Jawaharlal Nehru Engineering College

Laboratory Manual

Computer Aided Power System Analysis

For

First Year Master Of Engineering (EPS) Students

Manual made by

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FOREWORD

It is my great pleasure to present this laboratory manual for First Year Master of Engineering **ELECTRICAL POWER SYSTEMS** engineering students for the subject of Computer Aided Power System Analysis. Keeping in view the vast coverage required for visualization of concepts of Computer Aided Power System Analysis with simple language.

As a student, many of you may be wondering with some of the questions in your mind regarding the subject and exactly what has been tried is to answer through this manual.

Faculty members are also advised that covering these aspects in initial stage itself, will greatly relive them in future as much of the load will be taken care by the enthusiasm energies of the students once they are conceptually clear.

H.O.D. (EEP)

LABORATORY MANUAL CONTENTS

This manual is intended for the First year students of **ELECTRICAL POWER SYSTEM** master of engineering branch in the subject of Computer Aided Power System Analysis. This manual typically contains practical/Lab Sessions related Computer Aided Power System Analysis covering various aspects related to the subject to enhance understanding.

Although, as per the syllabus, only descriptive treatment is prescribed, we have made the efforts to cover various aspects of Computer Aided Power System Analysis subject covering types of different power system analysis tools, their operating principals, their characteristics and Applications will be complete in itself to make it meaningful, elaborative understandable concepts and conceptual visualization.

Students are advised to thoroughly go through this manual rather than only topics mentioned in the syllabus as practical aspects are the key to understanding and conceptual visualization of theoretical aspects covered in the books.

Good Luck for your Enjoyable Laboratory Sessions

Prof. Avinash S. Welankiwar

SUBJECT INDEX

1. DO's and DON'Ts:

DO's in Laboratory:

1. Use this software by using license key provided at the main server.
2. Any crash, invalid debugs may hang the software. In such cases, please wait for that program to respond otherwise this will directly delete the files if not saved properly.

DONT's in Laboratory:

1. Don't disturb the standard layout of the software.
2. Don't disturb the license settings.

Instructions for Laboratory Teachers:

1. Submission related to whatever lab work has been completed should be done during the next lab session. The immediate arrangements for printouts related to submission on the day of practical assignments.

2. Students should be taught for taking the observations /readings of different measuring instruments under the able observation of lab teacher.

3. The promptness of submission should be encouraged by way of marking and evaluation patterns that will benefit the sincere students.

2. Lab Exercise:

Practical 1 : (2 Hours):

MODELING OF POWER SYSTEM COMPONENTS SUCH AS ALTERNATORS, TRANSFORMERS, AND TRANSMISSION LINES.

AIM: To simulate models of different power system components such as Alternators, Transformers, and Transmission lines..

APPARATUS:

