

# A GUI Based Load Flow Analyzer for Power System Study

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**Abstract:** Size and complexity of power systems impose significant challenges for the power system analysis and control. As the power system becomes more complex there is a great need to develop improved and sophisticated tools for power system analysis and simulation. These tools should be able to accurately replicate real events that occur in electric power network and help to understand dynamics of changes. A number of software packages have been developed for power system research, analysis, planning, designing and teaching. Over the years, power networks have become more complex and complicated for the analysis and control. To manage such networks, simulation tools are needed due to their possibility to create accurate simulation and replicate of all the physical effects that are running in the network.

**Keywords:** Power system analysis , software packages , load flow analysis , Matlab , Scilab , open source

## 1. Introduction

### 1.1 Introduction to Micro Grids

While not directly applicable to the project, a micro grid is a type of grid where the power flow problem is very relevant. In the program created for this project, the power network being drawn can be called a micro grid, so a basic understanding of what micro grids are can be useful to understanding the power flow problem, and this project[10]. A micro grid is a localized grouping of power generators, loads, and storage facilities that act as a single entity with regard to the greater grid. Some of the benefits of such a grid are:

- A grid with multiple generators can incorporate renewable energy sources that may have not been able to independently supply the entire grids demands [1, 3].
- A more versatile generation that allows scaling to meet the network's demand and therefore wastes less resources[15].
- Redundancy by not counting on a single source with long transmission lines.
- Use of excess heat locally.
- Future proofing the network by allowing easy upgrades.

The hard part of creating a micro grid is that it requires a lot more planning and calculating as well as a lot more equipment for monitoring and controlling the network. The power flow problem is one of the problems that needs to be solved when planning an efficient micro grid.

### 1.2 Power Flow Problem

A network has three primary components:

- 1) generators that supply power to the network,
- 2) loads that use power from the network (essentially negative generators) and
- 3) buses that distribute the power throughout the network.

The values of a network can be viewed as the value at each bus, these values are:

- The power supplied to the bus, this is the power at the bus (and doesn't take any losses from transmission lines into account).
- The buses shunt admittance (or impedance).
- The admittance (or impedance) between two buses.
- The voltage at each bus.
- The total current at the bus.
- The current between two buses.

Given a network where some of the values are known, and others aren't, the power flow problem aims to solve the unknown values [26]. The system of equations describing the network is essentially Kirchhoff's law at each bus, this is a nonlinear system of equations that can be solved numerically [30].

### 1.3 The Equations

The power being supplied through bus i is:

$$S_{Gi} = P_{Gi} + jQ_{Gi}$$

The power being demanded at bus i is:

$$S_{Li} = P_{Li} + jQ_{Li}$$

Resulting in a total power

$$S_i = S_{Gi} - S_{Li} = P_i + jQ_i$$

The self-admittance at bus i is:

$$Y_{ii} = G_{ii} + jB_{ii}$$

And the line admittance between bus i and bus k is:

$$Y_{ik} = G_{ik} + jB_{ik}$$

The current at each line can be expressed as (n is the total amount of buses):

$$I_i = Y_{ii}V_i + \sum_{1 < k < n, k \neq i} Y_{ik}(V_i - V_k) = V_i \sum_{1 < k < n} Y_{ik} - \sum_{1 < k < n, k \neq i} Y_{ik}V_k$$

If we redefine

$$\tilde{Y}_{kk} = \sum_{1 < k < n} Y_{ik} \text{ and } \tilde{Y}_{ik} = -Y_{ik}$$

We get:

$$I_i = \sum_{1 < k < n} V_k \tilde{Y}_{ik}$$

Using the basic relation between power voltage and current we get

$$S_i = V_i I_i^* = V_i \sum_{1 < k < n} V_k \tilde{Y}_{ik}^*$$

Being that the values are complex and that we are solving for n buses we get a system of 2n equations [22], in a case where 2n values are unknown [i.e. we know the values of the power and the admittances (or impedances) for the network, and would like to figure out the values of the voltages are (the current can be deduced from the voltage

and admittance).] While not linear, this problem can be solved numerically using iterative algorithms such as the Gauss-Seidel method, the Newton-Raphson method and others [23].

