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VIRTUAL IMPLEMENTATION AND REMOTE MONITORING OF POWER ANALYZER USING LABVIEW

[1]Koppaka Lalitha, [2]Dr. N. Prema Kumar

[1]M. Tech 2nd year student, [2]Professor & Head of the department, EE, AUCEW

Electrical Engineering Department

[1]Andhra University, Visakhapatnam, Andhra Pradesh, India.

Abstract: This paper proposes a power quality monitoring system which has been developed by designing the Virtual Instruments (VIs) using LABVIEW software. Due to the intensive use of power converters, non-linear loads and other uncertain events in the utility, consumer, and manufacturer side lead to increase in deterioration of system performance. Poor power quality affects the functioning of utilities, industrial units, productions, system performance, customer services and operating cost. There is always a need for power quality monitoring systems owing to the growing number of sources of disturbances in AC power systems. Thus, a real-time signal detection and harmonic analysis is of great significance to provide power quality solutions.

Key Words – PQ(Power Quality), PQM(Power Quality Monitoring), VI(Virtual Instrument), LabVIEW(Laboratory Virtual Instrument Engineering Workbench), TDMS(Technical Data Management Streaming).

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 equipment 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 contact 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 main 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 sub cycles. 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 this paper, a power quality analyzer has been developed using LabVIEW which facilitates the simulation of signals, acquisition and displaying those signals with waveform graphs. Knob and numeric controls are available on the front panel for feeding the required parameters. Also, the numeric, Boolean and string indicators are inserted to display the various system parameters and events.

II. POWER QUALITY

Electricity with a bad quality is dangerous and uneconomical at both utility and consumer end. There is a big need to focus on the quality of power being supplied to the loads.

Power quality is the ability of a power grid to supply power to the consumers efficiently and it also expresses the ability of an equipment to consume the power being supplied to it. In technical terms, power quality is the measure, study, and enhancement of sinusoidal waveform at the rated voltage and frequency. Any deviation in the voltage or current from the ideal value is a power quality disturbance.

III. Power Quality Monitoring

Power quality monitoring (PQM) is to collect, analyse and use the electrical data to improve the power quality and system's performance. It ensures energy management, quality control, preventive maintenance, and overall cost deductions. Nowadays, consumers are aware of power quality and expect efficient electrical service. For this reason, electrical facilities are concerned about power quality monitoring and use digital fault recorders, smart relays or other special purpose power quality equipment. Modern power plants regularly monitor the quality of voltage and currents supplied to the consumer to optimize the power quality. Every power system should improve its performance, efficiency and elongate the lifetime of the equipment. Conclusively, power quality problems are often interconnected. It is compulsory to analyse power quality issues from aspect of an entire plant along with complete focus on how they affect individual loads. Sometimes resolving a power quality issue can make another problem worse. By having a look at big picture, power quality analysis enables you to identify and mitigate the reasons of power quality issues. Increasing power quality problems are also giving rise to the awareness of power quality among the utilities and consumers as well. A deep analysis and understanding are required in every power system to maximize the proficiency of the electrical systems everywhere. There are several reasons for monitoring power quality. The most important reason is the economic damage produced by electromagnetic phenomena in critical process loads. Effects on equipment and process operations can include malfunctions, damage, process disruption, and other anomalies. It is noted that monitoring, alone, is not the solution for power quality problems. In order to solve the power quality problems, some other remedies more than the installation of power quality monitors are needed. In fact, monitoring provides the essential data which are needed for the improvement of power quality. In many projects related to finding a solution for power quality problems, monitoring plays a decisive role, and, therefore, managing monitoring properly helps to minimize the cost of solving problems.

Major parameters of power quality:

The inputs to the proposed system are simulated voltage and current signal, allows for the measurement and analysis of system parameters such as RMS values of voltage and current, frequency, power (apparent, active, reactive, and instantaneous), Total Harmonic distortion (THD) (%), ratio of Signal-to-Noise and Distortion (SINAD) in dB. The system also displays and records the various types of events occurring in the power system along with time stamp based on input signals. The dynamic performance and remote monitoring of the virtual power analyzer with LABVIEW software is assessed and emphasized with results.

