# Experiment No. 04

## 4.1 Experiment Name

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

## 4.2 Objectives

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

## 4.3 Apparatus

- MATLAB

## 4.4 Theory

The Y-bus matrix is a N × N matrix used in power engineering to describe a power system with N buses. In a practical power system, each bus is often connected to only a few other buses via transmission lines.

In terms of load currents, 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. If $\boldsymbol{I_{bus}}$ is the bus currents in matrix form and $\boldsymbol{Y_{bus}}$ is the admittance matrix and $\boldsymbol{V_{bus}}$ is the bus voltages in matrix form then they can be related as $\boldsymbol{I_{bus}}=\boldsymbol{Y_{bus}V_{bus}}$

The current and voltage of specific branches under different situations are sometimes more interesting than others. In that instance, the unimportant buses can be decreased to make the system easier to understand. Buses from bus admittance matrix can be reduced using the following equation:

$$\boldsymbol{Y_{i,j}}(new) = \boldsymbol{Y_{i,j}}(old) - \frac{\boldsymbol{Y_{i,n}} * \boldsymbol{Y_{n,j}}}{\boldsymbol{Y_{n,n}}}$$

Here $\boldsymbol{i}$, $\boldsymbol{j}$=1,2,3, .........(n-1) and $\boldsymbol{Y}$ is the bus admittance matrix. By using the reduced bus, the admittance between the buses directly not connected can be found and using that admittance power flow can be determined.

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.