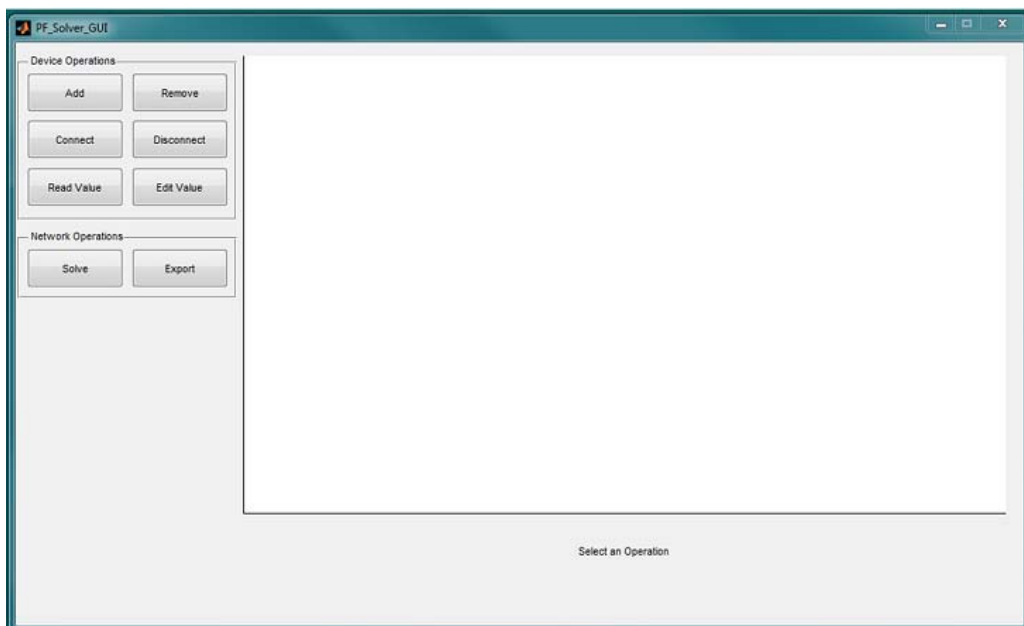
## 2. Result Analysis

### 2.1 Programs Structure

The program was written in Matlab, so Matlab is needed to run it. There are five files associated with this program which all need to be located in the same directory in order for the program to run. The files are:

- PF\_Solver\_GUI.m – The code
- PF\_Solver\_GUI.fig – A figure with many of the programs graphical elements
- Bus.jpeg, Gen.jpeg and Load.jpeg – The icons used for network elements

Running the program is done by opening the code in Matlab and clicking “run”. The program should open in a new window as shown in figure given below:



**Figure 1:** Complete GUI layout of the system

### 2.2 The Schematic

The schematic is the white box on the right of the program. This is where the network is drawn. Below the schematic is a message box which will read instructions and information based on the programs current state [3].

### 2.3 Program Controls

The left of the program is used to draw and solve the network. It is comprised of toggle buttons that need to be clicked in order to perform different operations on the network (only one can be toggled at a time)[1][2]. The operations are divided into two types: device operations

(operations that effect single devices or lines) and network operations (operations that are based on the entire network). Toggling some operations will cause a panel to appear where the user can further control the specific operation [8].

### 2.4 Entering Values

In the various parts of the program, where the user will need to enter values, this is done in a text box. The values entered can be imaginary, prefacing a number with the letters i or j is the proper way to enter imaginary numbers [typing 3 j is equivalent to( ) 3 · j ]. Although the program will recognize arithmetic values in the text box, it is preferred not to enter arithmetic values unless absolutely necessary in order to

avoid entering incorrect values. Where applicable the user can enter a value as admittance (Y) or impedance (Z) where the relationship is

$$Y = \frac{1}{Z} = \frac{\bar{Z}}{Z \cdot \bar{Z}} \text{ (and vice versa).}$$

### 2.5 Program Operations

As stated before program operations are divided into two types of operations: device operations (which effect single devices or lines), and network operations (which are based on the entire network). The options for device operations are: adding, removing, connecting, disconnecting, reading and editing and the options for network operations are: solving the network and exporting the network values [6].

