# POWER SYSTEM COMPUTER AIDED DESIGN LABORATORY

## LAB MANUAL

| | | |
|---|---|---|
| Subject Code | : | AEE113 |
| Regulations | : | R-16 |
| Class | : | VII Semester |


# INSTITUTE OF AERONAUTICAL ENGINEERING

**(Autonomous)**

**Dundigal – 500 043, Hyderabad**

## Department of Electrical And Electronics Engineering

# INSTITUTE OF AERONAUTICAL ENGINEERING

**(Autonomous)**

**Dundigal, Hyderabad - 500 043**

**ELECTRICAL AND ELECTRONICS ENGINEERING**

| Program Outcomes | |
|---|---|
| **PO1** | **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. |
| **PO2** | **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences |
| **PO3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| **PO4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| **PO6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO7** | **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| **PO10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO11** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |
| **PO12** | **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **Program Specific Outcomes** | |
| **PSO1** | **Professional Skills:** Able to utilize the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work. |

| | |
|---|---|
| **PSO2** | **Problem - Solving Skills:** To explore the scientific theories, ideas, methodologies and the new cutting edge technologies in renewable energy engineering, and use this erudition in their professional development and gain sufficient competence to solve the current and future energy problems universally. |
| **PSO3** | **Successful Career and Entrepreneurship:** To be able to utilize of technologies like PLC, PMC, process controllers, transducers and HMI and design, install, test, and maintain power systems and industrial applications. |

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## ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

| Exp. No. | Experiment | Program Outcomes Attained | Program Specific Outcomes Attained |
|---|---|---|---|
| 1 | Formation of bus admittance and impedance matrices | PO1, PO5 | PSO2 |
| 2 | Load flow solution using Gauss Seidel method | PO1, PO2, PO5 | PSO2 |
| 3 | Load flow solution using Newton Raphson and FDLF method | PO1, PO2, PO5 | PSO2 |
| 4 | Power system fault analysis | PO4, PO5 | PSO2 |
| 5 | Point by point method | PO1, PO2, PO5 | PSO2 |
| 6 | Transient response of RLC circuit | PO1, PO2, PO5 | PSO2 |
| 7 | Three phase short circuit analysis in a synchronous machine | PO2, PO3, PO5 | PSO2 |
| 8 | Study of transmission system and short circuit analysis of 9 bus system | PO2, PO3, PO5 | PSO2 |
| 9 | Transformer inrush current | PO2, PO3, PO5 | PSO2 |
| 10 | Small signal stability analysis | PO2, PO3, PO4, PO5 | PSO2 |
| 11 | Transmission line parameters | PO2, PO3, PO4, PO5 | PSO2 |
| 12 | Load frequency control | PO3, PO4, PO5 | PSO2 |
| 13 | Power quality | PO3, PO4 | PSO2 |
| 14 | Distance protection | PO1, PO3, PO4 | PSO2 |

# POWER SYSTEM COMPUTER AIDED DESIGN LABORATORY

## OBJECTIVE:

The objective of the electrical circuits and virtual instrumentation laboratory is to expose the students to apply different techniques used in circuit analysis to calculate circuit parameters and two port network parameters, applications of Fourier transforms in electric circuits and design filters and analyze through digital simulation. It also aims to introduce MATLAB, PSCAD a circuit simulation software tools. It enables the students to gain sufficient knowledge on the programming and simulation of Electrical circuits.

## OUTCOMES:

Upon the completion of electrical circuits and virtual instrumentation laboratory practical course, the student will be able to attain the following:

1. Familiarity with AC circuit analysis techniques.
2. Analyze complicated circuits using different network functions or two port parameters.
3. Acquire skills of using MATLAB, PSCAD software for electrical circuit studies.

## EXPERIMENT – 1 (A)

## FORMATION OF BUS ADMITTANCE AND IMPEDANCE MATRICES

### 1.1 AIM:

Formation of bus admittance matrices by adding one element at a time using MATLAB.

### 1.2 APPARATUS:

| S. No | Software Used | Desk Top Quantity |
|---|---|---|
| 1 | MATLAB | 36 |

### 1.3 CIRCUIT DIAGRAM:

**ALGORITHM:**

STEP1: Read all the data namely R and X for the system.
STEP2: Calculate the mutual or transfer reactance for the reactance between i and j and i=j= 1, 2, 3,4
STEP3: Calculate the self- admittance or point admittance bus i=1, 2, 3, 4…
STEP4: Output the Y-bus matrix.
STEP5: Print the result

### 1.4 PROBLEMS:

Form the Ybus matrix for the given power system. Write and execute a MATLAB program and also verify the output with the manual calculation results.

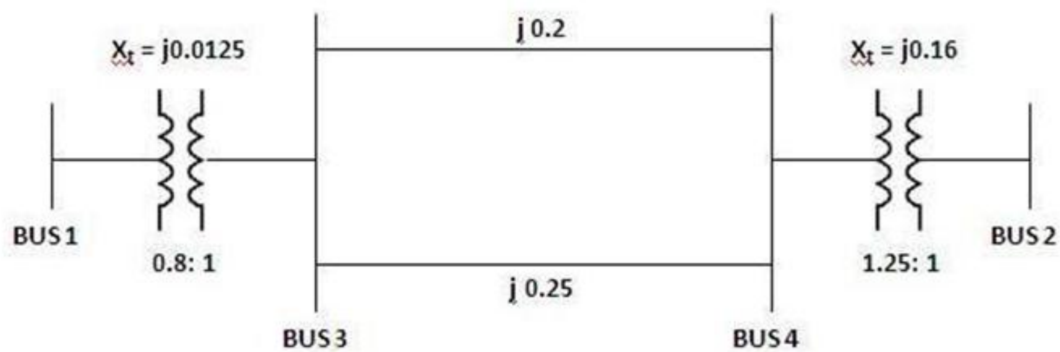


Fig: 1 Bus system

### 1.5 PROGRAM:

```
clear all; clc;
n= input('Enter the number of buses');
fprintf('Enter your choice');
p= input ('1. impedance, 2. admittance');
```

```
 if (p==1)
for q= 1:n
for r=q+1:n
fprintf('Enter the impedance value between %d-%d',q,r);
z(q,r)=input(':');
if (z(q,r)==0)
y(q,r)=0;
 else
y(q,r)=inv(z(q,r));
end
y(r,q)= y(q,r);
fprintf('enter the half line charging admittance');
 x(q,r)= input(':');
x(r,q)=x(q,r);
end
end
elseif (p==2)
for a= 1:n
for b=a+1:n
fprintf('Enter the admittance value between %d-%d',a,b);
y(a,b)=input(':');
y(b,a)= y(a,b);
fprintf('enter the half line charging admittance');
x(a,b)= input(':');
x(b,a)=x(a,b); end
end else
fprintf('enter the correct choice');
end
tr=zeros(n,n);
fprintf('Off-Nominal Tap ratio exists in the system? Enter 1.Yes 2.No');
o= input(':');
if(o==1)
for k=1:n
for l=k+1:n
fprintf('Transformer tap for %d-%d exists? 1.Yes 2.No',k,l)
 g=input(':');
if(g==1)
fprintf('Enter the choice 1.1:a 2.a:1     ?') d=input(':');
fprintf('Enter the tap ratio value(a) between %d-%d',k,l);
t(k,l)=input(':');
```

```
if (t(k,l)==0)
tr(k,k)=0;
tr(k,l)=0;
 else
yse=y(k,l)/t(k,l);
ysh1=((1-t(k,l))/(t(k,l)^2))*y(k,l);
ysh2=((t(k,l)-1)/t(k,l))*y(k,l);
end
if (d == 1) tr(k,k)=yse+ysh2;
tr(l,l)=yse+ysh1;
 tr(k,l)=yse;
tr(l,k)=tr(k,l);
else tr(k,k)=yse+ysh1;
tr(l,l)=yse+ysh2;
tr(k,l)=yse;
 tr(l,k)=tr(k,l);
end
y(k,l)=0; y(l,k)=y(k,l); end
end end end
for s=1:n
fprintf('enter the self admittance of the bus %d',s);
u(s)=input(':');
end ybus=zeros(n,n);
 for a = 1:n
for b=1:n if (a==b)
for c = 1:n
ybus(a,a)= ybus(a,a)+ y(a,c)+x(a,c);
end
else
ybus(a,b)=-y(b,a);
end
end ybus(a,a)=ybus(a,a)+u(a);
end
for r=1:n for h = 1:n if(r==h)
ybus(r,r)=ybus(r,r)+tr(r,r);
else
ybus(r,h)=-(y(r,h)+tr(r,h));
end
end
end
```

```
ybus
```

## 1.6 RESULT:

## 1.7 PRE LAB VIVA QUESTIONS:

1. What are the elements of Y bus matrix?
2. What is Y bus in power system?
3. What is singular transformation method?

## 1.8 POST LAB VIVA QUESTIONS:

1. What is load flow solution?
2. What is generator bus?
3. Why load flow analysis is done?

# FORMATION OF BUS IMPEDANCE MATRICES – 1 (B)

## 1.1 AIM:

To form the bus impedance matrix ($Z_{bus}$) for a given power system using MATLAB program.

## 1.2 ALGORITHM:

It in the step by step programmable technique which place's branch by branch. It is the advantage that modification of the network does not require complete rebuilding of Z bus.

STEP1: Start the new document, give a impedance value
STEP2: Choose the type of bus in a network

1. Start the new network.
2. Adding a new bus to reference bus
3. Adding a new bus to already existing bus
4. Adding a new element between already existing bus and reference bus
5. Adding a element between two existing bus

STEP3: Build the Z bus for the given network & print the Z bus matrix

## 1.3 PROBLEM:

Form the $Z_{bus}$ matrix for the given power system. Write and execute a MATLAB program and also verify the output with the manual calculation results.

