Power Quality disturbance generator using Labview

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***ABSTRACT*-- Power quality disturbance is a one the challenging issues, where many researchers are gaining the attention towards it, now a day it is very much necessary to monitor power quality disturbances for analyze and other purpose. For developing tools for power quality (PQ) analysis and diagnosis PQ data is required. Therefore a software controlled scheme for generation of the typical power quality disturbances, is presented in this paper. PQ disturbance signal generator is based on the LabVIEW. The developed virtual instrument (VI) can generate five different categories of the PQ disturbances like voltage swells, sags, swells with harmonics and sags with harmonics in addition to the normal voltage waveform of single phase system. Each of simulated PQ disturbances can be predefined and easily changed according to user requirements, using various combinations of the knobs and controls provided on the front panel VI. The simulated PQ data can be applied as a part of the procedures for verification testing and calibration of the instruments and equipment developed for monitoring, measurement and software based processing of the basic PQ parameters, prescribed by the relevant quality standards.**

***KEYWORDS* - Electric Power Quality, Power quality disturbance, LabVIEW application software, and Virtual instrumentation.**

I. INTRODUCTION

Now a day's electric utilities and end users of electric power are becoming increasingly concerned about the quality of electric power. The term *power quality* has become one of the most prolific buzzwords in the power industry since the late 1980s. It is an umbrella concept for a multitude of individual types of power system disturbances. The issues that fall under this umbrella are not necessarily new. What is new is that engineers are now attempting to deal with these issues using a system approach rather than handling them as individual problems.
There are four major reasons for the increased concern:

Newer-generation load equipment, with microprocessor-based controls and power electronic devices, is more sensitive to power quality variations than was equipment used in the past.
The increasing emphasis on overall power system efficiency has resulted in continued growth in the application of devices such as high-efficiency, adjustable-speed motor drives and shunt capacitors for power factor correction to reduce losses. This is resulting in increasing harmonic levels on power systems and has many people concerned about the future impact on system capabilities.
End users have an increased awareness of power quality issues. Utility customers are becoming better informed about such issues as interruptions, sags, and switching transients and are challenging the utilities to improve the quality of power delivered.
Many things are now interconnected in a network. Integrated processes mean that the failure of any component has much more important consequences [1][2].

- POWER QUALITY

There can be completely different definitions for power quality, depending on one's frame of reference. For example, a utility may define power quality as reliability and show statistics demonstrating that its system is 99.98 percent reliable. Criteria established by regulatory agencies are usually in this vein. A manufacturer of load equipment may define power quality as those characteristics of the power supply that enable the equipment to work properly. These characteristics can be very different for different criteria.

'Any power problem manifested in voltage, current, or frequency deviations that result in failure or misoperation of customer equipment.

- CONCERNED ABOUT POWER QUALITY.

The ultimate reason that we are interested in power quality is economic value. There are economic impacts on utilities, their customers, and suppliers of load equipment.
The quality of power can have a direct economic impact on many industrial consumers. There has recently been a great emphasis on revitalizing industry with more automation and more modern equipment. This usually means electronically controlled, energy-efficient equipment that is often much more sensitive to deviations in the sup- ply voltage than were its electromechanical predecessors. Thus, like the blinking clock in residences, industrial customers are now more acutely aware of minor disturbances in the power system. acutely aware of minor disturbances in the power system. There is big money associated with these disturbances. It is not uncommon for a single, commonplace, momentary utility breaker operation to result in a $10,000 loss to an average-sized industrial concern by shutting down a production line that requires 4 hours to restart. In the semiconductor

manufacturing industry, the economic impacts associated with equipment sensitivity to momentary voltage sags resulted in the development of a whole new standard for equipment ride-through (SEMI Standard F-47, Specification for Semiconductor Process Equipment Voltage Sag Immunity).
The electric utility is concerned about power quality issues as well. Meeting customer expectations and maintaining customer confidence are strong motivators. With today's movement toward deregulation and competition between utilities, they are more important than ever. The loss of a disgruntled customer to a competing power supplier can have a very significant impact financially on a utility [3][4].

- POWER QUALITY ISSUES.

Power quality is a simple term, yet it describes a multitude of issues that are found in any electrical power system and is a subjective term. The concept of good and bad power depends on the end user. If a piece of equipment functions satisfactorily, the user feels that the power is good. If the equipment does not function as intended or fails prematurely, there is a feeling that the power is bad. In between these limits, several grades or layers of power quality may exist, depending on the perspective of the power user. Understanding power quality issues is a good starting point for solving any power quality problem. Figure1 provides an overview of the power quality issues.
Power frequency disturbances are low-frequency phenomena that result in voltage sags or swells. These may be source or load generated due to faults or switching operations in a power system. The end results are the same as far as the susceptibility of electrical equipment is concerned [5].

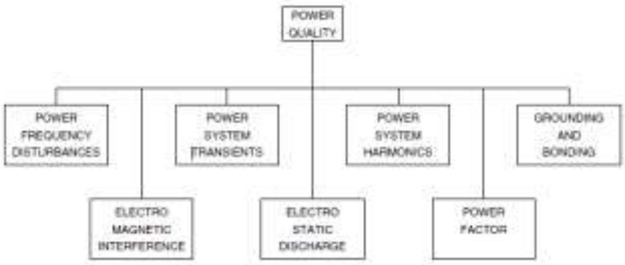


Figure1. Overview of the power quality issues.

