Experiment No. 03

3.1 Experiment Name

Generate an algorithm and write a program to calculate the Y-bus matrix of a given power system

3.2 Objectives

- To become acquainted with the Y-bus matrix of a given power system
- To learn how to generate a MATLAB code for a Y-bus matrix of a given power system
- To get familiar with the procedure of designing and analyzing a power system in MATLAB

3.3 Apparatus

- MATLAB

3.4 Theory

The Y-bus matrix is a N × N matrix used in power engineering to describe a power system with N buses. It reflects the buses' nodal admittance in a power system. The Y matrix is relatively sparse in realistic systems with thousands of buses.

In a practical power system, each bus is often connected to only a few other buses via transmission lines. The Y Matrix is also one of the data requirements needed to formulate a power flow study.

One of the strategies developed to study power systems is the Node voltage method. In terms of load currents, the equations in the nodal admittance form result in a simultaneous complex algebraic equation. The voltages and currents of the buses are obtained by solving these equations. The power and load flow on all buses in the system may then be determined. That is why the construction of the admittance bus matrix Y-bus is very important.

If I_{bus} is the bus currents in matrix form and Y_{bus} is the admittance matrix and V bus is the bus voltages in matrix form then they can be related as $I_{bus}=Y_{bus}V_{bus}$

The general mathematical expressions are

$$Yij=-yij \text{ ; if i}\neq\text{j}$$
$$Yij=\sum_{k=1}^{n} y_{ik} \text{ ; if i=j}$$

The nodal admittance matrix form

$$Y=\begin{bmatrix} y_{11} & \cdots & y_{1n} \\ \cdots & \cdots & \cdots \\ y_{1n} & \cdots & y_{nn} \end{bmatrix}$$

Before constructing the equations that comprise the Y Matrix, three major steps must be taken beginning with a single line diagram of a power system. The single line diagram is first transformed into an impedance diagram. Following that, all voltage sources are translated to their corresponding current sources. The impedance diagram is then transformed into an admittance diagram.

The bus impedances can be recorded in an excel file for better management. The excel file can then be put into MATLAB to create the admittance matrix.

