Application of Graphical User Interface (GUI) for Analysis of Voltage Sag in Power System using RMS Method

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***Abstract*--- This paper is to analyze and detect voltage events in power system using digital signal processing tools with the method of Root Mean Square (RMS) voltage. The magnitude of voltage supply during a voltage event will be computed using RMS magnitude. The voltage events are considered those that cause a temporary increase or decrease in the RMS voltage magnitude over the limits recommended. Voltage events are used to describe an abnormal and temporary variation of the magnitude of voltage supply and unpredictable. In this paper, the voltage event detected is voltage sag. Voltage sag is a decrease between 0.1 to 0.9 p.u. in power quality. Graphical representation of the voltage sag is displayed on the Graphical User Interface (GUI). GUI can serve as a simple and reliable tool for voltage sag detection.**

Keywords – Power Quality, Root Mean Square (RMS), Voltage Sag, Graphical User Interface (GUI)

I. INTRODUCTION

Power quality is the interaction of electrical power with electrical equipment. It is a term used to describe electric power that motivates an electrical load and the load's ability to function properly with that electric power. Without the proper power, an electrical device load may malfunction and may not operate at all. Power quality becomes more important in recent years due to the user require higher quality of power than before due to the increase in sensitive loads [1]. There are many ways in which electric power can be of poor quality and many more causes of such poor quality power. Surges, spikes, transients, swell, sag, noise are some examples of power quality.

Figure 1 shows the voltage swell, an increase in voltage outside normal rated tolerance of equipment.

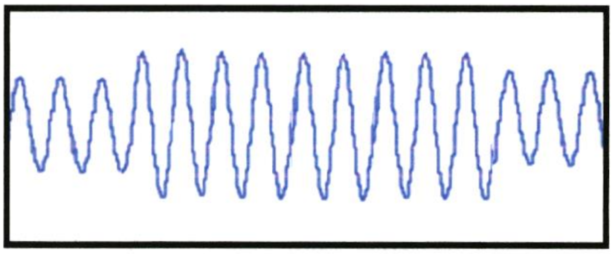

Figure 1: Voltage Swell

Figure 2 shows transient voltage, an undesirable voltage that appears on the power supply line with high over-voltage disturbances (up to 20KV) that last for a very short time.

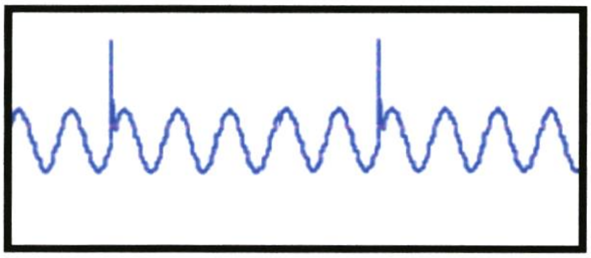

Figure 2: Transient

Figure 3 shows noise problem, where it is an undesirable disturbance with random variations within the frequency band.

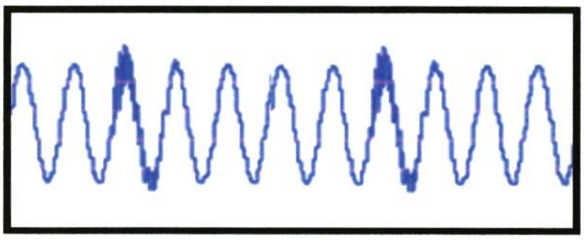

Figure 3: Noise

Essentially, power quality problems occur due to a number of factors such as distortion of sinusoidal voltage waveform and disturbances of the RMS voltage. One of the most common power quality problems is voltage sag. Voltage sag means a reduction in the voltage amplitude below 0.90 pu of the normal voltage. Voltage sag possibly caused by switching of loads with large amounts of initial starting or inrush current.

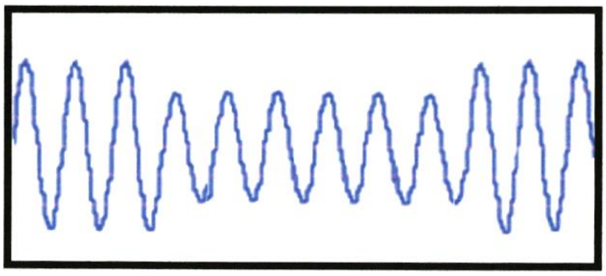

Figure 4: Voltage Sag

Voltage sag is characterized by its magnitude and duration [2]. The magnitude is defined as the percentage of the remaining voltage during the sag. The duration of sag is the time between the sag commencement and end.

