Power System Analysis

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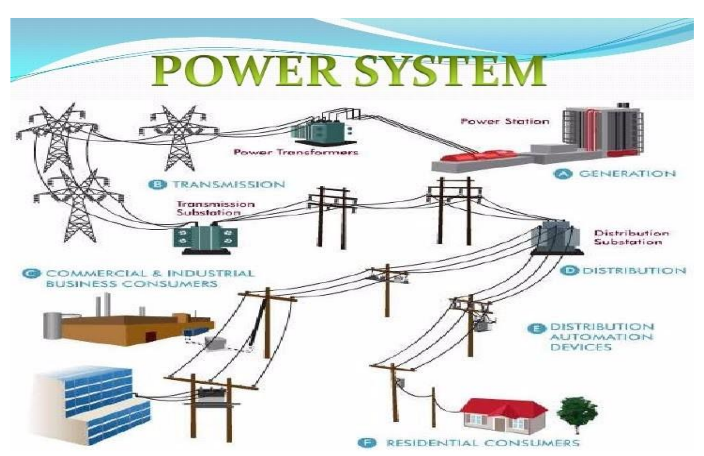
Background

This research project is focused on analyzing power systems under steady state operating conditions. This can be accomplished by solving the Power Flow problem. Power systems are composed of three subsystems: generation, transmission and distribution. The transmission and distribution networks consist of power transformers, transmission lines, capacitors, reactors and protection devices. The purpose of power system analysis is to determine the bus voltages and line power flows for a given set of bus load and scheduled power generation at the various power stations. The main challenge in solving the power flow problem is that the power flow equations are non-linear and thus require the use of an iterative method such as Newton Raphson for the solution.

$$P_k = \sum_{j=1}^{N} |V_k||V_j|\left(G_{kj}\cos(\theta_k - \theta_j) + B_{kj}\sin(\theta_k - \theta_j)\right)$$

$$Q_k = \sum_{j=1}^{N} |V_k||V_j|\left(G_{kj}\sin(\theta_k - \theta_j) - B_{kj}\cos(\theta_k - \theta_j)\right)$$



Introduction

Power systems are specified by two types of data: Bus Data (generation, load, voltages) and Branch Data (parameters R,X,B).Power system buses can be one of three different types. The **Slack Bus**, the **Generation Bus** (PV Bus) and the **Load Bus** (PQ Bus). The slack Bus is used as the reference bus where a reference angle(δ) and voltage(V) are specified.

Bus types	Quantities specified	Unknown values
Generator Bus	$\lvert V_i\rvert$, P_i	Q_i , δ_i
Load Bus	P_i , Q_i	$\lvert V_i\rvert$, δ_i
Slack Bus	$\lvert V_i\rvert$, δ_i	P_i , Q_i

Types of Buses

where;
P = Power
V = Voltage
Q = Reactive Power
δ = Angle

Objective

- The purpose of the research project was to create a **Graphical User Interphase (GUI)** using Matlab in order to facilitate the utilization of power flow data files which have different formats but carry similar information.
- The GUI will select the appropriate executable for the power flow solution based on the type of input files chosen.
- The results for both types of data files will be saved in a common format so that they can be handled and visualized in the same manner irrespective of their input file formats.
- The project also aims to provide a training opportunity for the student to learn more about GUI development in Matlab environment.

Methods

Creating a GUI: The first step of the research was to create graphical user interphase using Matlab.