3.5 Block diagram

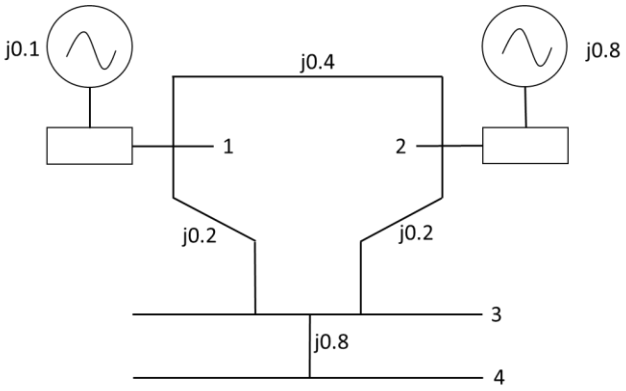


Fig 3.1: Diagram of Y- bus no.1

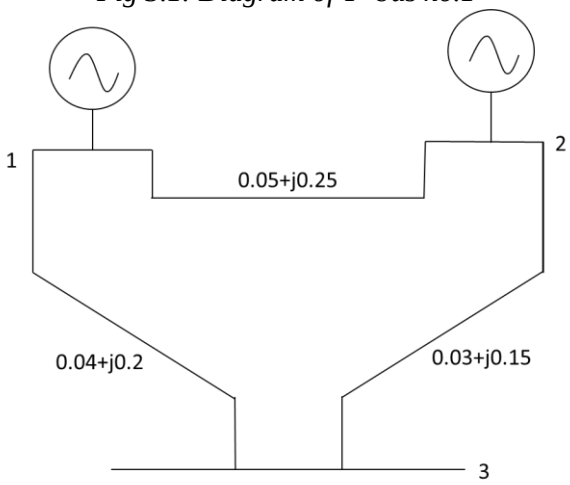


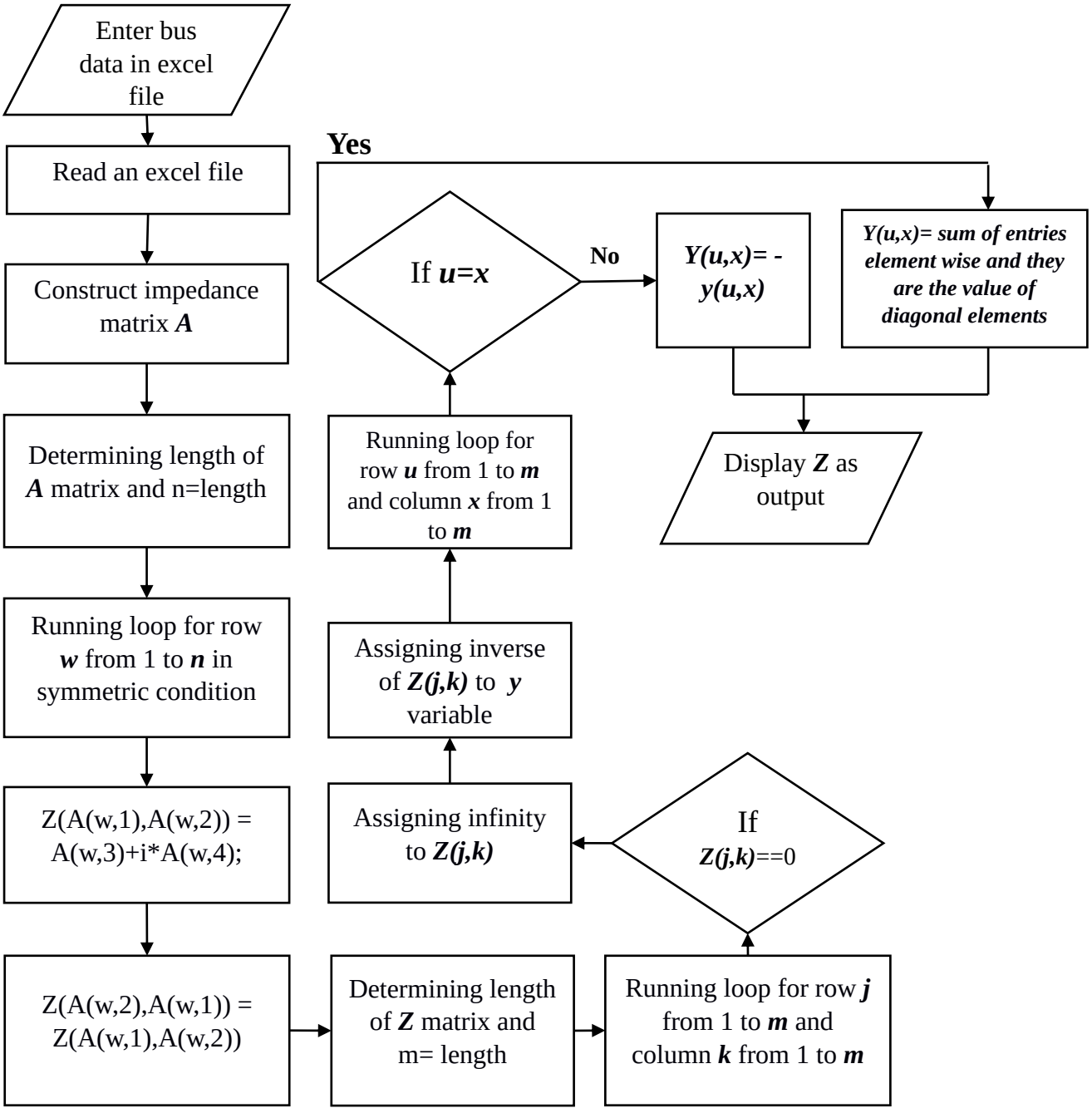
Fig 3.1: Diagram of Y- bus no.2

3.6 Algorithm

1. Start
2. Read an excel file that has bus numbers ***i*** and ***j*** in the first two columns and resistance and admittance value in the third and fourth columns which represent impedance between the buses
3. Construct a matrix ***A*** whose element $a_{i,j}$ denotes the impedance between ***i*** and ***j*** buses
4. Determine the length of matrix ***A***
5. Perform symmetric condition and construct a new matrix ***Z*** where 3rd and 4th column element of the excel file is equivalent to ***a+bj*** and it can be assigned to $Z_{i,j}$ later applying symmetric condition $Z_{i,j} = Z_{j,i}$
6. Determine the length of new matrix ***Z***
7. Use looping condition for row j from 1 to length of Z and for column k from1 to length Z

8. If value of ***j*** row and ***k*** column is equal to zero, assign the element value as infinity
9. Determine inverse matrix of ***Z*** and assigned to ***Z***
10. Calculate the summation of ***Y*** matrix element row wise
11. Use looping condition for row u from1 to length of ***Z*** and for column x from1 to length ***Z***
12. Use formula if ***u≠x*** $Y_{ux} = -y_{ux}$, else $Y_{ux} = \sum_{k=1}^{n} y_{ux}$
13. Display ***Y*** as output
14. End

3.7 Flow chart



3.8 MATLAB Code & Output

- **Generalized MATLAB Code for Y bus no.1**

```
clc;  %Clears previous data from command window
clear all; %Removes all variables from the current workspace
cd('F:\Study material\Lab\3-2\Power System I'); %change the
file directory
A = xlsread('Exp02'); %Read the excel file
n = length(A); %Determine the length of the excel file

% Applying symmetric condition
for w=1:n
     Z(A(w,1),A(w,2)) = A(w,3)+i*A(w,4);
     Z(A(w,2),A(w,1)) = A(w,3)+i*A(w,4);
end

m = length(Z) %Determine the length of the new matrix
for j=1:m
     for k=1:m
         if Z(j,k) == 0
            Z(j,k) = inf;
         end
     end
end
fprintf(' Z matrix is \n') %Display the text
disp(Z) %Display the output
y = 1./Z %Taking inverse impedance matrix
p = sum(y,2) %Taking symmetric summation

%Apply looping condition to determine value of the matrix
element
for u=1:m
     for x=1:m
         if u~=x
            Y(u,x)= -y(u,x); %For diagonal element
         else
            Y(u,x)= p(u); %For non-diagonal element
         end
     end
end
fprintf(' Y- bus matrix is \n') %Display the text
disp(Y) %Display the output
```