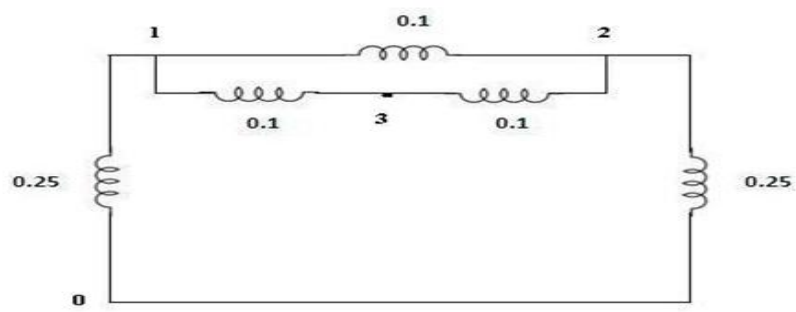


Fig – 1(B). Power System

## 1.4 PROGRAM:

```
clc;

clear all;

e = input('enter the no of elements:');
disp('1.Btwn a new node and reference');
disp('2.Btwn a new node and existing node');
disp('3.Btwn an existing node and reference');
disp('4.Btwn two existing nodes');
zb=complex(0,0);
```

```
zt=complex(0,0);
for i=1:e if(i==1)

a=0;

else
[a,c]=size(zb);
end

b=a+1;

disp(['elements no:',num2str(i)]);
ty(i)=input('enter the type of element:');
z(i)=input('enter the impedance value:');
s(i)=input('enter the starting node:');
t(i)=input('enter the ending node:');
if(ty(i)==1)

zb(b,b)=z(i);
for j=1:a
zb(j,b)=0;

zb(b,j)=0;
end disp(zb);

elseif(ty(i)==2)

zb(b,b)=z(i)+zb(t(i),t(i));

for j=1:a

zb(b,j)=zb(t(i),j);

zb(j,b)=zb(j,t(i));
end

disp(zb);
elseif(ty(i)==3)

zb(b,b)=z(i)+zb(s(i),s(i));
for j=1:a zb(b,j)=zb(s(i),j);

zb(j,b)=zb(j,s(i));
end

w=zb(b,b);
for j=1:a for
k=1:a

zt(j,k)=complex(0,0); zt(j,k)=zb(j,k)-
(zb(j,b)*zb(b,k))/w; end

end zb=zt;
disp(zb);

elseif(ty(i)==4)
```

```
zb(b,b)=z(i)+zb(s(i),s(i))+zb(t(i),t(i))-2*zb(s(i),t(i));
for j=1:a

zb(j,b)=zb(j,s(i))-zb(j,t(i));

zb(b,j)=zb(s(i),j)-zb(t(i),j);
end

w=zb(b,b);
for j=1:a for
k=1:a

zt(j,k)=complex(0,0); zt(j,k)=zb(j,k)-
(zb(j,b)*zb(b,k))/w; end

end
zb=zt;
else

disp('wrong data');
end

end

disp('bus impedance matrix');
disp(zb);
```

## 1.10 RESULT:

Thus, the formation of bus impedance matrix is done by using MATLAB and the output is verified for the given power system.

## 1.11 PRE LAB VIVA QUESTIONS:

1. What is a primitive network?
2. What is load bus?
3. What are the methods of load flow analysis?

## 1.12 POST LAB VIVA QUESTIONS:

1. How a load flow study is performed?
2. What is bus architecture?
3. What are the 3 types of buses in power system?

## EXPERIMENT – 2

## LOAD FLOW SOLUTION USING GAUSS SEIDEL METHOD

### 2.1 AIM:

To find load flow studies without and with generator buses using Gauss Seidel Method.

### 2.2 APPARATUS:

| S. No | SOFTWARE USED | DESK TOP QUANTITY |
|---|---|---|
| 1 | MATLAB | 36 |

### 2.3 ALGORITHM:

STEP1: The slack bus voltage magnitude and angle are measured usually V1 =1 p.u. with the load profile known at each bus, we allocate Pi and Qi to all generating Stations with this step, bus injections (Pi+Qi) are known at all buses other than the slack bus.

STEP2: Assembly of bus admittance matrix: with the line and shunt admittance data stored in the computer. Y bus is assembled by using the algorithm developed earlier. Alternatively bus is assembled using Y bus= ATYA where the input is in the form of primitive admittance matrix Y and singular connection bus incidence matrix A.

STEP3: Iterative computation of bus voltages (Vi, i=1,2….n) to start iteration a set of initial values is assumed, since in a power system the voltage spread is not too wide, it is normal practice to use a flat voltage start, i.e. initially all voltages are set equal to (1+j0) expect slack bus voltage which is fixed . this reduced the n equations in complex number which are to solved iteratively for finding complex voltages V2,V3,...Vn. If complex no options are not available in a computer, the equation is real unknown js

Vi=ei +jfi= Vi ΣjΣl, We also define,
Ai=Pi-jQi/Yii=2,……..n Bik=Yik I=2,…….k#i

Now for (r+1) the iteration the voltage becomes, Vi(r+1) =[Ai /(Vir) * -Σi-1 (Bik

Vk(r+1) -Σbik Vk r]

The iterative process is continued till the change in magnitude of bus voltage |ΔVi(r+1)

Between two consecutive is less than a certain for all bus voltages i.e.,

|ΔVi (r+1)= | Vi(r+1)-Vi (r)| ≤εi=2……….,n Also we see if

|ΔVi | min ≤ | ΔVi|max I=2 ………….n
If not, we fix |ΔVi |at one of extreme values i.e.

|Δ Vi |min if |Δ Vi | ≤ |Δ Vi |min or |Δ Vi |max if |Δ Vi | ≤ |Δ Vi |

STEP4: Computation of slack bus power; substitution of all bus voltages computed in step3 with Vi and I=1 yield real and reactive power at slack bus i.e, S1=P1+jQ1

STEP5: Computation of line flows; this is the last step in the load flow analysis where in the power flows on the various lines of the network are computed. This also enables us to check whether any line overloaded. Consider the line connecting buses I and k. The line and transformer at each end can be represented by a circuit with series admittance Yik and to shunt admittances Yiko. As the current fed by bus Iin to the line can be expressed as

Iik = Iik1+Iik0= (Vi-Vk)Yik+ Viyik0.

## 2.4 PROBLEM:

Figure shows the one-line diagram of a three-bus power system with generation at bus1. The magnitude of voltage at bus1 is adjusted to **1.05** per unit. The scheduled loads at buses 2 & 3 are as marked on the diagram. Line impedances are marked in per unit on a **100MVA** base and the line charging susceptances are neglected.

i). Using Gauss-Seidal method, determine the phasor values of the voltage at the load buses 2 & 3 (PQ buses) accurate to 4 decimal places.

ii). Write and execute a MATLAB program and also verify the output with the manual calculation results.

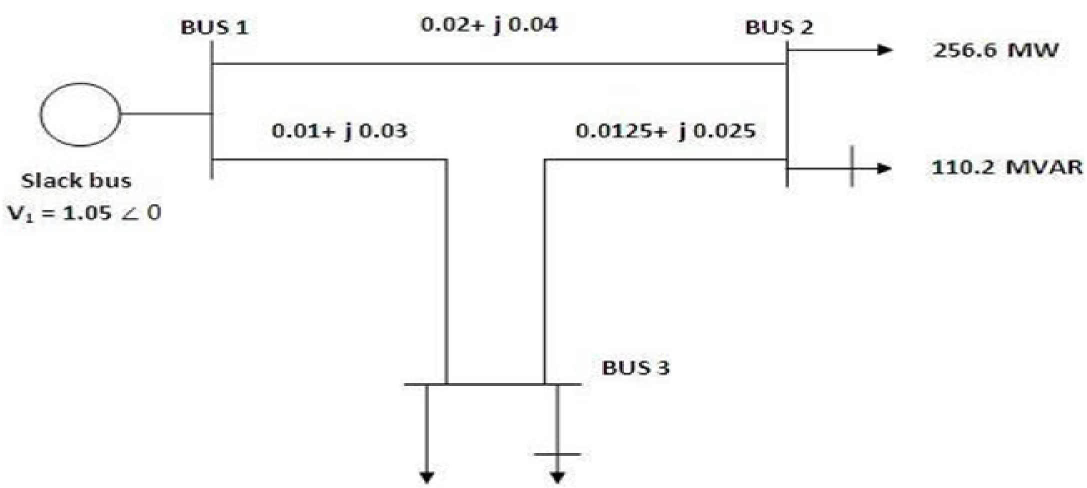


**Fig. 3.1 Bus system**

## 2.5 PROGRAM:

```
%----- FORMATION OF YBUS -----%

clear all; clc;

n= input('Enter the number of buses '); fprintf('Enter your

choice');
```

```
p= input ('1. impedance, 2. admittance'); if (p==1)
for q= 1:n for
r=q+1:n
fprintf('Enter the impedance value between %d-%d',q,r); z(q,r)=input(':');
if (z(q,r)==0)
y(q,r)=0; else
y(q,r)=inv(z(q,r)); end
y(r,q)= y(q,r);

end end
elseif (p==2) for a=
1:n for b=a+1:n
fprintf('Enter the admittance value between %d-%d',a,b); y(a,b)=input(':');
y(b,a)= y(a,b); end
end else
fprintf('enter the correct choice'); end
ybus=zeros(n,n); for a =
1:n
for b=1:n if (a==b)
for c = 1:n
ybus(a,a)= ybus(a,a)+ y(a,c); end
else
ybus(a,b)=-y(b,a); end
end end
ybus
%----- BUSDATA -----%
busdata =input(' Bus number | 1.Slack 2.PQ 3.PV | V| angle|Pg | Qg | PL
| QL      | Qmin | Qmax '); bus =
busdata(:,1); type = busdata(:,2);
V = busdata(:,3);
th = busdata(:,4); GenMW =
busdata(:,5); GenMVAR =
busdata(:,6); LoadMW =
busdata(:,7);
```

```
LoadMVAR = busdata(:,8); Qmin =
busdata(:,9); Qmax = busdata(:,10);
nbus = max(bus);
P = GenMW - LoadMW;
Q = GenMVAR - LoadMVAR;
Vprev = V; toler
= 1;
iteration = 1;
disp(' Bus number | 1.Slack 2.PQ 3.PV | V| angle|Pg | Qg | PL | QL | Qmin | Qmax ');
busdata ybus

%----- VOLTAGE CALCULATION -----%
while (toler> 0.00001) for i =
2:nbus
sumyv = 0;
for k = 1:nbus if i ~= k
sumyv = sumyv + ybus(i,k)* V(k); end
end
if type(i) == 2
Q(i) = -imag(conj(V(i))*(sumyv + ybus(i,i)*V(i)));
if (Q(i) >Qmax(i)) || (Q(i) <Qmin(i)) if Q(i) <Qmin(i)
Q(i) = Qmin(i); else
Q(i) = Qmax(i); end
type(i) = 3; end
end
V(i) = (1/ybus(i,i))*((P(i)-j*Q(i))/conj(V(i)) - sumyv); if type(i) == 2
V(i) = pol2rect(abs(Vprev(i)), angle(V(i))); end
end
iteration = iteration + 1;
toler = max(abs(abs(V) - abs(Vprev))); Vprev = V;
end iteration V
Vmag = abs(V)
Ang = 180/pi*angle(V) sum=0;

%----- REAL AND REACTIVE POWER CALCULATION -----%
for i=1:nbus if i==1
```

```
for f=1:nbus sum=sum+(ybus(i,f)*V(f));
real_power(i)=(real(V(i)*sum))*100;
reactive_power(i)=-(imag(V(i)*sum))*100; end
else end
end
real_power reactive_power
```

## 2.6 RESULT:

## 2.7 PRE LAB VIVA QUESTIONS:

1. What is meant by Gauss Seidel method?
2. Why we use Gauss Seidel method?
3. Why power flow analysis is made?

## 2.8 POST LAB VIVA QUESTIONS:

1. Does Gauss Seidel always converge?
2. What is Gauss elimination method in Matrix?
3. What is the method of Gauss?

# EXPERIMENT – 3

## LOAD FLOW SOLUTION USING NEWTON RAPHSON AND FDLF METHOD

### 3.1 AIM:

To develop in MATLAB to find load flow studies using Newton Raphson and fast Decoupled load Flow (FDLF) method.

### 3.2 APPARATUS:

| S. No | SOFTWARE USED | DESK TOP QUANTITY |
|---|---|---|
| 1 | MATLAB | 36 |

### 3.3 CIRCUIT DIAGRAM:

STEP 1: Assume a flat profile 1+j0 for all buses except the slack bus in the Specified voltage and it is not modified in any iteration.

