Development of A Power System Simulation Application using MATLAB

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Abstract— **To develop an application in MATLAB which includes Load flow analysis, Short circuit analysis, power angle diagram for synchronous generator and Economic dispatch. This proposed project aims at writing codes in MATLAB m-file for calculation of load flow analysis by Newton-Raphson and Gauss-Seidal methods. Custom made libraries developed in SIMULINK helps to draw power system network(limited to 3 buses) and the inputs such as Voltage, Active power, Reactive power, impedances are taken to the m-file through the GUI. Similarily same methodology is used in short circuit analysis, power angle diagram and economic dispatch. All the four systems are integrated to form the "Canara Power System Simulation" package.**

Keywords— MATLAB, GUI, Simulink, Load flow analysis, Power system, Short circuit analysis.

I. INTRODUCTION

Many power system softwares used in industries are not student friendly and are expensive. Hence there is a need to develop a power system simulation package for training the students for better understanding of load flow analysis ,fault analysis etc in power system.

This proposal is focusing on the development of a tool box for power system using MATLAB/Simulink/GUI.

In this proposal, GUI is developed which will act as a human-machine interface. The given power system is drawn (maximum of 3 buses) using the custom made library developed in Simulink/MATLAB. The library will include generators, buses, load so on. The codes written in m-file will extract the input through GUI and Simulink and computes the load flow calculations and the results are obtained on the GUI.

II. METHODOLOGY

LOAD FLOW ANALYSIS

Load flow analysis is an important tool used by power engineers for planning and determining the steady state operation of a power system. Power flow studies provide a systematic mathematical approach to determine the various bus voltages, phase angles, active and reactive power flows through different branches, generators, transformer settings and load under steady state conditions. Load flow analysis has a great significance in future expansion planning in operation, in stability studies and in determining the best economical operation for existing power systems. Also load flow results are very valuable for setting the proper protection devices to ensure the security of the power system network.

The main information obtained from the load flow or power flow analysis comprises magnitudes and phase angles of load bus voltages, reactive powers and voltage phase angles at generator buses, real and reactive power flows on transmission lines together with power at the reference bus; other variables being specified. The resulting equations in terms of power, known as the power flow equations become non-linear and must be solved by iterative techniques using numerical methods. Numerical methods are techniques by which mathematical problems are formulated so that they can be solved with arithmetic operations and they usually provide only approximate solution.

Classification of Buses:

In Bus Classification, each bus has four variables in the power system: voltage magnitude |V|, voltage phase angle |δ|, real power (P) and reactive power (Q). During the operation in the power system, each bus has two known variables and two unknown variables. Generally, the bus must be classified as one of the following bus types:

1. Slack Bus or Swing Bus
2. Voltage Controlled or Generator Bus (PV)
3. Load Bus (PQ)

Slack or Swing Bus:

1. This bus is taken as the reference bus. Always it is connected to a generator of high rating relative value to the other generators. During the operation in power system, the voltage of this bus must be specified and remains constant in magnitude and angle.

2 Generator or Voltage Controlled Bus:

During the operation in power system network the voltage magnitude at this bus is kept as constant. Also, the active power supplied is kept constant at the magnitude which satisfies the economic operation of the power system.

Load Bus:

This bus is not connected with a generator so that neither voltage nor real power can be controlled in this bus.

LOAD FLOW ANALYSIS BY GAUSS SEIDEL METHOD

The Gauss Seidel (GS) method is a popular iterative algorithm for solving non-linear algebraic equations. An initial solution vector is assumed, chosen from past experiences, statistical data or from practical considerations. At every subsequent iteration, the solution is updated till convergence is reached. The GS method applied to power flow problem is explained in detail below

