S.J.P.N Trust's

Hirasugar Institute of Technology, Nidasoshi

Inculcating Values, Promoting Prosperity

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Tq: Hukkeri **Dist: Belagavi**

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGG.

LABORATORY MANUAL

Name of the Lab: Power System Simulation Laboratory

Semester: VII

Subject Code: 18EEL76

Staff Incharge: Prof. Pramod M Murari

Technical Staff: Shri. Rajendra S Bardol

AY 2021-22

Vision of Institute

"To be a preferred institution in Engineering Education by achieving excellence in teaching and research and to remain as a source of pride for its commitment to holistic development of individual and society."

Mission of Institute

"To continuously strive for the overall development of students, educating them in a state-of-the-art-infrastructure, by retaining the best practices, people and inspire them to imbibe real time problem solving skills, leadership qualities, human values and societal commitments, so that they emerge as competent professionals."

Vision of Program

"To be the centre of excellence in teaching and learning to produce the competent & socially responsible professionals in the domain of Electrical & Electronics Engineering."

Mission of Program

"To educate students with core knowledge of Electrical and Electronics Engineering by developing problem solving skills, professional skills and social awareness to excel in their career."

List of Experiments

Power system simulation using Matlab/Octave/Mi-Power

1. ABCD parameters: verification of AD-BC=1, determination of coefficient and regulation
   a) For short transmission line
   b) For medium transmission line
   c) For long transmission line
2. Y_{Bus} formation for power system
   a) By Inspection method
   b) By singular transformation Without mutual coupling.
   c) By singular transformation With mutual coupling.
3. Formation of Z_{Bus}, using Z_{Bus} building algorithm.
4. Determination of power angle diagrams for salient and non-salient pole synchronous machines, reluctance power, excitation, EMF and regulation.
5. Determination of swing curve for a single machine connected to infinite bus.
6. Load flow analysis using GS method for both pq and pv buses.
7. Load flow analysis using NR method for formation of Jacobean matrix.
8. Determination of fault currents and voltages in a single transmission line for SLGF, DLGF
9. Optimal generator scheduling for thermal power plants.

1a. Short transmission line

Aim:
Determination of ABCD paratmeters for short transmission line with a given condition and hence study the performance of the line regulation and efficiency.

Problem statement:
A 3-phase overhead transmission line deliver a 1100kW at 11kV at 0.8pf lagging the total resistance and inductive reactance of the line are 8 ohm and 16 ohm respectively. Determine 1) Line current 2) Sending end voltage 3)Sending end power factor 4)Sending end real power 5)Sending end reactive power 6)Transmission efficiency 7)Percentage regulation 8)ABCD parameters.

Appartus required: Matlab software

Theory: Refer Principle of power system by V K Mehta & Rohit Mehta

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on matlab icon in the desktop.
- Type **edit** and press enter to get the Editor window.
- Type the program.
- Save and run the program.
- Enter the inputs in the command window and see the output response.
- Note down the simulated results.

Calculations:

Program

```
%short transmission line
clear;
clc;
R=input('resistance of the line in ohm=');
X=input('reactance of the line in ohm=');
VR3ph=input('voltage at receiving end in KV=');
PR=input('real load at receiving end in MW=');
QR=input('reactive load at receiving end in MVAR=');
Z=R+j*X;
ABCD=[1     Z;     0      1];
VR=VR3ph/sqrt(3)+j*0;
SR=PR+j*QR;
IR=conj(SR)/(3*conj(VR));
VSIS=ABCD*[VR;IR];
VS=VSIS(1);
VS3ph=sqrt(3)*abs(VS);
IS=VSIS(2);
ISm=1000*abs(IS);
pfs=cos(angle(VS)-angle(IS));
SS=3*VS*conj(IS);
Reg=((VS3ph-VR3ph)/(VR3ph))*100;
Eff=PR/real(SS)*100;
fprintf('\n IS=%g A',ISm);
fprintf('\n pf=%g',pfs);
fprintf('\n VS=%g KV',VS3ph);
fprintf('\n PS=%g MW',real(SS));
fprintf('\n QS=%g MVAR',imag(SS));
fprintf('\n percentage voltage regulation=%g',Reg);
fprintf('\n percentage transmission line efficiency=%g',Eff);
fprintf('\n ABCD parameters of transmission line\n');
disp(ABCD);
```

Inputs

resistance of the line in ohm=___________________

reactance of the line in ohm=___________________

voltage at receiving end in KV=___________________

real load at receiving end in MW=___________________

reactive load at receiving end in MVAR=___________________

Output response/Simulation Results:

I_S=___________________ A

pf=___________________

V_S=___________________ KV

P_S=___________________MW

Q_S=___________________ MVAR

Percentage voltage regulation=

Percentage transmission line Efficiency=

ABCD parameters of transmission line

1b. Medium Transmission Line

Aim:
Determination of ABCD paratmeters for medium transmission line with a given condition and hence study the performance of the line regulation and efficiency.

Problem statement 1:
A 3-phase 50Hz overhead tranmission line delivers 10 MW at 0.8pf lagging at 66 kV. The resistance, inductive reactance and capacitive susceptance 10 ohm, 20 ohm and 4*10^-4 siemen. Determine 1)Sending end current 2)Sending end voltage 3)Sending end power factor 4)ABCD parameter 5) Regulation 6) Transmission effeciency using nominal T method.

Appartus required: Matlab software

Theory: Refer Principle of power system by V K Mehta & Rohit Mehta

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on matlab icon in the desktop.
- Type **edit** and press enter to get the Editor window.
- Type the program.
- Save and run the program.
- Enter the inputs in the command window and see the output response.
- Note down the simulated results.

