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Power Quality Monitoring using LabView

Dr. Puneet Pahuja*, Ravi**, Prateek Chandra and Savita*******

**Asstt. Professor, Department of Electrical Engineering, Hindu College of Engineering, Sonepat, (HR), INDIA*
***S. D.O., U.H.B.V.N., Sonepat, (HR), INDIA*
****M. Tech. Scholar, Department of Electrical Engineering, Hindu College of Engineering, Sonepat, (HR), INDIA*
*****Asstt. Professor, Department of Mathematics, Hindu College, Sonepat, (HR), INDIA*

(Corresponding author: Dr. Puneet Pahuja)

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ABSTRACT: In this paper a Power Quality Monitor using LabView is developed. Due to the intensive use of power converters and other non linear loads in industry and by consumers in general, it can be observed an increasing deterioration of the power systems voltage and current waveforms. The presence of harmonics in power lines results in greater power losses in the distribution system, interference problems in communication systems and, sometimes, in operation failures of electronic equipments, which are more and more sensitive since they include microelectronic control systems which work with very low energy levels. During the last years a concern with quality and reliability of electric energy is increasing.

Keywords: PQM(Power Quality Monitor), LabVIEW (Laboratory Virtual Instrument Engineering Workbench).

I. INTRODUCTION

A Power Quality problem is "any occurrence manifested in a nonstandard voltage, current, or frequency deviation that results in damage, upset, failure, or disoperation of end-use equipment". Power Quality is an umbrella term & usually refers to the monitoring, measurement, analysis and improvement of the bus voltage, usually a load bus voltage, to maintain that voltage to be a sinusoid at rated voltage and frequency. With the intense drive for profits, industrial plants are concerned about any kind of production shutdown. At the same time, sophisticated electronics are being rapidly introduced into most production processes. These are often in the form of such power-quality-sensitive equipments such as Computers, Telecommunications, Electronic process controls, Robotics, Adjustable speed drives (ASDs). The reliability of this type of equipment is much more closely tied to quality of the power supply, as compared to older or more traditional equipment that may have had relay controls or electrical contactor controls.

The term electric Power Quality (PQ) is widely used to indicate the different electromagnetic phenomena existing on ac power supply systems that can cause problems for the operation of the supplied equipment. A lack of quality in a power system (both a public mains or an industrial power supply network) concerns the interruptions and deviations of the actual supply signals from the nominal characteristics. It generally falls into two categories.

The first one, which has received most of the attention in the industrial technical literature, is the problem of harmonic distortion. The second one concerns the field of short- and long-term transient phenomena, such as voltage dips, impulses, and sags. Harmonics produce steady-state distortion of a voltage or current signal when compared to a pure sine wave. The harmonic voltage distortions can be caused by the harmonic current injection of a load, such as a variable-speed drive or a power supply based on a switching regulator. The harmonic distortion of supply voltage produces annoying effects in electrical power systems and problems in industrial and communication apparatus. Short transients are voltage disturbances superimposed on the nominal waveform, evidenced by sharp brief discontinuities, with duration generally measured in subcycles. Longer term variations in voltage, such as sags and swells, are generally measured as variations to the rms value of voltage and are characterized by longer time intervals, which are usually measured in duration of cycles or even seconds. Voltage fluctuations can be generated by brightness regulators that produce large voltage variations or by adding or removing loads from the line. Interruptions, sags, and swells can produce equipment shutdown, which can require minutes (e.g., computers) or hours (e.g., plastic molding machines) to restart. Power disturbances can cover a large interval of frequencies. The supply frequency harmonics are in the range of up to some kilohertz, but other disturbances and transients present in the power lines have a higher frequency.

In some cases, the frequency and width of voltage variations can produce a physiological irritating phenomenon, due to the fluctuations of lighting (flicker). The flicker is an annoying effect produced by a periodical amplitude modulation of the voltage sinusoidal waveform with a frequency of 0.5–25 Hz, sufficient in duration to produce a visual observation of the luminance fluctuations in an incandescent lamp.

