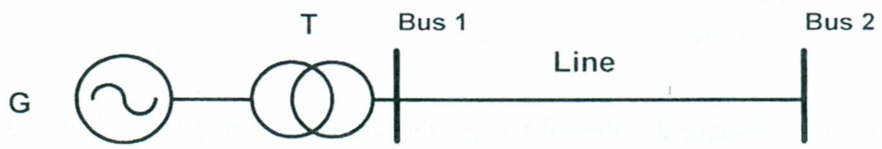

Fig.1

Question # 3: (20 Mark)

a- What are the different types of reactive power compensation and their objectives in power system?

b- Compare briefly between the different types of FACTS devices such as SVC, STATCOM, TCSC, SSSC and UPFC in terms of :

-Load flow. – Power stability. – Voltage quality.

c- Figure 2 shows a bus bar 4 connected to three infinite bus bars 1, 2 and 3. Bus bars 1 and 2 operate at 220 kV while 3 and 4 operate at 132 kV. The transformer reactances are on 200 MVA base. Assume 200 MVA and 220 kV at bus 1 as base. If the voltage at bus 4 falls by 4 kV, find the VAR injection at bus 4 to bring back the bus voltage to its original value.

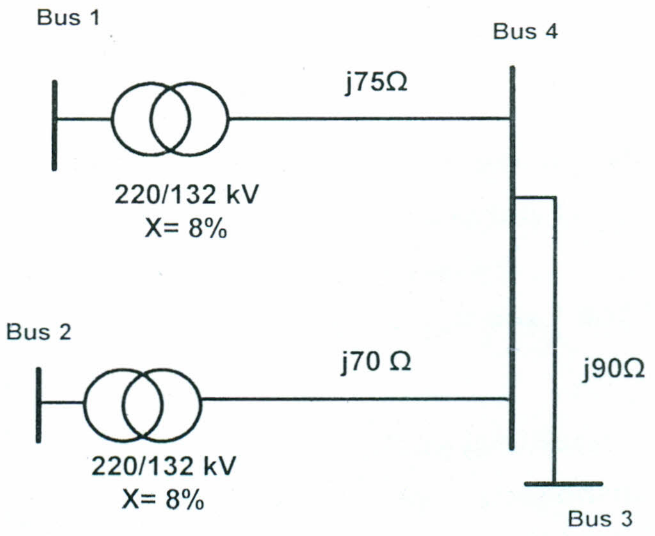

Fig.2

Question # 4: (20 Mark)

a- Why does voltage instability occur in power system? How is voltage stability classified?

b- Discuss briefly the different representation of load models and their significance on voltage stability.

c- A transmission line with a transfer reactance X has V_s and V_r as the sending and receiving end voltages. The line feeds a static load at receiving end.

(i) Derive an expression for voltage stability limit as (dQ_r/dV_r).

(ii) Find the value of (V_r/V_s) at the point of maximum power if the load power factor is:

- zero lag.
- unity.

With My Best Wishes

Prof. Dr. Mohammed El-Saied