Calculations:

Program:

```
%medium transmission line
clear;
clc;
R=input('resistance of the line in ohm=');
X=input('reactance of the line in ohm=');
B=input('susceptance of shunt line in mho=');
VR3ph=input('voltage at receiving end in KV=');
PR=input('real load at receiving end in MW=');
QR=input('reactive load at receiving end in MVAR=');
Z=R+j*X;
Y=0+j*B;
type=input('type(P-Pie/T-tmethod)=','s');
switch type
case'P'
   ABCD=[1+Z*Y/2            Z;       Y*(1+Z*Y/4)          1+Z*Y/2];
case'T'
   ABCD=[1+Z*Y/2            Z*(1+Z*Y/4);          Y                1+Z*Y/2];
   otherwise
      Error('Invaid type choosen!!!')
      end
      VR=VR3ph/sqrt(3)+j*0;
      SR=PR+j*QR;
      IR=conj(SR)/(3*conj(VR));
      VSIS=ABCD*[VR;IR];
      VS=VSIS(1);
      VS3ph=sqrt(3)*abs(VS);
      IS=VSIS(2);
      ISm=1000*abs(IS);
      Pfs=cos(angle(VS)-angle(IS));
      SS=3*VS*conj(IS);
      Reg=(VS3ph-VR3ph)/VR3ph*100;
      Eff=PR/real(SS)*100;
      fprintf('\n IS=%g A',ISm);
      fprintf('\n Pfs=%g',Pfs);
      fprintf('\n VS=%g KV',VS3ph);
      fprintf('\n PS=%g MW',real(SS));
      fprintf('\n QS=%g MVAR',imag(SS));
      fprintf('\n percentage voltage regulation=%g',Reg);
      fprintf('\n percentage transmission line efficiency=%g',Eff);
      fprintf('\n ABCD parameters of transmission line\n');
      disp(ABCD);
```

Inputs:

resistance of the line in ohm=___________________

reactance of the line in ohm=___________________

voltage at receiving end in KV=___________________

real load at receiving end in MW=___________________

reactive load at receiving end in MVAR=___________________

susceptance of shunt line in mho=___________________

type(P-Pie/T-tmethod)= ___________________

Output response/Simulation Results:

I_S=__________________ A

Pfs=___________________

V_S=___________________ KV

P_S=___________________ MW

Q_S=___________________ MVAR

percentage voltage regulation=_________________

percentage transmission line efficiency=___________________

ABCD parameters of transmission line

Problem statement 2:

A 3-phase 50Hz overhead transmission line of 100 km has the following constants.
Resistance/km/phase=0.1 ohm
Inductive reactance/km/phase=0.5 ohm
Capacitive susceptance/km/phase=10*10^-5 siemen
The line supplies the load of 20MW at 0.9pf lagging at 66kV at receiving end.
Determine 1)Sending end current 2)Sending end voltage 3)Sending end power factor 4)ABCD parameter 5) Regulation 6) Transmission effeciency using nominal pi method.

Calculations:

Input:

resistance of the line in ohm==___________________

reactance of the line in ohm==___________________

susceptance of shunt line in mho==___________________

voltage at receiving end in KV==___________________

real load at receiving end in MW==___________________

reactive load at receiving end in MVAR==___________________

type(P-Pie/T-tmethod)= =___________________

Output response/Simulation Results:

I_S==___________________A

Pfs==___________________

V_S=___________________KV

P_S=___________________MW

Q_S=___________________MVAR

percentage voltage regulation=___________________

percentage transmission line efficiency=___________________

ABCD parameters of transmission line

1c. Long Transmission Line

Aim:

Determination of ABCD paratmeters for long transmission line with a given condition and hence study the performance of the line regulation and efficiency.

Problem statement 1:

Determine the efficiency and regulation of 3-phase, 50Hz, 120km long transmission line delivering 40MW at 132kV at 0.8 lagging pf with following details.
Resistance/km/phase=0.2 ohm
Inductive reactance/km/phase=1.3mH
Capactive susceptance/km/phase=0.01 micro farad

Appartus required: Matlab software

Theory: Refer Principle of power system by V K Mehta & Rohit Mehta

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on matlab icon in the desktop.
- Type **edit** and press enter to get the Editor window.
- Type the program.
- Save and run the program.
- Enter the inputs in the command window and see the output response.
- Note down the simulated results.

Calculations:

Program:

```
%long transmission line
clear;
clc;
R=input('resistance of the line in ohm=');
X=input('reactance of the line in ohm=');
B=input('susceptance of shunt line in mho=');
VR3ph=input('voltage at receiving end in KV=');
PR=input('real load at receiving end in MW=');
QR=input('reactive load at receiving end in MVAR=');
Z=R+j*X;
Y=0+j*B;
gamma=sqrt(Z*Y);
ZC=sqrt(Z/Y);
A=cosh(gamma);
B=ZC*sinh(gamma);
C=1/ZC*sinh(gamma);
D=A;
ABCD=[A B;C D];
VR=VR3ph/sqrt(3)+j*0;
SR=PR+j*QR;
IR=conj(SR)/(3*conj(VR));
VSIS=ABCD*[VR;IR];
VS=VSIS(1);
VS3ph=sqrt(3)*abs(VS);
IS=VSIS(2);
ISm=1000*abs(IS);
Pfs=cos(angle(VS)-angle(IS));
SS=3*VS*conj(IS);
Reg=(VS3ph-VR3ph)/VR3ph*100;
Eff=PR/real(SS)*100;
Val=(A*D)-(B*C);
fprintf('\n IS=%g A',ISm);
fprintf('\n Pfs=%g',Pfs);
fprintf('\n VS=%g KV',VS3ph);
fprintf('\n PS=%g MW',real(SS));
fprintf('\n QS=%g MVAR',imag(SS));
fprintf('\n percentage voltage regulation=%g',Reg);
fprintf('\n Efficiency=%g',Eff);
fprintf('\n A*D-B*C=%g',Val);
fprintf('\n ABCd parameters of transmission line\n');
disp(ABCD);
```