Power Quality has become an important concern for utility, facility, and consulting engineers in recent years. End-use equipment is more sensitive to disturbances that arise both on the supplying power system and within the customer facilities. Also, this equipment is more interconnected in networks and industrial processes so that the impacts of a problem with any piece of equipment are much more severe. The increased concern for Power Quality has resulted in significant advances in monitoring equipment that can be used to characterize disturbances and power quality variations. Analysis tools can present the power quality information as individual events (disturbance waveforms), trends, or statistical summaries. By comparing events with libraries of typical power quality variation characteristics and correlating with system events (e.g., capacitor switching), causes of the variations can be determined. In the same manner, the measured data should be correlated with impacts to help characterize the sensitivity of end use equipment to Power Quality variations. This will help identify equipment that requires power conditioning and provide specifications for the protection that can be developed based on the power quality variation characteristics.

Here a menu driven Power Quality monitor using LabVIEW; having the facility of simulating a signal, acquiring and displaying that signal using waveform charts is developed. Numeric controls are available on the front panel for feeding the required parameters.

II. LITERATURE REVIEW

Due to the intensive use of power converters and other non linear loads in industry and by consumers in general, it can be observed an increasing deterioration of the power systems voltage and current waveforms. The presence of harmonics in power lines results in greater power losses in the distribution system, interference problems in communication systems and, sometimes, in operation failures of electronic equipments, which are more and more sensitive since they include microelectronic control systems which work with very low energy levels. During the last years a concern with quality and reliability of electric energy is increasing.

Some of the books referred on the Power Quality are [1], [2], [3], [4]. According to G.T. Heydt [1], Electric power quality means different things to different people. To most electric power engineers, the term refers to a certain sufficiently high grade of electric service, but beyond that generality, there is no universal agreement. Part of difficulty arises from the fact that power quality at the transmission level implies different things that power-quality at the distribution level. In some sense, all of power engineering is devoted to power quality, but the term has come to mean a mere restricted area of interest which generally relates to the faithfulness of the load bus voltage the maintain a sinusoidal waveform at rated voltage & frequency. The main points of disagreement center about outages: if an outage is prolonged, the failure of service is often relegated to a subject considered in transmission and distribution engineering. A momentary outage, however, is usually taken as a power-quality issue. Prolonged poor voltage regulation is usually considered in transmission & distribution engineering because this difficulty is usually analyzed and removed by standard methods from analysis of the electrical network. However, if a single cycle in the bus voltage is irregularly low in amplitude, this is an issue of power quality. Power quality is an umbrella term & usually refers to the monitoring, measurement, analysis and improvement of the bus voltage, usually a load bus voltage, to maintain that voltage to be a sinusoid at rated voltage and frequency.

Gupta Sanjay and John Joseph [5], Virtual Instrumentation Using LabVIEW, describes the basic concepts of LabVIEW. The basic concepts regarding LabVIEW and working in LabVIEW environment is discussed very clearly. Loops and Structures, Arrays and Clusters, Graphs and Charts etc. are mentioned.

Jose Batista, Jaco L. Afonso and Julio S. Martins [6] have discussed the development of a low-cost digital system useful for power quality monitoring and power measurement. Voltage and current measurements are made through Hall-effect sensors connected to a standard data acquisition board, and the applications were programmed in LabVIEW , running on Windows in a regular PC. The system acquires data continuously, and stores in files the events that result from abnormalities detected in the monitored system. The acquired information can be visualized in tables and/or in charts.

III. SOFTWARE USED

LabVIEW software is used for project development. LabVIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and multimeters. LabVIEW contains a comprehensive set of tools for acquiring, analyzing, displaying, and storing data, as well as tools to help to troubleshoot the code. LabVIEW(Laboratory Virtual Instrument Engineering Workbench) is a development environment based on the graphical programming language G. A VI contains the three components-the front panel, the block diagram, and the icon and connector pane. The front panel serves as the user interface.

The block diagram contains the graphical source code that defines the functionality of the VI. The icon and connector pane identifies the VI so that a VI can be used in another VI. The power of LabVIEW lies in the hierarchical nature of the VI. After a VI is created, it can be used on the block diagram of another VI. A VI within another VI is called a subVI. A subVI corresponds to a subroutine in text-based programming languages. Using subVIs helps to manage changes and debug the block diagram quickly. LabVIEW was the first implementation of data-flow programming and continues to be the dominant implementation.

Figure 1 displays the Block diagram of the project. The working of the project is divided into simulate, acquire, analyze.