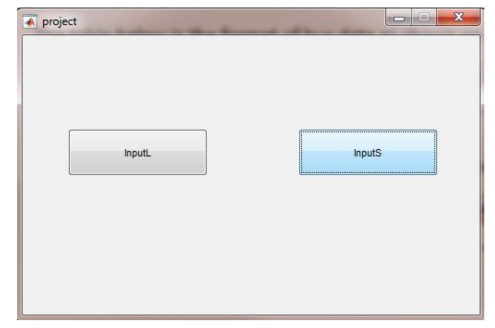


Fig1: First Sample GUI

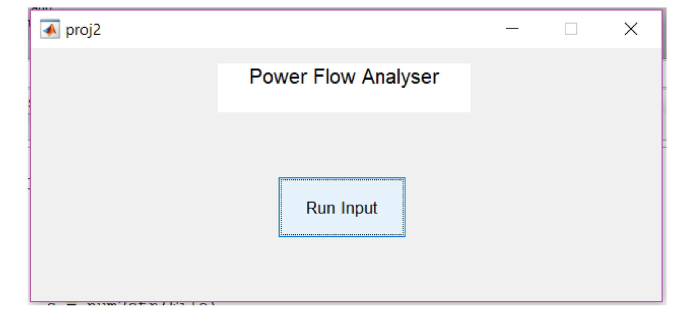
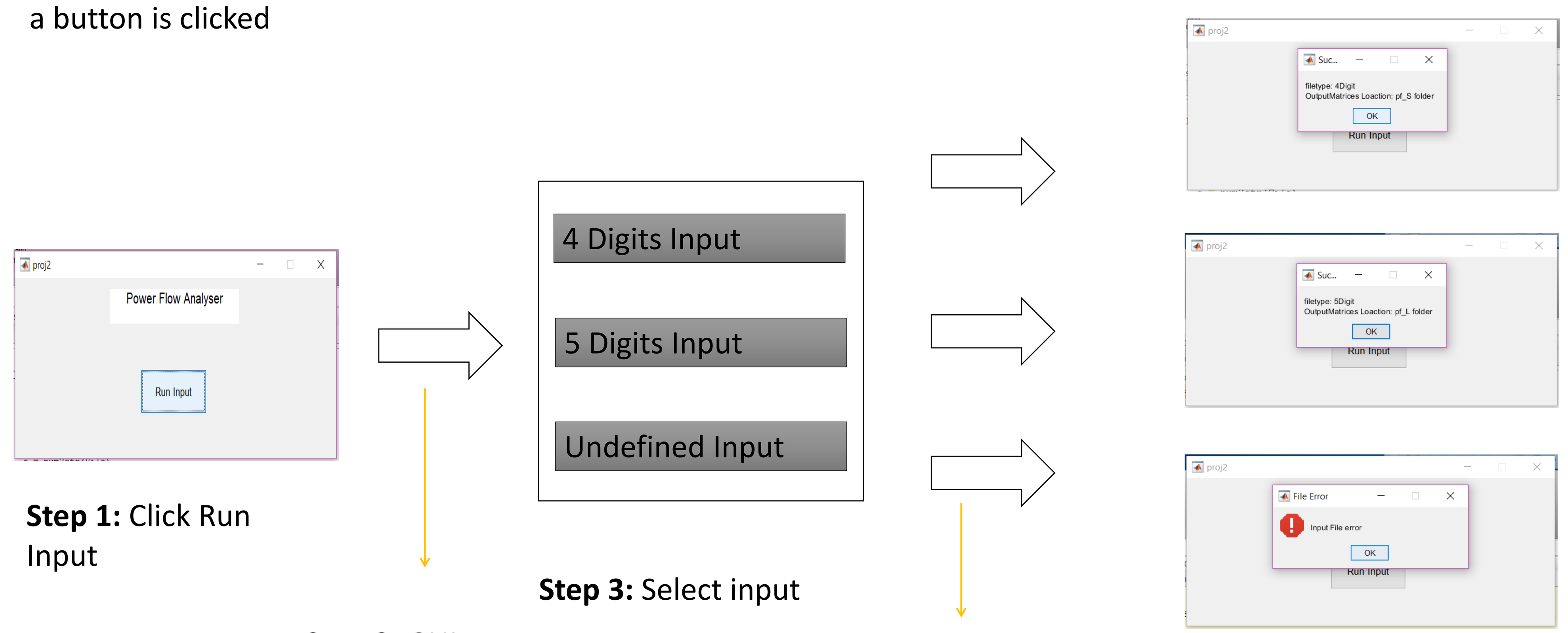