1) MATLAB Software
2) Sim Power System Toolbox

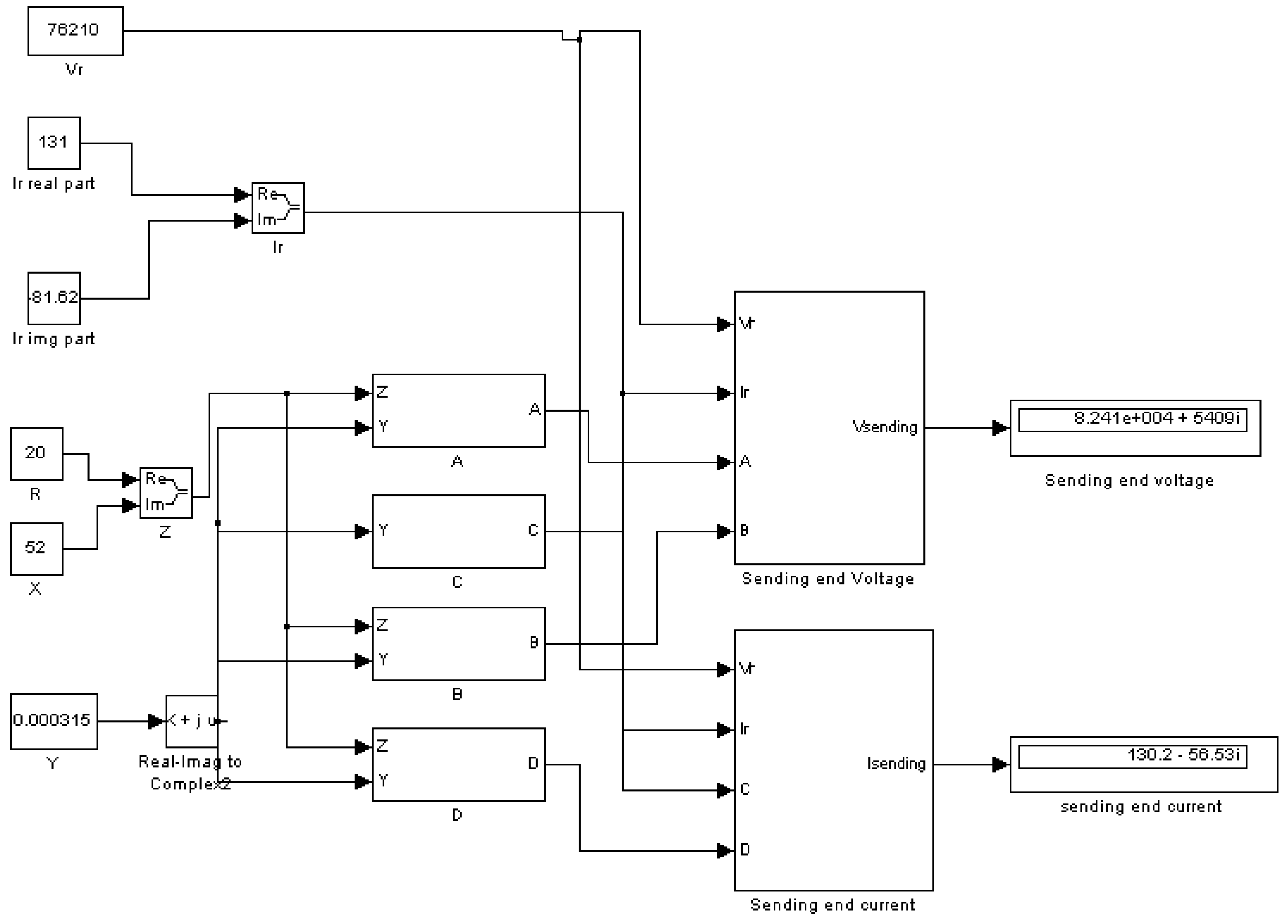
THEORY:

1. What is modeling of power systems components?
2. How this modeling helps to understand the nature of that particular power system component?
3. What is the relation of output and input of that device and how that results can be compared to the output of Model developed in MATLAB?

PROCEDURE:

1) Make a new model file in MATLAB.
2) Use Sim Power System Toolbox and Mathematical Operations Toolbox for inserting the models of different mathematical operations such as add, subtract, limiters etc. and different electrical displays such as scope and Displays .
3) Insert the blocks from respective toolboxes into new model by dragging it and connect that blocks.
4) Give proper input to the model and check the output at the output port/display/scope.
5) Calculate & plot the graphs. Output Vs speed, Output Vs Efficiency, Output Vs motor current.
Output Vs slip, output Vs P.F.

Example: Mathematical model development of transmission line



T model of transmission line

OBSERVATIONS: Observe the readings of input quantities and output quantities.

CONCLUSION:

Modelling of any power system components is to develop the mathematical relationships between different operating parameters of that device that helps to study of detailed analysis of that power system component such as Transformer, Transmission lines, Alternator etc.

<u>Practical 2 : (2 Hours):</u>

Formation of Y bus and Z Bus matrices for given networks.

AIM: Formulate Y bus and Z Bus matrices for given networks.

APPARATUS:

1) MATLAB Software
2) Sim Power System Toolbox

THEORY:

1) What is admittance and how it is represented?

2) what is admittance matrix and Impedance matrix and how the self and mutual elements of this matrices are calculated?

MATAB CODE:

<u>Y BUS MATRIX FORMATION:</u>

[redacted]

[redacted]

CONCLUSION:

We conclude that Y bus and Z bus are the characteristic matrices of an electrical network which helps in fault analysis and impedance characterization of that network.