STEP 2: Assume a suitable value of ε called convergence criterion. Hence ε is A specified change in the residue that is used to compare the actual residue that is used to compare the actual residue at the end of each iteration.

STEP 3: Set the iteration count K=0 and assumed voltage profile of the buses are denoted as $V1^0, V2^0 \ldots\ldots V_n^0$.

STEP 4: Set the bus count p=1

STEP 5: Check for slack bus. If it is a slack bus then go to step 13. Otherwise go to next step.

STEP 6: Calculate the real & reactive power of bus p using the following equation,

$$Ppk=\Sigma^k \; q=1\{ep \; (eq^k Gpq^k+fq^k Bpq^k)+fp \; (fq^k Gpq^k-eq \, Bpq^k)\}$$

$$Qpk=\Sigma^k q=1\{fp \; (eq^k +Gp^k +fq^k Bpq^k)+ep \; (fq^k Gpq^k-eq \, Bpq^k)\}$$

STEP 7: Calculate the change in real power,

$\Delta P^k=Pp \text{ spec} -P_p^k$

Where,

Pp spec=specified real power of bus p.

STEP 8: Check for generator bus. If it is a generator bus gob to next step otherwise go to step 12.

STEP 9: Check for generator bus. If it is a generator reactive power limit Violation of generator buses. For this compare the calculated. Reactive power Q with specified limits. If the limits are violated go to step11. Otherwise go to next step.

STEP 10: If the calculated reactive power is within the soecified limit then consider this bus as generator bus. Now calculate the voltage residue using the equation

$$|VP^K|^2 =|Vp \text{ spec}|^2 -|Vp^k|^2$$

erehW|Vp spec| = specified voltage magnitude for generation bus. Then go to step 13.

STEP 11: If the reactive power limit violated the treat this bus as a load bus. Now the specified reactive power for this bus will correspond to Limit violated

STEP 12: Calculate the change in reactive power for load bus change in reactive power,

$\Delta Q_k = |\Delta Q_p\ spec| - Q_p^k$

STEP 13: Repeat the step 5 to 12 until all residues are calculated for increment the bus count n. by 1 to 5 steps until the bus count is n.

STEP 14: Determine the largest of the absolute value of the residue (i.e.)

Find the largest value among $\Delta P_p^k$, $\Delta Q_p^k$ or $|\Delta V_p^k|^2$

STEP 15: Compare ΔE and E, if ΔE<E then go to step 20. If ΔE>E go to next Step.

STEP 16: Determine the element, the load flow equation using k$^{th}$ iteration Value.

STEP 17: Calculate the increment in real and reactive part of voltage $\Delta e^k$ and $\Delta f_p$ by solving the matrix equation B=JC.

STEP 18: Calculate the new bus voltage.

STEP 19: Advance the iteration count k=k+1 and go to step 4.

STEP 20: Calculate the line flows.

## 3.4 PROBLEMS:

Figure shows the one-line diagram of a three-bus power system with generators at buses 1& 3. The magnitude of voltage at bus1 is adjusted to 1.05 per unit. The magnitude of voltage at bus 3 is fixed at 1.04pu with a real power generation of 200 MW. A load consists of 400 MW and 250 MVAR is taken from bus2. Line impedances are marked in per unit on a 100MVA base and the line charging susceptances are neglected.

i). Obtain the load flow solution by Newton-Raphson method.

ii). Write and execute a MATLAB program and also verify the output with the manual calculation results.

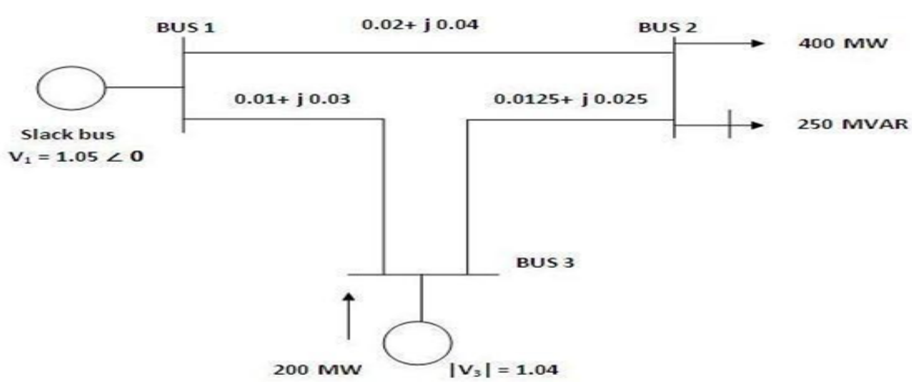


**Fig: 3.1 Bus system**

### 3.5 PROGRAM:

```
clear all; clc;
v=[1.05;1.0;1.04]; d=[0;0;0];
ps=[-4;2.0]; qs=-2.5;
n= input('Enter the number of buses '); fprintf('Enter your
choice');
p= input ('1. impedance, 2. admittance'); if (p==1)
for q= 1:n
for r=q+1:n
fprintf('Enter the impedance value between %d-%d',q,r); z(q,r)=input(':');
if (z(q,r)==0)
y(q,r)=0; else
y(q,r)=inv(z(q,r)); end
y(r,q)= y(q,r); end
end
elseif (p==2) for a=
1:n for b=a+1:n
fprintf('Enter the admittance value between %d-%d',a,b); y(a,b)=input(':');
y(b,a)= y(a,b); end
end else
fprintf('enter the correct choice'); end
ybus=zeros(n,n); for a =
1:n
for b=1:n if (a==b)
for c = 1:n
ybus(a,a)= ybus(a,a)+ y(a,c); end
else
ybus(a,b)=-y(b,a); end
end end
ybus
y=abs(ybus); t=angle(ybus); iter=0;
pwracur=0.00025;% Power accuracy
dc=10;% Set the maximum power residual to a high value while
max(abs(dc))>pwracur
iter=iter+1 p=[v(2)*v(1)*y(2,1)*cos(t(2,1)-
```

```
d(2)+d(1))+v(2)^2*y(2,2)*cos(t(2,2))+v(2)*v(3)*y(2,3)*cos(t(2,3)- d(2)+d(3));
v(3)*v(1)*y(3,1)*cos(t(3,1)-
d(3)+d(1))+v(3)^2*y(3,3)*cos(t(3,3))+v(3)*v(2)*y(3,2)*cos(t(3,2)- d(3)+d(2))];
q=-v(2)*v(1)*y(2,1)*sin(t(2,1)-d(2)+d(1))-v(2)^2*y(2,2)*sin(t(2,2))-
v(2)*v(3)*y(2,3)*sin(t(2,3)-d(2)+d(3));
j(1,1)=v(2)*v(1)*y(2,1)*sin(t(2,1)- d(2)+d(1))+v(2)*v(3)*y(2,3)*sin(t(2,3)-d(2)+d(3));
j(1,2)=-v(2)*v(3)*y(2,3)*sin(t(2,3)-d(2)+d(3)); j(1,3)=v(1)*y(2,1)*cos(t(2,1)-
d(2)+d(1))+2*v(2)*y(2,2)*cos(t(2,2))+v(3)*y(2,3)*cos(t(2,3)-d(2)+d(3));
j(2,1)=-v(3)*v(2)*y(3,2)*sin(t(3,2)-d(3)+d(2));
j(2,2)=v(3)*v(1)*y(3,1)*sin(t(3,2)-
d(3)+d(1))+v(3)*v(2)*y(3,2)*sin(t(3,2)-d(3)+d(2));
j(2,3)=v(3)*y(2,3)*cos(t(3,2)-d(3)+d(2));
j(3,1)=v(2)*v(1)*y(2,1)*cos(t(2,1)-
d(2)+d(1))+v(2)*v(3)*y(2,3)*cos(t(2,3)-d(2)+d(3));
j(3,2)=-v(2)*v(3)*y(2,3)*cos(t(3,2)-d(2)+d(3));
j(3,3)=-v(1)*y(2,1)*sin(t(2,1)-d(2)+d(1))-2*v(2)*y(2,2)*sin(t(2,2))- v(3)*y(2,3)*sin(t(2,3)-
d(2)+d(3));
dp=ps-p; dq=qs-
q; dc=[dp;dq] j
dx=j\dc d(2)=d(2)+dx(1);
d(3)=d(3)+dx(2);
v(2)=v(2)+dx(3);
v,d,delta=180/pi*d; end
p1=v(1)^2*y(1,1)*cos(t(1,1))+v(1)*v(2)*y(1,2)*cos(t(1,2)-
d(1)+d(2))+v(1)*v(3)*y(1,3)*cos(t(1,3)-d(1)+d(3));
q1=-v(1)^2*y(1,1)*sin(t(1,1))-v(1)*v(2)*y(1,2)*sin(t(1,2)-d(1)+d(2))-
v(1)*v(3)*y(1,3)*sin(t(1,3)-d(1)+d(3));
q3=-v(3)*v(1)*y(3,1)*sin(t(3,1)-d(3)+d(1))-v(3)*v(2)*y(3,2)*sin(t(3,2)- d(3)+d(2))-
v(3)^2*y(3,3)*sin(t(3,3));

% Fast decoupled method, Voltage Controlled
V1= 1.05; V2 = 1.0; V3 = 1.04;
d1 = 0; d2 = 0; d3=0;
Ps2=-4; Ps3 =2.0;
Qs2= -2.5;
YB = [ 20-j*50 -10+j*20 -10+j*30
```

```
-10+j*20 26-j*52 -16+j*32
-10+j*30 -16+j*32 26-j*62];
Y = abs(YB); t=angle(YB);
B =[-52 32; 32 -62]
Binv = inv(B)
iter=0;
pwracur = 0.0003; % Power accuracy
DC = 10; % Set the max of power mismatch to a high value
while max(abs(DC)) > pwracur
iter = iter +1;
P2= V2*V1*Y(2,1)*cos(t(2,1)-d2+d1)+V2^2*Y(2,2)*cos(t(2,2))+ ...
V2*V3*Y(2,3)*cos(t(2,3)-d2+d3);
P3= V3*V1*Y(3,1)*cos(t(3,1)-d3+d1)+V3^2*Y(3,3)*cos(t(3,3))+ ...
V3*V2*Y(3,2)*cos(t(3,2)-d3+d2);
Q2=-V2*V1*Y(2,1)*sin(t(2,1)-d2+d1)-V2^2*Y(2,2)*sin(t(2,2))- ...
V2*V3*Y(2,3)*sin(t(2,3)-d2+d3);
DP2 = Ps2 - P2; DP2V = DP2/V2;
DP3 = Ps3 - P3; DP3V = DP3/V3;
DQ2 = Qs2 - Q2; DQ2V = DQ2/V2;
DC =[DP2; DP3; DQ2];
Dd = -Binv*[DP2V;DP3V];
DV = -1/B(1,1)*DQ2V;
d2 =d2+Dd(1);
d3 =d3+Dd(2);
V2= V2+DV;
angle2 =180/pi*d2;
angle3 =180/pi*d3;
R = [iter d2 d3 V2 DP2 DP3 DQ2];
disp(R)
end
Q3=-V3*V1*Y(3,1)*sin(t(3,1)-d3+d1)-V3^2*Y(3,3)*sin(t(3,3))- ...
V3*V2*Y(3,2)*sin(t(3,2)-d3+d2);
P1= V1^2*Y(1,1)*cos(t(1,1))+V1*V2*Y(1,2)*cos(t(1,2)-d1+d2)+ ...
V1*V3*Y(1,3)*cos(t(1,3)-d1+d3);
Q1=-V1^2*Y(1,1)*sin(t(1,1))-V1*V2*Y(1,2)*sin(t(1,2)-d1+d2)- ...
V1*V3*Y(1,3)*sin(t(1,3)-d1+d3);
```

S1=P1+j*Q1

Q3

## 3.6 RESULT:

## 3.7 PRE LAB VIVA QUESTIONS:

1. What is meant by newton raphson method?
2. What is Y bus in power system?
3. What is meant by FDLF method?

## 3.8 POST LAB VIVA QUESTIONS:

1. What is Newton Raphson method in power system?
2. What is generator bus?
3. What is fast decoupled flow method?

## EXPERIMENT – 4

## POWER SYSTEM FAULT ANALYSIS

### 4.1 AIM:

To Analysis of symmetrical and unsymmetrical faults using symmetrical components using MATLAB.