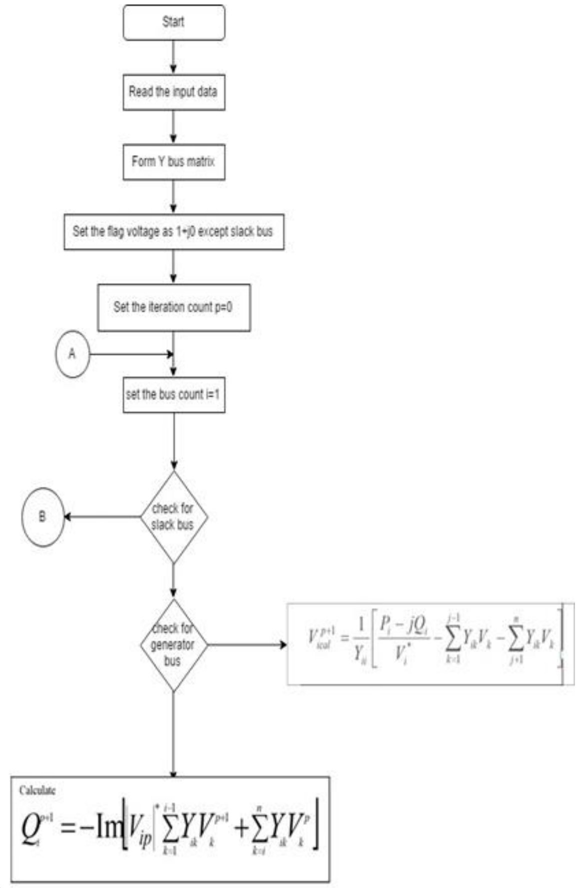

Fig 1: Flowchart for Gauss-Seidal method

LOAD FLOW ANALYSIS BY NEWTON RAPHSON METHOD

This method was named after Isaac Newton and Joseph Raphson. The origin and formulation of Newton-Raphson method was dated back to late 1960s. It is an iterative method which approximates a set of non-linear simultaneous equations to a set of linear simultaneous equations using Taylor's series expansion and the terms are limited to the first approximation. It is the most iterative method used for the load flow because its convergence characteristics are relatively more powerful compared to other alternative processes and the reliability of Newton-Raphson approach is comparatively good since it can solve cases that lead to divergence with other popular processes. If the assumed value is near the solution, then the result is obtained very quickly, but if the assumed value is farther away from the solution then the method may take longer to converge.

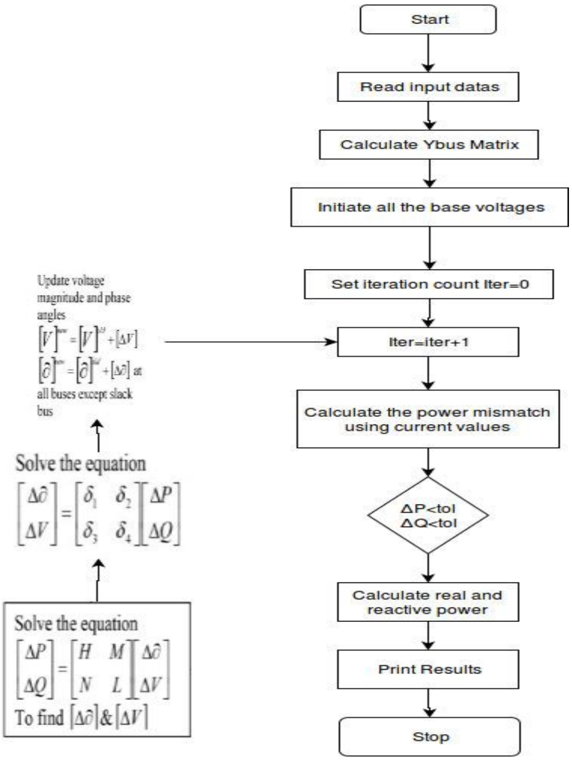

Fig 2: Flowchart for Newton Raphson method

POWER ANGLE DIAGRAM OF SYNCHRONOUS MACHINE.

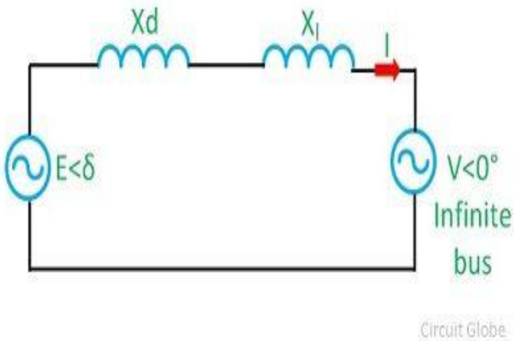

Fig 3: Circuit diagram for power angle diagram of synchronous generator.

Equivalent diagram of synchronous machine connected to an infinite bus through a transmission line of series reactance X_l is shown below .

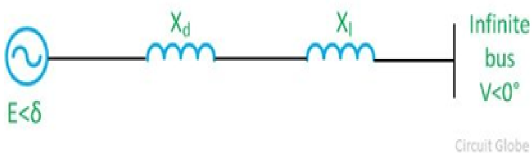

Fig 4: Equivalent diagram.

The graphical representation of P_e and the load angle δ is called the power angle curve. It is widely used in power system stability studies. The power angle curve is shown below

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Maximum power is transferred when δ = 90º. As the value of load angle δ is above 90, Pe decrease and becomes zero at δ = 180º. Above 180º, Pe becomes negative, which show that the direction of power flow is reversed, and the power is supplied from infinite bus to the generator. The value of Pe is often called pull out power. It is also called the steady-state limit.