IV. Software Used: LabVIEW

Laboratory Virtual Instrument Engineering Workbench also known as LabVIEW is a visual programming language. LabVIEW was developed by National Instruments as a workbench for controlling test instrumentation. However, its applications have spread well beyond just test instrumentation to the whole field of system design and operation. It is a system-design platform and development environment that was aimed at enabling all forms of system to be developed. LabVIEW is essentially an environment that enables programming in G – this is a graphical programming language created by National Instruments that was initially developed to communicate via GPIB, but since then it has been considerably updated. Nowadays, G can be used for automated test applications, general data acquisition, programming FPGAs, etc.

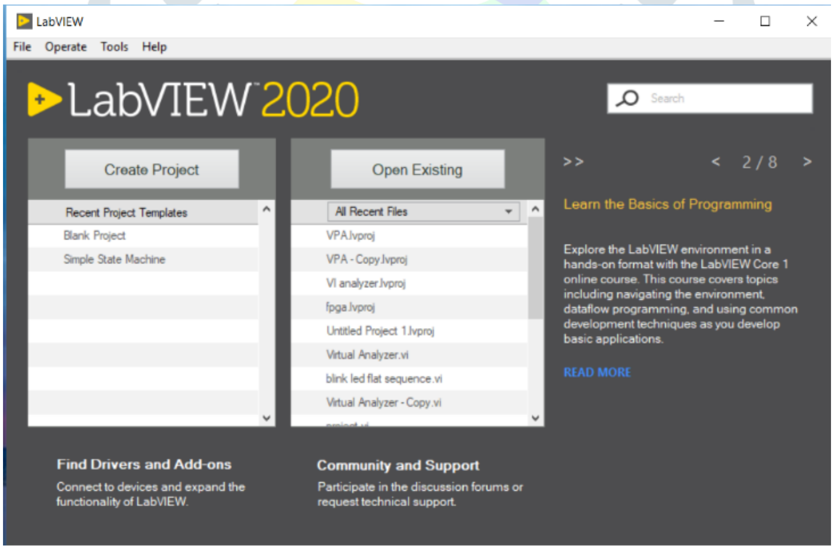


Fig1: LABVIEW

V. Development Of Virtual Power Analyzer

A power analyzer, also known as a power quality analyzer, is the equipment used to monitor the power quality in devices. Power quality is usually understood as the compatibility between a power/electric source and load plugged in so that the load could function properly. When power quality is low the load could get damaged or may malfunction. There are many causes of poor power quality. Voltage, frequency of the signal, and waveform are the factors considered to measure power quality. When the power quantity has a steady supply voltage that stays in prescribed limits, and its A.C frequency is steady and close to the rated value with a smooth voltage curve, it is considered as good power quality. The quality of power may vary due to discontinuity in service, variation in voltage magnitude, Transient currents, harmonics raising in A.C power. For power quality troubleshooting, the power analyzer helps in calibrating and eliminating issues such as dips in voltage, swells, harmonics, unbalance etc., seen in electric power. The developed power analyzer using Virtual instruments measure all the parameters and displays power quality events along with the time stamp.

A. Measurement of Power Quality Parameters and Harmonic Analysis

The figure represents the flow of measurement of system parameters and Calculation of power.

