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Course: EECE 306

Problem – 1

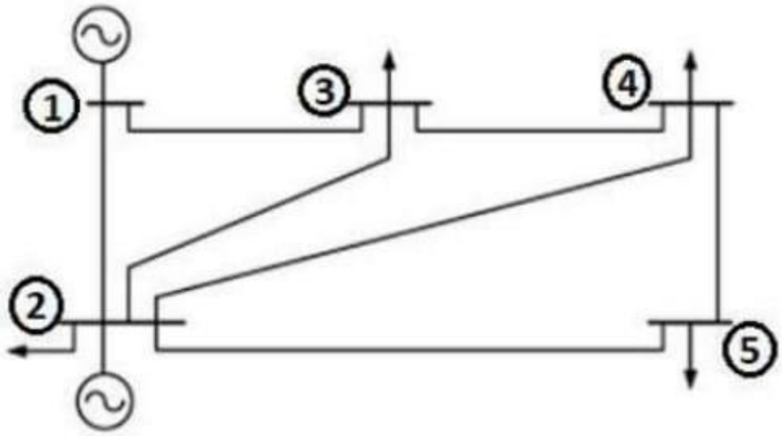


Fig. 1

Table-1: Bus Data

Bus No	Bus Voltage	Generation		Load	
		MW	MVar	MW	MVar
1	1.06+j0.0	0	0	0	0
2	1.0+j0.0	40	30	20	10
3	1.0+j0.0	0	0	45	15
4	1.0+j0.0	0	0	40	5
5	1.0+j0.0	0	0	60	10

Table-2: Transmission Line Data

Line	Line Impedance		Line Charging
	R per unit	X per unit	
1-2	0.02	0.06	0.0+j0.03
1-3	0.08	0.24	0.0+j0.025
2-3	0.06	0.25	0.0+j0.02
2-4	0.06	0.18	0.0+j0.02
2-5	0.04	0.12	0.0+j0.015
3-4	0.01	0.03	0.0+j0.01
4-5	0.08	0.24	0.0+j0.025

Q-1

Perform load flow studies of the power system of Fig. 1 to identify slack bus (Bus no. 1) power and bus voltages (Bus no. 2 to Bus no. 3). Compute line flows and line losses also. [Use any simulation software]