### 4.2 APPARATUS:

| S. No | SOFTWARE USED | DESKTOP QUANTITY |
|---|---|---|
| 1 | MATLAB | 36 |

### 4.3 PROGRAM:

```
V012 = [0.6 90
1.0 30
0.8 -30];
rankV012=length(V012(1,:));
if rankV012 == 2
mag= V012(:,1); ang=pi/180*V012(:,2);
V012r=mag.*(cos(ang)+j*sin(ang));
elseif rankV012 ==1
V012r=V012;
Else

fprintf('\n Symmetrical components must be expressed in a one column array in rectangular complex
form \n')
fprintf(' or in a two column array in polar form, with 1st column magnitude & 2nd column \n')
fprintf(' phase angle in degree. \n')
return, end
a=cos(2*pi/3)+j*sin(2*pi/3);
A = [1 1 1; 1 a^2 a; 1 a a^2];
Vabc= A*V012r
Vabcp= [abs(Vabc) 180/pi*angle(Vabc)];
fprintf(' \n Unbalanced phasors \n')
fprintf(' Magnitude Angle Deg.\n')
disp(Vabcp)
Vabc0=V012r(1)*[1; 1; 1];
Vabc1=V012r(2)*[1; a^2; a];
```

```
Vabc2=V012r(3)*[1; a; a^2];
```

## 4.4 PROCEDURE:

1. Open Matlab--> File ---> New---> Script
2. Write the program
3. Enter F5 to run the program
4. Observe the results in MATLAB command window.

## 4.5 RESULT:

## 4.6 PRE LAB VIVA QUESTIONS:

1. What are the causes of electrical faults?
2. What is unsymmetrical fault?
3. Why is fault current asymmetrical in nature?

## 4.7 POST LAB VIVA QUESTIONS:

1. What are the different faults?
2. How can we prevent electrical faults?
3. What is difference between symmetrical and unsymmetrical fault?

## EXPERIMENT – 4 (B)

## UNBALANCED VOLTAGES FROM SYMMETRICAL COMPONENTS

### 4.1 AIM:

To Analysis of symmetrical and unsymmetrical faults using symmetrical components using MATLAB.

### 4.2 APPARATUS:

| S. No | SOFTWARE USED | DESKTOP QUANTITY |
|---|---|---|
| 1 | MATLAB | 36 |

### 4.3 PROGRAM:

```
Iabc = [1.6 25
1.0 180
0.9 132];
rankIabc=length(Iabc(1,:));
if rankIabc == 2
mag= Iabc(:,1); ang=pi/180*Iabc(:,2);
Iabcr=mag.*(cos(ang)+j*sin(ang));
elseif rankIabc ==1
Iabcr=Iabc;
else
fprintf('\n Three phasors must be expressed in a one column array in rectangular complex form \n')
fprintf(' or in a two column array in polar form, with 1st column magnitude & 2nd column \n')
fprintf(' phase angle in degree. \n')
return, end

a=cos(2*pi/3)+j*sin(2*pi/3);
A = [1 1 1; 1 a^2 a; 1 a a^2];
I012=inv(A)*Iabcr;
symcomp= I012
I012p = [abs(I012) 180/pi*angle(I012)];
fprintf(' \n Symmetrical components \n')
fprintf(' Magnitude Angle Deg.\n')
disp(I012p)
Iabc0=I012(1)*[1; 1; 1];
Iabc1=I012(2)*[1; a^2; a];
```

```
Iabc2=I012(3)*[1; a; a^2];
```

## 4.4 RESULT:

## 4.5 PRE LAB VIVA QUESTIONS:

1. What are the causes of electrical faults?
2. What is unsymmetrical fault?
3. Why is fault current asymmetrical in nature?

## 4.6 POST LAB VIVA QUESTIONS:

1. What are the different faults?
2. How can we prevent electrical faults?
3. What is difference between symmetrical and unsymmetrical fault?

# EXPERIMENT – 5

# POINT BY POINT METHOD

## 5.1 AIM:

Development of MATLAB program for Transient stability analysis of single machine infinite bus and multi machine system by point by point method.

## 5.2 APPARATUS:

| S. No | Software Used | Quantity |
|---|---|---|
| 1 | MATLAB | 01 |

## 5.3 PROGRAM:

A 20 MVA, 50Hz generator delivers 18MW over a double circuit line to an infinite bus. The generator has KE of 2.52MJ/MVA at rated speed. The generator transient reactance is Xd=0.35p.u. Each transmission circuit has R=0 and a reactance of 0.2pu on 20 MVA Base. |E|=1.1 p.u and infinite bus voltage V=1.0. A three phase short circuit occurs at the midpoint of one of the transmission lines. Plot swing curves with fault cleared by simultaneous opening of breakers at both ends of the line at 6.25 cycles after the occurrence of fault. Also plot the swing curve over the period of 0.5 s if the fault sustained. Solve the swing equation by point-by point method theoretically and verify using MATLAB Program. Comment on system stability.

## 5.4 MATLAB PROGRAM:

**PROGRAM - 1:**

Save this part in another m-file with name swing.m

```
%Defining the function swing

function[time ang]=swing(tc)

k=0;v=1;E=1.1;pm=0.9;T=0.5;delT=0.05;ddelta=0;time(1)=0;ang(1)=21.64;xdf=1

.25;xaf=0.55;t=0;

delta=21.64*pi/180;i=2;

m=2.52/(180*50);

while t<T
if t<tc

x=xdf;

else x=xaf;
```

```
end
pmax=(E*v)/x;
pa=pm-pmax*sin(delta);
ddelta=ddelta+(delT^2*(pa/m));
delta=(delta*180/pi+ddelta)*(pi/180);
deltadeg=delta*180/pi;
t=t+delT;
time(i)=t;
ang(i)=deltadeg;
i=i+1;
end
end
```

**PROGRAM - 2:**

Main program that is dependent on swing.m

```
%solution of Swing equation by point-by-point method
clc
clear all
close all
for i=1:2
tc=input('enter the value of clearing time:\n');
[time,ang]=swing(tc)
t(:,1)=time;
a(:,i)=ang;
end
plot(t,a(:,1),'*-',t,a(:,2),'d-')
axis([0 0.5 0 inf])
t,a
```

**Inputs to main program:**

Enter the value of clearing time as

0.25 sec, and

5 sec

## 5.5 EXPECTED OUTPUT:

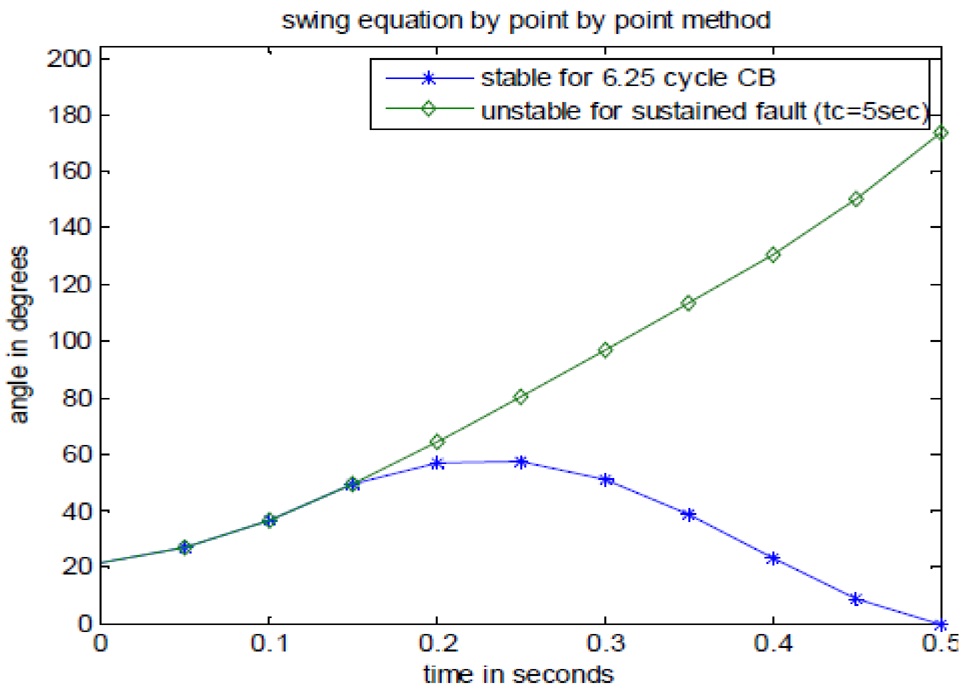


**Fig: 5.1 Swing equation by point by point method**

## 5.6 RESULT:

## 5.7 PRE LAB VIVA QUESTIONS:

1. What are the trasients?
2. what is single machine infinite bus system
3. what is multi machine infinite bus system

## 5.8 POST LAB VIVA QUESTIONS:

1. How is the real power in a power system controlled?
2. What is the need for large mechanical forces in speed-governing system?
3. What is the exciter

## EXPERIMENT - 6

# TRANSIENT RESPONSE OF RLC CIRCUIT

## 6.1 AIM:

Obtain transient response of RLC circuit using PSCAD.

## 6.2 APPARATUS:

| S. No | Software Used | Desktop Quantity |
|---|---|---|
| 1 | PSCAD | 36 |

## 6.3 CIRCUIT DIAGRAMS:

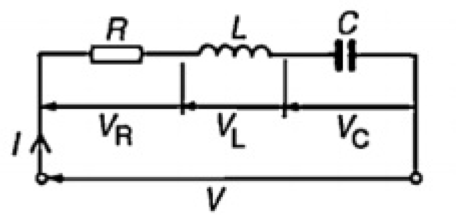


**Fig. 6.1 RLC circuit**

## 6.4 PROCEDURE:

1. Make the connections as shown in the circuit diagram by using PSCAD master library.
2. Measure current in each element.
3. Observe the wave forms

## 6.5 RESULT:

## 6.6 PRE LAB VIVA QUESTIONS:

1. What are transients?
2. What are initial and steady state conditions?
3. Define step signal, unit step signal, step voltage and step current.
4. How do resistor, inductor and capacitor behave when step voltage and step current applied to them?