Inputs:

resistance of the line in ohm=___________________

reactance of the line in ohm=___________________

susceptance of shunt line in mho=___________________

voltage at receiving end in KV=___________________

real load at receiving end in MW=___________________

reactive load at receiving end in MVAR=___________________

Output response/Simulation Results:

I_S=___________________A

Pfs=___________________

V_S=___________________ KV

P_S=___________________MW

Q_S=___________________MVAR

percentage voltage regulation=___________________

Efficiency=___________________

A*D-B*C=___________________

ABCD parameters of transmission line

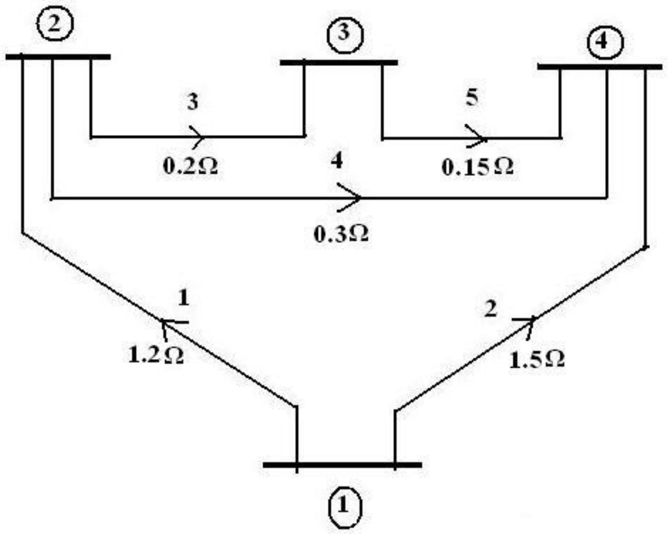
2a. Y_{Bus} by Inspection Method

Aim:

Determination of Y_{Bus} for given network by inspection method.

Problem statement:

Obtain the Ybus by inspection method for the network shown in fig below.



Appartus required: Matlab software

Theory: Refer Principle of power system by V K Mehta & Rohit Mehta

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on matlab icon in the desktop.
- Type **edit** and press enter to get the Editor window.
- Type the program.
- Save and run the program.
- Enter the inputs in the command window and see the output response.
- Note down the simulated results.

Calculations:

Program:

```
%formation of Ybus by inspection
clear;
clc;
%        en   fb   tb admittance
Ydata=[1     1    2    1.2
       2     1    4    1.5
       3     2    3    0.2
       4     2    4    0.3
       5     3    4    0.15];
bus=max(max(Ydata(:,2)),max(Ydata(:,3)));
element=max(Ydata(:,1));
Ybus=zeros(bus,bus);
for row=1:element;
   i1=Ydata(row,2);
   j1=Ydata(row,3);
   if i1~=0&j1~=0
      Ybus(i1,i1)=Ybus(i1,i1)+Ydata(row,4);
      Ybus(j1,j1)=Ybus(j1,j1)+Ydata(row,4);
   end
end
for k=1:element,
   Ybus(Ydata(k,2),Ydata(k,3))=-Ydata(k,4);
   Ybus(Ydata(k,3),Ydata(k,2))=-Ydata(k,4);
end
disp(Ybus);
```

Output response/Simulation Results: Bus admittance matrix

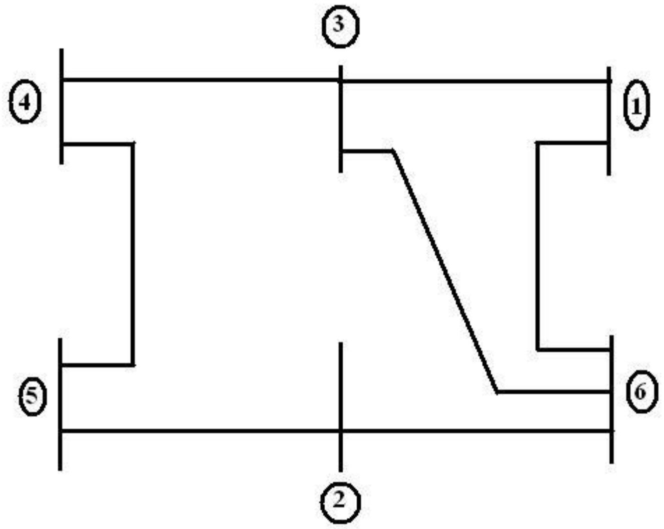
2b. Y_{Bus} by singular transformation(without mutual coupling)

Aim:

Determination of Y_{Bus} for given network by singular transformation method.

Problem statement:

For the system defined by the line data determine the Y_{Bus} admittance matrix by singular transformation method. Select bus no. 1 as reference bus and treat elements 6 & 7 as links.



Line data:

Element no	1	2	3	4	5	6	7
Bus code	1-6	2-6	2-5	1-3	3-4	4-5	3-6
Admittance	20j	35j	10j	5j	20j	10j	25j

Appartus required: Matlab software

Theory: Refer Principle of power system by V K Mehta & Rohit Mehta

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on matlab icon in the desktop.
- Type **edit** and press enter to get the Editor window.
- Type the program.
- Save and run the program.
- Enter the inputs in the command window and see the output response.
- Note down the simulated results.