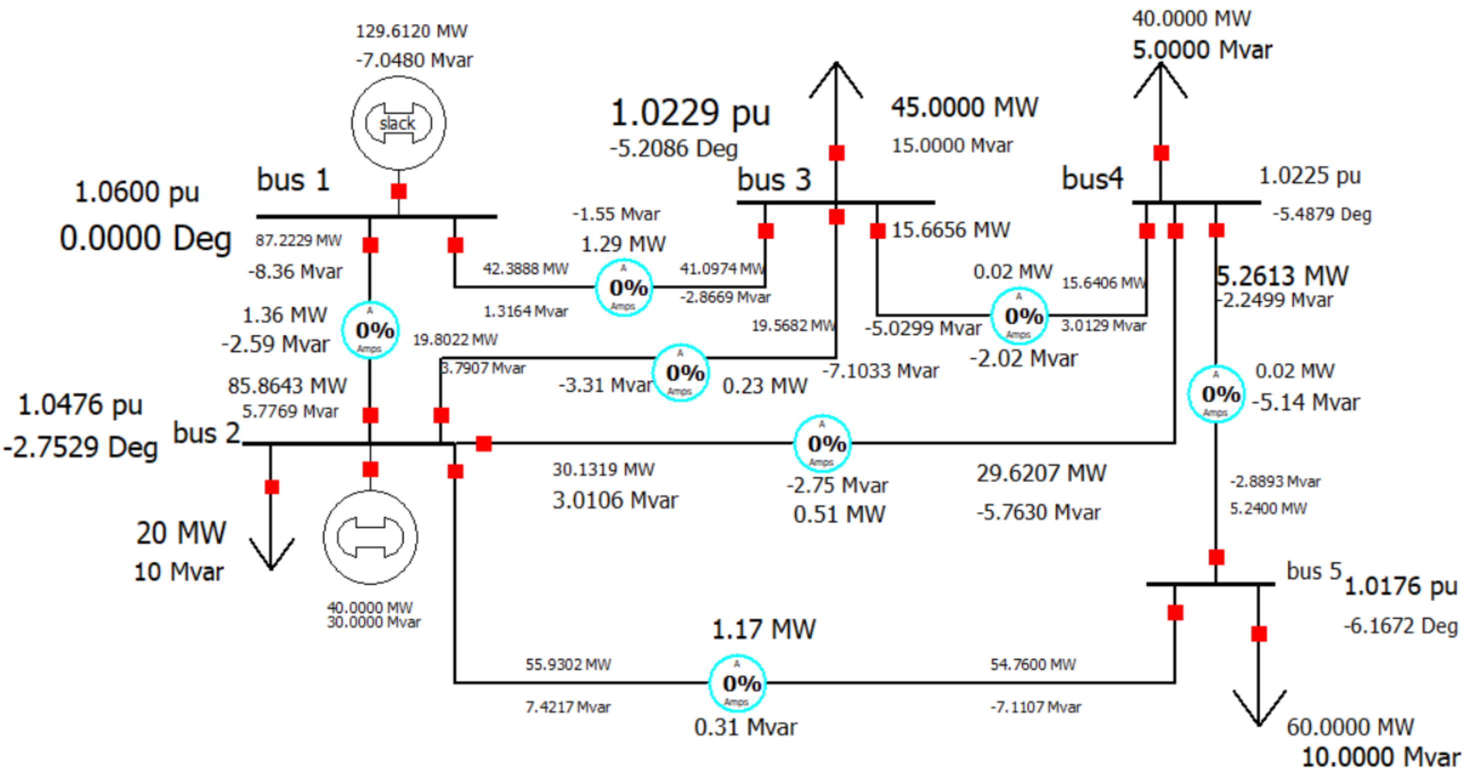


Fig : Simulation using power world software

In order to simulate the following bus bar system, we used the Power World software and obtained the required values. Here we determined all the values including per unit voltages, amgle, Transmisson line power folw, power losses etc. At bus 1 , the generator is a slack bus . Slack bus is also called swing bus and at bus both PV bus and PQ bus were added.

There are 3types of buses:

i. Load Buses

ii. Voltage Controlled Buses

iii. Slack or swing Buses

Load bus or PQ Bus

- A bus at which Active power and Reactive power are specified.
- Magnitude and phase angle of the voltage need to be calculated.
- This type of buses is the most common, comprising 80% of all buses in power system.
- In these buses no generators are connected and hence the generated realpower PGi and reactive power QGi are taken as zero.

Voltage controlled Bus

- A bus at which the magnitude of voltage and active power is defined.
- Reactive power and phase angles need to be determined through load flow equation. υ This bus is always connected to generator and is also known as PV bus.
- This type of bus comprises of 10% of all buses in power system.
- These are the buses where generators are connected. Therefore, the power generation in such buses is controlled through a prime mover while the terminal voltage is controlled through the generator excitation.

Slack bus

- Voltage magnitude and voltage phase angle are specified and real and reactive power are to be obtained.
- Normally there is only one bus of this type present in a given power system. υ One generator bus is selected as the reference bus.
- In slack bus voltage angle and magnitude is normally considered 1+j0 pu.
- This bus sets the angular reference for all the buses.

