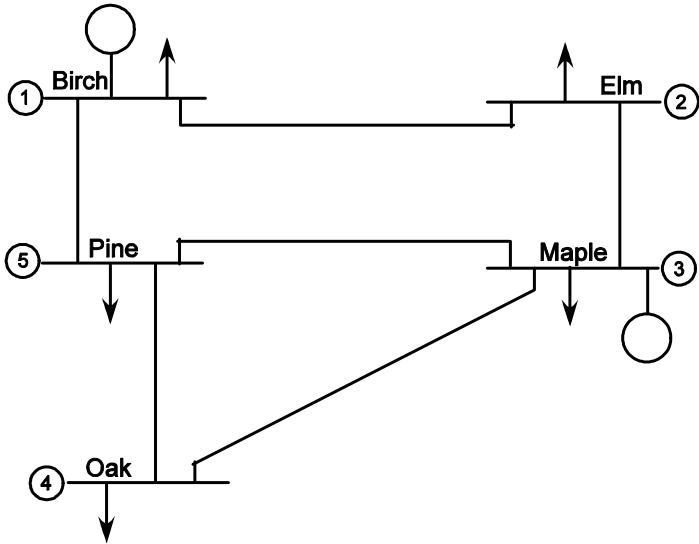


ECE 470 POWER SYSTEMS I

Lab # 7 - Load Flow Analysis

In Lab 6 you will run a simple tutorial to get used to entering data. Now you will perform an actual Load Flow, which is taken from chapter 8 of "Elements of Power System Analysis" by W.D. Stevenson. The data is shown below for the system whose base values are 100 MVA and 138 kV.



Charging MVAR in Table 1 accounts for the distributed capacitance of the transmission lines (the SKM icon looks like a transmission tower). The data input to SKM asks for this in ohms and is converted as follows:

4.1 - 4645 Ω , 3.1 - 6143 Ω , 8.2 - 2322 Ω ,
5.1 - 3734 Ω , 6.1 - 3122 Ω .

Table 1

Line bus to bus	R Ω	X Ω	Charging MVAR
1 - 2	8	32	4.1
1 - 5	6	24	3.1
2 - 3	6	24	3.1
3 - 4	16	64	8.2
3 - 5	10	40	5.1
4 - 5	12	48	6.1

The loads are presented in Table 2 as P+jQ, but SKM wants them as P and pf, so you have to work out the pf.

Table 2

Bus	Generation		Load		V, per unit	Remarks
	P, MW	Q, Mvar	P, MW	Q, Mvar		
1	234.7	100.1	65	30	1.04 $\angle 0^\circ$	Swing bus
2	0	0	115	60	1.00 $\angle 0^\circ$	Load bus (inductive)
3	180	33.3	70	40	1.02 $\angle 0^\circ$	Voltage magnitude constant
4	0	0	70	30	1.00 $\angle 0^\circ$	Load bus (inductive)
5	0	0	85	40	1.00 $\angle 0^\circ$	Load bus (inductive)

Each generator needs to have its rating input, use 500 MVA with a nominal pf of 0.9 lag. Additionally, generator 2 needs to have its MVAR limits input, use ± 500 MVAR but note that this has to be input as kVAR. Voltages are asked for in volts not kV. We do not want to include the voltage drop inside the generators, so go to ANSI Contribution and reduce the X" values from 0.15 to 0.001 pu. You are now ready to run the load flow.

The converged load flow is shown below in Table 3 and you should check your results against this. Use your results to determine the total system losses.

Table 3

REPORT OF POWER FLOW CALCULATIONS FOR AREA 1, BUS DATA							
BUS	NAME	VOLTS	ANGLE	GENERATION MW	MVAR	LOAD MW	MVAR
1	BIRCH	1.040	0.0	234.7	100.1	65.0	30.0
2	ELM	0.961	-6.3	0.0	0.0	115.0	60.0
3	MAPLE	1.020	-3.7	180.0	110.3R	70.0	40.0
4	OAK	0.920	-10.9	0.0	0.0	70.0	30.0
5	PINE	0.968	-6.2	0.0	0.0	85.0	40.0
AREA TOTALS				414.7	210.4	405.0	200.0

It can be seen that the voltage at bus 4 is 0.92 pu and is unacceptable for practical operation. Convert this to a PV bus with a specified voltage magnitude of 0.95 pu and re-run the study. Specify the MVAR rating (at 138 kV) of the capacitor bank needed for this correction. If the capacitors cost \$50/kVAR to purchase and install what would be the total cost. If this money is borrowed at 3%, how long will the reduction in losses take to pay for the bank? Assume the cost of losses is \$50/MWh.

An alternative to installing a capacitor bank is to build another line. Study the effect of adding an identical line in parallel with line 4 from bus 3 to bus 4. What will be the voltage at bus 4? What will be the system losses? If the line costs 10M\$ to build and this money is borrowed at 3%, how long will the reduction in losses take to pay for the line?