Calculations:

Program:

```
% Ybus formation by singular transformation method
clear;
clc;
%        en     fb     tb     self adm.     en     mut adm.
Ydata=[1        1      6       20i          0       0
          2     2      6       35i          0       0
          3     2      5       10i          0       0
          4     1      3        5i          0       0
          5     3      4       20i          0       0
          6     4      5       10i          0       0
          7     3      6       25i          0       0];
element=max(Ydata(:,1));
buses=max(max(Ydata(:,2)),max(Ydata(:,3)));
buses=buses-1;
A=zeros(element,buses);
for i=1:element;
   if(Ydata(i,2)~=1)A(i,Ydata(i,2)-1)=1;
   end
   if(Ydata(i,3)~=1)A(i,Ydata(i,3)-1)=-1;
   end
end
% formation of primitive impedance matrix
Yprimitive=zeros(element,element);
for i=1:element,
Yprimitive(i,i)=Ydata(i,4);
if Ydata(i,5)>0,
   Yprimitive(i,Ydata(i,5))=Ydata(i,6);
   Yprimitive(Ydata(i,5),i)=Ydata(i,6);
end
end
Yprimitive=(Yprimitive);
Ybus=A'*Yprimitive*A;
fprintf('\n\t\t Bus admittance matrix\n');
disp(Ybus);
```

Output response/Simulation Results:

Bus admittance matrix

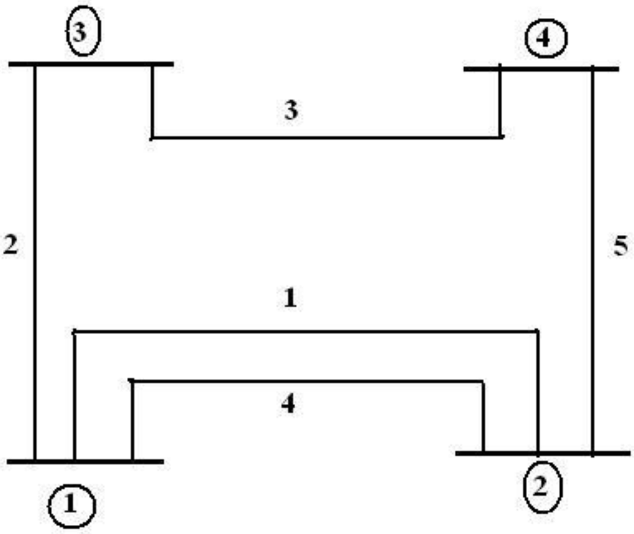
2c. Y_{Bus} by singular transformation(with mutual coupling)

Aim:

Determination of Y_{Bus} for given network by singular transformation method with mutual coupling.

Problem statement:

Find Ybus for the power system given below by singular transformation method with mutual coupling.



Line data:

Element no	Self bus code	Imp Zpq in pu	Bus code	Imp Zpq
1	1-2	0.6j	-	0
2	1-3	0.5j	1-2	0.1j
3	3-4	0.5j	-	0
4	1-2	0.4j	1-4	0.2j
5	2-4	0.2j	-	0

Appartus required: Matlab software

Theory: Refer the computer techniques in power system by e.stagg

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on matlab icon in the desktop.
- Type **edit** and press enter to get the Editor window.
- Type the program.
- Save and run the program.
- Enter the inputs in the command window and see the output response.
- Note down the simulated results.

Calculations:

Program:

```
% Ybus formation by singular transformation method
clear;
clc;
%        en     fb    tb     self imp     en     mut imp.
Zdata= [1        1     2        0.6        0       0
        2        1     3        0.5        1       0.1
        3        3     4        0.5        0       0
        4        1     2        0.4        1       0.2
        5        2     4        0.2        0       0];
elements=max(Zdata(:,1));
buses=max(max(Zdata(:,2)),max(Zdata(:,3)));
buses=buses-1;
A=zeros(elements,buses);
for i=1:elements,
   if(Zdata(i,2)~=1)A(i,Zdata(i,2)-1)=1;
   end
   if(Zdata(i,3)~=1)A(i,Zdata(i,3)-1)=-1;
   end
end
% formation of primitive impedance matrix
Zprimitive=zeros(elements,elements);
for i=1:elements,
   Zprimitive(i,i)=Zdata(i,4);
   if Zdata(i,5)>0,
      Zprimitive(i,Zdata(i,5))=Zdata(i,6);
      Zprimitive(Zdata(i,5),i)=Zdata(i,6);
   end
end
Yprimitive=inv(Zprimitive);
Ybus=A'*Yprimitive*A;
fprintf('\n\t\t Bus admittance matrix\n');
disp(Ybus);
```

Output response/Simulation Results:

Bus admittance matrix

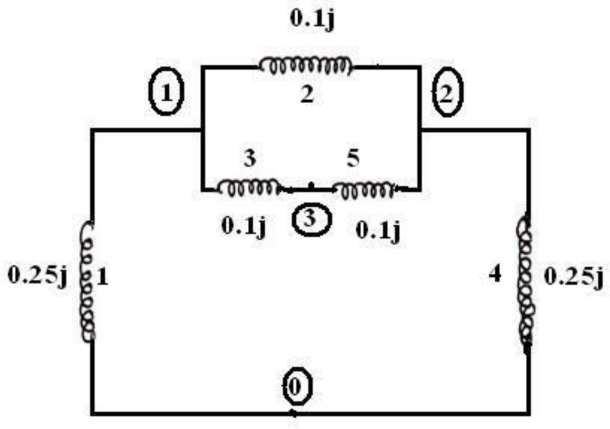
3. Z_{Bus} building algorithm

Aim:

Forming Z_{Bus} by building algorithm

Problem statement:

Form the Z_{Bus} by building algorithm for the following network shown.