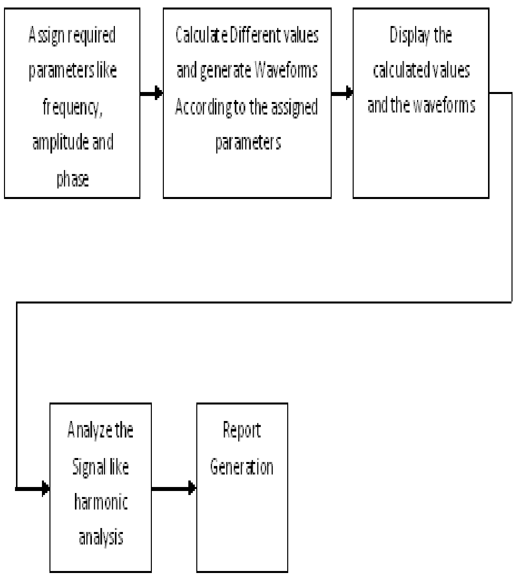

Fig. 1. Block diagram of the developed project.

IV. STEPS OF PQM DEVELOPMENT

LabVIEW 7.1 is used for development of Power quality monitor. First of all the tab controls is created. Then the VIs are used to calculate different values and display the waveforms using the waveform charts. The next step is the harmonic analysis of the signal, calculate THD, display amplitude versus frequency.

Fig. 2 shows creating Tab Control. Tab control of pages is used to save the space on the front panel. In this project four pages are used and are controlled by Tab control. The color of each page can be changed. The color is selected by clicking on the color box constant which is placed on the Block Diagram. Then run on the Front panel is pressed once. The color which was selected on the color box constant appears on each of the pages of the front Panel. By using this feature the front panel of any color can be formed. Figure 2(a) shows Front Panel of Tab control VI. Figure 2(b) shows the Block Diagram of Tab Control VI.

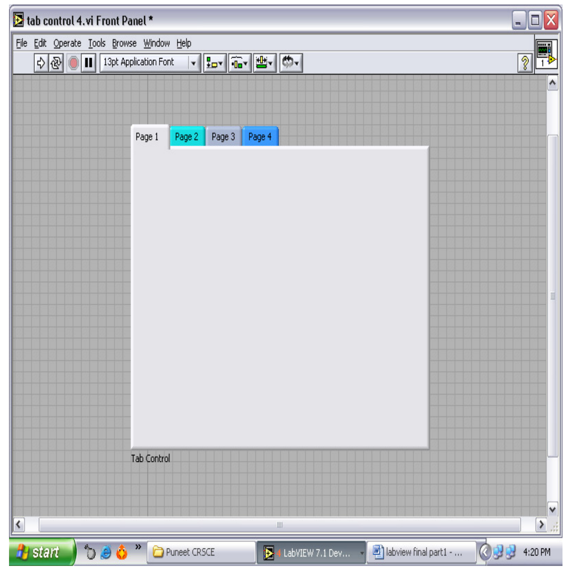

Fig. 2. (a): Front Panel of Tab control VI.

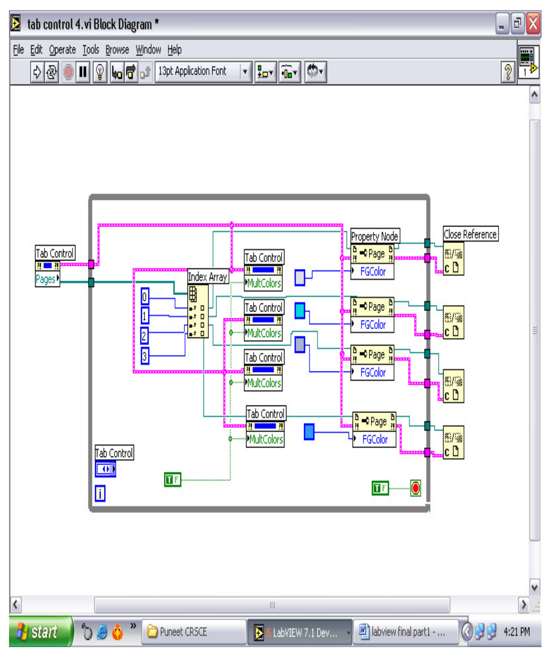

Fig. 2. (b): Block Diagram of Tab Control VI.

Fig. 3 shows numeric controls for entering the different values, Calculation of Different values; displaying them and waveforms display. The values of the required parameters are fed through the numeric controls named as Voltage Frequency, Voltage Amplitude, Current Frequency and Current Amplitude. The waveforms of Voltage, Current, Power, and Volage waveform merged with current waveform are displayed by the charts.