## 6.7 POST LAB VIVA QUESTIONS:

1. Write any three reasons of transients in any circuit. Define time constant.
2. Determine equation for i(t), vR(t) and vL(t) when an R-L series circuit is switched on to a voltage of V volts.

## EXPERIMENT – 7

## THREE PHASE SHORT CIRCUIT ANALYSIS IN A SYNCHRONOUS MACHINE

### 7.1 AIM:

Analyze symmetrical faults and short circuit studies in a given synchronous machine using PSCAD.

### 7.2 APPARATUS:

| S. No | Software Used | Desktop Quantity |
|---|---|---|
| 1 | PSCAD | 36 |

### 7.3 CIRCUIT DIAGRAMS:

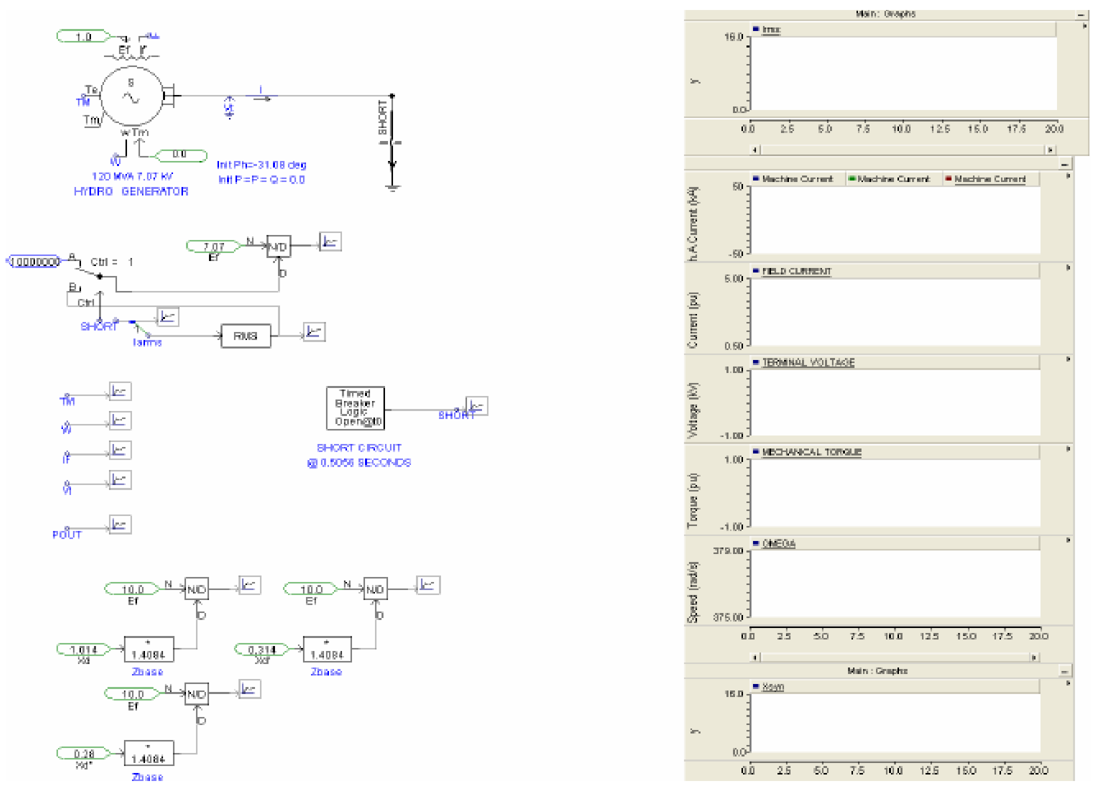


**Fig: 7.1 symmetrical faults**

### 7.4 PROCEDURE:

1. Make the connections as shown in the circuit diagram by using PSCAD master library.
2. Measure readings in each element.
3. Observe the wave forms

## 7.5 RESULT:

## 7.6 PRE LAB VIVA QUESTIONS:

1. In what way synchronous motor is different from other motors?
2. What happens when the field current of a synchronous motor is increased beyond the normal value at constant input?

## 7.7 POST LAB VIVA QUESTIONS:

1. What is the phasor relation between induced emf and terminal voltage of a 3 phase synchronous motor?
2. What are the effects of Negative currents on the rotor (field) winding?
3. Give the equivalent circuits of synchronous machine under the influence of the three sequence currents.

## EXPERIMENT – 8

## STUDY OF TRANSMISSION SYSTEM AND SHORT CIRCUIT ANALYSIS OF 9 BUS SYSTEM

### 8.1 AIM:

Study of simple transmission system and also perform short circuit analysis on IEEE 9 bus system using PSCAD.

### 8.2 APPARATUS:

| S. No | Software Used | Desktop Quantity |
|---|---|---|
| 1 | PSCAD | 36 |

### 8.3 CIRCUIT DIAGRAM:

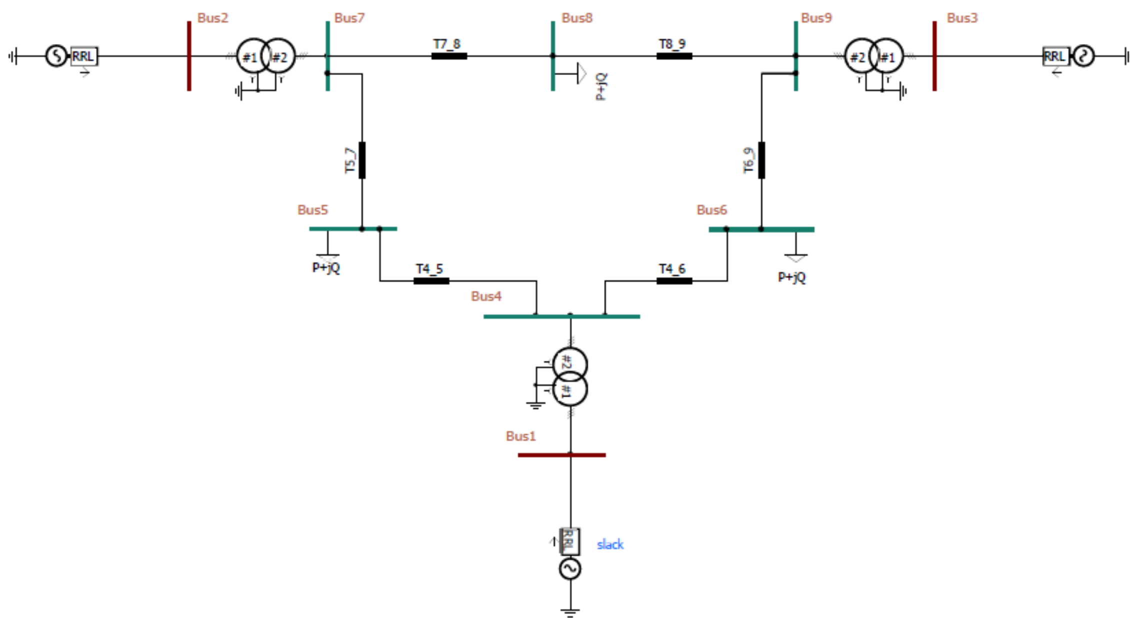


Fig – 8.1 PSACD model of IEEE 9-bus system

### 8.4 PROCEDURE:

1. Make the connections as shown in the circuit diagram by using PSCAD master library.
2. Measure readings in each element.
3. Observe the wave forms

## 8.6 RESULT:

## 8.7 PRE LAB VIVA QUESTIONS:

1. Why, when birds sit on transmission lines or current wires doesn't get shock?
2. What are the different types of transmission lines based on capacity?
3. What is a one line / Single line diagram?

## 8.9 POST LAB VIVA QUESTIONS:

1. What are the major components of a distribution system?
2. When do you call a fault symmetrical and unsymmetrical
3. What is the need for slack bus?

# EXPERIMENT -9

# TRANSFORMER INRUSH CURRENT

## 9.1 AIM:

Determination of transformer inrush current under unbalanced three phase parameters using PSCAD.