Appartus required: Matlab software

Theory: Refer the computer techniques in power system by e.stagg

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on matlab icon in the desktop.
- Type **edit** and press enter to get the Editor window.
- Type the program.
- Save and run the program.
- Enter the inputs in the command window and see the output response.
- Note down the simulated results.

Calculations:

Program:

```
%Zbus building algorithm
clear;
clc;
%             en   fb  tb  self imp
Zprimary=[1   1   0   0.25
               2   2   1   0.1
               3   3   1   0.1
               4   2   0   0.25
               5   2   3   0.1];
   [elements columns]=size(Zprimary);
   Zbus=[];
   currentbusno=0;
   for i=1:elements,
      [rows columns]=size(Zbus);
      from=Zprimary(i,2);
      to=Zprimary(i,3);
      value=Zprimary(i,4);
      newbus=max(from,to);
      ref=min(from,to);
      if newbus>currentbusno & ref==0
         Zbus=[Zbus zeros(rows,1);
            zeros(1,columns) value]
         currentbusno=newbus;
         continue
      end
      if newbus>currentbusno & ref~=0
         Zbus=[Zbus Zbus(:,ref);
            Zbus(ref,:) value+Zbus(ref,ref)]
         currentbusno=newbus;
         continue
      end
      if newbus<=currentbusno & ref==0
         Zbus=Zbus-1/(Zbus(newbus,newbus)+value)*Zbus(:,newbus)*Zbus(newbus,:);
         continue
      end
      if newbus<=currentbusno & ref~=0
         Zbus=Zbus-1/(value+Zbus(from,from)+Zbus(to,to)-
2*Zbus(from,to))*(Zbus(:,from)-Zbus(:,to))*(Zbus(from,:)-Zbus(to,:));
         continue
      end
   end
   fprintf('\n Thus Zbus by building algorithm is \n');
   disp(Zbus);
```

Output response/Simulation Results:

Thus Zbus by building algorithm is

4. Power angle curve

Aim:

Determination of power angle curve for salient and non-saline pole synchronous machine and determine relunctance power, salient power, non-salient power, excitation emf and regulation.

Problem statement:

A 34.64 kV 60MVA synchronous generator has direct axis reactance 13.5 ohm and quadratute axis reactance 9.33 ohm is operating at 0.8 pf. Determine the excitation emf, regulation, non-salient power, reluctance power, salient power and also plot the power angle curves for non-salient pole and salient pole synchronous machine.

Appartus required: Matlab software

Theory: Refer the computer techniques in power system by e.stagg

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on matlab icon in the desktop.
- Type **edit** and press enter to get the Editor window.
- Type the program.
- Save and run the program.
- Enter the inputs in the command window and see the output response.
- Note down the simulated results.

Calculations:

Program:

```
%power angle curve
clear;
clc;
p=input('power in mw=');
pf=input('power factor=');
vt=input('line to line voltage in kv=');
xd=input('xd in ohms=');
xq=input('xq in ohms=');
vt_ph=vt*1000/sqrt(3);
pf_a=acos(pf);
q=p*tan(pf_a);
i=(p-j*q)*1000000/(3*vt_ph);
delta=0:1:180;
delta_rad=delta*(pi/180);
if xd==xq
    %non salientsyn motor
    ef=vt_ph+(j*i*xd);
    excitation_emf=abs(ef)
    reg=(abs(ef)-abs(vt_ph))*100/abs(vt_ph)
    power_non=abs(ef)*vt_ph*sin(delta_rad)/xd;
    net_power=3*power_non/1000000;
    plot(delta,net_power);
    xlabel('delta(deg)-->');
    ylabel('three phase power(mw)->');
    title('plot:power angle curve for non salient pole synchronous m/c');
    legend('non salient power')
end
if xd~=xq
    %salient syn motor
    eq=vt_ph+(j*i*xq);
    id_mag=abs(i)*sin(angle(eq)-angle(i));
    ef_mag=abs(eq)+((xd-xq)*id_mag)
    excitation_emf=ef_mag
    reg=(ef_mag-abs(vt_ph))*100/abs(vt_ph)
    pp=ef_mag*vt_ph*sin(delta_rad)/xd;
    reluct_power=vt_ph^2*(xd-xq)*sin(2*delta_rad)/(2*xd*xq);
    net_reluct_power=3*reluct_power/1000000;
    power_sal=pp+reluct_power;
    net_power_sal=3*power_sal/1000000;
    plot(delta,net_reluct_power,'k');
    hold on
    plot(delta,net_power_sal,'r');
    xlabel('delta(deg)-->');
    ylabel('three phase power(pu)-->');
    title('plot:power angle curve for salient pole synchronous m/c');
    legend('reluct_power','salint_power')
end
    grid;
```

Non-salient pole synchronous machine

Inputs:

power in mw=_______

power factor=___________

line to line voltage in kv=_________

xd in ohms=________

xq in ohms=___________

Simulation Results:

excitation_emf =______________

reg = _______________

Salient pole synchronous machine

Inputs:

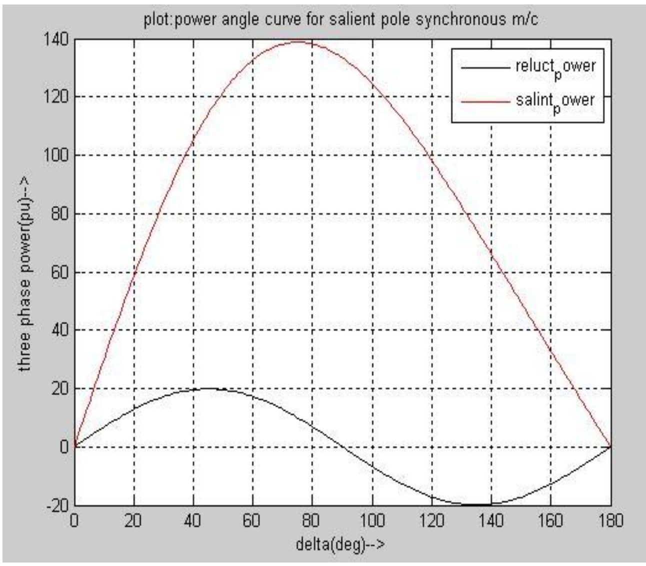
power in mw=____________

power factor=_____________

line to line voltage in kv=______

xd in ohms=________

xq in ohms=____________



Simulation Results:

ef_mag =_________________

excitation_emf =________________

reg =_________________

5. Swing curve

Aim:

Determination of swing curve and critical clearing time of the machine connected to infinite bus.

