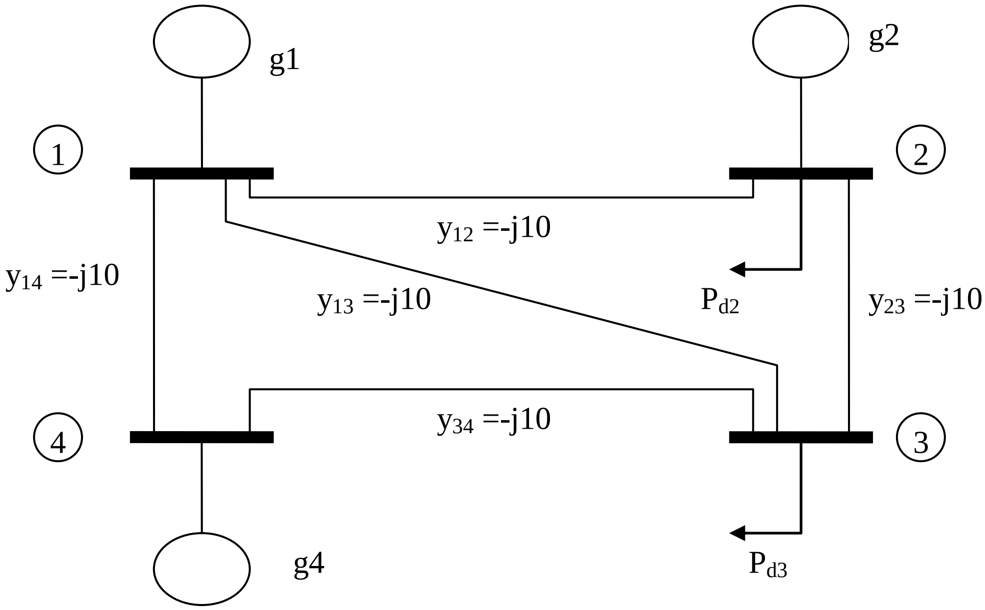
EE 553, Spring 2012, HW7, Due Monday 12/3/2012

Consider the network we have been using in class and replicated below.



Starting from the CPLEX file provided on the website (UC24a.lp), add appropriate code to model the following additional constraints.

1. <u>Modeling reserve margin</u>: Spinning reserve should be, in any hour, according to $\sum_i r_{it} \geq 0.10 \times D_t$, Note that this replaces constraint (3) in our formulation (slide 4 of SCUC ppt slides). Note also that these constraints are on the *units*, not on individual *offers*. Provide the solution in terms of a plot of unit dispatch (generation) vs. time for all three units. Compare the 24-hour solution in terms of hourly unit dispatch with and without these constraints. Identify any differences. Provide a sample of your CPLEX code to show how you implemented this.

2. <u>Modeling ramp rates</u>: Assume Unit 1 has $MxInc_i$=$MxDec_i$=0.4 pu, Unit 2 has $MxInc_i$=$MxDec_i$=0.3 pu, and Unit 4 has $MxInc_i$=$MxDec_i$=0.2 pu. Note that these affect constraints (7) and (8) in our formulation (slide 4 of SCUC ppt slides). Add these constraints to the model you developed in #1 of this assignment (the one with reserves). Provide the solution in terms of a plot of unit dispatch (generation) vs. time for all three units. Compare the 24-hour solution you obtain (with these constraints modeled) with the solution you obtained in #1 (with reserves but without these new ramp rate constraints modeled). Identify any differences. Provide a sample of your CPLEX code to show how you implemented this.

   Note: At hour 19 the load is 2.8 pu. At hour 20 it is 2.0 pu, dropping by 0.8 pu, the largest drop of the simulation. Therefore the composite ramping capability of the three units has to be at least 0.8 in order to avoid infeasibility.

3. Modeling ramp rate requirements: Describe how you would implement the following constraint: 50% of the reserve requirement must be able to ramp up at least 0.3 pu in one hour. Describe why implementing such a constraint could be of interest. Add this constraint for all hours to the model you developed in #2 of this assignment. Provide the solution in terms of a plot of unit dispatch (generation) vs. time for all three units. Compare the 24-hour solution you obtain (with this constraint) to the solution obtained without this constraint. Identify any differences. Provide a sample of your CPLEX code to show how you implemented this.

4. Line flow constraints: Assume the total load equally divides between buses 2 & 3.
   a. Determine the generation shift factors a_{ki} for this network under the assumption of a single slack (see notes on "Sensitivities," pp. 14-16 to understand why you need to use a single slack), where a_{ki} is the linearized coefficient relating bus *i* injection to line *k* flow.
   b. Assume each line k is constrained to a flow limit of $MxFlow_k$ under normal conditions, i.e., under conditions when all circuits are in. Using your generation shift factors obtained in (a), write down constraints corresponding to normal flow limits for all circuits, per equation (11) of slides 12-13 in the SCUC ppt slides.
   c. Determine the effective generation shift factors $a^{(j)}_{ki}$ for this network under the assumption of a single slack and outage of the circuit terminated by buses 1 and 2, where $a^{(j)}_{ki}$ is the linearized coefficient relating bus *i* injection to line *k* flow under the condition that branch *j* is outaged.
   d. Assume each line k is constrained to a flow limit of $EMxFlow_k$ under emergency conditions, i.e., under conditions associated with an outage. Using your effective generation shift factors obtained in part (c), write down constraints corresponding to security line flow limits for outage of circuit 1-2, per equation (12) of slides 12-13 in the SCUC ppt slides.