There are some methods used in the voltage sag detection such as Kalman filter and Wavelet analysis, but these techniques are complicated [3]. In this paper, voltage sag is detected by using RMS voltage method. This method is simple and easy to apply. The most common processing tool used for voltage measurement in power systems is the calculation of the RMS [5].

RMS voltage is a quantity commonly used in power systems as an easy way of accessing and describing power system phenomena [7]. It is defined for periodic signals. The voltage sag becomes one of the most important power quality problems.

The RMS voltages of waveforms are characterized by this equation:

$$Vrms = \sqrt{\frac{1}{N}\sum_{i=1}^{N} v_i{}^2} \quad \text{------ (1)}$$

Where v_i refers to the voltage samples and N is an integer of the number of samples during one half-cycle of the power system frequency.

II. METHODOLOGY

This paper discusses the development of GUI in analyzing and detection of voltage sag. A graphical user interface (GUI) is a graphical display in one or more windows containing controls, called components, which enable a user to perform interactive tasks. The user of the GUI does not have to create a script or type commands at the command line to accomplish the tasks. Unlike coding programs to accomplish tasks, the user of a GUI need not understand the details of how the tasks are performed.

GUI enables user to interact with the system through graphic components such as menus, toolbars, push buttons, radio buttons, list boxes, and sliders. Each component is associated with one or more user written routines known callback. The execution of each callback is activated by user action like button pushed or mouse click. The GUI should behave in an understandable and predictable manner so that user knows what to expect when performs an action [11].

GUI can be created using MATLAB program with GUIDE, an interactive GUI builder tool. GUIDE is the development environment that consists of tools for creating GUI [8]. This tool simplifies the process of laying out the graphic component and programming the GUI. When GUI layout is saved, GUIDE automatically generates M-file that controls the operation of GUI. This allows user to quickly access and initialize the properties of GUI components. Each type of GUI components has different properties for controlling appearance and behavior. The property inspector eases the task of determining what is available for each GUI component.

GUI created using MATLAB tools can also perform any type of computation, read and write data files, communicate with other GUI and display data as tables or as plots [10].

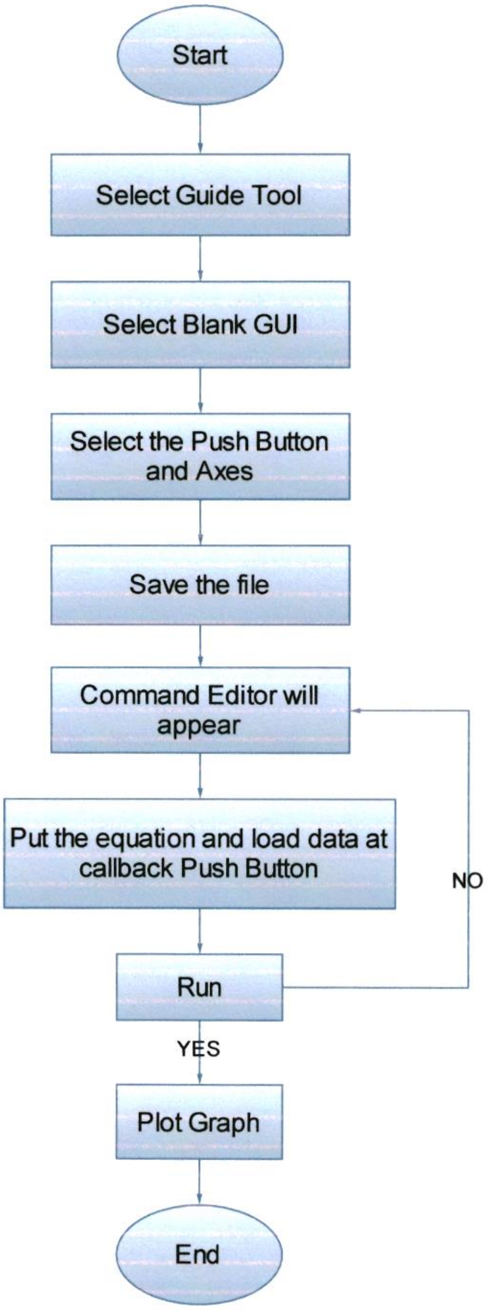

Figure 5: Flowchart of Developing GUI

The above flowchart shows the steps in creating the GUI. Firstly, user selects the GUIDE tool in MATLAB and chooses the blank GUI. By using the palette on the left of the window, drag and drop, resize and position the pushbuttons and the axes that needed. Then, save the window. GUIDE will automatically save it to Fig-file and M-file. Fig-file contains a complete description of the GUI figure while M-file contains the function required to launch and control the GUI.