The rms values are displayed by the numeric indicators labeled as Voltage rms value, Current rms value and Power. Amplitude and level measurement blocks are used on the block diagram for getting various values from the simulated signal. Figure 3(a) shows the Front panel with numeric controls, numeric indictors, and waveforms Figure 3(b) shows the Block Diagram for calculating various outputs and displaying waveforms.

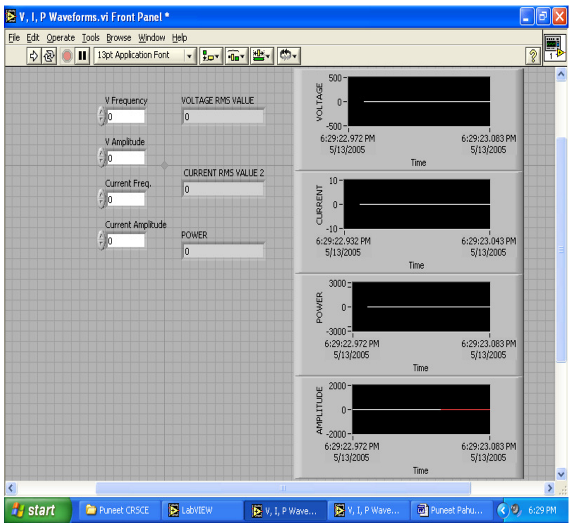

Fig. 3(a). Front panel with numeric controls, numeric indictors, and waveforms.

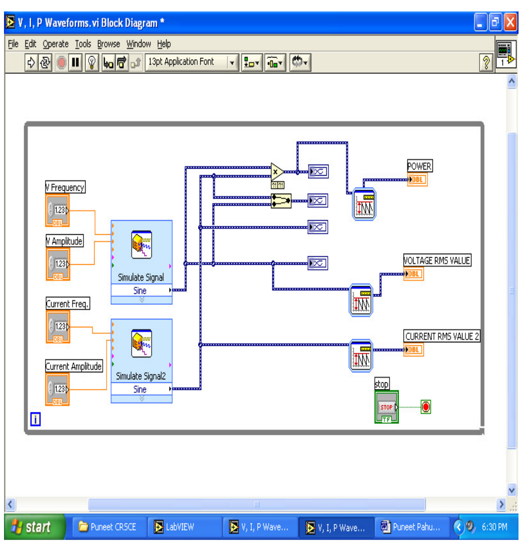

Fig. 3(b). Block Diagram for calculating various outputs and displaying waveforms.

Fig. 4 shows how to feed the different values and waveforms display with phase angle. Values of the required parameters are fed through the numeric controls; the calculated values are shown by the numeric indicators and waveform charts.

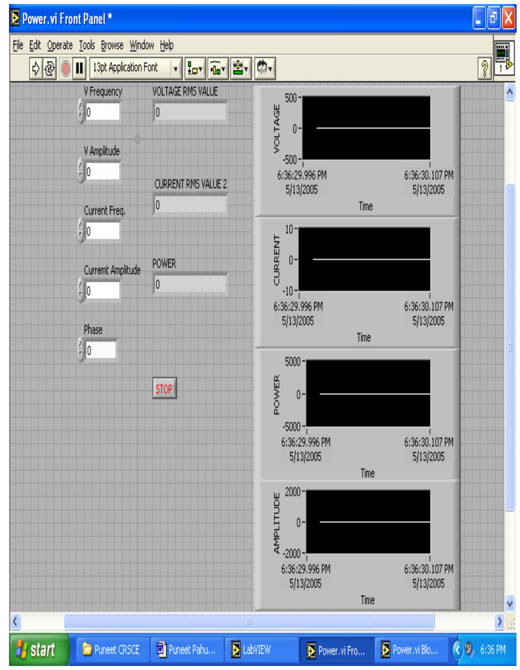

Fig. 4(a). Front Panel for displaying waveforms with phase angle.