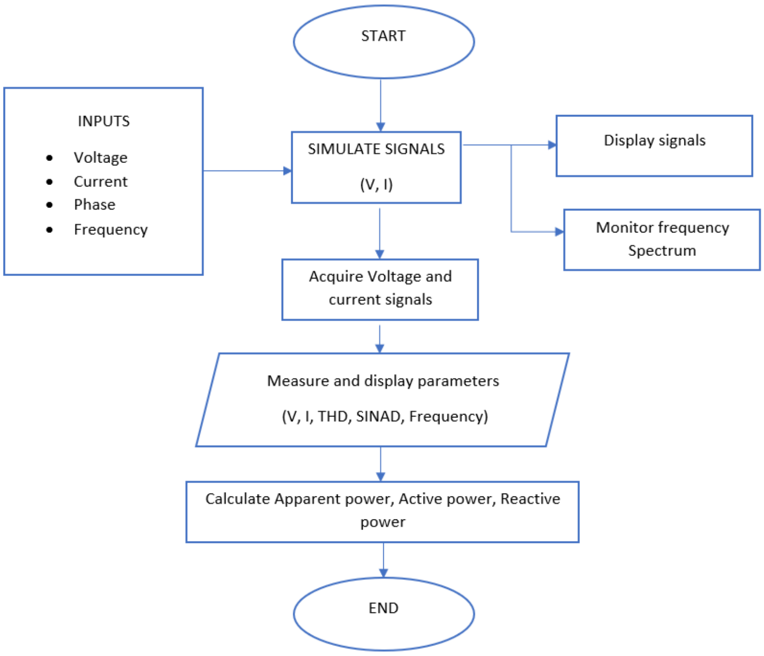


Fig.2: Flow chart for the measurement of Power Quality parameters

The Virtual instrument designed for the measurement of system parameters is as shown in the picture.

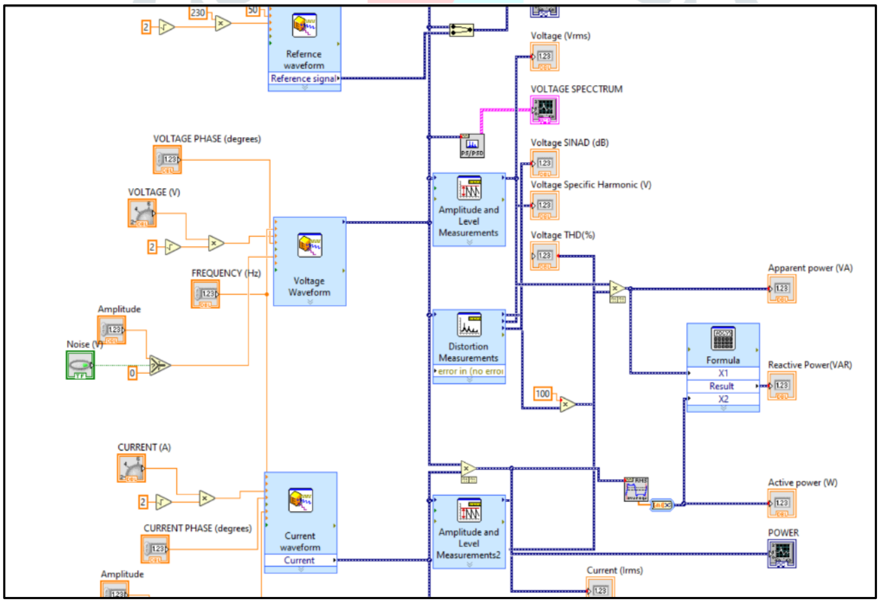


Fig.3: Block diagram of Virtual Analyzer in LabVIEW

B. Power Quality Event Detection

Power quality (PQ) events are the disturbances that are characterized by magnitude and duration. A virtual instrument is designed for the detection of various events which were discussed earlier related to power quality such as Interruption, Voltage Sag, Normal Voltage and Voltage swell. The programming has also been done for further classification of events depending on the duration of event occurrence.

The Virtual Instrument of event detector implemented takes the input of measured RMS Voltage (V_{RMS}) of the simulated signal and comparisons are done to determine the type of issue.

