# Title Page

## Load Flow Analysis of a Multi-Bus Power System

## Network

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|---|---|
| **Course Code: EEE- 3520**<br>**Course Title: Power System Analysis Sessional**<br>**Course Teacher: Engr. Sk. Md. Golam Mostafa**<br>              **Associate Professor of EEE, IIUC**<br>**Date of Submission: 16.01.2025** | |

# Simulation Report: Load Flow Analysis of a Multi-Bus Power System Network

## 1. Introduction

Load flow analysis is a crucial tool in power system studies to understand the steady-state operation of electrical networks. This report presents the load flow analysis for a 9-bus power system network, focusing on the determination of bus voltages, line power flows, and system losses. The objective is to identify potential issues, such as voltage violations or high losses, and propose recommendations for system improvements.

## 2. Methodology

**Network Modeling**: The 9-bus system includes 3 generator buses (slack and PV type) and 6 load buses (PQ type) connected via 10 transmission lines.

**Software Used**: MATLAB was employed to perform the load flow analysis using the Newton-Raphson method.

**Data Parameters**: System data (bus, line, generation, and load) were derived based on unique University ID (UID).

- **Voltage Magnitude Limits**: 0.95 to 1.05 p.u.
- **Slack Bus**: Voltage set at 1.0 p.u.
- **Generator Limits**:

    - Pmax=(04 × 10) MW = 40 MW
    - Qmax=(04 × 5) MVAr = 20 MVAR

  **Load Demands** : Load demand at PQ buses:

    - Active Power = (22 × 5) MW = 110MW
    - Reactive Power = (06 × 2) MVAr = 12 MVAr

**Line Data:**

   **- Impedance (R+jX) for each line**:

- **Resistance (R)** = (02 × 0.01) Ω = 0.02 Ω
- **Reactance (X)** =(06 × 0.02) Ω = 0.12 Ω

**Analysis**: Load flow results were obtained using MATLAB's simulation environment.

# MATLAB Code:

```
clc;

clear;


% Input Data based on Student ID: ET223104


Pmax = 40; % Maximum active power generation (MW)

Qmax = 20; % Maximum reactive power generation (MVAr)

Pd = 110;  % Active power demand at load buses (MW)

Qd = 12;   % Reactive power demand at load buses (MVAr)

R = 0.02;  % Line resistance (pu)

X = 0.12;  % Line reactance (pu)


% Bus Data

bus_data = [

  1 3 0   0    1.0  0; % Slack Bus

  2 2 0   0    1.05  0; % Generator Bus

  3 1 Pd  Qd   1.0  0; % Load Bus
```

```
    4 1 Pd  Qd    1.0   0; % Load Bus

    5 2 0   0     1.05  0; % Generator Bus

    6 1 Pd  Qd    1.0   0; % Load Bus

    7 2 0   0     1.05  0; % Generator Bus

    8 1 Pd  Qd    1.0   0; % Load Bus

    9 1 Pd  Qd    1.0   0; % Load Bus
];


% Line Data
line_data = [

    1 2 R X 0; % Line from Bus 1 to Bus 2

    1 4 R X 0; % Line from Bus 1 to Bus 4

    2 3 R X 0; % Line from Bus 2 to Bus 3

    3 4 R X 0; % Line from Bus 3 to Bus 4

    4 5 R X 0; % Line from Bus 4 to Bus 5

    5 6 R X 0; % Line from Bus 5 to Bus 6

    6 7 R X 0; % Line from Bus 6 to Bus 7

    7 8 R X 0; % Line from Bus 7 to Bus 8

    8 9 R X 0; % Line from Bus 8 to Bus 9

    9 1 R X 0; % Line from Bus 9 to Bus 1
];


% Convert data to Matpower format

mpc.version = '2';

mpc.baseMVA = 100;
```

```matlab
% Bus Matrix

mpc.bus = [

    bus_data(:,1), ... % Bus Number

    bus_data(:,2), ... % Bus Type

    bus_data(:,3), ... % Pd

    bus_data(:,4), ... % Qd

    zeros(size(bus_data,1),1), ... % Gs

    zeros(size(bus_data,1),1), ... % Bs

    ones(size(bus_data,1),1)*100, ... % Area

    bus_data(:,5), ... % Vm

    bus_data(:,6), ... % Va

    ones(size(bus_data,1),1)*230, ... % BaseKV

    ones(size(bus_data,1),1), ... % Zone

    1.1*ones(size(bus_data,1),1), ... % Vmax

    0.9*ones(size(bus_data,1),1) ... % Vmin

];


% Generator Matrix

gen_bus = find(bus_data(:,2) == 2);

mpc.gen = [

    gen_bus, ... % Bus Number

    Pmax*ones(size(gen_bus)), ... % Pg

    zeros(size(gen_bus)), ... % Qg

    Qmax*ones(size(gen_bus)), ... % Qmax
```

```
    -Qmax*ones(size(gen_bus)), ... % Qmin

    ones(size(gen_bus)), ... % Vg

    100*ones(size(gen_bus)), ... % mBase

    ones(size(gen_bus)), ... % Status

    Pmax*ones(size(gen_bus)), ... % Pmax

    zeros(size(gen_bus)), ... % Pmin

];


% Branch Matrix
mpc.branch = [

    line_data(:,1:2), ... % From and To Buses

    line_data(:,3), ... % R

    line_data(:,4), ... % X

    line_data(:,5), ... % B

    999*ones(size(line_data,1),1), ... % RateA

    zeros(size(line_data,1),1), ... % RateB

    zeros(size(line_data,1),1), ... % RateC

    ones(size(line_data,1),1), ... % Tap

    zeros(size(line_data,1),1), ... % Shift Angle

    ones(size(line_data,1),1), ... % Branch Status

    -360*ones(size(line_data,1),1), ... % Minimum Angle Difference

    360*ones(size(line_data,1),1) ... % Maximum Angle Difference

];
```