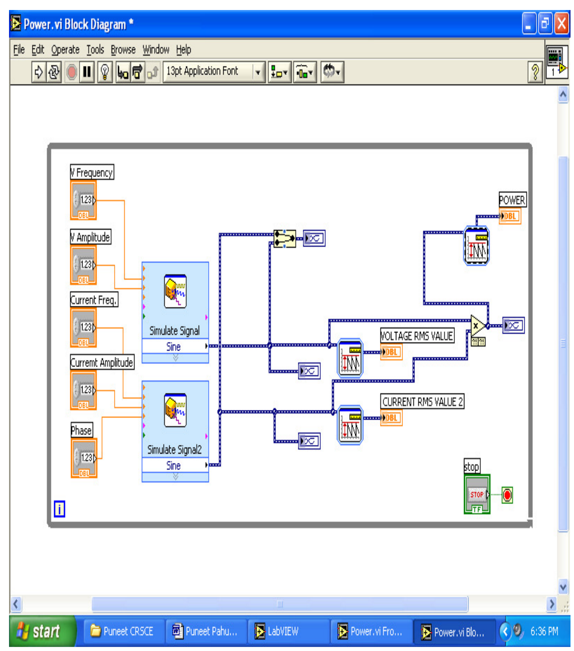

Fig. 4(b). Block Diagram for calculating different values and displaying waveforms.

Fig. 5 shows harmonic analysis of a signal distorted by another signal with waveforms of the fundamental signal, added signal, and distorted signal. It shows the total harmonic distortion.

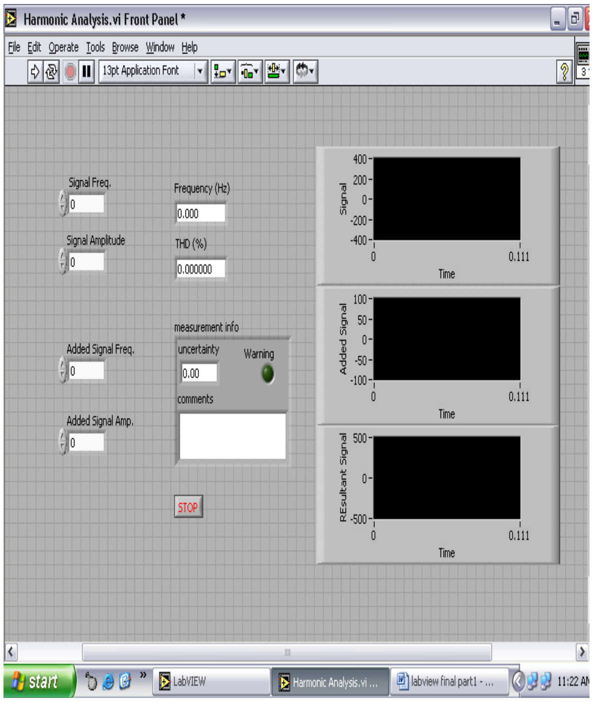

Fig. 5(a). Front panel for harmonic analysis of a signal distorted by another signal.

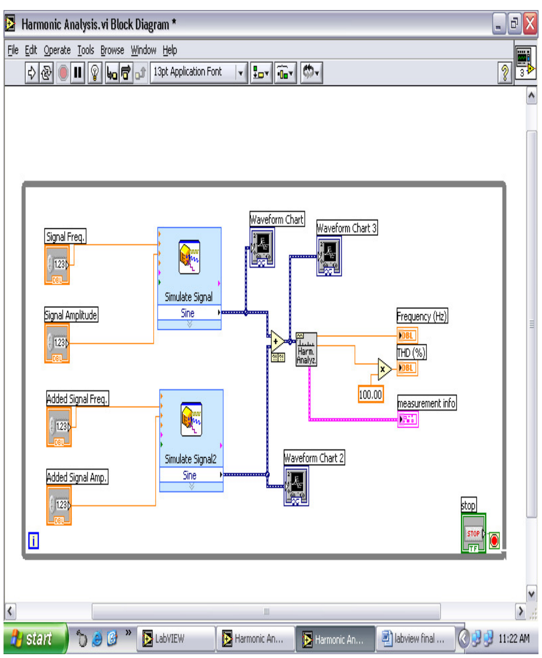

Fig. 5(b). Block Diagram for harmonic analysis of a signal distorted by another signal.

Fig. 6 shows harmonic analysis of a signal added with another signal and the power spectrum of the resultant signal. The signal frequency and signal amplitude of the fundamental signal are fed first. Then the frequency of the signal and the amplitude of the signal to be added are entered in the numeric controls. The output display on the Front Panel displays the fundamental frequency. It also shows the total harmonic distortion as a percentage. Different window functions can be used for analysis. Visual display is available as the amplitude vs. frequency.