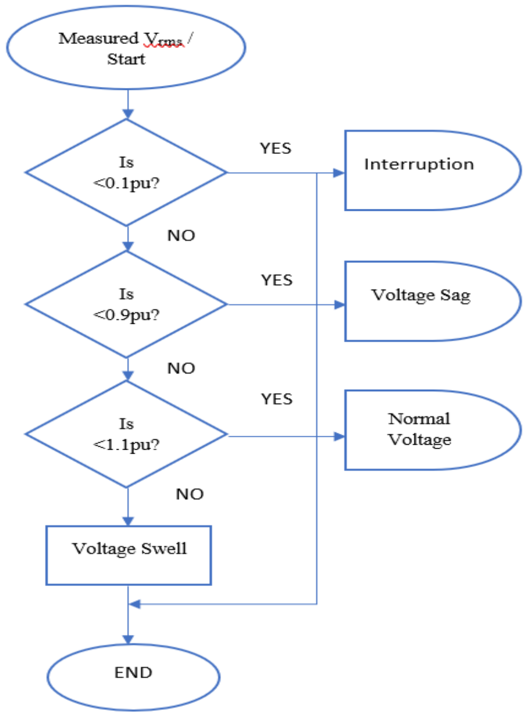


Fig.4: Flow chart for Event Detection

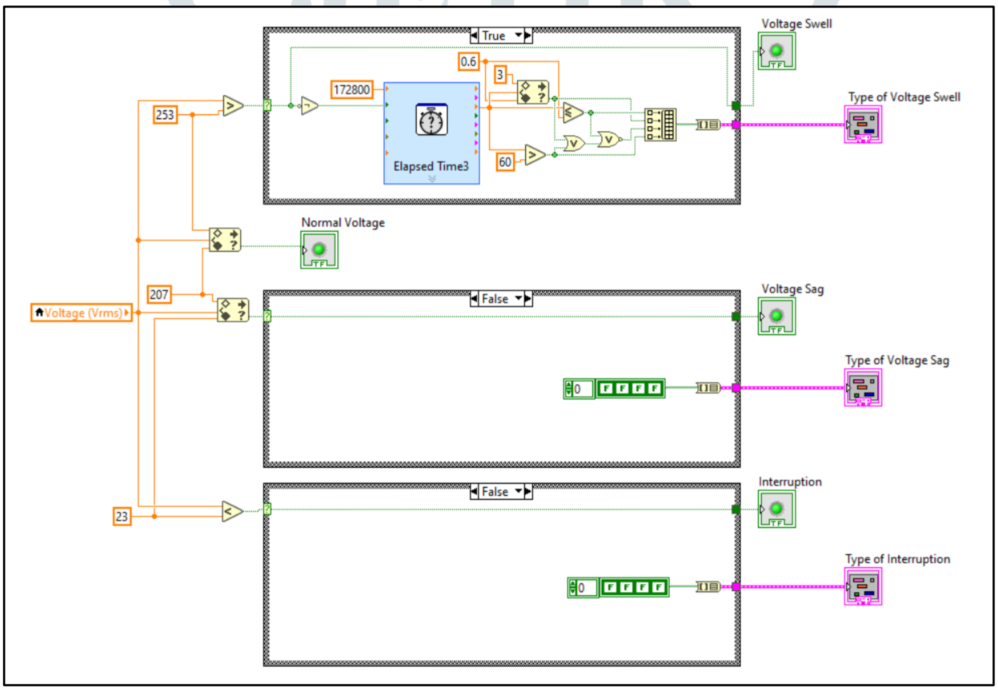


Fig.5: Block Diagram for Event detection

The events that are implemented namely Interruption, Voltage Sag and Voltage Swell are classified as follows

1. Interruption:

As per Standard (IEEE 1159) if the V_{RMS} measured is <0.1pu of actual reference voltage, the analyzer displays the event as Interruption. Interruption which lasts for a time from 0.5 cycles to 30 cycles, is termed as Instantaneous Interruption while that which persists for 30 cycles and up to 3 seconds is termed as Momentary Interruption. If it exists for a time between 3 seconds and 60 seconds, then Temporary Interruption is said to have occurred. If the time duration of the event exceeds 60 seconds, then it is classified as Sustained Interruption.

2. Voltage sag:

As per international standards (IEEE 519), if the voltage of the system is in between 0.1p.u and 0.9pu of the nominal voltage, i.e., between 23V and 207V of a single phase 230V AC supply, then the condition is termed as a sag.

Sag which lasts for a time from 0.5 cycles to 30 cycles, is termed as Instantaneous Sag while that which persists for 30 cycles and up to 3 seconds is termed as Momentary Sag. If it exists for a time between 3 seconds and 60 seconds, then Temporary Sag is said to have occurred. If the time duration of the event exceeds 60 seconds, then it is classified as under voltage.

