ECEN 615 Problem Set #3 Fall 2018
Due 10/11/18

1 Modify your program from Problem Set 2 to allow for an off-nominal transformer turns ratio, t, on the transformer between buses 3 and 4. Assume the off-nominal turns ratio is on the Bus 4 side. Solve your power flow with a value of t=1.02. For this use the original case in which the generator at Bus 3 is regulating its own voltage (i.e., not as modified in question 1). Note, if you compare your results to the PowerWorld results the off-nominal turns ratio in PowerWorld is on the Bus 3 side. In order to check your results use 1/t for the ratio in PowerWorld. Your output should be a list of the bus voltage magnitudes and angles at each iteration. Also calculate the reactive power output for the generators and the real power output for the slack bus generator. Use a 100 MVA per unit base, and use a per unit convergence value of 0.1 MVA. Turn in the output.

Solution: Since off-nominal turns ratio is on side of bus 4, update following Ybus admittance entries as:

$$Y_{34} = Y_{43} = \frac{-y_{34}}{t}$$

$$Y_{33} = y_{34}$$

$$Y_{44} = y_{24} + y_{45} + \frac{y_{34}}{t^2} + \frac{B_{24}}{2} + \frac{B_{45}}{2}$$

Only Y_{33} remains unchanged. Run the power flow program from HW2, Q1 and obtain the approximate following values:

Buses	Voltage Mag.	Voltage Ang.	
	(P.U.)	(Rad.)	(Deg.)
1	1.000	0.000	0.000
2	0.854	-0.380	-21.772
3	1.050	-0.012	-0.688
4	1.037	-0.051	-2.922
5	0.985	-0.079	-4.526

	Gen. @ slack 1	Gen. @ bus 3
Real Power, P (p.u.)	3.936	5.200
Reactive Power, Q (p.u.)	0.622	3.666

2. Code the LU factorization discussed in class for full matrices, along with the forward/backward substitution. To test your algorithm use it to factor and solve the below matrix. You do not need to code pivoting.

$$\mathbf{A} = \begin{bmatrix} 5 & 1 & 0 & -4 \\ 1 & 4 & 0 & -3 \\ 0 & 0 & 3 & -2 \\ -4 & -3 & -2 & 10 \end{bmatrix} \quad \mathbf{b} = \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \end{bmatrix}$$

Solution : Using MATLAB

```
%% *** Matrix reduction ***
n = size(A,1);
 for i = 2:n
     for j = 1:i-1
         A(i,j) = A(i,j)/A(j,j);
         for k = (j+1):n
             A(i,k) = A(i,k) - A(i,j)*A(j,k);
         end
     end
 end
 %% *** 1) Forward substitution (solves y from Ly = b)***
 %  the b matrix is being overwritten (replaced by y)

 for i = 2:n
     for j=1:(i-1)
         b(i) = b(i)-A(i,j)*b(j); % using only the L matrix
     end
 end

 %% *** 2) Backward substitution (solves x from y = Ux) ***
 for i = n:-1:1
     for j = (i+1):n
         b(i) = b(i) - A(i,j)*b(j);
     end
     b(i)=b(i)/A(i,i);
 end
```

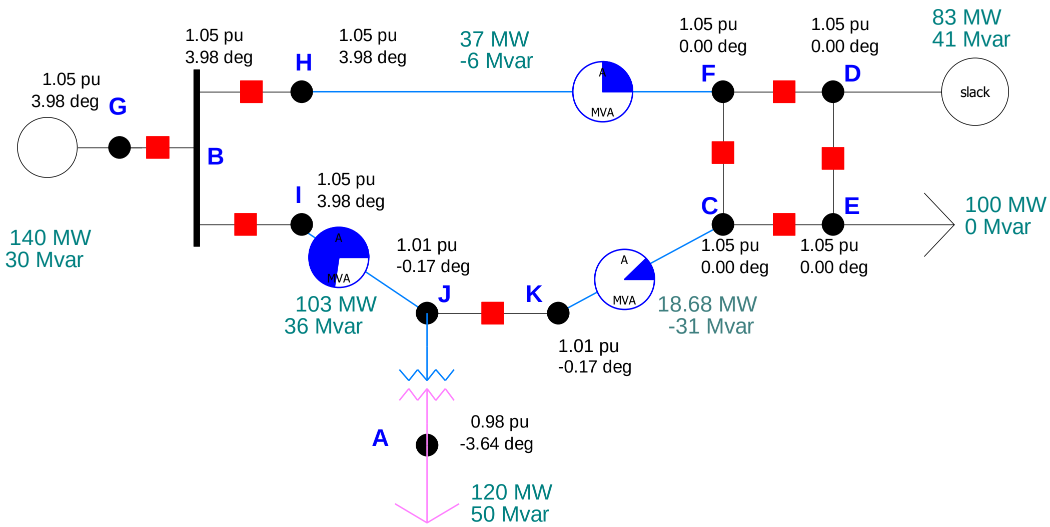
Then, the solution of the linear equation, Ax = b is:

```
1.3849
1.5565
2.2469
1.8703
```

3. Modify your power flow program from Poblem Set 2 to use the LU factorization and forward/backward routines you developed for problem 2. Provide a complete listing of your code and verification that your code is working correctly. You should use this code for all future power flow problems (until we replace it with the sparse code in the next problem set).

Solution: Apply a similar LU decomposition algorithm to factorize the Jacobian matrix ineach iteration, and solve for the states (magnitude and angle of all bus voltages) . Arrive at the same state values similar to HW2,Q1.

4. Order the following network using Tinney Scheme 1. Give the permutation vector entries and the number of fills (i.e., twice the number of lines added). Break ties alphabetically (i.e., A before B).



Solution:

Old order	Node	Degree	Tinney-1 order	# of new lines	New line
1	A	1	1	0	-
2	B	3	7	1	-
3	C	3	4	0	E-F
4	D	2	5	1	-
5	E	2	8	0	B-F
6	F	3	9	0	B-J
7	G	1	11	0	C-J
8	H	2	2	1	J-F
9	I	2	3	1	-
10	J	3	6	0	-
11	K	2	10	1	-

Permutation vector entries = [1,7,4,5,8,9,11,2,3,6,10]; Total fills = 2*(5 new lines) = 10 fills