Command editor will be appear. The power quality data need to be load here together with all the equations that are needed. Next, click the run button to operate the system. If there is any problem, the command editor will appear again and user needs to do correction to that particular error. If no error, a graph will be plotted at the axis created before. Finally, user can analyze the voltage sag.

Figure 6 shows the blank GUI frame that appears after selecting the GUIDE tool. User must click OK to create new GUI.

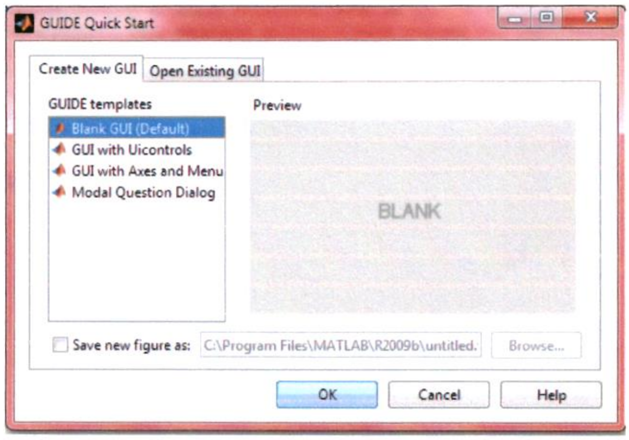

Figure 6: A blank GUI frame

Figure 7 shows the pushbutton and axes have been drag from the left panel to be located on the GUI frame.