Analysing Result

Table 01: Line flow and Line loses

Line	**Ps (MW)**	**Qs (MVAR)**	**Pr (MW)**	**Qr (MVAR)**	**Ploss(Mw)**	**Qloss(Mvar)**
1-2	87.229	-8.36	85.8643	5.7769	1.36	-2.59

1-3	42.388	1.3164	41.0974	-2.8869	1.29	-1.55
2-3	19.8022	3.7907	19.5682	-7.1033	0.23	-3.31
2-4	30.1319	3.0106	29.6207	-5.7630	0.51	-2.51
2-5	55.9302	7.4217	54.7600	-7.1107	1.17	0.31
3-4	15.6656	-5.0299	15.6406	3.0129	0.02	-2.02
4-5	5.2613	-2.2499	5.2400	-2.8893	0.02	-5.14

Table 02: For slack bus

Voltage	**Angle**	**Real Power(MW)**	**Reactive power(MVAR)**
1.0600	0	129.6120	-7.0480

Table 03: BUS bar information

Bus No	**Voltage(V)**	**Angle(Deg)**
2	1.0476	-2.7529
3	1.0229	-5.2086
4	1.0225	-5.4879
5	1.0176	-6.1672

Q –2 :

Verify the results obtained in Task no. 1 by writing a Matlab code adopting any load flow analysis method.

Answer:

```
clc
clear all
close all
% Sloving load flow analysis using Gause seidal Method
%Getting the line data input
line_data=[1 2 0.02+0.06i 0.03i; 1 3 0.08+0.24i 0.025i; 2 3 0.06+0.25i 0.02i; 2 4 0.06+0.18i 0.02i;
2 5 0.04+0.12i 0.015i;3 4 0.01+0.03i 0.01i; 4 5 0.08+0.24i 0.025i]
%implementatation of Y bus
sb=line_data(:,1);
rb=line_data(:,2);
z=line_data(:,3);
hc=line_data(:,4);
y=1./z;
sb1=max(sb);
rb1=max(rb);
bus= max( sb1,rb1);
line=length(line_data);
Y= zeros( bus,bus);
for i=1:line
   p=sb(i);
   q=rb(i);
   Y(p,p)= Y(p,p)+y(i)+hc(i);
   Y(q,q)= Y(q,q)+y(i)+hc(i);
   Y(p,q)= Y(p,q)-y(i);
   Y(q,p)=Y(p,q);
end
Y
%per unit volt angle data
n=5;
tol=.001;
iter=0;
volt = [1.06 1 1 1 1];
v=volt;
realp = [0 .20 -.45 -.40 -.60];
reactive = [0 .20i -.15i -.05i -.10i];

while tol>.0000001
   for i=2:n
      s=0;
      volt=v;
      for j=1:n
         if i~=j
            s=s+Y(i,j)*v(j);
         end
```

```
      end
      v(i)=(((realp(i)-reactive(i))/conj(v(i)))-s)/Y(i,i); %GAUSS FORMULA
    end
    tol=max(abs(abs(v)-abs(volt)));%comparing tolerance
    iter=iter+1;
    vo(iter)=v(1); %setting the value of slag bus constant
end
manitude= abs(v)
phase_angle = (angle(v)*180)/3.1416

k=0;
for i=1:n
    k=k+(v(i)*Y(1,i));
    AP=100*((conj(v(1)))*k)
end
S=conj(AP)
P=real(S)
Q=(imag(S))
```

Output of the Matlab code:

```
manitude =

    1.0600    1.0476    1.0229    1.0225    1.0176


phase_angle =

         0   -2.7529   -5.2086   -5.4879   -6.1671


S =

   1.2961e+02 - 7.0483e+00i


P =

  129.6109


Q =

   -7.0483
```

Bus	Voltage(Simulation)	Voltage (Matlab)	Angle(Simulation)	Angle(Matlab)	Error(%) For voltage	Error(%) For angle
1	1.0600	1.0600	0	0	0	0
2	1.0476	1.0476	-2.7529	-2.7529	0	0
3	1.0229	1.0229	-5.2086	-5.2086	0	0
4	1.0225	1.0225	-5.4879	-5.4879	0	0
5	1.0176	1.0176	-6.1672	-6.1679	0	0

For slack Bus power

Real power(MW) simulation	Real power(MW) Matlab	Reactive Power simulation	Reactive power Matlab	Error(%) Real power	Error(%) Reactive power
129.6120	129.6109	-7.0480	-7.0483	8.48e-4	4.256e-3

Q3

Make an undervoltage event in Bus-4 and apply any technique to overcome the undervoltage problem of the system. (Consider, below 90% to be undervoltage for any bus).