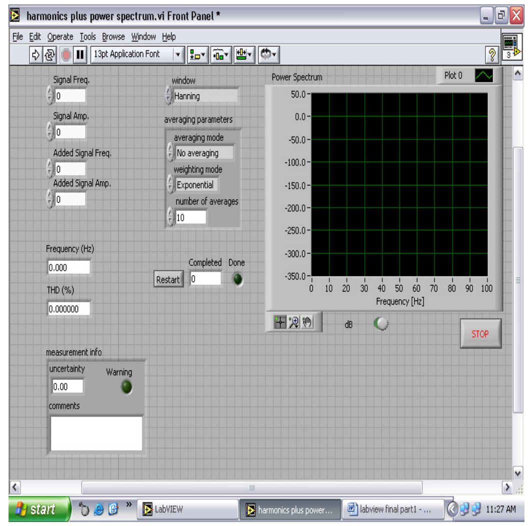

Fig. 6(a). Harmonics and Power Spectrum analysis of a signal added with another signal.

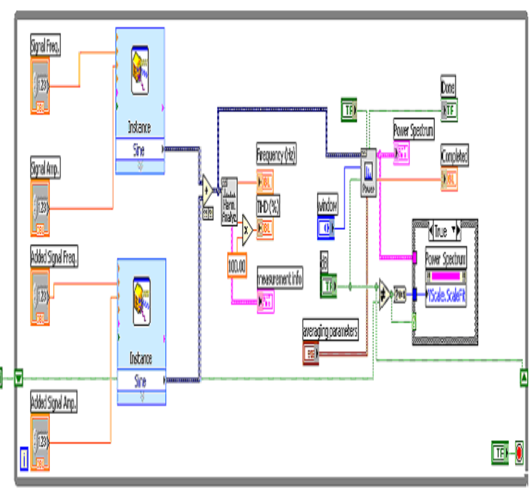

Fig. 6(b). Block Diagram for Harmonics and Power Spectrum analysis of a signal added with another signal.

Fig. 7 shows combining all the features discussed above to design finally the Power Quality Monitor. There are four pages which are controlled by the Tab Control. Any page on the Front Panel can be selected and its contents can be displayed. The values of require parameters are fed through the numeric control shown on the front panel i.e. Voltage Frequency, Current Frequency, Voltage Amplitude, Current Amplitude and Phase.

The first page shows the waveforms of Voltage, Current, Power, and their rms values. The second page displays the harmonic analysis. The third page shows to save the data in file and finally the report generation. The path to store the data in file is given by the user.

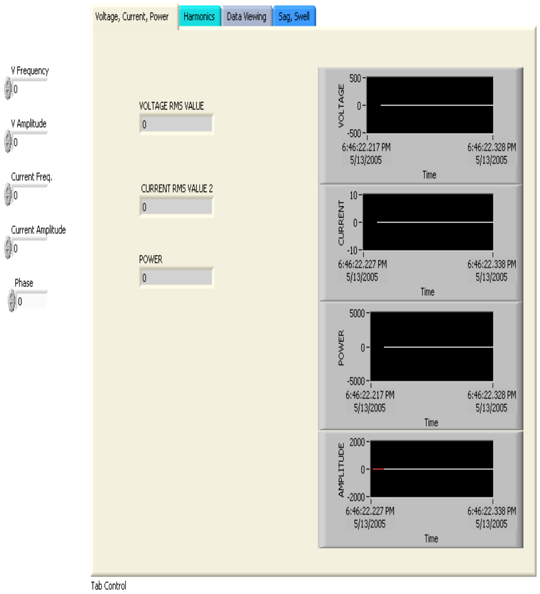

Fig. 7(a). First page of Front Panel showing the calculation of various values and the Waveforms display.