## 4.5 Required apparatus

- MATLAB

## 4.6 Block diagram

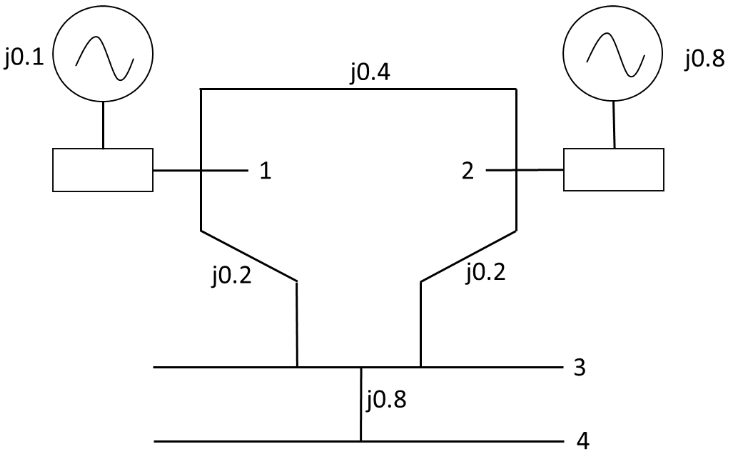



*Fig. 4.1: Diagram of Y- bus no.1*

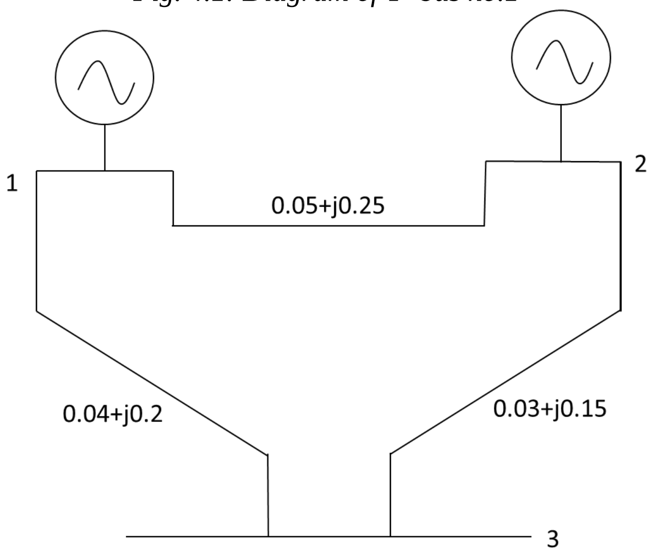



*Fig. 4.2: Diagram of Y- bus no.2*

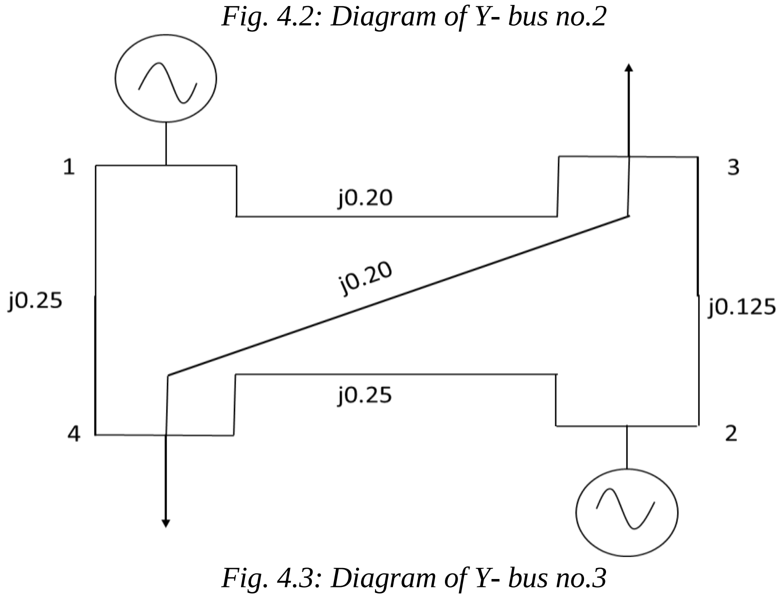



*Fig. 4.3: Diagram of Y- bus no.3*

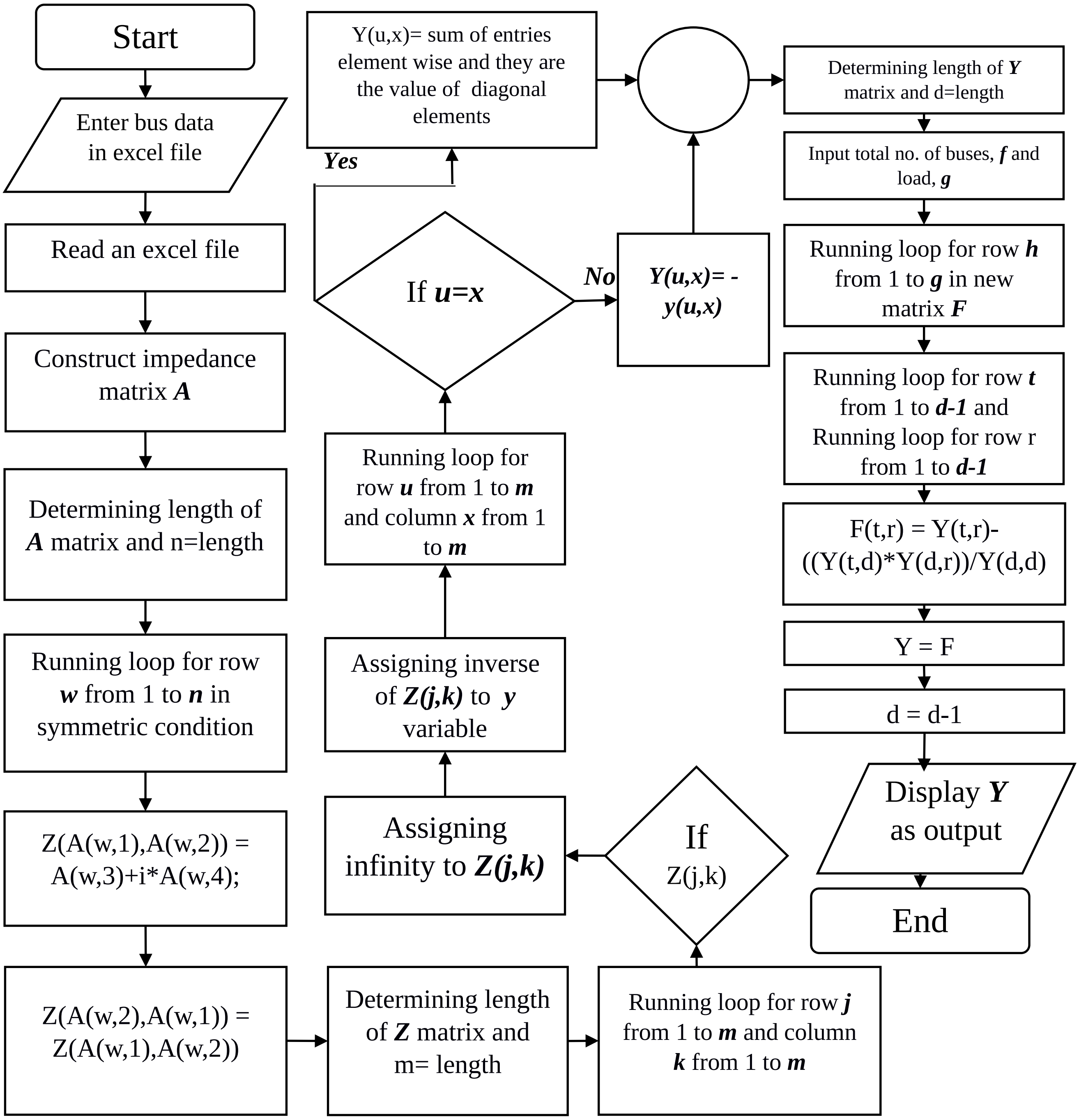
### 4.7 Algorithm

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*** from 1 to length of ***Z*** and for column ***x*** from 1 to length ***Z***
12. Use formula if $u \neq x$ $Y_{ux} = -y_{ux}$, else $Y_{ux} = \sum_{k=1}^{n} y_{ux}$
13. Display ***Y*** as output
14. Determine the length of ***Y*** bus matrix
15. Provide the total no. of buses and load to be reduced as input
16. Use looping condition for ***h*** from 1 to length of load to be reduced and define new matrix, ***F*** inside the loop
17. Now use the formula inside a loop condition where for row ***t*** from 1 to (total no. Of buses-1) and for column ***r*** from 1 to (total no. of buses-1) to obtain the reduced bus matrix,

$$\boldsymbol{Y}_{i,j}(new) = \boldsymbol{Y}_{i,j}(old) - \frac{\boldsymbol{Y}_{i,n} * \boldsymbol{Y}_{n,j}}{\boldsymbol{Y}_{n,n}}$$

18. End

### 4.8 Flow chart



### 4.9 MATLAB Code & Output

- **Generalized MATLAB Code for Y bus reduction for all the problems**

```
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
d = length(Y);
f = input('Total no. of buses: ');
g = input('No. of reduction: ');
for h=1:g %No. of reduction
     F = zeros(d-1); %Define a new matrix
     for t=1:(d-1) %Access all Y matrix element
         for r=1:(d-1) %
         F(t,r) = Y(t,r)-((Y(t,d)*Y(d,r))/Y(d,d));
         end
     end
     Y = F;
    d = d-1;
```

```
end
fprintf(' Z matrix is \n') %Display the text
disp(Y)
```

- **Output for Y- bus no. 1**

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