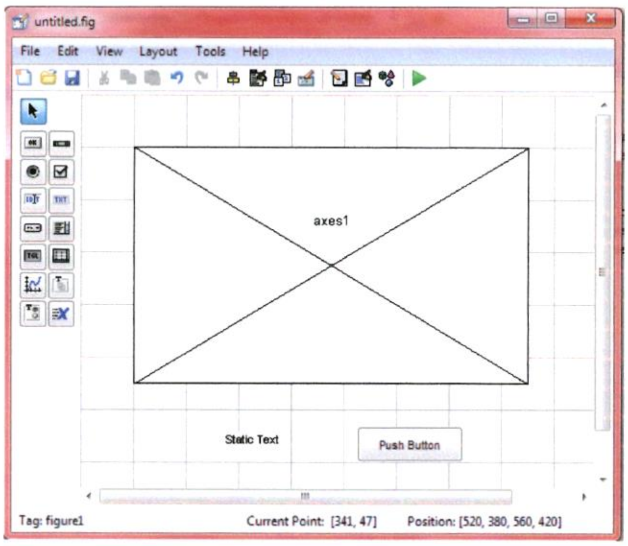

Figure 7: Pushbutton and axes located on the GUI frame

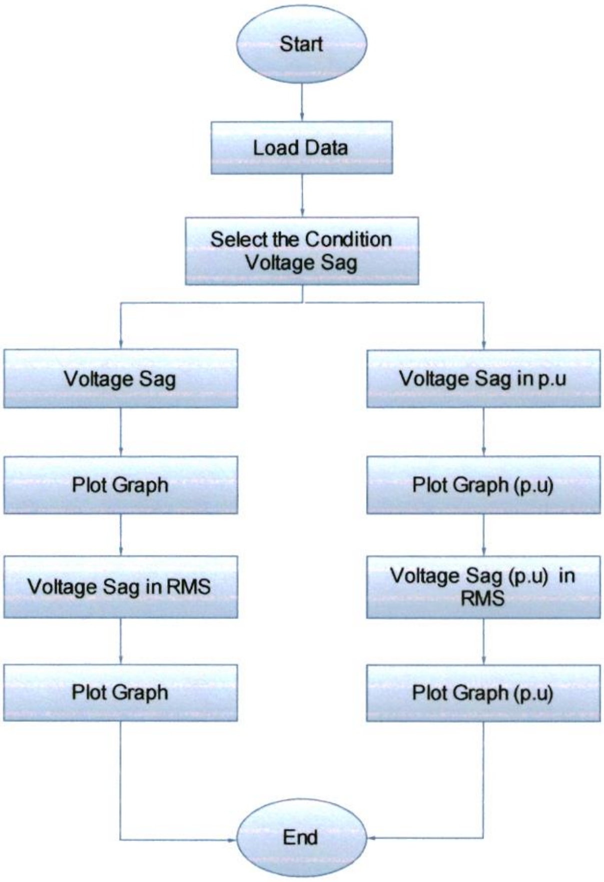

Figure 9: Flowchart of Voltage Sag Detection

Flowchart above shows the steps when user uses the system to detect voltage sag. User can choose any condition of voltage sag that needs to be detected either nominal voltage sag or voltage sag in p.u. Then power quality data will be loaded into GUI. When user choose nominal voltage sag button, a plotted graph of voltage sag will be appear. The RMS magnitude of voltage sag can be seen when user click the RMS button and new window that shows the graph of voltage sag in RMS will be appear. If user wish to select the other condition of voltage sag, user need to click the back button and this will bring the user to the previous window. Here, user will do the same action to see the graph of voltage sag in p.u and graph of voltage sag in p.u in RMS magnitude.

III. RESULT AND DISCUSSION

Figure 10 shows the start window where user can choose condition of voltage sag either nominal voltage sag or voltage sag in p.u.

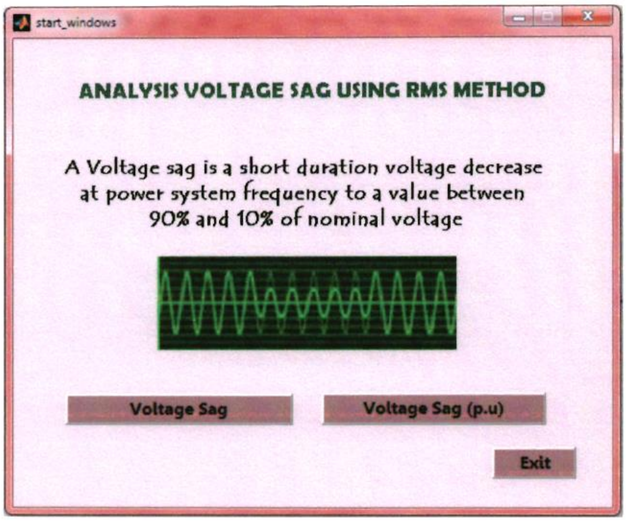

Figure 10: Start Window

Figure 11 shows the nominal voltage sag when data was loaded into GUI. The graph of this nominal voltage sag consists of 400 hundred samples and voltage sag happen at 49 to 330 of the sample. So, the duration of the voltage sag is 281 samples /cycle.

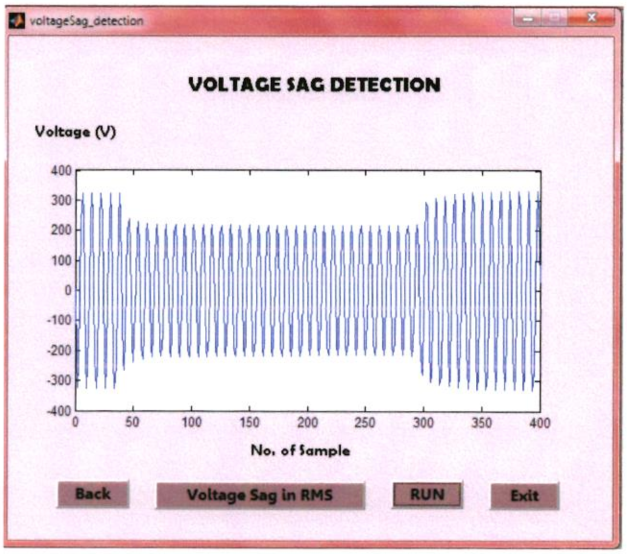

Figure 11: Voltage Sag Detection

Figure 12 shows the voltage sag in RMS magnitude. It can be seen that the graph only appears at positive side of the axis due to the equation (1) that has been applied to the voltage sag data. The duration of voltage sag is the same, 281 samples /cycle.