<u>Practical 3 : (2 Hours):</u>

REPRESENTATION OF SEQUENCE NETWORKS.

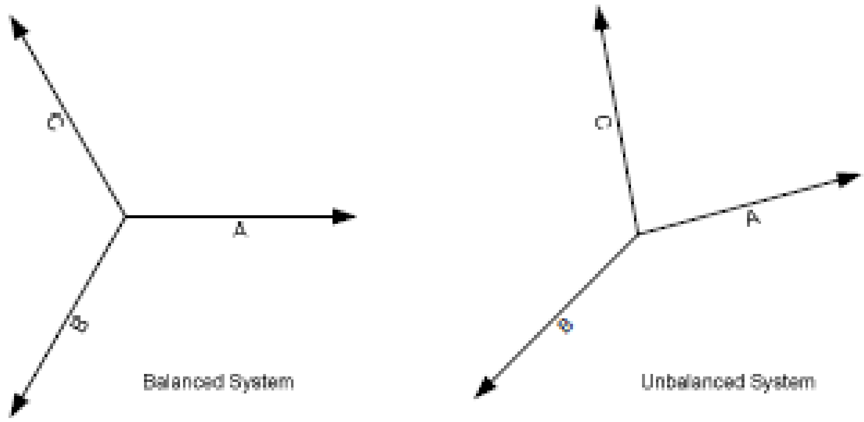
AIM: - To simulate Sequence Networks using basic mathematical relationships of it.

APPARATUS:

1) MATLAB Software
2) SIM POWER SYSTEM Toolbox

THEORY:-

The theory of symmetrical components resolves any set of unbalanced voltages or currents into three sets of symmetrical balanced phasors. These are known as positive, negative and zero-sequence components. Fig. shows balanced and unbalanced systems.



Consider the symmetrical system of phasors in Fig. 7.2. Being balanced, the phasors have equal amplitudes and are displaced 120 relative to each other. By the definition of symmetrical components, V_{b1} *always lags* V_{a1} by a fixed angle of 120 deg .and always has the same magnitude as V_{a1} . Similarly V_{c1} leads V_{a1} by 120 deg. It follows then that,

$$V_{a1} = V_{a1}$$
$$V_{b1} = (1\angle 240^o)V_{a1} = a^2V_{a1}$$
$$V_{c1} = (1\angle 120^o)V_{a1} = aV_{a1}$$

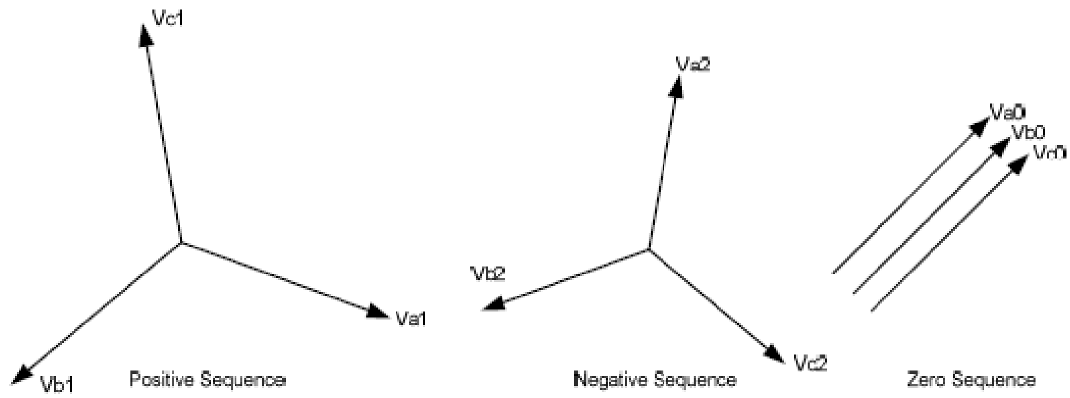
Negative sequence components are given by,

$$V_{a2} = V_{a2}$$
$$V_{b2} = (1\angle 120^o)V_{a2} = aV_{a2}$$
$$V_{c2} = (1\angle 240^o)V_{a2} = a^2V_{a2}$$

Zero Sequence components are given by,

$$V_{a0} = V_{a0}$$
$$V_{b0} = V_{a0}$$
$$V_{c0} = V_{a0}$$

Where the subscript (2) designates the negative-sequence component and subscript (0) designates zero-sequence components. For the negative-sequence phasors the order of sequence of the maxima occur cba, which is opposite to that of the positive-sequence. The maxima of the instantaneous values for zero-sequence occur simultaneously.