- **Output**

```
m =

   4
```

Z matrix is

0.0000 + 0.1000i 0.0000 + 0.4000i 0.0000 + 0.2000i Inf + 0.0000i

0.0000 + 0.4000i 0.0000 + 0.8000i 0.0000 + 0.2000i Inf + 0.0000i

0.0000 + 0.2000i 0.0000 + 0.2000i Inf + 0.0000i 0.0000 + 0.0800i

Inf + 0.0000i Inf + 0.0000i 0.0000 + 0.0800i Inf + 0.0000i

y =

0.0000 -10.0000i 0.0000 - 2.5000i 0.0000 - 5.0000i 0.0000 + 0.0000i

0.0000 - 2.5000i 0.0000 - 1.2500i 0.0000 - 5.0000i 0.0000 + 0.0000i

0.0000 - 5.0000i 0.0000 - 5.0000i 0.0000 + 0.0000i 0.0000 -12.5000i

0.0000 + 0.0000i 0.0000 + 0.0000i 0.0000 -12.5000i 0.0000 + 0.0000i

p =

0.0000 -17.5000i

0.0000 - 8.7500i

0.0000 -22.5000i

0.0000 -12.5000i

Y- bus matrix is

0.0000 -17.5000i 0.0000 + 2.5000i 0.0000 + 5.0000i 0.0000 + 0.0000i

0.0000 + 2.5000i 0.0000 - 8.7500i 0.0000 + 5.0000i 0.0000 + 0.0000i

0.0000 + 5.0000i 0.0000 + 5.0000i 0.0000 -22.5000i 0.0000 +12.5000i

0.0000 + 0.0000i 0.0000 + 0.0000i 0.0000 +12.5000i 0.0000 -12.5000i

- **Generalized MATLAB Code for Y bus no.2**

```
clc;  %Clears previous data from command window
clear all; %Removes all variables from the current workspace
cd('F:\Study material\Lab\3-2\Power System I'); %change the
file directory
A = xlsread('Exp02'); %Read the excel file
n = length(A); %Determine the length of the excel file

% Applying symmetric condition
for w=1:n
```

```
    Z(A(w,1),A(w,2)) = A(w,3)+i*A(w,4);
    Z(A(w,2),A(w,1)) = A(w,3)+i*A(w,4);
end

m = length(Z) %Determine the length of the new matrix
for j=1:m
    for k=1:m
        if Z(j,k) == 0
            Z(j,k) = inf;
        end
    end
end
fprintf(' Z matrix is \n') %Display the text
disp(Z) %Display the output
y = 1./Z %Taking inverse impedance matrix
p = sum(y,2) %Taking symmetric summation

%Apply looping condition to determine value of the matrix
element
for u=1:m
    for x=1:m
        if u~=x
            Y(u,x)= -y(u,x); %For diagonal element
        else
            Y(u,x)= p(u); %For non-diagonal element
        end
    end
end
fprintf(' Y- bus matrix is \n') %Display the text
disp(Y) %Display the output
```

- **Output**

m =

3

Z matrix is

0.0000 + 1.0000i 0.0500 + 0.2500i 0.0400 + 0.0200i

0.0500 + 0.2500i 0.0000 + 1.0000i 0.0300 + 0.1500i

0.0400 + 0.0200i 0.0300 + 0.1500i Inf + 0.0000i

y =

0.0000 - 1.0000i 0.7692 - 3.8462i 20.0000 -10.0000i

0.7692 - 3.8462i 0.0000 - 1.0000i 1.2821 - 6.4103i

20.0000 -10.0000i 1.2821 - 6.4103i 0.0000 + 0.0000i

p =

20.7692 -14.8462i

2.0513 -11.2564i

21.2821 -16.4103i

Y- bus matrix is

20.7692 -14.8462i -0.7692 + 3.8462i -20.0000 +10.0000i

-0.7692 + 3.8462i 2.0513 -11.2564i -1.2821 + 6.4103i

-20.0000 +10.0000i -1.2821 + 6.4103i 21.2821 -16.4103i

3.9 Discussion & Conclusion

In this experiment, we designed an algorithm, flow chart, and programmed a generalized code for two different Y- bus system. In each case, we extracted the values from an excel file and formulated necessary condition to assign values to variables. Through this generalized coding format, we easily design and calculate Y bus matrix for any given power system.

The only adjustment to the code we may need is changing the directory of the file to work with and the given data saved inside the file. The bus numbers and the resistance and reactance values must also be given in the order defined for the code to work and give accurate result.