3. Voltage swell:

As per international standards (IEEE 519), if the voltage of the system is greater than 1.1p.u. of the nominal voltage, i.e., 253V and above for a single phase 230V AC supply, then the condition is termed as a swell. Swell which lasts for a time from 0.5 cycles to 30 cycles, is termed as Instantaneous Swell while that which persists for 30 cycles and up to 3 seconds is termed as Momentary Swell. If it exists for a time between 3 seconds and 60 seconds, then Temporary Swell is said to have occurred. If the time duration of the event exceeds 60 seconds, then it is classified as over voltage.

The programming has also been done to indicate the status of the event and to record the time and duration for which the event has occurred which is shown in Fig.5.5.

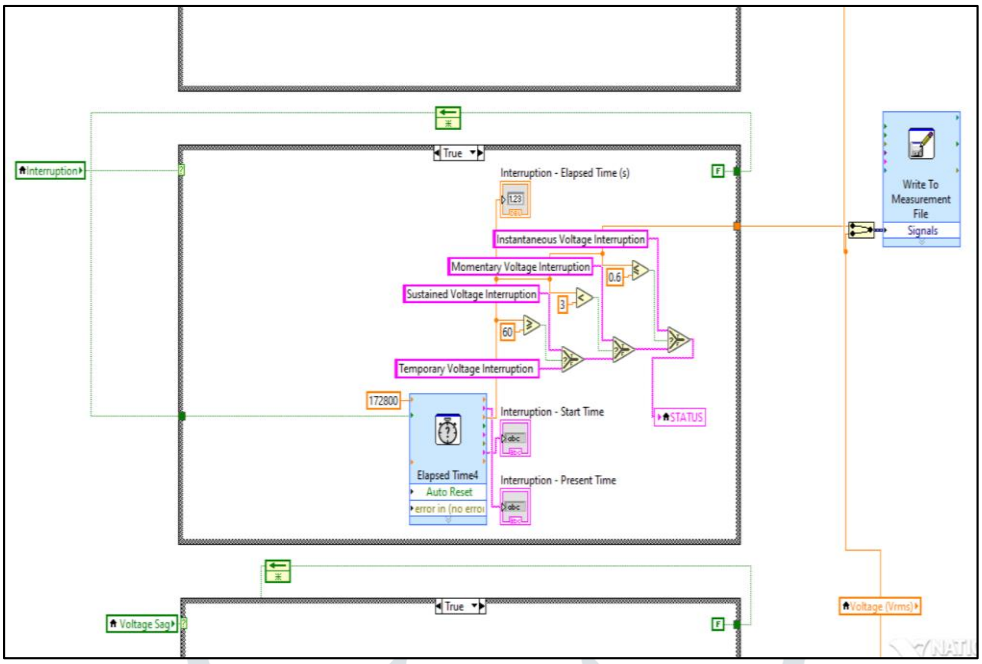


Fig.6: Block diagram for Status indication and data logging

VI. VIRTUAL INSTRUMENTATION RESULTS:

In this thesis, using LabVIEW internal programs, different noises or disturbances were generated to view different events of power quality on simulated signals by the developed Virtual Power Analyzer.

Fig.7 represents the simulated front panel to control the inputs parameters of voltage and current waveform generators using knob and numeric controllers.

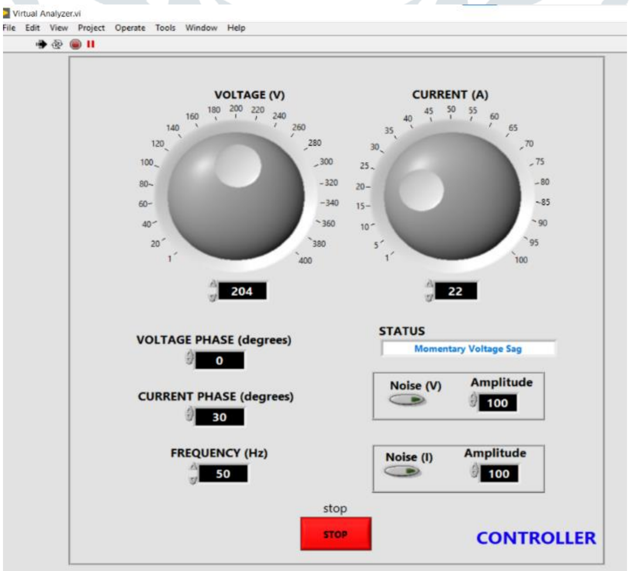


Fig.7: Front panel controls to simulate signals

Fig.8 shows the result of acquired voltage and current signals, their respective harmonic frequency spectrum and their waveform quality parameters.