Problem statement:

A 20MVA, 50Hz generator delivers 18MW over a double circuit line to an infinite bus. The generator has kinetic energy of 2.52 MJ/MVA at rated speed. The generator transient reactance is Xd'=0.35pu. Each transmission circuit has R=0 and a reactance of 0.2pu on a 20MVA base. |E'| =1.1pu and infinite bus voltage V=1.0 at 0 degree. A three phase short circuit occurs at the mid point of the transmission lines. Plot swing curves with fault cleared by simultaneous opening of breakers at both ends of the line at 2.5 cycles and 6.25 cycles after the occurrence of fault. Also plot the swing curve over the period of 0.5 seconds if the fault is sustained.

Appartus required: Matlab software

Theory: Refer the modern power system analysis by D P Kothari & I J Nagarth

Procedure:

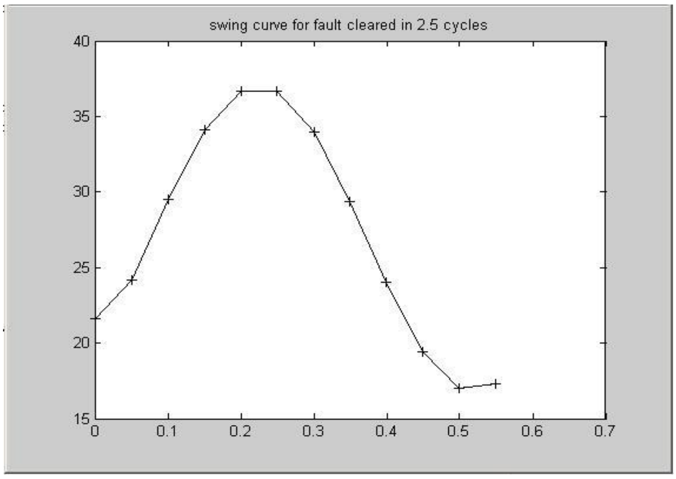
- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on matlab icon in the desktop.
- Type **edit** and press enter to get the Editor window.
- Type the program.
- Save and run the program.
- Enter the inputs in the command window and see the output response.
- Note down the simulated results.

Calculations:

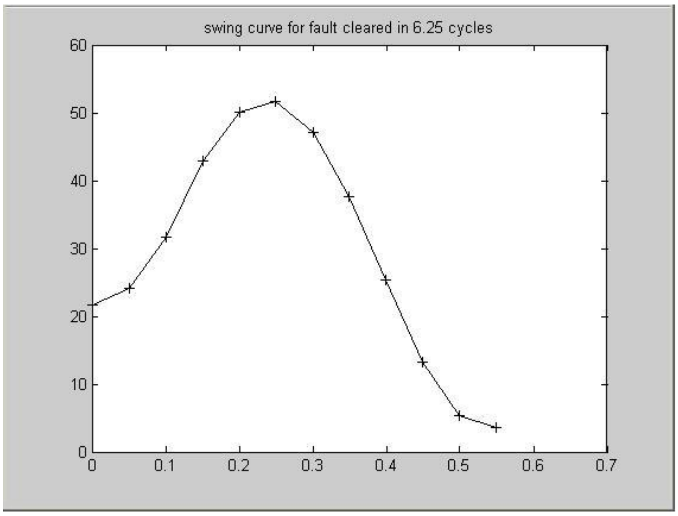
Program:

```
%swing curve
clear;
clc;
t=0;
tf=0;
tfl=0.5;
tc=0.05;      %tc=0.05,0.125,0.5 sec for 2.5cycles,6.25cycle & 25cycle resp
ts=0.05;
m=2.52/(180*50);
i=2;
dt=21.64*pi/180;
ddt=0;
time(1)=0;
ang(1)=21.64;
pm=0.9;
pm1=2.44;
pm2=0.88;
pm3=2.00;
while t<tfl,
    if (t==tf),
        pam=pm-pm1*sin(dt);
        pap=pm-pm2*sin(dt);
        paav=(pam+pap)/2;
        pa=paav;
    end
    if (t==tc),
        pam=pm-pm2*sin(dt);
        pap=pm-pm3*sin(dt);
        paav=(pam+pap)/2;
        pa=paav;
    end
    if (t>tf&t<tc),
        pa=pm-pm2*sin(dt);
    end
    if (t>tc),
        pa=pm-pm3*sin(dt);
    end
    ddt=ddt+(ts*ts*pa/m);
    dt=(dt*180/pi+ddt)*pi/180;
    dtdg=dt*180/pi;
    t=t+ts;
    time(i)=t;
    ang(i)=dtdg;
    i=i+1;
end
axis([0 0.6 0 160])
plot(time,ang,'k+-')
title('swing curve for fault cleared in 2.5 cycles')
```