### 2.6 Reading Values

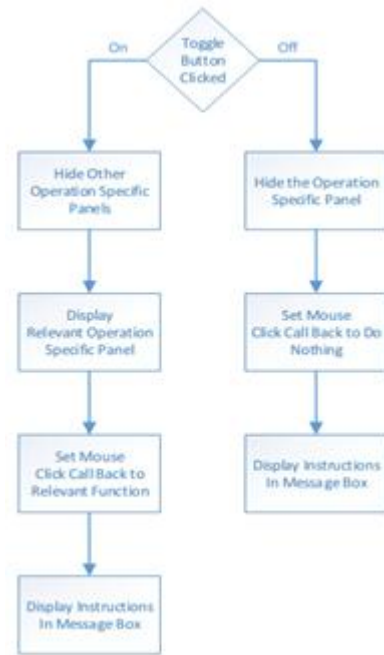
When the “Read Value” button is toggled, a panel is displayed this will allow the user to select whether he wishes to read the value of a device or a line. Reading a device’s value is done by clicking on the device. Reading a line value is done by clicking on the two buses at each end of the line [22]. The values are displayed at the bottom left of the screen. If the network was not yet solved, only the values that were entered will be displayed. Once the network is solved, the last set of results will be displayed. If changes were made to the network since it was last solved, the last set of results will be displayed, along with a notification informing the user that there have been changes made to the network since the last time it was solved. The program will find the following actions invalid:

- Clicking on a location that is not a device.
- When reading a line value, clicking on a load or generator.
- Attempting to read a line value connecting a bus to it (by clicking on the same bus twice).
- Attempting to read a line value between two buses that are not connected [19].

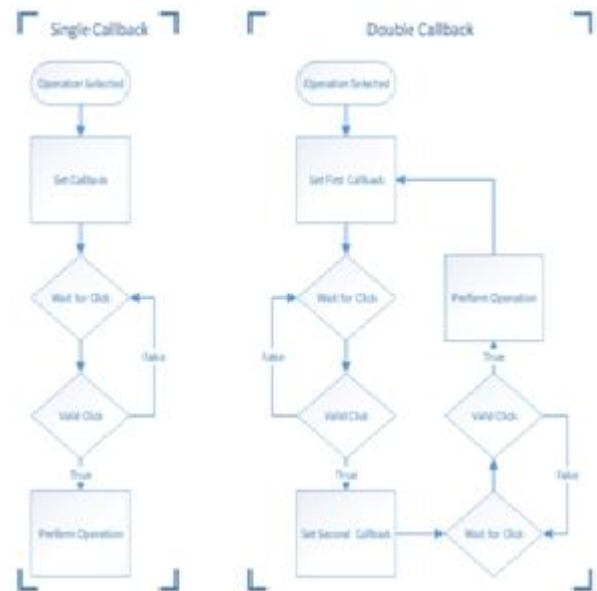
## 3. Algorithms

### 3.1 Back End Algorithms

Various algorithms are used to provide the flexibility to the end user [29]. There have been extensive coding for implementing a graphical user interface which is intuitive [35]. Figure below explains all of them in detail:



**Figure 2:** Algorithm for the toggle buttons



**Figure 3:** Algorithm for single and double callback function

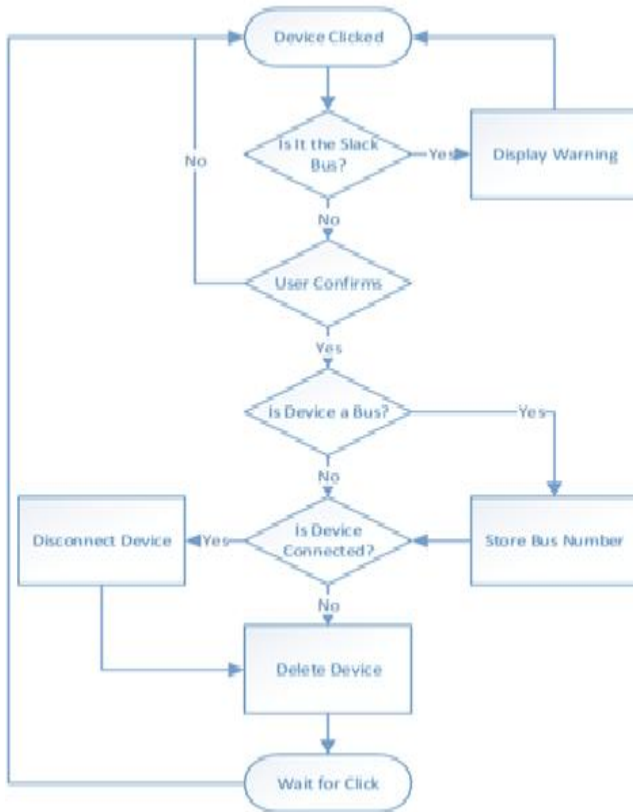


Figure 4: Algorithms for deleting devices

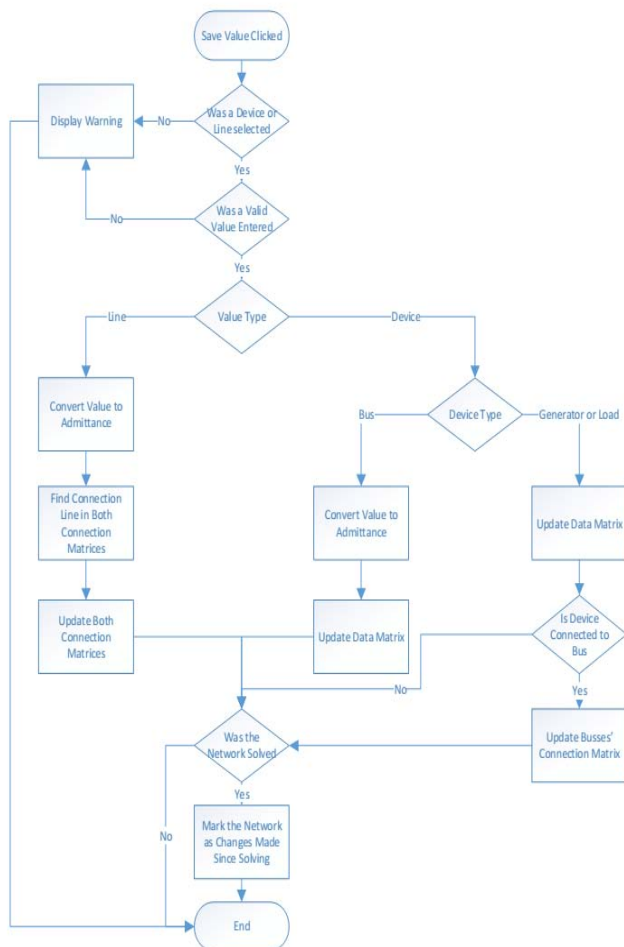


Figure 5: algorithm for adding new devices

## 4. Conclusion

This paper presents an overview of the user friendly and widely used simulation software's of different types used in power systems networks with their unique features. Simulation software's discussed above can be used as a major educational tool in the teaching power systems, power electronics and electrical drive of UG and PG courses as well as in research also . The paper provides relevant information about simulation tools and may act as a potential source of information for simulation agencies, research scholars, manufacturers and electrical utilities working in the field of power systems research.

This paper presents several power system analysis software's which are simple, user-friendly, easy to use and reliable. The software's are designed to give the best possible performance while remaining simple to use and understand. It contains user interface which provides drawing one-line diagrams, entering data parameters and displaying simulation results. User is allowed to manipulate and modify one-line diagrams with the multiple options such as rotate, move, copy, zoom, etc. For better interpretation and visualization of the system, all network components are presented with suitable graphical symbols. This facilitates network creation and gives better demonstration of the principles of electric power flow. Thus, software's can offer great possibilities for engineers, scientists, utilities, manufacturer, and technical or research institutions.

As we have seen in our base paper and other reference papers used in this paper , the software currently being used in the field of power systems are not fit for under graduate students , because either they are too complex or they are not generalized. Our system is very easy to use, as it has graphical user interface and in built help utility for the user . Moreover our system is fully generalized, i.e it is not limited to the no of buses or lines, even very complex power systems can be analyzed using our system.

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