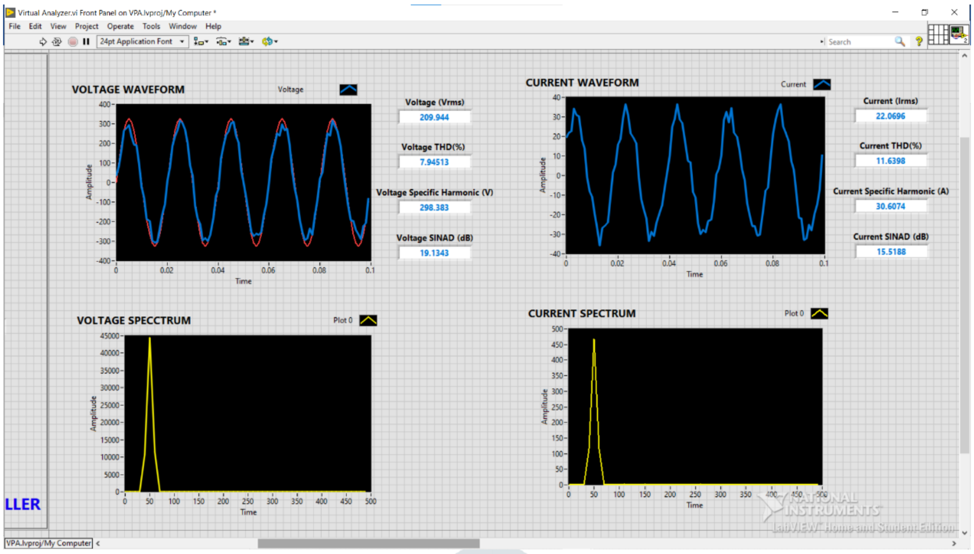


Fig.8: Front panel displaying the voltage and current signals along with their parameters

Fig.9 displays the front panels of power waveform and the readings of active, reactive, and apparent power of the acquired signals.

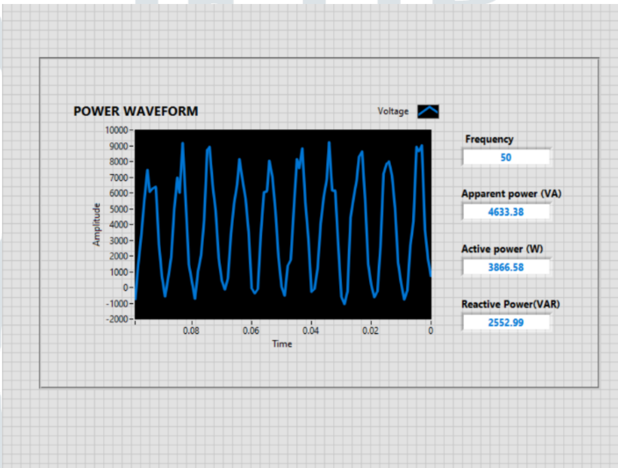


Fig.9: Front panel of waveform and the indicators of power

From **Fig.10** we observed that the result of event detection of power quality based on the magnitude of acquired voltage signal and it also displays the date and time and elapsed time of the event.