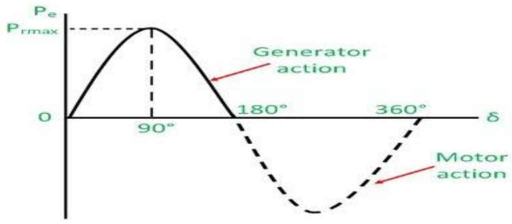


Fig 5: Power angle diagram of a synchronous generator.

SHORT CIRCUIT ANALYSIS

Shunt faults cab be classified into four categories.

• Line to Ground Fault: This type of fault exists when one phase of any transmission lines establishes a connection with the ground either by ice, wind, falling tree or any other incident. 70% of all transmission lines faults are classified under this category.

• Line to Line Fault: As a result of high winds, one phase could touch anther phase & line-to-line fault takes place. 15% of all transmission lines faults are considered line-to-line faults.

• Double Line to Ground Fault: Falling tree where two phases become in contact with the ground could lead to this type of fault. In addition, two phases will be involved instead of one at the line-to-ground faults scenarios. 10% of all transmission lines faults are under this type of faults.

• Three Phase Fault: In this case, falling tower, failure of equipment or even a line breaking and touching the remaining phases can cause three phase faults. In reality, this type of fault not often exists which can be seen from its share of 5% of all transmission lines faults.

III. LIBRARY

SHORT CIRCUIT ANALYSIS

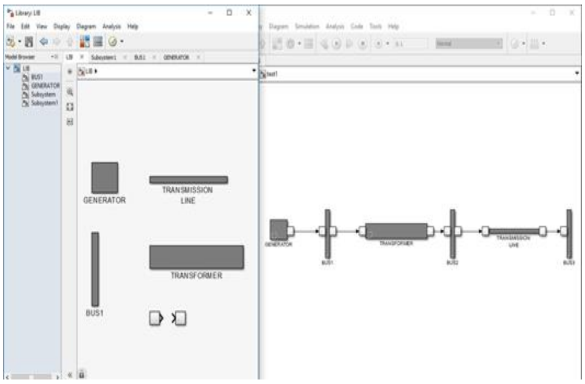


Fig 6: Library for short circuit analysis.

LOAD FLOW ANALYSIS

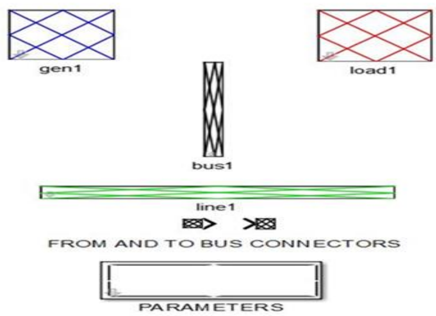


Fig 7: Library for load flow analysis

POWER ANGLE DIAGRAM USING SYNCHRONOUS GENERATOR.

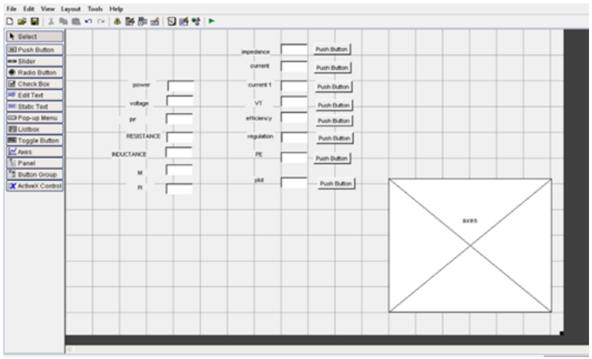


Fig 8: GUI for power angle diagram of a synchronous generator.

IV. RESULT

SHORT CIRCUIT ANALYSIS

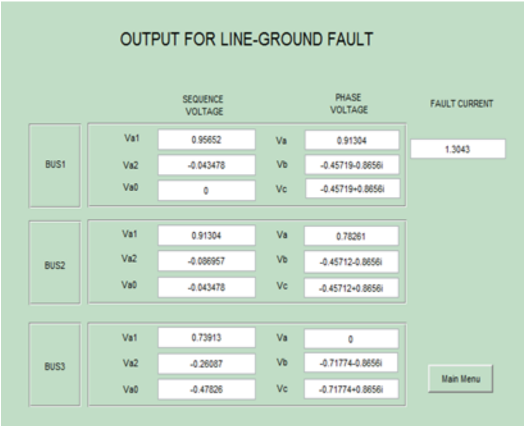
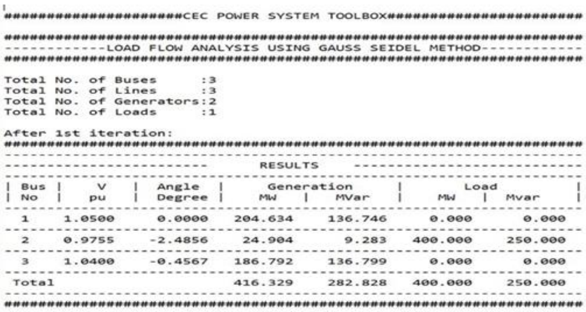


Fig 9: Output window of short circuit analysis.