## Library for Simulation & Code:

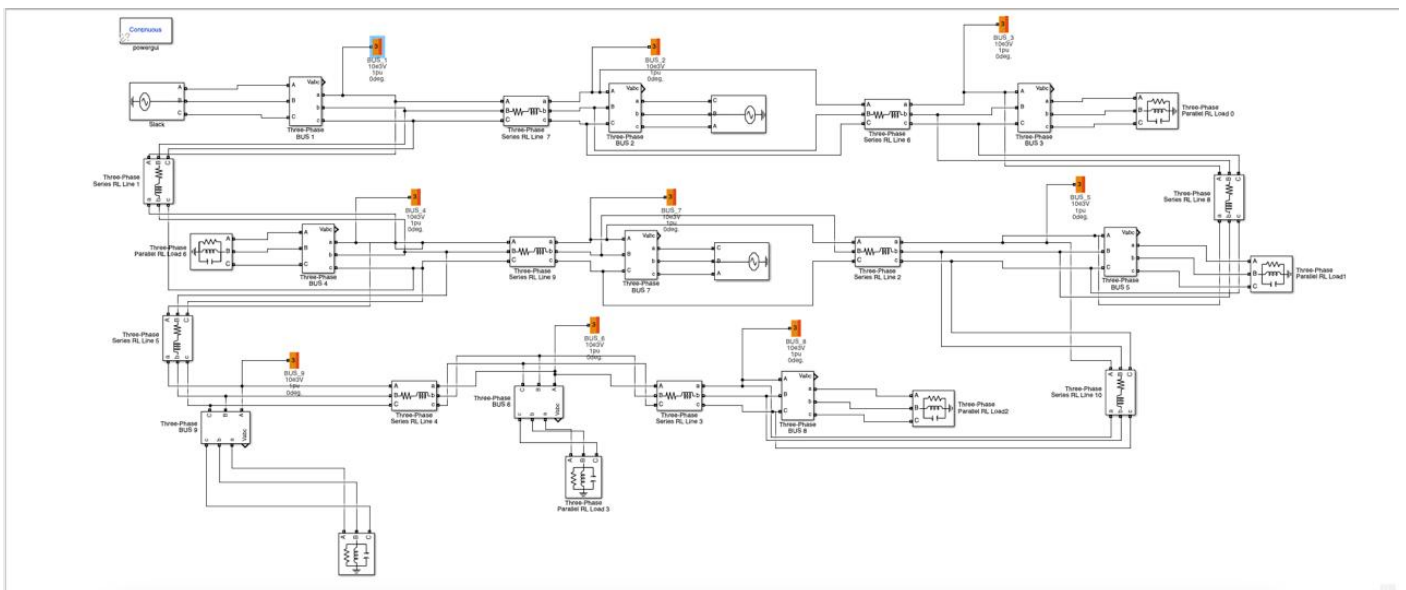① Simulation: For Simulation its need <u>Simscape Power Library</u>.

② Code : For Our Code Generation its need <u>Mathpower 6.0 version</u>. Must include the all header file path In Matlab path include section.