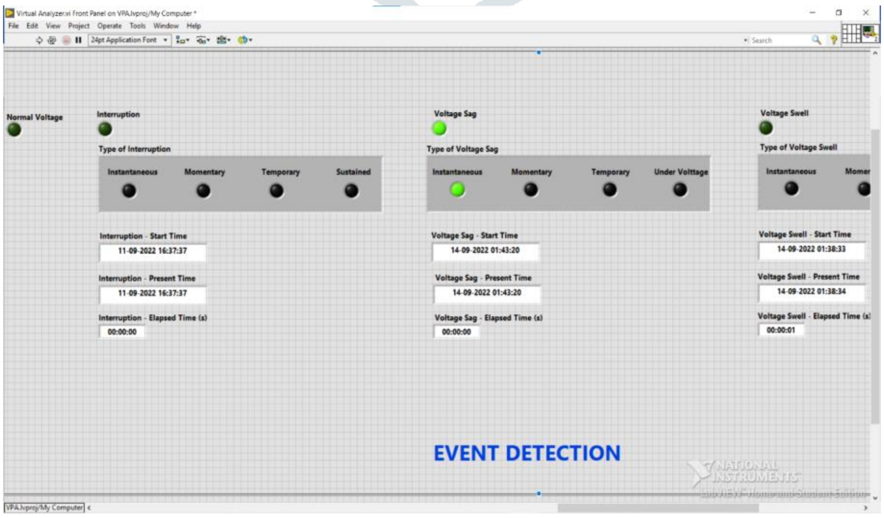
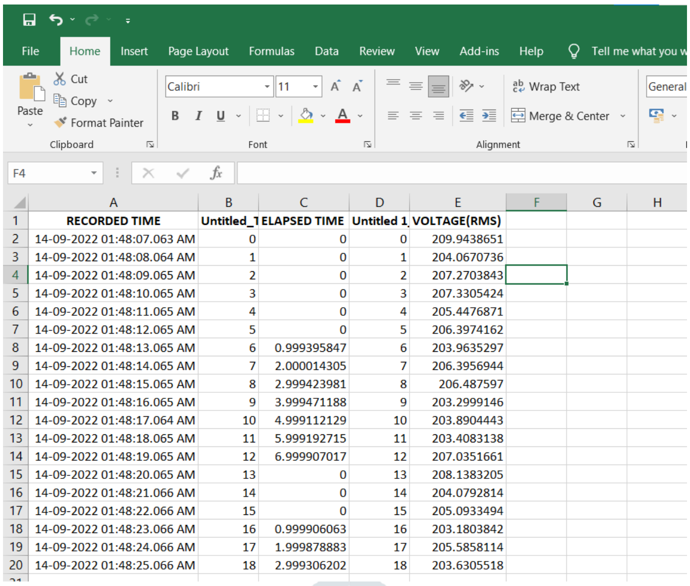


Fig.10: Front panel of Power Quality Event Detection

Fig.11 shows the record of event elapsed time and magnitude of voltage at every instant of time.



	A	B	C	D	E
1	RECORDED TIME	Untitled_1	ELAPSED TIME	Untitled 1	VOLTAGE(RMS)
2	14-09-2022 01:48:07.063 AM	0	0	0	209.9438651
3	14-09-2022 01:48:08.064 AM	1	0	1	204.0670736
4	14-09-2022 01:48:09.065 AM	2	0	2	207.2703843
5	14-09-2022 01:48:10.065 AM	3	0	3	207.3305424
6	14-09-2022 01:48:11.065 AM	4	0	4	205.4476871
7	14-09-2022 01:48:12.065 AM	5	0	5	206.3974162
8	14-09-2022 01:48:13.065 AM	6	0.999395847	6	203.9635297
9	14-09-2022 01:48:14.065 AM	7	2.000014305	7	206.3956944
10	14-09-2022 01:48:15.065 AM	8	2.999423981	8	206.487597
11	14-09-2022 01:48:16.065 AM	9	3.999471188	9	203.2999146
12	14-09-2022 01:48:17.064 AM	10	4.999112129	10	203.8904443
13	14-09-2022 01:48:18.065 AM	11	5.999192715	11	203.4083138
14	14-09-2022 01:48:19.065 AM	12	6.999907017	12	207.0351661
15	14-09-2022 01:48:20.065 AM	13	0	13	208.1383205
16	14-09-2022 01:48:21.066 AM	14	0	14	204.0792814
17	14-09-2022 01:48:22.066 AM	15	0	15	205.0933494
18	14-09-2022 01:48:23.066 AM	16	0.999906063	16	203.1803842
19	14-09-2022 01:48:24.066 AM	17	1.999878883	17	205.5858114
20	14-09-2022 01:48:25.066 AM	18	2.999306202	18	203.6305518

Fig.11 Data logging

Fig.12 indicates that the developed virtual power analyzer can be monitored and controlled using the web browser.