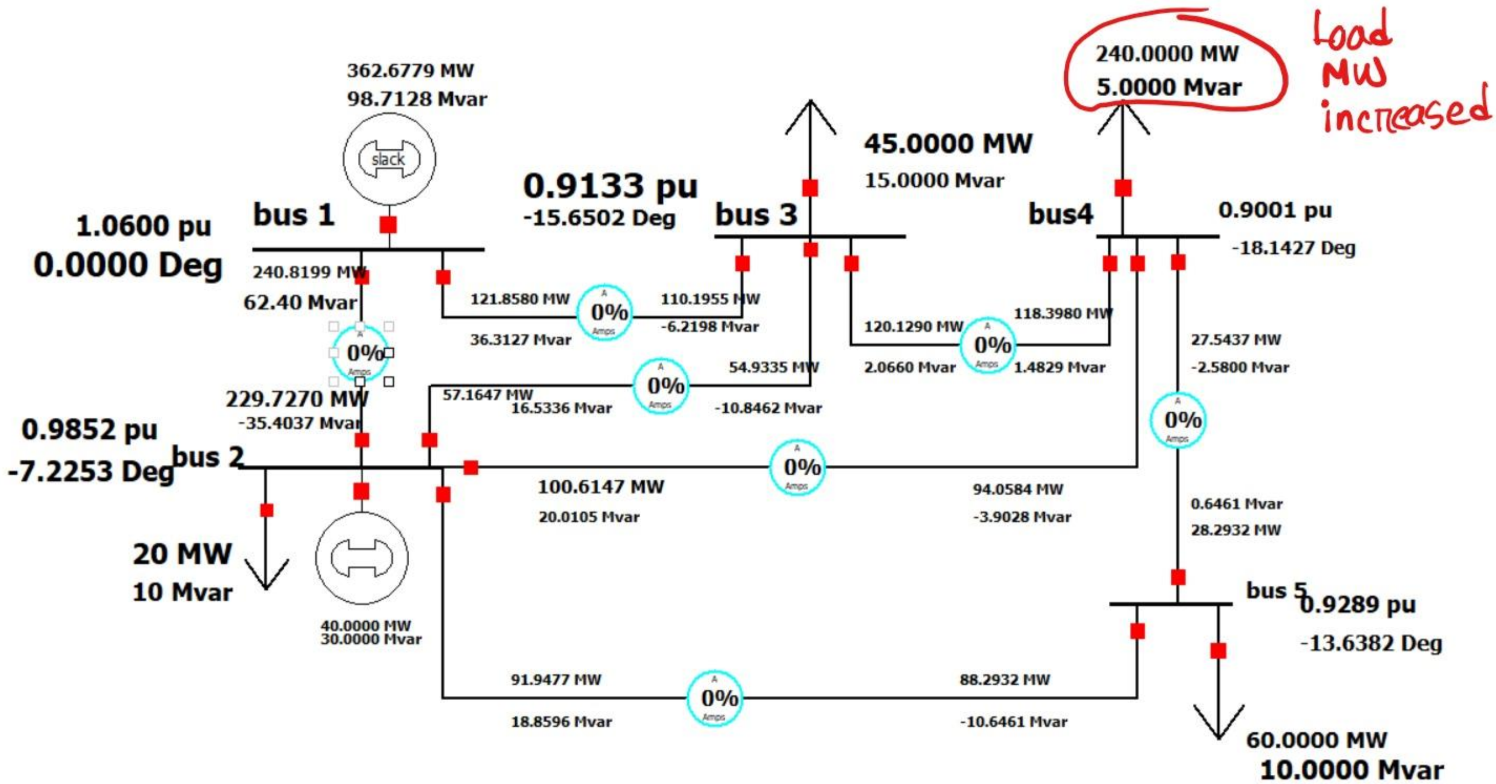


Fig: Making under voltage condition

In a power system, under voltage refers to a condition where the voltage level at a particular location or point in the system falls below the specified or desired value.