## 3. Results

The results are summarized in tabular and graphical formats:

## Matlab Graphical Simulation:



**Fig: MATLAB Graphical Simulation with 9 Bus and 10 Transmission Line**

**Load Flow Analyzer**

Model  Units  Help

Model: ET223104_complex_lab    [Update]    The load flow converged!  The table shows the load flow solution. Click Apply to update the model with this solution.    [Compute] [Apply] [Add bus blocks] [Report]

| | Block name | Block type | Bus type | Bus ID | Vbase (kV) | Vref (pu) | Vangle (deg) | P (MW) | Q (Mvar) | Qmin (Mvar) | Qmax (Mvar) | V_LF (pu) | Vangle_LF (deg) | P_LF (MW) | Q_LF (MVA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Slack | Vsrc | swing | BUS_1 | 10.0000 | 1.0000 | 0 | 40.0000 | 20.0000 | -Inf | Inf | 1.0000 | 0 | 991.8063 | 483.2341 |
| 2 | Three-Phase Source2 | Vsrc | PQ | BUS_2 | 10.0000 | 1.0500 | 0 | 40.0000 | 20.0000 | -Inf | Inf | 0 | 0 | 0 | NaN |
| 3 | Three-Phase Parallel RL Load 0 | RLC load | PQ | BUS_3 | 10.0000 | 1.0500 | 0 | 110.0000 | 11.9999 | -Inf | Inf | 0.7507 | -16.5121 | 110.0000 | 11.9999 |
| 4 | Three-Phase Parallel RL Load 6 | RLC load | PQ | BUS_4 | 10.0000 | 1.0500 | 0 | 110.0000 | 11.9999 | -Inf | Inf | 0.7799 | -13.1813 | 110.0000 | 11.9999 |
| 5 | Three-Phase Source1 | Vsrc | PQ | BUS_7 | 10.0000 | 1.0500 | 0 | 40.0000 | 20.0000 | -Inf | Inf | 0 | 0 | 0 | NaN |
| 6 | Three-Phase Parallel RLC Load4 | RLC load | PQ | BUS_9 | 10.0000 | 1.0500 | 0 | 110.0000 | 11.9999 | -Inf | Inf | 0.6857 | -22.1340 | 110.0000 | 11.9999 |
| 7 | Three-Phase Parallel RL Load 3 | RLC load | PQ | BUS_6 | 10.0000 | 1.0500 | 0 | 110.0000 | 11.9999 | -Inf | Inf | 0.6431 | -27.5475 | 110.0000 | 11.9999 |
| 8 | Three-Phase Parallel RL Load2 | RLC load | PQ | BUS_8 | 10.0000 | 1.0500 | 0 | 110.0000 | 11.9999 | -Inf | Inf | 0.6451 | -27.5446 | 110.0000 | 11.9999 |
| 9 | Three-Phase Parallel RL Load1 | RLC load | PQ | BUS_5 | 10.0000 | 1.0500 | 0 | 110.0000 | 11.9999 | -Inf | Inf | 0.6917 | -22.1902 | 110.0000 | 11.9999 |