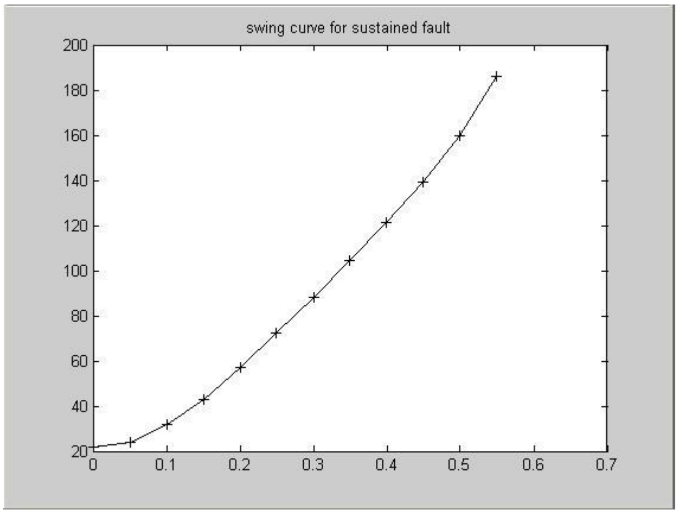
Simulation Results:
Swing curve for fault cleared in 2.5 cycles (tc=0.05)



Swing curve for fault cleared in 6.25 cycles (tc=0.125)



Swing curve for sustained fault (tc=0.5)



6. Load flow analysis by GS method

Aim: To determine the bus power, line losses, line flows and slack bus power for given system using GS method.

Problem statement 1:

Figure below shows the one line diagram of a simple three bus system with generators at buses 1 and 3. The line parameters are given in the table A and the generator data is given in table B. The line impedances are marked in pu on a 100 MVA base and line charging susceptances are neglected. The voltage at bus 3 is maintained at 1.04pu. Taking bus 1 as slack bus. Obtain the load flow solution using GS iteration method.

Table A:

Bus code	Impedance in pu
1-2	0.02+0.04j
1-3	0.01+0.03j
2-3	0.0125+0.025j

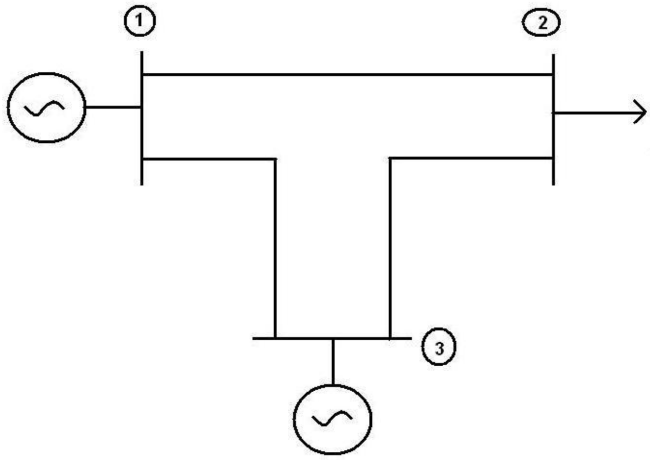


Table B:

Bus no	Bus voltage	Generation		Load	
		MW	MVAR	MW	MVAR
1	1.05+0j	-	-	-	-
2	-	0	0	400	250
3	1.04+0j	200	-	0	0

Appartus required: Mipower software

Theory: Refer the modern power system analysis by D P Kothari & I J Nagarth & mipower software manual.

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on mipower icon in the desktop.
- Creat the database with .mdb extension.
- Draw the one line diagram.
- Save and simulate.
- Note the results.

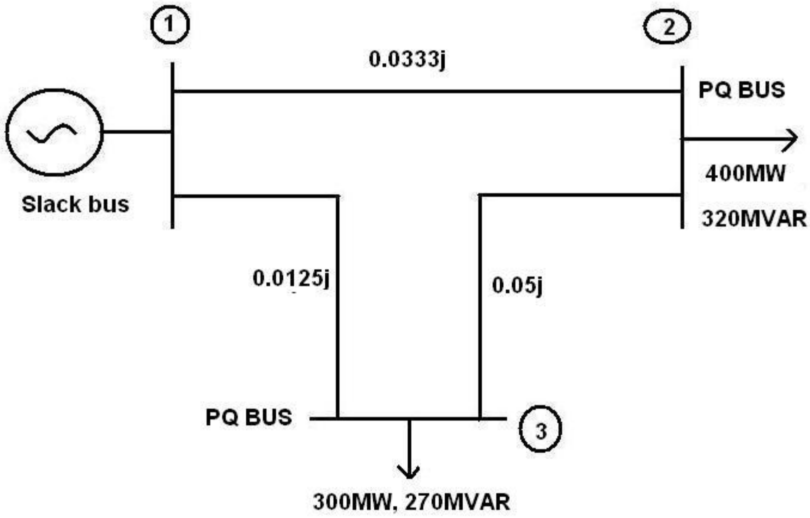
Calculations:

Simulation Results: Bus voltages and power

Bus	Voltage(pu)	angle	Generation		Load	
			MW	MVAR	MW	MVAR
Slack						
PQ						
PV						

Problem statement 2:

Figure below shows the one line diagram of a simple three bus system with generator at bus 1. The voltage at bus 1 is $1\angle 0^{o}$ unit. The scheduled loads on buses 2 & 3 are marked on the diagram. Line impedances are marked in pu on a base of 100 MVA. Using GS method with initial estimate of V_2=V_3=$1\angle 0^{o}$. Conduct load flow analysis.



Appartus required: Mipower software

Theory: Refer the modern power system analysis by D P Kothari & I J Nagarth & mipower software manual.

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on mipower icon in the desktop.
- Creat the database with .mdb extension.
- Draw the one line diagram.
- Save and simulate.
- Note the results.