Here the perioud load in bus 4 was 40MW. Now inorder to decrease the voltage below 90% extra load is given to the bus4. After addition of certain load, the voltge is droped and thus under voltage condition was created.

Previous load(MW)	New load(MW)	Previous voltage(p.u)	New voltage(p.u)
40	240	1.0225	0.9001

Overcoming The situation:

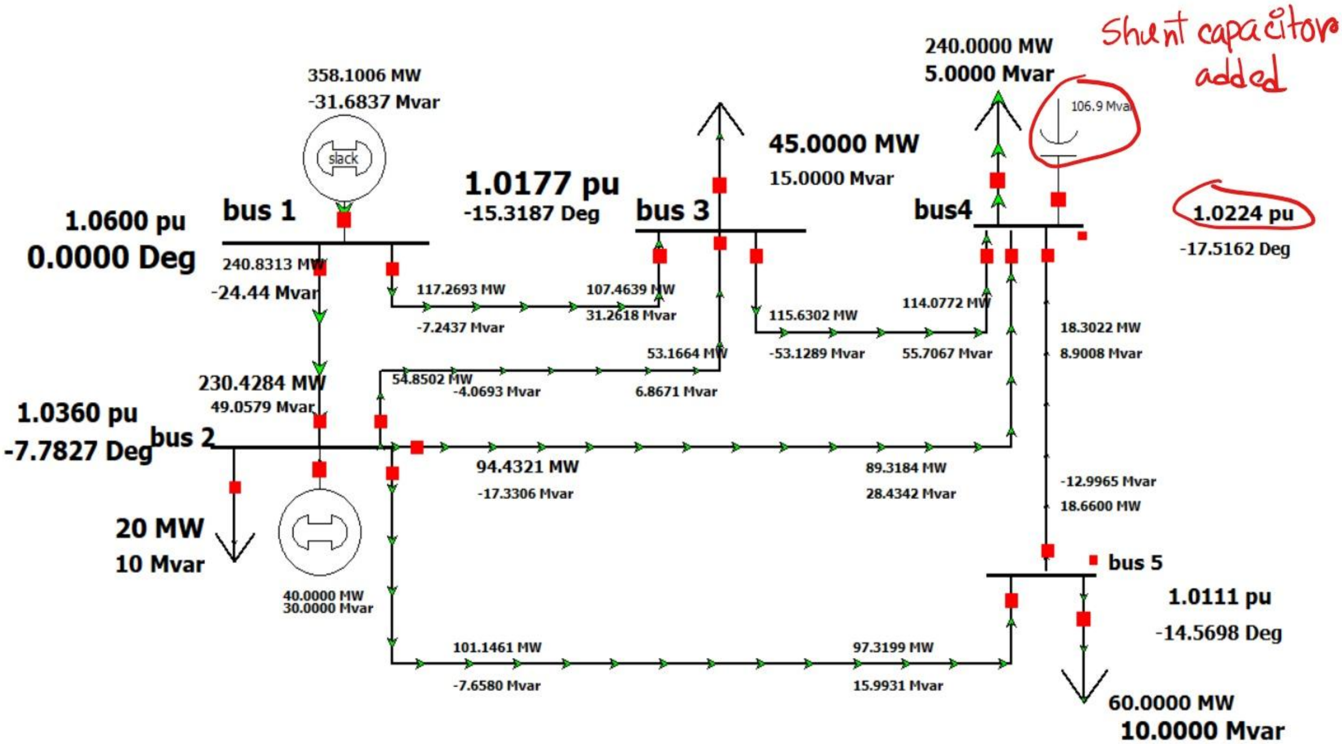


Fig: Solving Under voltage by adding capacitor

Here to overcome the under voltage condition, a shunt capacitor is added to the same bus. We know that capacitor supplies negative VAR to the system and helps to increase the voltage at over excited condition. In this case, to go back to its previous voltage 106.5 MVAR was needed.