# Fig: MATLAB Simulation Result

## Bus voltages, line flows, and system losses in tabular

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**Command Window**

```
MATPOWER Version 6.0, 16-Dec-2016 -- AC Power Flow (Newton)

Newton's method power flow converged in 5 iterations.

Converged in 0.33 seconds
============================================================================
|     System Summary                                                        |
============================================================================

How many?                    How much?           P (MW)          Q (MVAr)
---------------------        ---------------     -------------   -----------------
Buses               9        Total Gen Capacity  120.0           -60.0 to 60.0
Generators          3        On-line Capacity    120.0           -60.0 to 60.0
Committed Gens      3        Generation (actual) 605.7            394.0
Loads               5        Load                550.0            60.0
  Fixed             5          Fixed             550.0            60.0
  Dispatchable      0          Dispatchable      -0.0 of -0.0     -0.0
Shunts              0        Shunt (inj)         -0.0             0.0
Branches            10       Losses (I^2 * Z)    55.66            333.97
Transformers        10       Branch Charging (inj)  –             0.0
Inter-ties          0        Total Inter-tie Flow  0.0            0.0
Areas               1

                     Minimum                      Maximum
            ---------------------------    ---------------------------------
Voltage Magnitude    0.840 p.u. @ bus 9         1.000 p.u. @ bus 2
Voltage Angle       -46.12 deg   @ bus 8        0.00 deg   @ bus 2
P Losses (I^2*R)         –                       18.25 MW   @ line 1-2
Q Losses (I^2*X)         –                       109.51 MVAr @ line 1-2
```

```
================================================================================
|      Bus Data                                                                |
================================================================================
 Bus        Voltage           Generation            Load
  #    Mag(pu) Ang(deg)    P (MW)   Q (MVAr)    P (MW)   Q (MVAr)
----- -------- --------   -------- --------    -------- --------
   1   0.876  -21.301*       -         -          -         -
   2   1.000    0.000     525.66    185.39        -         -
   3   0.899  -17.836        -         -       110.00     12.00
   4   0.902  -28.194        -         -       110.00     12.00
   5   1.000  -35.271      40.00    108.39        -         -
   6   0.976  -43.365        -         -       110.00     12.00
   7   1.000  -43.827      40.00    100.19        -         -
   8   0.896  -46.118        -         -       110.00     12.00
   9   0.840  -38.966        -         -       110.00     12.00
                          -------- --------    -------- --------
                  Total:   605.66    393.97     550.00     60.00


================================================================================
|      Branch Data                                                             |
================================================================================
Brnch  From   To    From Bus Injection    To Bus Injection      Loss (I^2 * Z)
  #    Bus   Bus    P (MW)   Q (MVAr)    P (MW)   Q (MVAr)    P (MW)   Q (MVAr)
----- ----- -----  -------- --------    -------- --------    -------- --------
   1    1     2     -264.61     3.45      282.86   106.06      18.251   109.51
   2    1     4       74.58   -26.78      -72.94    36.59       1.636     9.82
   3    2     3      242.81    79.33     -229.76    -1.04      13.050    78.30
   4    3     4      119.76   -10.96     -116.18    32.41       3.575    21.45
   5    4     5       79.12   -81.01      -75.97    99.91       3.151    18.91
   6    5     6      115.97     8.47     -113.27     7.75       2.704    16.23
   7    6     7        3.27   -19.75       -3.18    20.26       0.084     0.50
   8    7     8       43.18    79.93      -41.53   -70.03       1.651     9.90
   9    8     9      -68.47    58.03       70.47   -45.99       2.006    12.04
  10    9     1     -180.47    33.99      190.03    23.33       9.553    57.32
                                                              -------- --------
                                                      Total:   55.661   333.97
```

Total:    55

```
Power Flow Results:
        version: '2'
        baseMVA: 100
            bus: [9×13 double]
            gen: [3×10 double]
         branch: [10×17 double]
          order: [1×1 struct]
             et: 0.3282
        success: 1
     iterations: 5
```

## 4. Discussion:

In this experiment we perform Multi-bus Power System in load flow analysis. We have 9 bus three generator , 6 load and 10 Transmission line . First, we set the core component of our simulation which is provide Simscape Power Library,

then we run the simulation and choose the option "Load Flow Analysis" and hit the run button again. The simulation table is shown up. Then we click compute to show our four unknown variable.
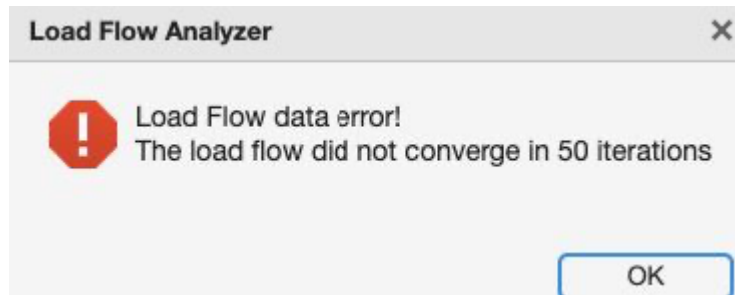


But in Simulink we have only 50 iteration limited that we have shown above. In case, we use common value 0.04 which is given in our requirement, then we compute it and get the result.

Secondly, in matlab code section, we used MATPOWER 6.0 version to get the result of our code. In the code section, we included all given buses, generators and loads. When the code finishes and hit the run button, the result of our code is shown up in MATLAB console and the resluts can be verified from there.

## 5. Conclusion

Load flow analysis is a fundamental tool in power system engineering, enabling the evaluation of the steady-state performance of electrical networks. In the context of the given 9-bus system, it plays a critical role in identifying voltage violations, power losses, and system inefficiencies. This analysis helps ensure reliable power delivery, maintain voltage levels within permissible limits, and minimize losses. By addressing these challenges through corrective actions, such as generator adjustments and capacitor installations, load flow analysis contributes to the overall stability, efficiency, and sustainability of modern power systems, aligning with both technical and societal energy needs.