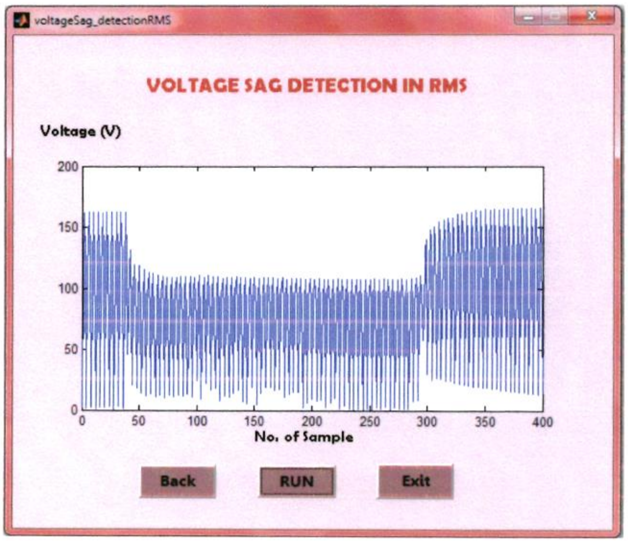

Figure 12: Voltage Sag Detection in RMS

For the figure 13 below, it shows the nominal voltage sag in p.u. Voltage sag happens between 0.1 and 0.9 p.u. to the waveform.

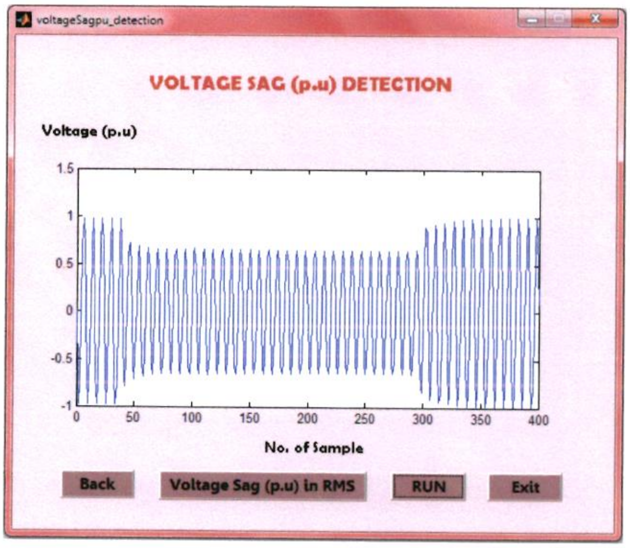

Figure 13: Voltage Sag Detection in p.u

The figure 14 below shows the voltage sag in p.u in RMS magnitude.

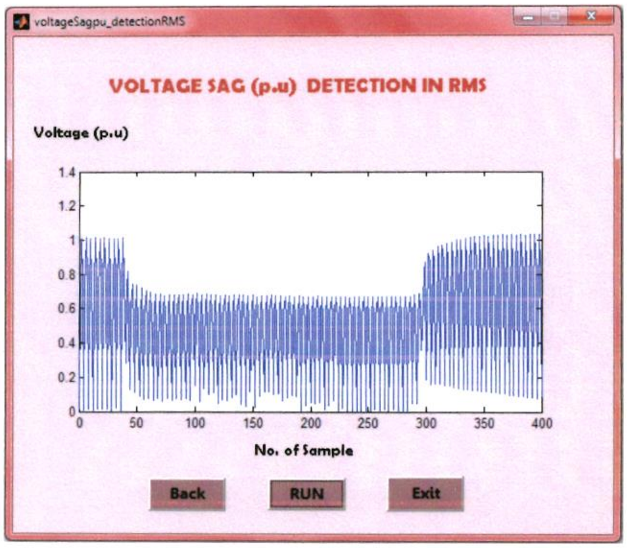

Figure 14: Voltage Sag Detection in RMS in p.u

IV. CONCLUSION

This paper presents the detection of voltage sag using RMS voltage method where the analysis is using MATLAB programming. The voltage sag detection is displayed to user using MATLAB Graphical User Interface (GUI). The feature of this GUI is the ability to graphically display the result to user. By using GUI, the analysis and detection of voltage sag can be done easily and practically.

V. REFERENCES

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