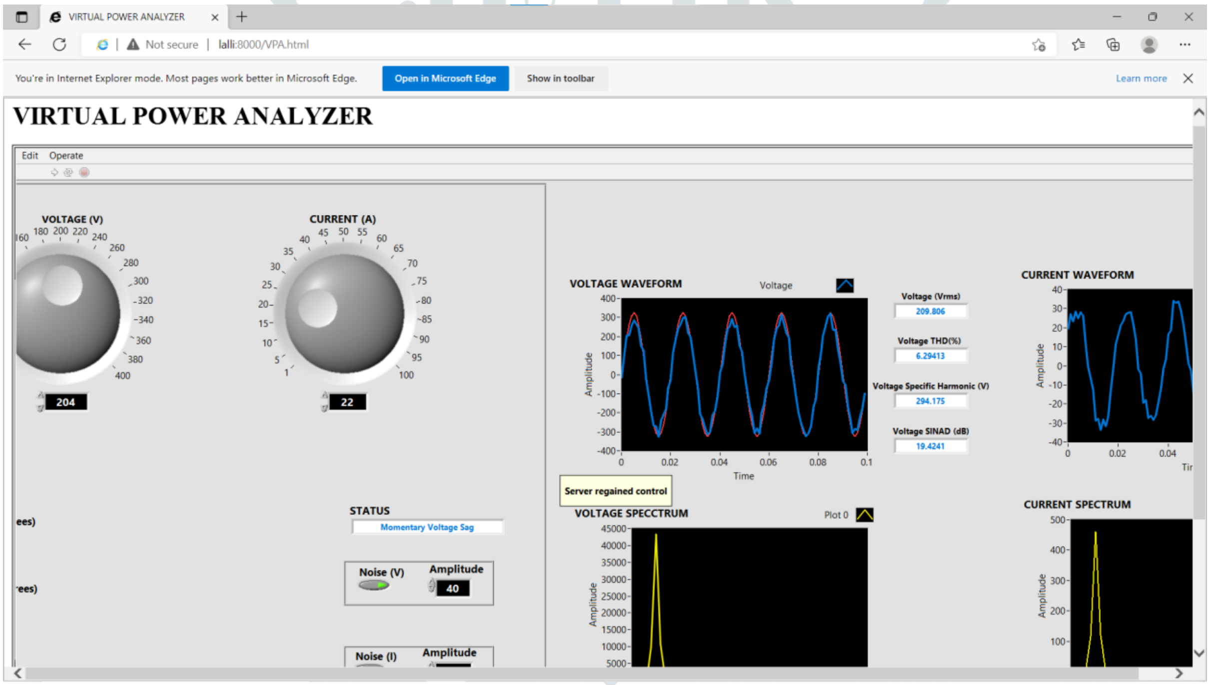


Fig.12 Remote monitoring of Virtual Instrument

VII. Conclusion And Future Scope

In this project, a Virtual Instrument for remote monitoring of power quality disturbances has been successfully developed using LabVIEW. Results have been displayed on instrument like front panels on a computer screen, called virtual instruments. The power quality monitoring system developed, offers some of the basic power quality monitoring features that are available in standard power quality monitoring equipment. Several experiments have been carried out to test the system for local and remote power quality monitoring. Some of the power quality variations such as Total Harmonic Distortion, SINAD have been monitored and, system parameters have been measured. A distinction has been made between different power quality events. The time and duration for which a particular event had occurred and its respective voltage readings have been recorded and saved as a TDMS file which can be used for future references. Remote monitoring and controlling of the virtual instrument have been done and the results are observed through web server.

The Power Quality Monitoring system developed here generates a simulated signal, displays various waveforms, analyses the harmonics content, and generates a report. A Data Acquisition (DAQ) card can be used for real time monitoring. Several other features are to be introduced in the instrument as well.

VIII. REFERENCES

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