## 9.2 APPARATUS:

| S. No | Software Used | Desktop Quantity |
|---|---|---|
| 1 | PSCAD | 36 |

## 9.3 CIRCUIT DIAGRAM:

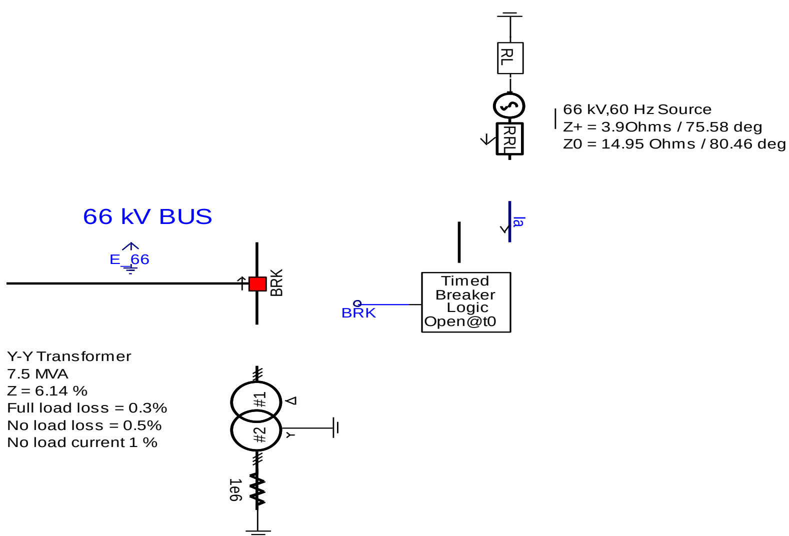


Fig – 9.1 Transformer energizing circuit

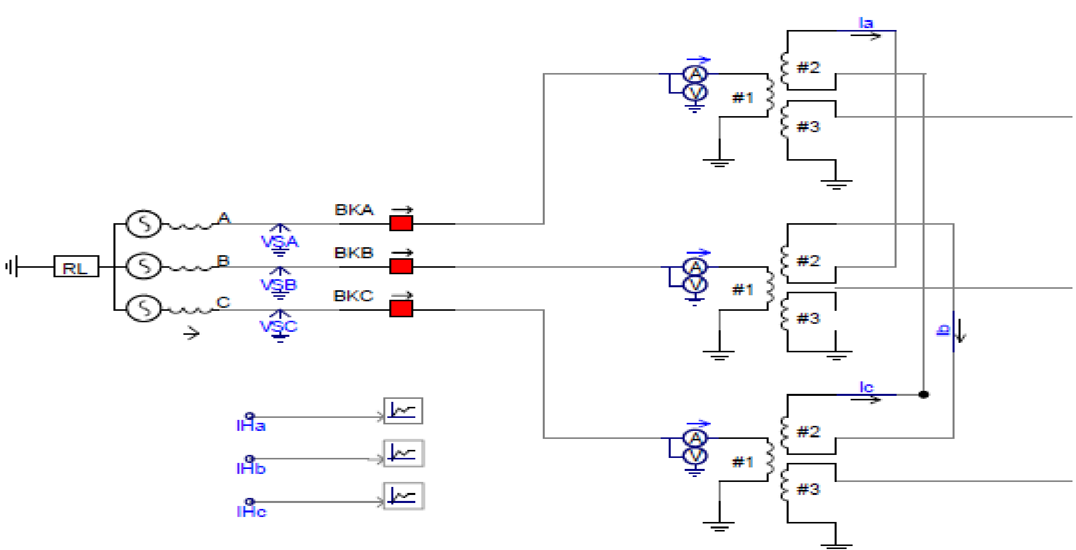


Fig – 9.2 Major Functional Block

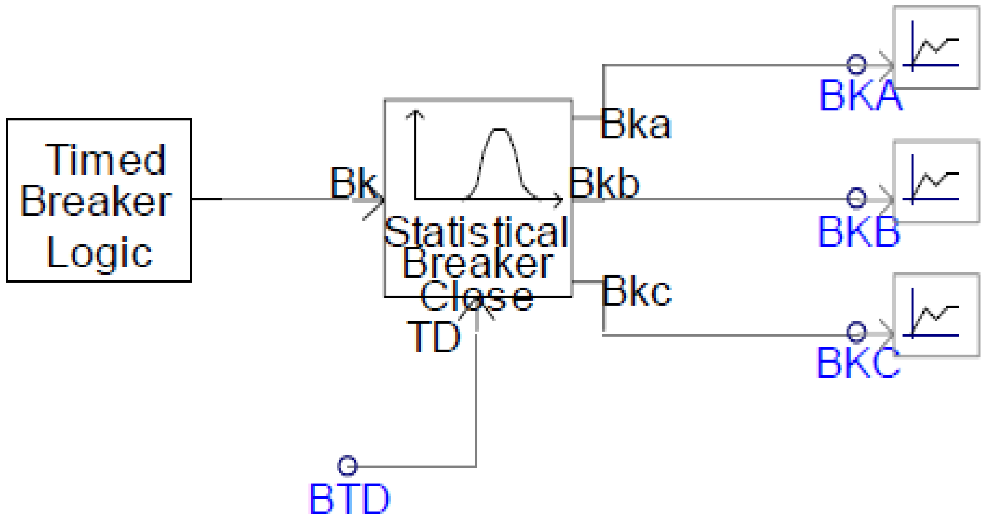


**Fig: 9.3 Statistical Switch Module**

## 9.4 PROCEDURE:

1. Make the connections as shown in the circuit diagram by using PSCAD master library.
2. Measure readings in each element.
3. Observe the wave forms

## 9.5 RESULT:

## 9.7 PRE LAB VIVA QUESTIONS:

1. What do you mean by transformer inrush current
2. How is magnetic leakage reduced to a minimum in commercial transformers?
3. Mention the factors on which hysteresis loss depends?