In all three systems of the symmetrical components, the subscripts denote the components in the different phases. The total voltage of any phase is then equal to the
sum of the corresponding components of the different sequences in that phase. It is nowpossible to write our symmetrical components in terms of three, namely, those referred to the a phase

$$V_a = V_{a0} + V_{a1} + V_{a2}$$
$$V_b = V_{b0} + V_{b1} + V_{b2}$$
$$V_c = V_{c0} + V_{c1} + V_{c2}$$

These components can be resolved by using 'a' operator,

$$V_a = V_0 + V_1 + V_2$$
$$V_b = V_0 + a^2 V_1 + a V_2$$
$$V_c = V_0 + a V_1 + a^2 V_2$$

Symmetrical components of voltage can be derived from phase voltage components by the relationship given below,

$$V_0 = \frac{1}{3}(V_a + V_b + V_c)$$
$$V_1 = \frac{1}{3}(V_a + aV_b + a^2 V_c)$$
$$V_2 = \frac{1}{3}(V_a + a^2 V_b + aV_c)$$

Similarly phase currents can be derived from symmetrical components of currents bys using relation ship

$$I_a = I_0 + I_1 + I_2$$
$$I_b = I_0 + a^2 I_1 + a I_2$$
$$I_c = I_0 + a I_1 + a^2 I_2$$

Sequence currents can be obtained by,

$$I_0 = \frac{1}{3}(I_a + I_b + I_c)$$
$$I_1 = \frac{1}{3}(I_a + a I_b + a^2 I_c)$$
$$I_2 = \frac{1}{3}(I_a + a^2 I_b + a I_c)$$

MATLAB PROGRAM FOR CALCULATION OF SYMETRICAL COMPONENTS:

RESULTS:

CONCLUSION: Symmetrical components of voltages or currents resolves that quantity into a set of three balanced vectors using 'a' operator. This helps in understanding the behavior of the unbalanced quantity and used in fault analysis

<u>Practical 4 : (2 Hours):</u>

PROGRAMMING OF POWER FLOW USING NEWTON-RAPHSON METHOD.

AIM: To simulate power flow using Newton-Raphson Method..

APPARATUS:

1) MATLAB Software
2) Sim Power System Toolbox

THEORY:

1. What is Load Flow.?
2. What is Newton Raphson method for load flow?
3. What is the accuracy for this method ?

MATLAB PROGRAM FOR NEWTON RAPHSON METHOD:

```
function Y = ybusppg(num)  % Returns Y

linedata = linedatas(num);      % Calling Linedatas...
fb = linedata(:,1);             % From bus number...
tb = linedata(:,2);             % To bus number...
r = linedata(:,3);              % Resistance, R...
x = linedata(:,4);              % Reactance, X...
b = linedata(:,5);              % Ground Admittance, B/2...
a = linedata(:,6);              % Tap setting value..
z = r + i*x;                    % z matrix...
y = 1./z;                       % To get inverse of each element...
b = i*b;                        % Make B imaginary...

nb = max(max(fb),max(tb));      % No. of buses...
nl = length(fb);                % No. of branches...
Y = zeros(nb,nb);               % Initialise YBus...

 % Formation of the Off Diagonal Elements...
 for k = 1:nl
     Y(fb(k),tb(k)) = Y(fb(k),tb(k)) - y(k)/a(k);
     Y(tb(k),fb(k)) = Y(fb(k),tb(k));
 end

 % Formation of Diagonal Elements....
 for m = 1:nb
     for n = 1:nl
         if fb(n) == m
             Y(m,m) = Y(m,m) + y(n)/(a(n)^2) + b(n);
         elseif tb(n) == m
             Y(m,m) = Y(m,m) + y(n) + b(n);
         end
     end
 end
 %Y;                 % Bus Admittance Matrix
 %Z = inv(Y);        % Bus Impedance Matrix
```

**** This program necessitates the LINE DATA and BUS DATA of a given Network. So, specify these matrices before debugging this program.