```

Total no. of buses: 4

No. of reduction: 2

Reduced Y- bus matrix is

```
   0.0000 -15.0000i   0.0000 + 5.0000i
   0.0000 + 5.0000i   0.0000 - 6.2500i
```

- **Output for Y- bus no. 2**

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

Total no. of buses: 3

No. of reduction: 1

Reduced Y- bus matrix is

2.8402 - 9.8757i  -2.8402 + 8.8757i

-2.8402 + 8.8757i   2.8402 - 9.8757i

- **Output for Y- bus no. 3**

Z matrix is

Inf + 0.0000i      Inf + 0.0000i   0.0000 + 0.2000i   0.0000 + 0.2500i

Inf + 0.0000i      Inf + 0.0000i   0.0000 + 0.1250i   0.0000 + 0.2500i

0.0000 + 0.2000i   0.0000 + 0.1250i      Inf + 0.0000i   0.0000 + 0.2000i

0.0000 + 0.2500i   0.0000 + 0.2500i   0.0000 + 0.2000i      Inf + 0.0000i y =

0.0000 + 0.0000i   0.0000 + 0.0000i   0.0000 - 5.0000i   0.0000 - 4.0000i

0.0000 + 0.0000i   0.0000 + 0.0000i   0.0000 - 8.0000i   0.0000 - 4.0000i

0.0000 - 5.0000i   0.0000 - 8.0000i   0.0000 + 0.0000i   0.0000 - 5.0000i

0.0000 - 4.0000i   0.0000 - 4.0000i   0.0000 - 5.0000i   0.0000 + 0.0000i

p =

0.0000 - 9.0000i

0.0000 -12.0000i

0.0000 -18.0000i

0.0000 -13.0000i

Y- bus matrix is

0.0000 - 9.0000i   0.0000 + 0.0000i   0.0000 + 5.0000i   0.0000 + 4.0000i

0.0000 + 0.0000i   0.0000 -12.0000i   0.0000 + 8.0000i   0.0000 + 4.0000i

0.0000 + 5.0000i   0.0000 + 8.0000i   0.0000 -18.0000i   0.0000 + 5.0000i

0.0000 + 4.0000i   0.0000 + 4.0000i   0.0000 + 5.0000i   0.0000 -13.0000i

Total no. of buses: 4

No. of reduction: 2

Reduced Y- bus matrix is

0.0000 - 5.1100i   0.0000 + 5.1100i

0.0000 + 5.1100i   0.0000 - 5.1100i

## 4.10 Discussion & Conclusion

In this experiment, we designed an algorithm, flow chart, and programmed a generalized code for three 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 reduced 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.