Fig2: Modified GUI

Writing Script files: After the GUI was created, the next step was to write Matlab scripts which run the Power Flow executable when the appropriate file is chosen on the GUI by the user. The Matlab script prompts the user to choose the file directory when a button is clicked



Step 1: Click Run Input

Step 2: GUI prompts Users to select input

Step 3: Select input

Step 4: GUI checks and runs input file

Step 5: Displays one of the following message at the end

Figure 3: General Overview

Results

After the GUI executes a particular type of input file using the appropriate executables, its saves the result in a common format. For this particular case the results are saved as Matlab files. This script also creates a bus data matrix and a branch data matrix from the output files as shown below.

BusNo	VoltageMagnitude	VoltageAngle	ActiveGeneration	ReactiveGeneration	ActiveLoad	ReactiveLoad

Figure 4: Bus Data Matrix Format

FromBus	ToBus	ActivePowerFlow	ReactivePowerFlow

Figure 5: Branch Data Matrix Format

Variables - bus_data
branch_data | bus_data
14x7 double

	1	2	3	4	5	6	7	8
1	1	1.0600	0	232.2834	-16.8876	0	0	
2	2	1.0450	-4.9800	40	42.3949	21.7000	12.7000	
3	3	1.0100	-12.7200	0	23.3925	94.2000	19	
4	4	1.0186	-10.3200	0	0	47.8000	-3.9000	
5	5	1.0203	-8.7800	0	0	7.6000	1.6000	
6	6	1.0700	-14.2200	0	12.2177	11.2000	7.5000	
7	7	1.0620	-13.3700	0	0	0	0	
8	8	1.0900	-13.3700	0	17.3568	0	0	
9	9	1.0563	-14.9500	0	0	29.5000	16.6000	
10	10	1.0513	-15.1000	0	0	9	5.8000	
11	11	1.0571	-14.7900	0	0	3.5000	1.8000	
12	12	1.0552	-15.0800	0	0	6.1000	1.6000	
13	13	1.0505	-15.1600	0	0	13.5000	5.8000	
14	14	1.0358	-16.0400	0	0	14.9000	5	
15								

Figure 6: Bus Data Matrix

Variables - branch_data
branch_data | bus_data
40x4 double

	1	2	3	4	5
4	2	4	56.1388	-2.2868	
5	2	3	73.1861	3.5653	
6	2	1	-152.5333	27.6541	
7	3	4	-23.3293	2.8089	
8	3	2	-70.8660	1.5836	
9	4	5	-61.2183	15.6651	
10	4	9	16.0891	-0.3220	
11	4	7	28.0858	-9.4216	
12	4	2	-54.4617	3.3931	
13	4	3	23.7005	-5.4212	
14	5	6	44.0606	12.8237	
15	5	1	-72.7882	2.5802	
16	5	2	-40.6109	-1.6335	
17	5	4	61.7348	-15.3662	
18	6	11	7.3389	3.4650	

Figure 7: Branch Data Matrix

Conclusions

- The main purpose of the research was to create a Graphical User Interphase(GUI) using Matlab and writing Matlab scripts to enable the GUI choose the right executable when a particular input file is selected in order to facilitate the utilization of power flow data files .
- During the course of the research, the above Graphical User Interphase was created where when its "Run Input" button is clicked, it enables the user to select an input file in a folder on the computer.
- When the user selects this file, the written Matlab scripts enable the GUI to check the input file format. The input files can be of two different formats (using 4 or 5 digit representation of bus numbers) but carry the same information.
- If the selected input file is in neither of these formats, an error message dialogue box is displayed and the program is terminated.
- The GUI was developed in a generic manner to read inputs files with different names. This was done by writing script files that copy and rename each appropriate input file prior to execution of the program.
- The Matlab scripts also create bus data matrix and branch data matrix after solving the power flow problem using the appropriate solver.
- When the GUI runs the input files successfully, a dialogue box is displayed at the end informing the user about the format of the input file and the location of the newly created output matrices

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