OBSERVATION :

This will consists of the output of MATLAB program giving different values of bus voltages, bus angles, and Power flow.

CONCLUSION:

From this Experiment we can conclude that using Newton Raphson method different values of bus voltages, bus angles, and Power flow can be calculated with less no. of iterations.

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Practical 5 : (2 Hours):

Programming of power flow using Gauss Seidel Method.

Aim :- To simulate Programming of power flow using Gauss Seidel Method.

APPARATUS:

1) MATLAB Software
2) Sim Power System Toolbox

Theory:-

1. What is Load Flow.?
2. What is Gauss Seidel method for load flow?
3. What is the accuracy for this method ?

MATLAB PROGRAM FOR GAUSS SEIDEL METHOD:

```
function ybus = ybusppg();  % Returns ybus

linedata = linedata6(); % Calling "linedata6.m" for Line Data...
fb = linedata(:,1);     % From bus number...
tb = linedata(:,2);     % To bus number...
r = linedata(:,3);      % Resistance, R...
x = linedata(:,4);      % Reactance, X...
b = linedata(:,5);      % Ground Admittance, B/2...
z = r + i*x;            % Z matrix...
y = 1./z;               % To get inverse of each element...
b = i*b;                % Make B imaginary...

nbus = max(max(fb),max(tb));    % no. of buses...
nbranch = length(fb);           % no. of branches...
ybus = zeros(nbus,nbus);        % Initialise YBus...

 % Formation of the Off Diagonal Elements...
 for k=1:nbranch
     ybus(fb(k),tb(k)) = -y(k);
     ybus(tb(k),fb(k)) = ybus(fb(k),tb(k));
 end

 % Formation of Diagonal Elements....
 for m=1:nbus
     for n=1:nbranch
         if fb(n) == m | tb(n) == m
             ybus(m,m) = ybus(m,m) + y(n) + b(n);
         end
     end
 end
 ybus;                  % Bus Admittance Matrix
 zbus = inv(ybus);      % Bus Impedance Matrix
```

**** This program necessitates the LINE DATA and BUS DATA of a given Network. So, specify these matrices before debugging this program.

OBSERVATION :

This will consists of the output of MATLAB program giving different values of bus voltages, bus angles, and Power flow.

CONCLUSION:

From this Experiment we can conclude that using Gauss seidel method different values of bus voltages, bus angles, and Power flow can be calculated.

Practical 6 : (2 Hours):

PROGRAMMING OF POWER FLOW USING FAST DECOUPLED METHOD.

Aim:- To simulate Programming of power flow using Fast Decoupled Method

APPARATUS:

1) MATLAB Software
2) Sim Power System Toolbox

Theory:-

1. What is Load Flow.?
2. What is Gauss Seidel method for load flow?
3. What is the accuracy for this method ?

MATLAB PROGRAM FOR Fast Decoupled METHOD:

```
clc
clear
%-------------v-----del-----Pg-----Qg----Pd----Qd------------
bus = [ 1   1.04    0.00   0.00   0.00  0.00  0.00  0.00  0.00 1;
        2   1.02533 0.00   1.63   0.00  0.00  0.00  0.00  0.00 2;
        3   1.02536 0.00   0.85   0.00  0.00  0.00  0.00  0.00 2;
        4   1.00    0.00   0.00   0.00  0.00  0.00  0.00  0.00 3;
        5   1.00    0.00   0.00   0.00  0.90  0.30  0.00  0.00 3;
        6   1.00    0.00   0.00   0.00  0.00  0.00  0.00  0.00 3;
        7   1.00    0.00   0.00   0.00  1.00  0.35  0.00  0.00 3;
        8   1.00    0.00   0.00   0.00  0.00  0.00  0.00  0.00 3;
      9   1.00    0.00   0.00   0.00  1.25  0.50  0.00  0.00 3];


% formation of y bus for nominal tap ratio i.e. a=1
%----------------r-------x------------b------------
line = [1 4     0.0     0.0576      0.     1. 0. ;
      4 5     0.017   0.092       0.158  1. 0. ;
        5 6     0.039   0.17        0.358  1. 0. ;
        3 6     0.0     0.0586      0.     1. 0. ;
        6 7     0.0119  0.1008      0.209  1. 0. ;
        7 8     0.0085  0.072       0.149  1. 0. ;
      8 2     0.0     0.0625      0.     1. 0. ;
        8 9     0.032   0.161       0.306  1. 0. ;
        9 4     0.01    0.085       0.176  1. 0. ];

r = size(line);
p = r(1);
w = line(:,2 );
buses = max(w);

% b=zeros(1,buses);
ybus = zeros(buses,buses);
y = zeros(buses,buses);


for k= 1:p                    % finding the elements of ybus
   l= line(k,1);
```

```
    m= line(k,2);

    y(l,m) = 1/(line(k,3)+ 1i*line(k,4));
    y(m,l) = y(l,m);
%     b(l) = b(l)+(i*line(k,5))/2;
%     b(m) = b(m)+(i*line(k,5))/2;

end

for i = 1:buses
    for j = 1:buses

        if i==j
            ybus(i,j) =  ybus(i,j)+sum(y(i,:)); %+ b(i);
        end

        if i~=j
            ybus(i,j) =  -1*y(i,j);
        end
    end
end
ybus;
b = -imag(ybus);

%formation of b' matrtix
b1=zeros(buses-1,buses-1);
for i = 1:buses-1
    for j = 1:buses-1
        b1(i,j) =b(i+1,j+1);
    end
end
b1;

%formation of b" matrtix
%assuming all the load buses are at last
b2=zeros(buses-3,buses-3);
for i = 1:buses-3
    for j = 1:buses-3
        b2(i,j) =b(i+3,j+3);
    end
end
b2


v = bus(:,2);
del = bus(:,3);
Pg = bus(:,4);
Qg = bus(:,5);
Pd = bus(:,6);
Qd = bus(:,7);

Pspec = Pg-Pd;
Qspec = Qg-Qd;
iter = 1;
slack = 1;
tolerance = .01;
flag=1
```

```
while flag==1;

    m = real(ybus);
    n = imag(ybus);
    P = zeros(buses,1);
    Q = zeros(buses,1);
    iter= iter+1;


for i=1:buses     %finding  bus real and reactive power
    for j=1:buses
        P(i) = P(i)+ (v(i)*v(j)*(m(i,j)*cos(del(i)-del(j))+n(i,j)*sin(del(i)-del(j))));
        Q(i) = Q(i)+ (v(i)*v(j)*(m(i,j)*sin(del(i)-del(j))-n(i,j)*cos(del(i)-del(j))));
    end
end

P
Q
%finding del P by v
for i=1:(buses-1)
    if(i<slack)
        delP(i,1)= Pspec(i)-P(i);
    else
        delP(i,1)=(Pspec(i+1)-P(i+1));

    end
    delPbyv(i,1)=delP(i,1)/v(i,1);
end

%finding del Q by v
c=0;
for i=1:buses
    if bus(i,10)==3
        c=c+1;
        delQ(c,1)= (Qspec(i)-Q(i));
        delQbyv(c,1)= delQ(c,1)/v(i,1);
    end
end

if max(abs(delP))>tolerance | max(abs(delQ))>tolerance
    flag=1;    % tolerance check
else
    flag=0;
end

%calc correction vector
deldel = inv(b1)*delPbyv;
delv = inv(b2)*delQbyv;

%updating values
for i=1:(buses-1)
    del(i+1,1)= del(i+1,1)+deldel(i,1);
end

c=0;
for i=1:buses
    if bus(i,10)==3
        c=c+1;
```

```
        v(i,1)=v(i,1)+delv(c,1);
    end
end

iter
v
del
end
```

**** This program necessitates the LINE DATA and BUS DATA of a given Network. So, specify these matrices before debugging this program.

OBSERVATION :

This will consists of the output of MATLAB program giving different values of bus voltages, bus angles, and Power flow.

CONCLUSION:

From this Experiment we can conclude that using Gauss seidel method different values of bus voltages, bus angles, and Power flow can be calculated.

Practical 7 : (2 Hours):

REPRESENTATION OF TWO PORT NETWORKS IN Z, Y, H TYPE.