## 9.8 POST LAB QUESTIONS:

1. Is Cu loss affected by power factor?
2. Does the transformer draw any current when its secondary is open?

## EXPERIMENT: 10

## SMALL SIGNAL STABILITY ANALYSIS

### 10.1 AIM:

Editing and Building a VI, Creating a VI

### 10.2 APPARATUS:

| S. No | Software Used | Desktop Quantity |
|---|---|---|
| 1 | PSCAD | 36 |

### 10.3 CIRCUIT DIAGRAMS:

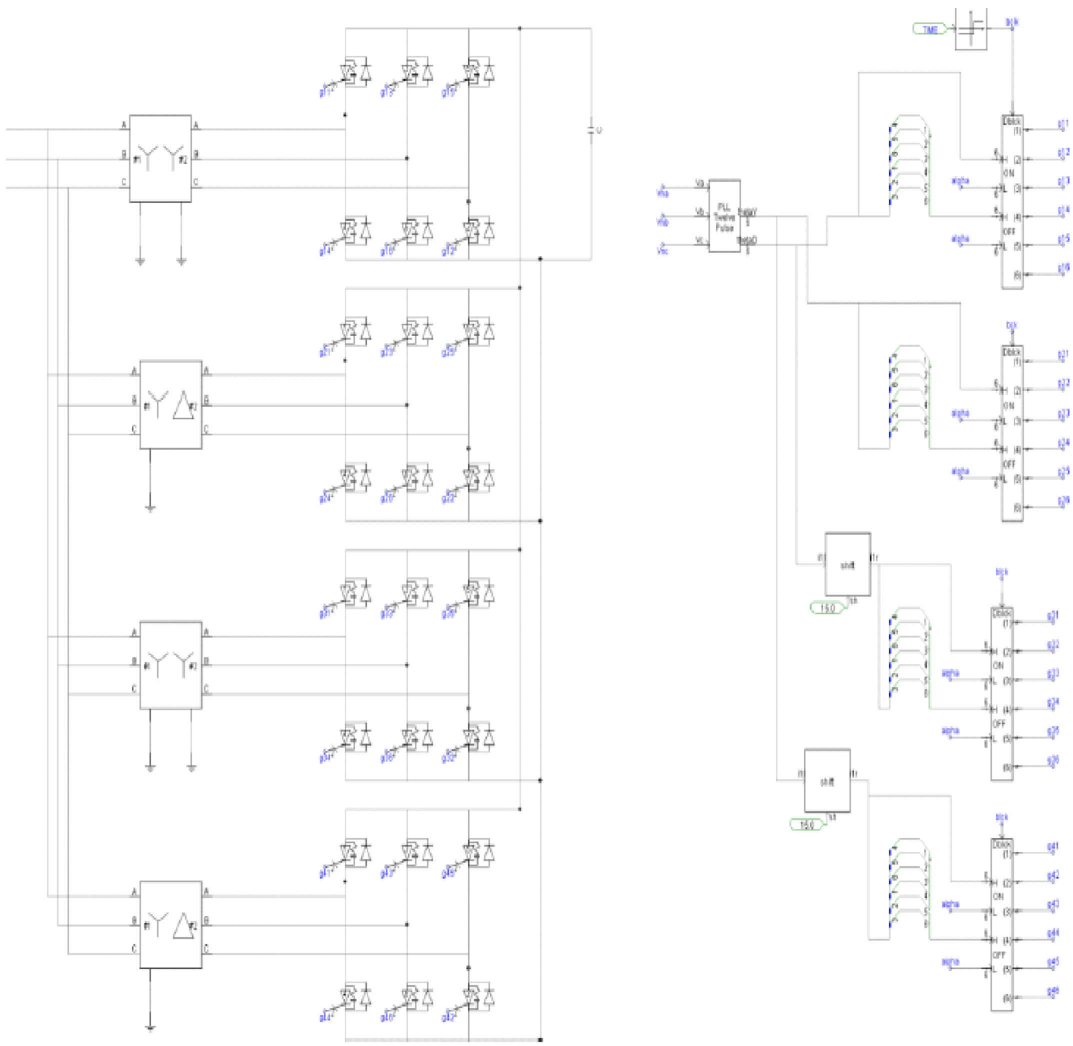

**Fig: 10.1 Simulation 24-pulse converter in PSCAD/EMTDC program**

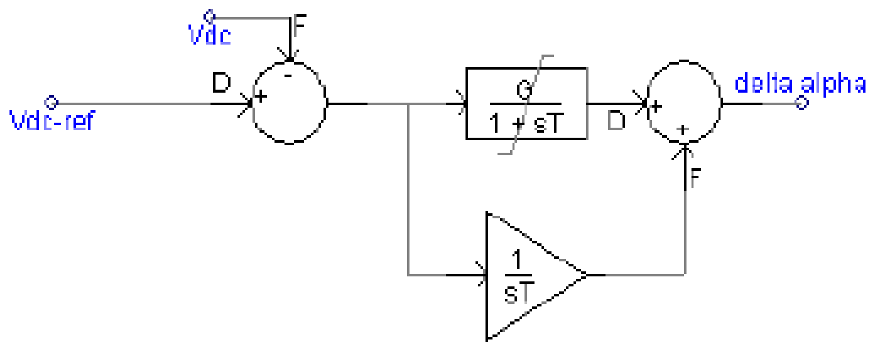


**Fig: 10.2 The control block for regulation of dc voltage of capacitor**

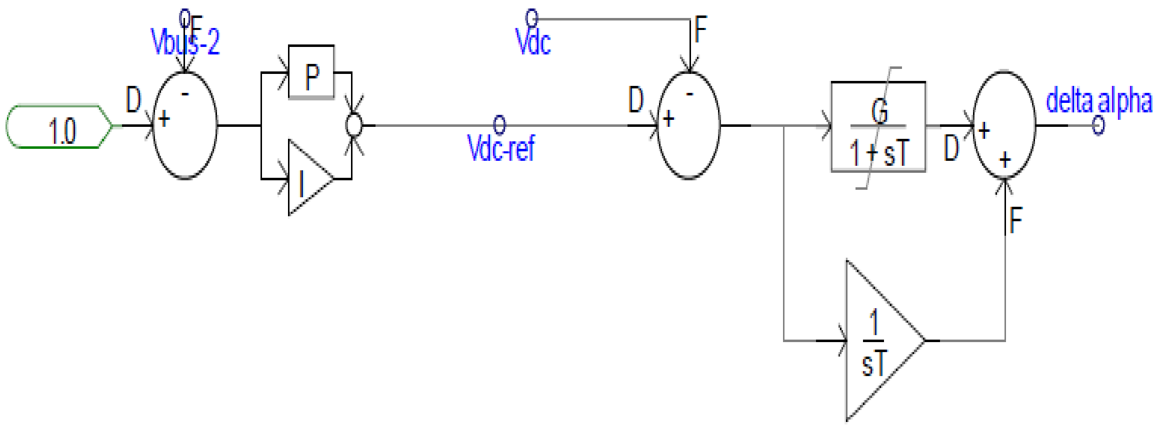


**Fig: 10.3 The control block of alternative voltage output of STSTCOM**

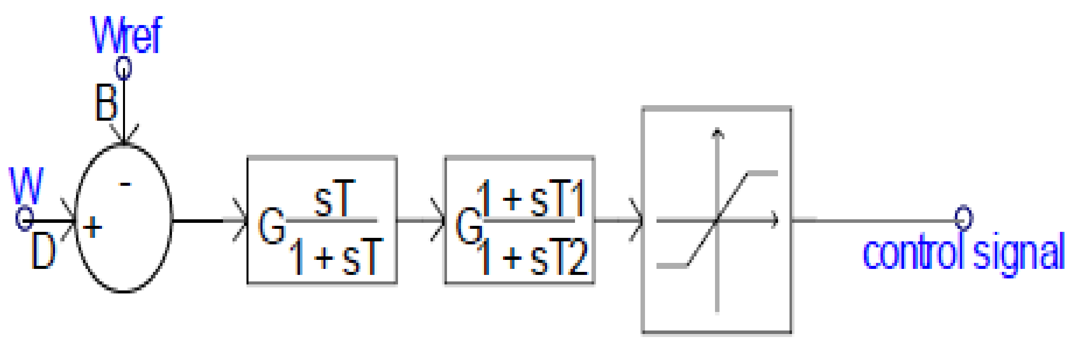


**Fig: 10.4 Control loop of STSTCOM for damping LFO**

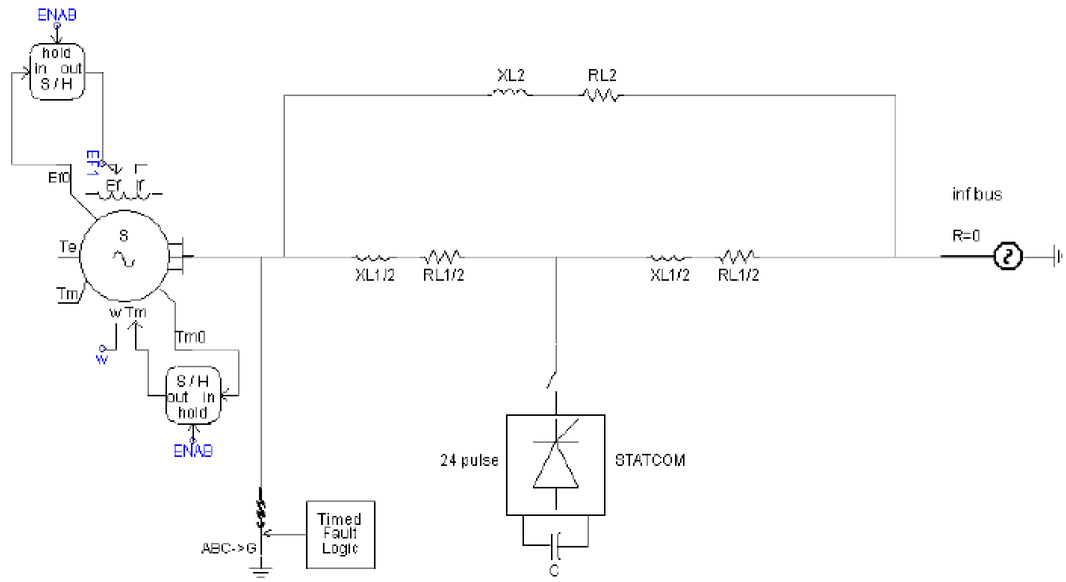


**Fig: 10.5 Single machine power system interconnected to inf.bus**

## 10.5 PROCEDURE:

1. Make the connections as shown in the circuit diagram by using PSCAD master library.
2. Measure recent in each element.
3. Observe the wave forms

## 10.6 RESULTS:

## 10.8 PRE LAB VIVA QUESTIONS:

1. What is meant by emerging facts controllers?
2. What is meant by STATCOM?
3. What are the functions of STATCOM in the improvement of power system performance area?
4. What are the common advantages of STATCOM?
5. Give details about first installed STATCOM device at Sullivan Sub-station.

## 10.9 POST LAB VIVA QUESTIONS:

1. What are the advantages of first installed STATCOM device at Sullivan Sub-station?
2. Write short notes on principle of operation of STATCOM.
3. Give the explanation about reactive power exchange between converter and the ac system.
4. What is the importance of V-I characteristics of STATCOM?

## EXPERIMENT – 11

## TRANSMISSION LINE PARAMETERS

### 11.1 AIM:

Obtain parameters of a typical transmission line and modeling it in PSCAD.

### 11.2 APPARATUS:

| S. No | Software Used | Desktop Quantity |
|---|---|---|
| 1 | PSCAD | 36 |

### 11.3 CIRCUIT DIAGRAM:

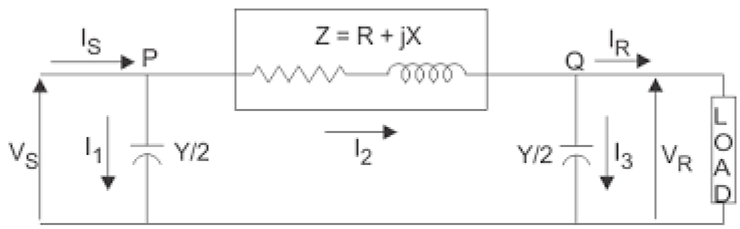


**Fig: 11.1 Transmission line**

### 11.4 PROCEDURE:

1. Make the connections as shown in the circuit diagram by using PSCAD master library.
2. Measure readings in each element.
3. Observe the wave forms

### 11.5 RESULT:

### 11.6 PRE LAB VIVA QUESTIONS:

1. What is skin effect?
2. Define symmetrical spacing.
3. Mention the factors governing the inductance of a line.
4. Define proximity effect.
5. What is a bundle conductor?

### 11.7 POST LAB VIVA QUESTIONS:

1. Define transmission efficiency.
2. What are the units of ABCD (generalized) constants of a transmission line?
3. Mention the range of surge impedance in overhead transmission lines.
4. Mention the range of surge impedance in underground cables.

# EXPERIMENT- 12

## LOAD FREQUENCY CONTROL

### 12.1 AIM:

Obtain the frequency response of single and two area power system using PSCAD.

### 12.2 APPARATUS:

| S. No | Software Used | Desktop Quantity |
|---|---|---|
| 1 | PSCAD | 36 |

### 12.3 CIRCUIT DIAGRAMS:

**One machine infinite bus case:**

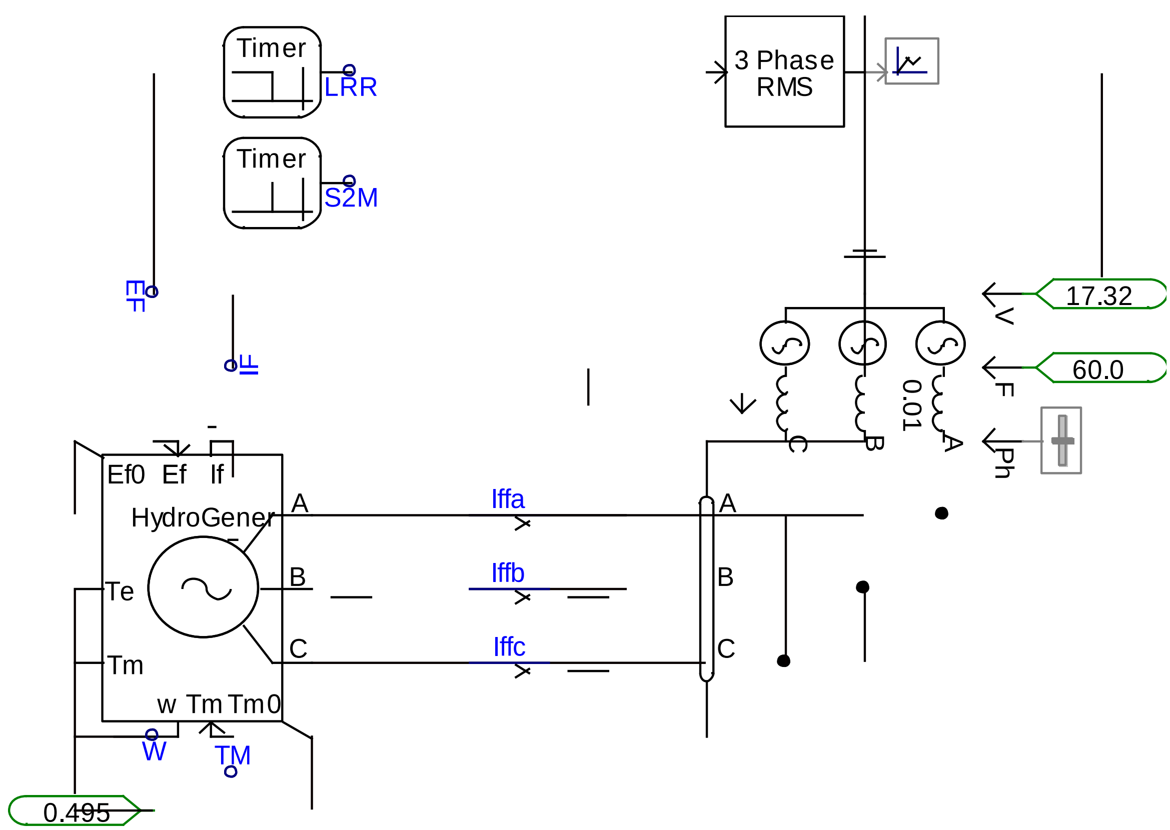


Fig: 12.1 Initializing the Machine to a Load Flow

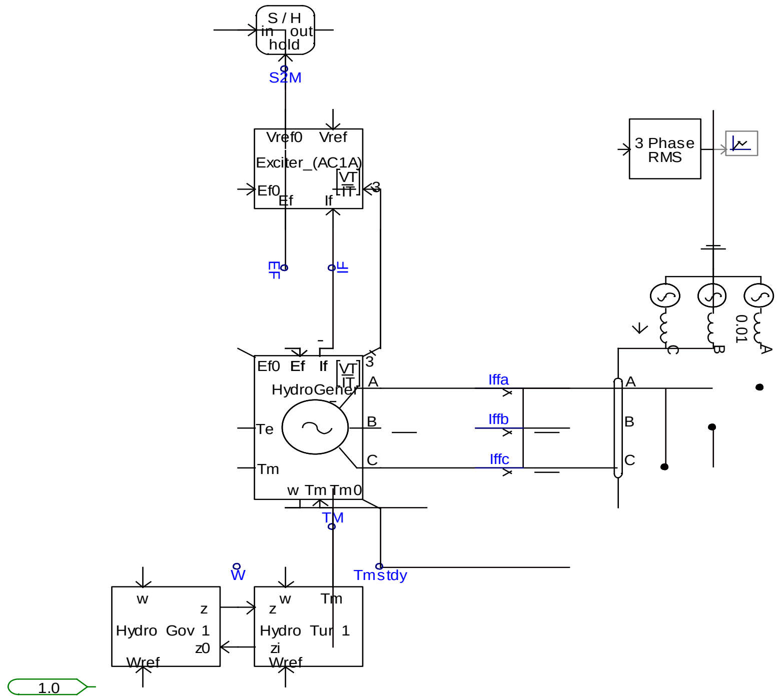


**Fig: 12.2 Initializing the multi machine to a Load Flow**

## 12.5 PROCEDURE:

1. Make the connections as shown in the circuit diagram by using PSCAD master library.
2. Measure readings in each element.
3. Observe the wave forms.