So solved the under-voltage problem.

Types	Load(MW, MVAR)	Voltage(V)	Angle(Deg)
Before Adding shunt Capacitance(Normal) Condition)	40	1.0225	-5.4879
Before Adding shunt Capacitance(under voltage Condition)	240	0.9001	-18.1427
After adding shunt capacitance	240, 106.9	1.0224	-17.5162

Q4

If the power flow through the transmission line (2-5) is to be made 75% of the normal condition, what should be the steps that can be adopted to do it? Implement any of them to do this job?

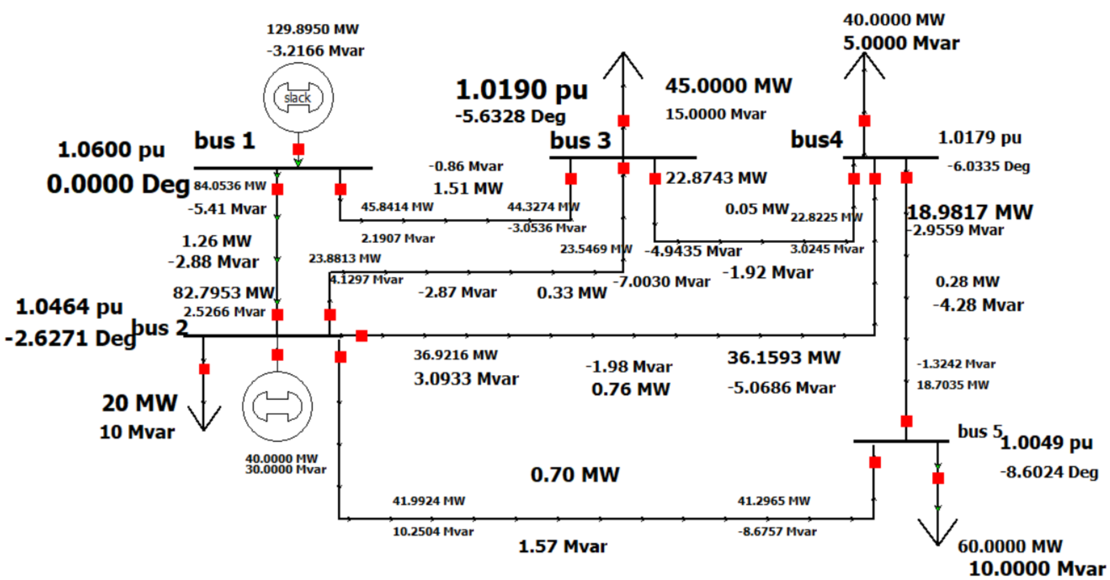
Answer:

From 2-5 bus the power flow through the transmission line is 55.9302 MW. So, 75% of the power through 2-5 line is 41.94765 MW. We can minimize the power flow through the transmission line in two methods:

- By increasing the reactance
- By adding transformers

By increasing reactance : current through the tranmission line can be written as **I = V / X**

From this equation, it is evident that an increase in reactance (X) leads to a decrease in current (I), assuming the voltage (V) remains constant. Since power (P) is the product of voltage and current (P = VI), a decrease in current results in a decrease in power flow.



Previous reactance	New reactance	Previous power	New Power
0.12	0.272	55.9302	41.9924

By adding transformers: Here we have used a transformer paralllel to the 2-5 trasmission line. Tap changing is a technique which is used to adjust the voltage level of transformers, which can indirectly affect power flow. By changing the tap position on a transformer, the voltage level at the secondary side can be adjusted, which in turn affects the voltage and current levels throughout the power system.Increasing the tap position on a transformer can raise the voltage level at the secondary side. When the voltage is increased, it can lead to an increase in power flow.