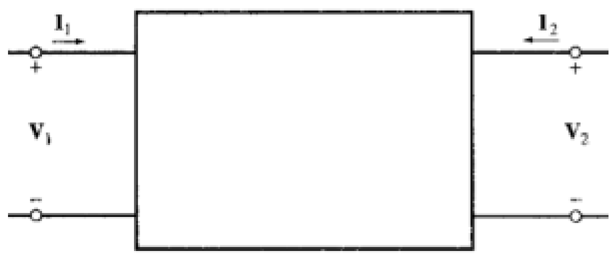
AIM: - To Represent Two port Networks in Z, Y, H type using MATLAB.

APPARATUS:

1) MATLAB Software
2) Sim Power System Toolbox

THEORY:-

A two-port network basically consists in isolating either a complete circuit or part of it and finding its characteristic parameters. Once this is done, the isolated part of the circuit becomes a "black box" with a set of distinctive properties, enabling us to abstract away its specific physical buildup, thus simplifying analysis. Any circuit can be transformed into a two-port network provided that it does not contain an independent source.



The parameters used in order to describe a two-port network are the following: Z, Y, A , h, g. They are usually expressed in matrix notation and they establish relations between the following parameters:

Input voltage V1
Output voltage V2
Input current I1
Output current I2

Z-model : In the Z-model or impedance model, the two currents $I1$ and $I2$ are assumed to be known, and the voltages $V1$and $V2$can be found by:

$$\begin{pmatrix} V_1 \\ V_2 \end{pmatrix} = \begin{pmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \end{pmatrix}$$

where

$$Z_{11} = \frac{V_1}{I_1}\Big|_{I_2=0} \qquad Z_{12} = \frac{V_1}{I_2}\Big|_{I_1=0}$$

$$Z_{21} = \frac{V_2}{I_1}\Big|_{I_2=0} \qquad Z_{22} = \frac{V_2}{I_2}\Big|_{I_1=0}$$

Here all four parameters Z_{11}, Z_{12} , Z_{21} and Z_{22} represent impedance. In particular, $Z21$ and Z12 are transfer impedances, defined as the ratio of a voltage $V1$(or $V2$) in one part of a network to a current $I2$(or $I1$) in another part . $Z12 = V1 / I2$. **Z** is a 2 by 2 matrix containing all four parameters.

Y-model : In the Y-model or admittance model, the two voltages $V1$ and $V2$ are assumed to be known, and the currents $I1$ and $I2$ can be found by:

$$\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix}$$

where

$$Y_{11} = \left.\frac{I_1}{V_1}\right|_{V_2=0} \qquad Y_{12} = \left.\frac{I_1}{V_2}\right|_{V_1=0}$$

$$Y_{21} = \left.\frac{I_2}{V_1}\right|_{V_2=0} \qquad Y_{22} = \left.\frac{I_2}{V_2}\right|_{V_1=0}$$

Here all four parameters Y_{11}, Y_{12} ,Y_{21} , and Y_{22} represent admittance. In particular, $Y21$ and $Y12$ are transfer admittances. **Y** is the corresponding parameter matrix.

ABCD -model : In the A-model or transmission model, we assume $V1$ and $I1$ are known, and find $V2$ and $I2$by:

$$\begin{pmatrix} V_2 \\ I_2 \end{pmatrix} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \begin{pmatrix} V_1 \\ I_1 \end{pmatrix}$$

where

$$A = \left.\frac{V_2}{V_1}\right|_{I_1=0} \qquad B = \left.\frac{V_2}{I_1}\right|_{V_1=0}$$

$$C = -\left.\frac{I_2}{V_1}\right|_{I_1=0} \qquad D = -\left.\frac{I_2}{I_1}\right|_{V_1=0}$$

Here A and D are dimensionless coefficients, B is impedance and C is admittance. A negative sign is added to the output current $I2$ in the model, so that the direction of the current is out-ward, for easy analysis of a cascade of multiple network models.