## 12.7 RESULT:

## 12.8 PRE LAB QUESTIONS:

1. What is function of load frequency control?
2. What do you mean by control area?
3. What is area control error?

## 12.9 POST LAB QUESTIONS:

4. How is the real power in a power system controlled?
5. What is the need for large mechanical forces in speed-governing system?
6. What is the exciter

## EXPERIMENT: 13

## POWER QUALITY

### 13.1 AIM:

Familiarization with PSCAD and Understanding of :

a) Reactive power and power factor correction in AC circuits.

b) Current harmonics drawn by power electronics interface

### 13.2 APPARATUS:

| S. No | Software Used | Desktop Quantity |
|---|---|---|
| 1 | PSCAD | 36 |

| S. No. | Name of the Equipment | Range | Type | Quantity |
|---|---|---|---|---|
| 1 | LABVIEW SOFTWARE | - | - | - |

### 13.3 CIRCUIT DIAGRAM:

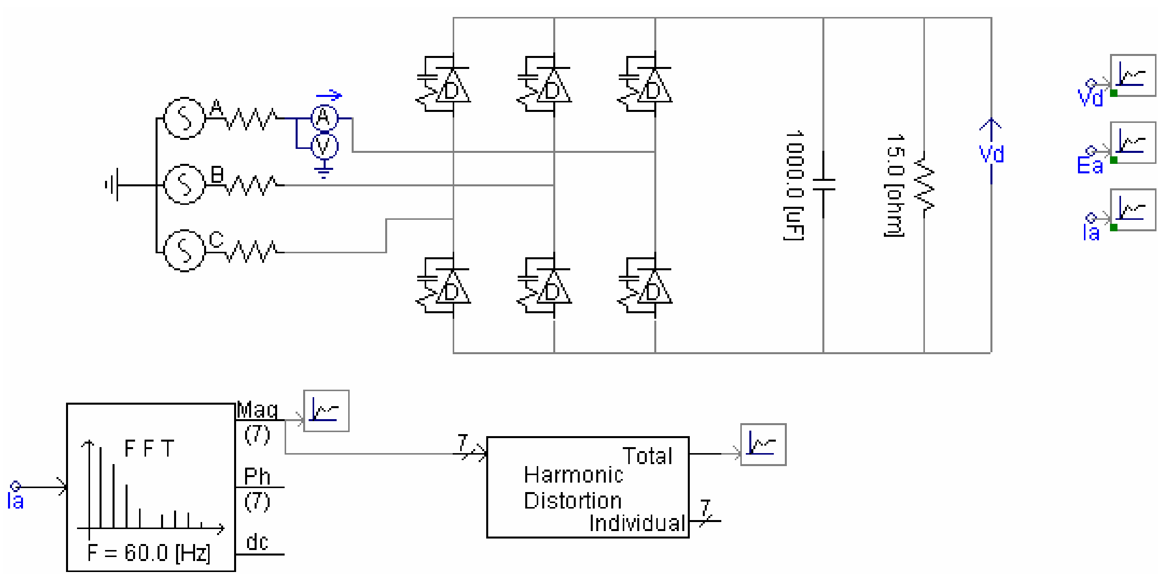


**Fig: 13.1 FFT and harmonic distortion blocks are taken from CSMF library**

### 13.4 PROCEDURE:

1. Make the connections as shown in the circuit diagram by using PSCAD master library.
2. Measure readings in each element.
3. Observe the wave forms

### 13.7 RESULT:

## 13.8 PRE LAB VIVA QUESTIONS:

1. What are all power quality measuring equipment
2. What are the parameters to be monitor for identify the power quality problems?
3. How can Power Quality problems be detected?

## 13.9 POST LAB VIVA QUESTIONS:

1. How do harmonics affect the load?
2. How do I know what level of Power Quality protects?
3. What are the types of Power Quality solutions available on the market today?

## EXPERIMENT: 14

## DISTANCE PROTECTION

### 14.1 AIM:

Development of PSCAD model to study the distance protection scheme in long transmission line.

### 14.2 APPARATUS:

| S. No | Software Used | Desktop Quantity |
|---|---|---|
| 1 | PSCAD | 36 |

### 14.3 CIRCUIT DIAGRAM:

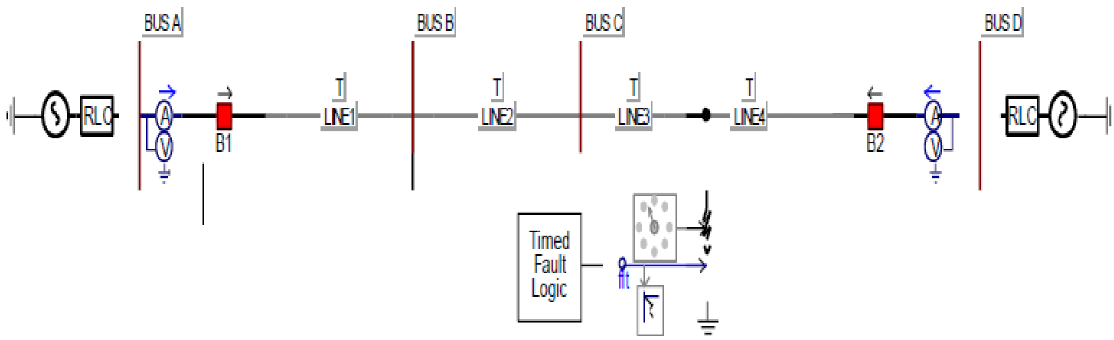


**Fig: 14.1 distance protection scheme**

### 14.5 PROCEDURE:

1. Make the connections as shown in the circuit diagram by using PSCAD master library.
2. Measure readings in each element.
3. Observe the wave forms

**L-G faults at different distances from the relay location.**

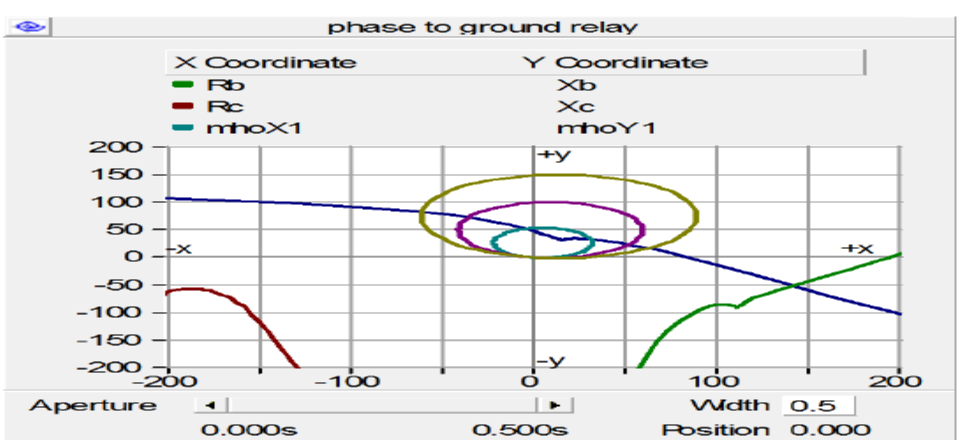


**Fig: 14.2 distance protection scheme graph**

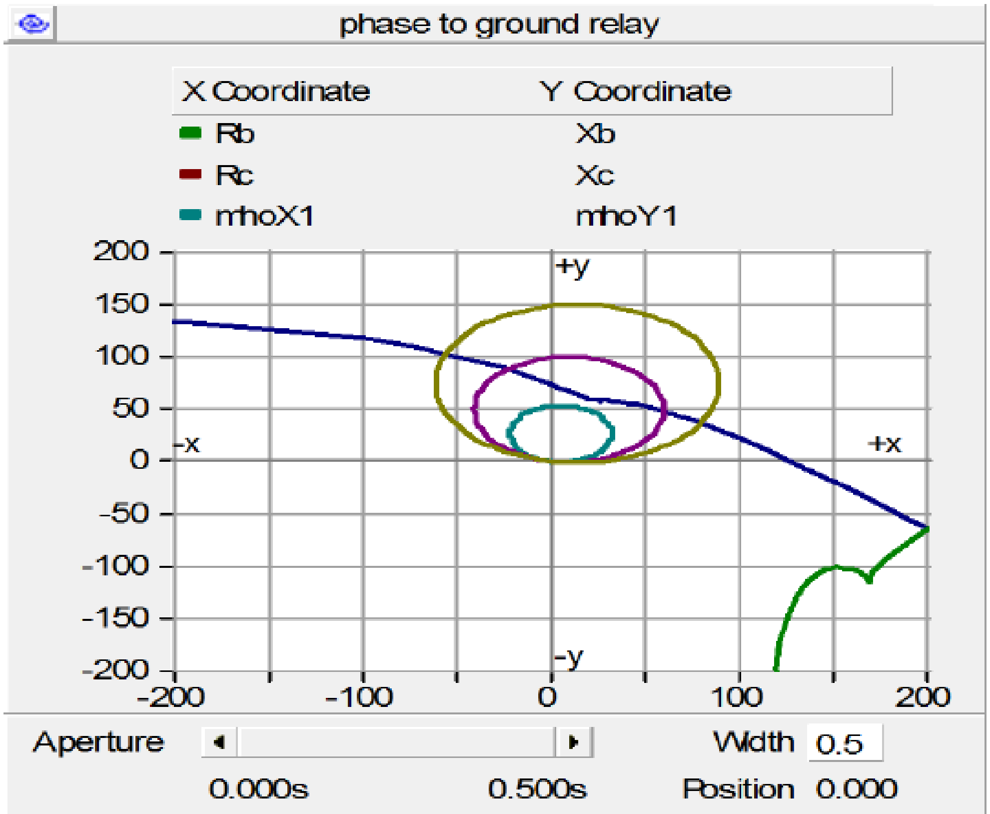


Fig: 14.3 Fault at 20 km from Bus-B, Zone 2

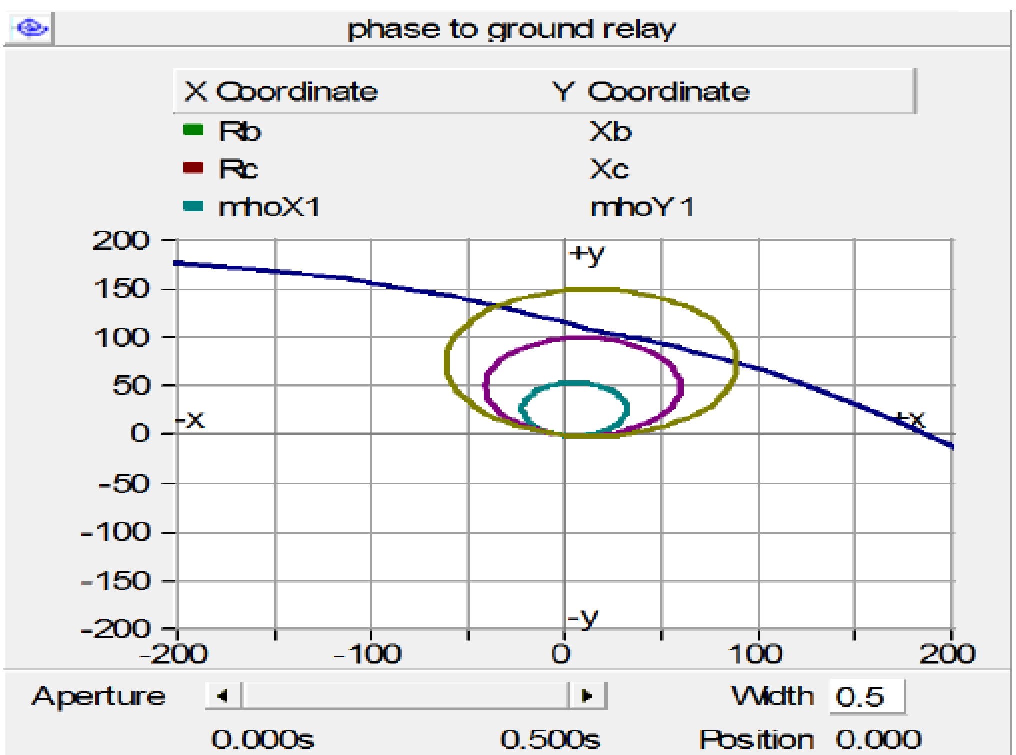


Fig: 14.4 Fault at 12 km from Bus-C, Zone 3

## 14.7 RESULT:

## 14.8 PRE LAB VIVA QUESTIONS:

1. Where Impedance relay, Reactance relay and Mho relays are employed?
2. What is the basic principle of distance protection? How it works?
3. What is the difference between impedance and mho characteristic?

## 14.9 POST LAB VIVA QUESTIONS:

1. Why do we use relays in the power systems?
2. What are the basic distance protection zones? Why different zones should be defined?