Calculations:

Simulation Results: Bus voltages and power

Bus	Voltage(pu)	angle	Generation		Load	
			MW	MVAR	MW	MVAR
1						
2						
3						

7. Load flow analysis by NR method

Aim: To determine bus voltages, line flows and line losses using NR method

Problem statement:

The 3 bus system is given below. The line parameters are given in table A and generator data are given in table B. Line impedances are marked in pu and line charging susceptances are neglected. Taking bus no.1 as a reference bus obtain the load flow analysis.

Table A:

Bus code	Impedance in pu
1-2	0.08+0.24j
1-3	0.02+0.06j
2-3	0.06+0.18j

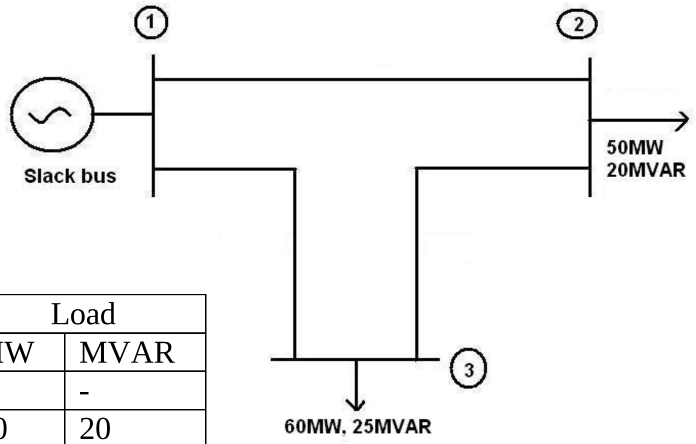


Table B:

Bus no	Bus voltage	Generation		Load	
		MW	MVAR	MW	MVAR
1	1.05+0j	-	-	-	-
2	-	-	-	50	20
3	-	-	-	60	25

Appartus required: Mipower software

Theory: Refer the modern power system analysis by D P Kothari & I J Nagarth & mipower software manual.

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on mipower icon in the desktop.
- Creat the database with .mdb extension.
- Draw the one line diagram.
- Save and simulate.
- Note the results.

Calculations:

Simulation Results:

Bus voltages and power

Bus	Voltage (pu)	angle	Generation		Load	
			MW	MVAR	MW	MVAR
1						
2						
3						

Jacobian Matrix

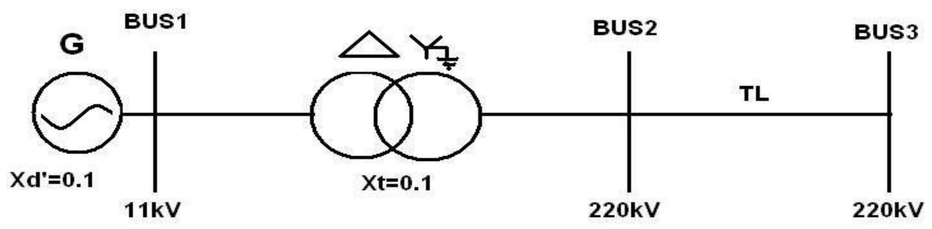
8. Fault analysis

Aim:

To determine the fault current and voltage in a single tranmssion line system for the following Y-Δ transformer at specified location for LG, LLG faults.

Problem statement:

For the given circuit find the fault current, voltage for the following type of the faults at bus-3
i)LG fault
ii)LLG fault
for the tranmission line assume X_1=X_2=0.4 and X_0=2.5X_L



Appartus required: Mipower software

Theory: Refer the modern power system analysis by D P Kothari & I J Nagarth & mipower software manual.

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on mipower icon in the desktop.
- Creat the database.
- Draw the one line diagram.
- Save and Solve-by clicking on Short Cicuit Analysis.
- Note the results.

Calculations:

Simulation Results:

SLGF(LG)	Voltage (mag)	angle	Phase (mag)	angle
At Bus 3				

DLGF(LLG)	Voltage (mag)	angle	Phase (mag)	angle
At Bus 3				

9. Optimal Generator Scheduling(Economic Dispatch)

Aim:

To determine economical operation for a given load demand, cost equation and loss co-efficient of different unit of a plant.

Problem statement:

The cost equations and loss co-efficients of different units in the plant are given. Determine economic generation for total load demand of 240MW.

Unit no.	Cost of fuel input in Rs/hr	Generation
1	$C_1=0.05P_1^2+20P_1+800$	$0 \le P_1 \le 100$
2	$C_2=0.065P_2^2+150P_2+1000$	$0 \le P_2 \le 100$
3	$C_1=0.07P_3^2+18P_3+900$	$0 \le P_3 \le 100$

Loss co-efficients are given below.

$B_{11}=0.0005$	$B_{21}=0.0005$	$B_{31}=0.0002$
$B_{12}=0.0005$	$B_{22}=0.0004$	$B_{32}=0.00018$
$B_{13}=0.0002$	$B_{23}=0.00018$	$B_{33}=0.0005$

Appartus required: Mipower software

Theory: Refer the modern power system analysis by D P Kothari & I J Nagarth & mipower software manual.

Procedure:

- Do the hand calculations and solve the problem.
- Note down the theoretical results.
- Double click on mipower icon in the desktop.
- In Tools Chose Economic dispatch by B Coefficients.
- Create a new file with .bci extension.
- Enter the details.
- Save and Execute.
- Note the results.

Calculations:

Simulation Results:

Initial total generation cost ________________________ Rs

Final cost of generation at generator 1=_______________________________MW

Final cost of generation at generator 2=__________________________________MW

Final cost of generation at generator 3=_________________________________MW

Final total generation cost is Rs ____