H-model : In the H-model or hybrid model, we assume $V2$ and $I1$ are known, and find $V1$ and $I2$ by:

$$\begin{pmatrix} V_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{pmatrix} \begin{pmatrix} I_1 \\ V_2 \end{pmatrix}$$

Where,

$$h_{11} = \left.\frac{V_1}{I_1}\right|_{V_2=0} \qquad h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0}$$

$$h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0} \qquad h_{22} = \left.\frac{I_2}{V_2}\right|_{I_1=0}$$

Here $h12$ and $h21$ are dimensionless coefficients, $h11$ is impedance and $h22$ is admittance.

g model : In g model or inverse hybrid model, we assume $V1$ and $I2$ are known, and find $V2$ and $I1$ by :

$$\begin{pmatrix} I_1 \\ V_2 \end{pmatrix} = \begin{pmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{pmatrix} \begin{pmatrix} V_1 \\ I_2 \end{pmatrix}$$

where

$$g_{11} = \left.\frac{I_1}{V_1}\right|_{I_2=0} \qquad g_{12} = \left.\frac{I_1}{I_2}\right|_{V_1=0}$$

$$g_{21} = \left.\frac{V_2}{V_1}\right|_{I_2=0} \qquad g_{22} = \left.\frac{V_2}{I_2}\right|_{V_1=0}$$

Here $g12$ and $g21$ are dimensionless coefficients, $g22$ is impedance and $g11$ is admittance.

PROCEDURE:-

1) Simple MATLAB scripts can be developed for the calculation of two port network Parameter calculations.

2) Input, output and the transfer parameters can be calculated by simply putting the conditions by using the conditional operators and by using the mathematical operations.

CONCLUSION:-

We conclude that two network parameters in Z,Y or H type can be useful in developing the input and output relationships in a given electrical network.

Practical 8 : (2 Hours):

SIMULATIONS OF FAULTS (LG, LL, LLG, 3 PHASE) ON A SINGLE MACHINE CONNECTED TO INFINITE BUS.

Aim:- To Study of Simulations of Faults (LG, LL, LLG, 3 phase) on a single machine connected to infinite Bus..

APPARATUS:-

1) MATLAB Software
2) Sim Power System Toolbox

THEORY:-

1) What are different types of faults in Power system?
2) How the faults induces instability in system?

MATLAB MODEL FOR SIMULATION OF FAULTS:

Conclusion:-

Faults induces instability in the system. Different types of faults have different severity levels.

2. Quiz on the Subject:

1. What is the working principle of AC. MOTOR?
2. What are the different types of D C Generator?
3. What is the working principle of D. C. Motor?
4. What are the different types of D C Motor?
5. What is the working principle of three phase Induction Motor?
6. Load characteristics of D.C. Compound Generator.
   a. What are the different types of D.C. compound Generator?
   b. What is the difference between flat compounded & over compounded generator.
   c. Why the terminal voltage drops when the generator is loaded?
   d. What happens if we connect the shunt field of compound generator in series with the armature & series field across the armature?
   e. What are the applications of d. c. compound generator?
   f. How to identify the series field & terminal at the terminal box?
7. Speed control of D.C. Shunt motor
   a. What are the factors on which speed of D.C. Shunt motor depends?
   b. Name the different speed control methods.
   C. What is the disadvantage of armature rheostat method?
   d. What is the advantage of Ward Leonard method?
   e. Where the D.C. Shunt motor is applicable?
8. Load test on d. c. shunt motor.
   a. What is the purpose of Load test on d. c. shunt motors?
   b. What is the relation between Ia and Armature Cu loss?
   c. What are different losses in D.C. shunt motor.
9. Generators
   a. Why speed control methods are not needed in d. c. generators?
   b. What is the use of commutator & brushes in D C Generator?
   c. How energy conversion takes place in D C Generator.
   d. What is the effect of increasing load on terminal voltage in D C shunt Generator.
10. Motor
    A. How energy conversion takes place in D C Generator.
    B. Why D C Motor is known as constant speed motor?
    C. Why starter is necessary for starting of D C motor?
    D. Explain the disadvantage of 3pt. Starter.
    E. How to reverse the direction of rotation of D C shunt Motor.
    F. What is the use of commutator & brushes in D C Motor?

5. Evaluation and marking system:

Basic honesty in the evaluation and marking system is absolutely essential and in the process impartial nature of the evaluator is required in the examination system to become popular amongst the students. It is a primary responsibility of the teacher that right students who are really putting up lot of hard work with right kind of intelligence are correctly awarded.

The marking patterns should be justifiable to the students without any ambiguity and teacher should see that students are faced with unjust circumstances.