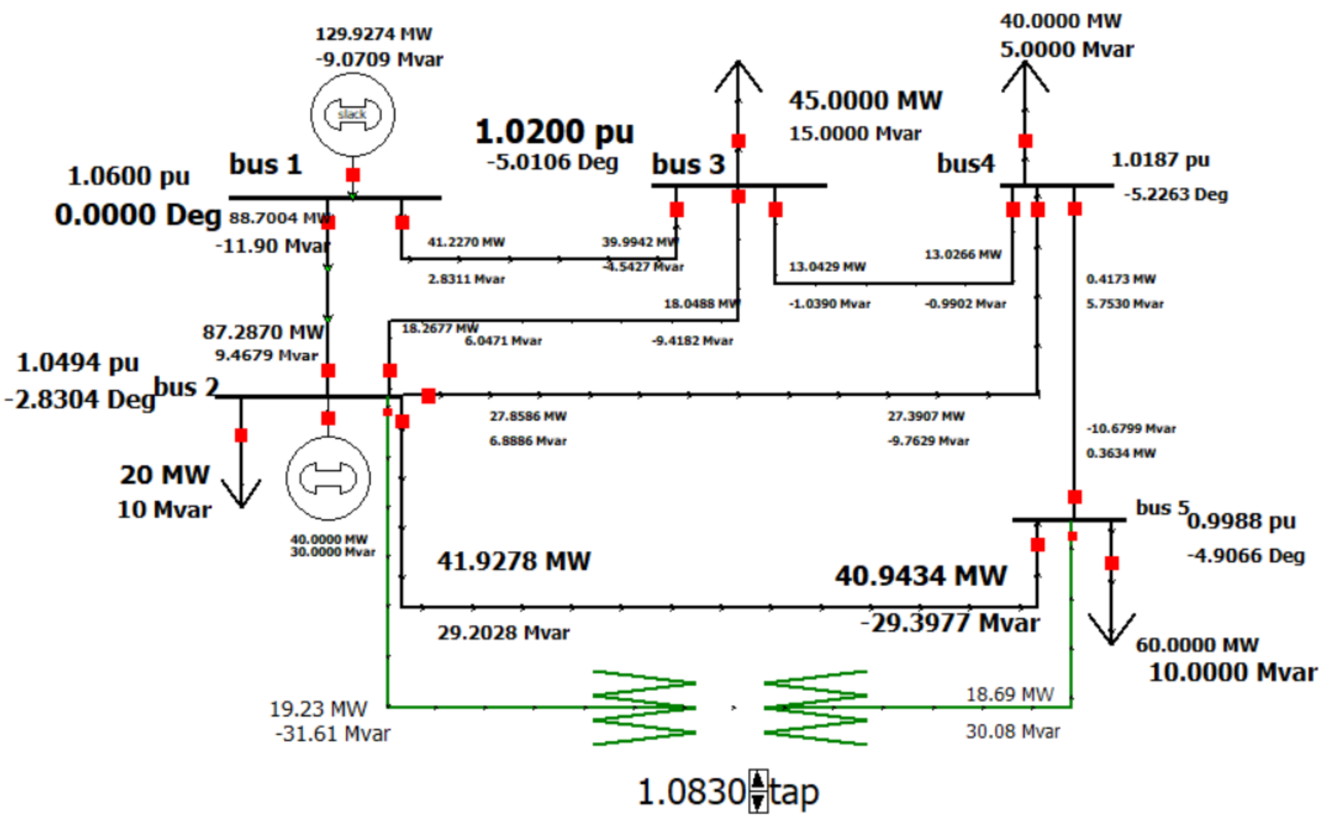


Fig : Adding Transformer

Methods	Previous power (MW)	New power (MW)	Percent value(%)	Error (%)
Increasing the reactance	55.9302	41.9924	75.08	0.106
Tap changing	55.9302	41.9278	73.305	2.25