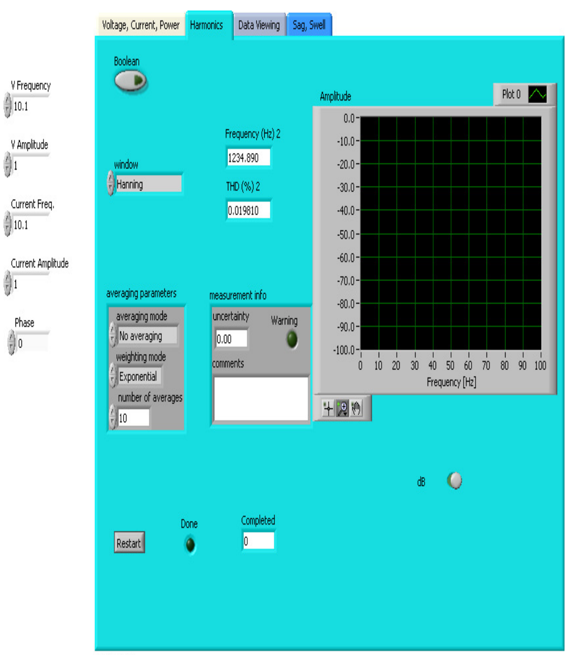

Fig. 7(b). Second page showing the harmonic analysis.

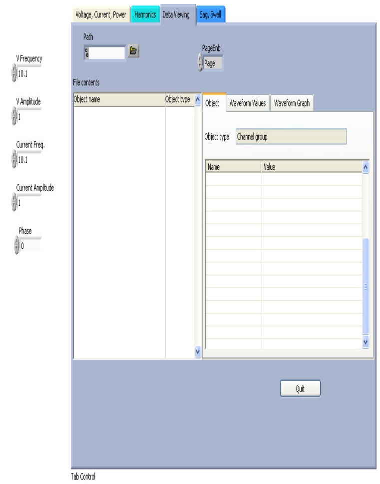

Fig. 7(c). Third page showing how the event data is stored in a file and the report generation.

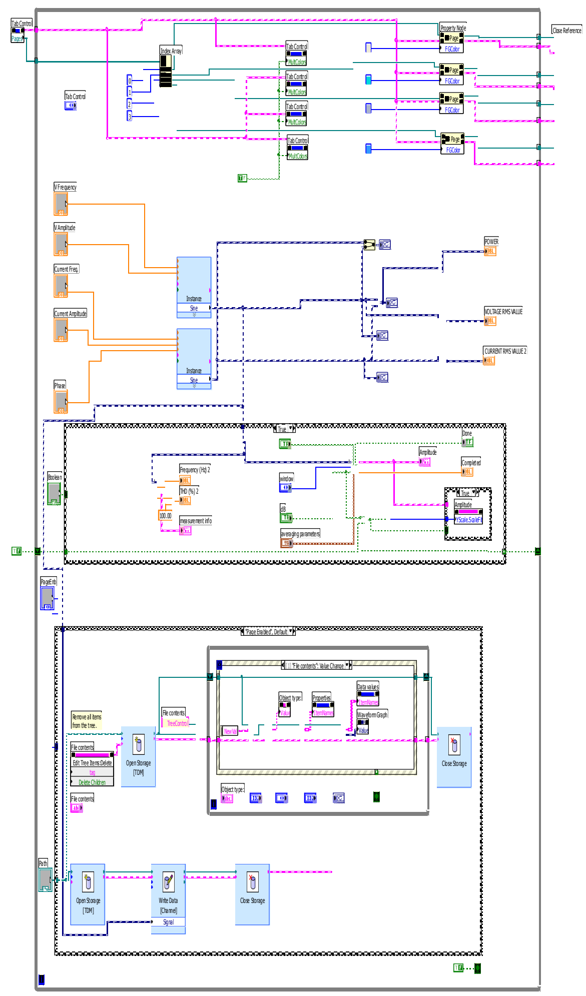

Fig. 8. Block Diagram of the developed project.

V. CONCLUSION AND FUTURE SCOPE

The PQM is developed in such a way that in future it can be extended to be more advanced. The PWM developed here generates a simulated signal, displays various waveforms, analyses the harmonics content, and generates a report. DAQ card is to be used for real time monitoring. Several other features are to be introduced in the instrument as well. The other feature that must be introduced in the instrument is the fundamental of triggering. A trigger is a mechanism by which a recording instrument (any variety) can recognize a particular point in time and sample the data around that point according to a predefined set of rules. Generally, a trigger can be related to a specific change from normal or is said to correspond to an "event." The instrument continuously monitors data points and, once the signal exceeds the predefined positive or negative value, the instrument "triggers" and records the data according to its sampling capabilities. A trigger could cause the meter to record text or waveform data.

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