LOAD FLOW ANALYSIS



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########################CEC POWER SYSTEM TOOLBOX########################

########################################################################
-----------LOAD FLOW ANALYSIS USING GAUSS SEIDEL METHOD-----------
########################################################################

Total No. of Buses      :3
Total No. of Lines      :3
Total No. of Generators:2
Total No. of Loads      :1

After 1st iteration:
########################################################################
------------------------------------------------------------------------
-----------------------        RESULTS     -----------------------------
------------------------------------------------------------------------
| Bus |    V     |  Angle  |      Generation      |        Load        |
| No  |    pu    | Degree  |    MW    |   MVar    |    MW    |  Mvar   |
------------------------------------------------------------------------
   1    1.0500     0.0000    204.634    136.746      0.000      0.000
------------------------------------------------------------------------
   2    0.9755    -2.4856     24.904      9.283    400.000    250.000
------------------------------------------------------------------------
   3    1.0400    -0.4567    186.792    136.799      0.000      0.000
------------------------------------------------------------------------
 Total                       416.329    282.828    400.000    250.000
------------------------------------------------------------------------
########################################################################
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Fig 10: Output window of load flow analysis.

POWER ANGLE DIAGRAM OF SYNCHRONOUS GENERATOR

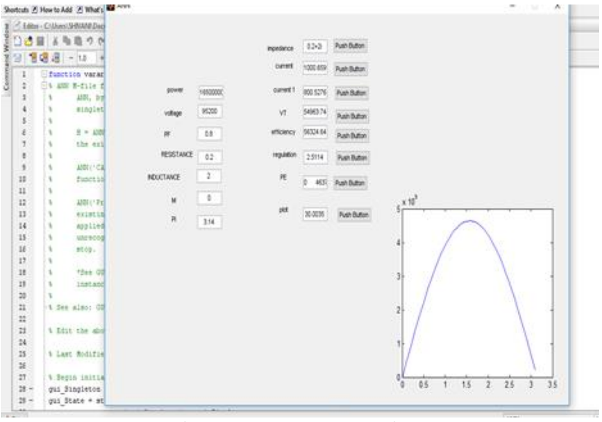

Fig 11: GUI window of power angle diagram of a synchronous generator.

V. CONCLUSION

Today the world demands better technology, better efficiency as well as better methods of solving the problems related to power system analysis. Power flow calculation is very important for power system operation, economic scheduling and planning. The aim of the study is to specifically obtain information on the magnitude and phase angle of the voltage at each bus and the real and reactive power flowing in the line.

For undergraduate study, the students need to manually solve the load flow problems which is time consuming. Commercially available software's have cost barriers and is according to the industrial standards. Recently, GUI MATLAB has become an active part in learning activities as well as to alleviate the students learning process and their understanding on the topic. This creates a need to develop a simple power system load flow analysis tool based by a user friendly graphical user interface using MATLAB.

This tool can be expanded for various power system related applications. Such as,
(i)Calculation of transmission losses in each line.
(ii)Economic load dispatch.
(iii)Short circuit analysis.

VI. ACKNOWLEDGEMENT

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VII. REFERENCES

[1] EMINOGLU, T. GO¨ ZEL,M.H. HOCAOGLU ,"Distribution systems power flow analysis package using Matlab Graphical user interface(GUI)", Article in Computer Applications in Engineering Education • December 2009.Hasmaini. Kuala Lumpur,Malaysia
[2] Mohamad, Zuhaina Zakaria, Muhamad Zulfakri Bin Mazlan ,"Development of GUI Power System Load Flow Analysis Tool based on Newton Raphson Method", Conference Paper • November 2015.
[3] Mudathir F. Akorede & Hashim Haram, "Teaching Power System Analysis Courses using MATPOWER", 2009 International Conference on Engineering EducatiKuala Lumpur,Malaysiaon (lCEED 2009), December 7-8, 2009.
[4] P. S. Bhowmik, D. V. Rajan, S. P. Bose," Load Flow Analysis: An Overview", World Academy of Science, Engineering and Technology International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering Vol: 6, No: 3, 2012.
[5] "Computer Techniques and Models in Power systems "by K. Uma Rao.
[6] "Power System Analysis" by Sadat H., McGraw-Hill
[7] https://in.mathworks.com/matlabcentral