Power system transients are fast, short-duration events that produce distortions such as notching, ringing, and impulse. The mechanisms by which transient energy is propagated in power lines, transferred to other electrical circuits, and eventually dissipated are different from the factors that affect power frequency disturbances.
Power system harmonics are low-frequency phenomena characterized by waveform distortion, which introduces harmonic frequency components. Voltage and current harmonics have undesirable effects on power system operation and power system components. In some instances, interaction between the harmonics and the power system parameters (*R*–*L*–*C*) can cause harmonics to multiply with severe consequences [6].

The subject of grounding and bonding is one of the more critical issues in power quality studies. Grounding is done for three reasons. The fundamental objective of grounding is safety, and nothing that is done in an electrical system should compromise the safety of people who work in the environment; in the U.S., safety grounding is mandated by the National Electrical Code. The second objective of grounding and bonding is to provide a low-impedance path for the flow of fault current in case of a ground fault so that the protective device could isolate the faulted circuit from the power source. The third use of grounding is to create a ground reference plane for sensitive electrical equipment. This is known as the signal reference ground (SRG). The configuration of the SRG may vary from user to user and from facility to facility. The SRG cannot be an isolated entity. It must be bonded to the safety ground of the facility to create a total ground system.
Electromagnetic interference (EMI) refers to the interaction between electric and magnetic fields and sensitive electronic circuits and devices. EMI is predominantly a high-frequency phenomenon. The mechanism of coupling EMI to sensitive devices is different from that for power frequency disturbances and electrical transients. The mitigation of the effects of EMI requires special techniques, as will be seen later.
Radio frequency interference (RFI) is the interaction between conducted or radiated radio frequency fields and sensitive data and communication equipment. It is convenient to include RFI in the category of EMI, but the two phenomena are distinct Electrostatic discharge (ESD) is a very familiar and unpleasant occurrence. In our day-to-day lives, ESD is an uncomfortable nuisance we are subjected to when we open the door of a car or the refrigerated case in the supermarket. But, at high levels, ESD is harmful to electronic equipment, causing malfunction and damage.
Power factor is included for the sake of completing the power quality discussion. In some cases, low power factor is responsible for equipment damage due to component overload. For the most part, power factor is an economic issue in the operation of a power system. As utilities are increasingly faced with power demands that exceed generation capability, the penalty for low power factor is expected to increase [7][8].
An understanding of the power factor and how to remedy low power factor conditions is not any less important than understanding other factors that determine the health of a power system.Table 1 provides information regarding typical spectral content, duration, and magnitude where appropriate for each category of electromagnetic phenomena. The categories of the table, when used with the attributes previously mentioned, provide a means to clearly describe an electromagnetic

disturbance. The categories and their descriptions are important in order to be able to classify measurement results and to describe electromagnetic phenomena which can cause power quality problems.
These individual PQ disturbance categories for generation can be predefined and simulated using different combinations of basic waveform parameters, such as for example: frequency value, number of the visible signal periods, start and stop time of the specific disturbance event, disturbance amplitude levels and amplitude levels of the individual high-order harmonics. Practically, these basic adjustments for individual disturbance simulation parameters need to be performed across developed programming sequence in LabVIEW environment, according to specific demands. Virtual instruments applied for definition and simulation of the mentioned PQ disturbance waveforms will be presented and described in the following paper section [9].

TABLE 1. Category and Characteristics of Power System Electromagnetic Phenomena

Categories	Typical spectral content	Typical duration	Typical voltage magnitude
1.0 Transients			
1.1 Impulsive			
1.1.1 Nanosecond	5 ns rise	< 50 ns	
1.1.2 Microsecond	1 μs rise	50 ns–1 ms	
1.1.3 Millisecond	0.1 ms rise	> 1 ms	
1.2 Oscillatory			
1.2.1 Low frequency	< 5 kHz	0.3–50 ms	0–4 pu
1.2.2 Medium frequency	5–500 kHz	20 μs	0–8 pu
1.2.3 High frequency	0.5–5 MHz	5 μs	0–4 pu
2.0 Short duration variations			
2.1 Instantaneous			
2.1.1 Sag		0.5–30 cycles	0.1–0.9 pu
2.1.2 Swell		0.5–30 cycles	1.1–1.8 pu
2.2 Momentary			
2.2.1 Interruption		0.5 cycles–3 s	< 0.1 pu
2.2.2 Sag		30 cycles–3 s	0.1–0.9 pu
2.2.3 Swell		30 cycles–3 s	1.1–1.4 pu
2.3 Temporary			
2.3.1 Interruption		3 s–1 min	< 0.1 pu
2.3.2 Sag		3 s–1 min	0.1–0.9 pu
2.3.3 Swell		3 s–1 min	1.1–1.2 pu
3.0 Long duration variations			
3.1 Interruption, sustained		> 1 min	0.0 pu
3.2 Undervoltages		> 1 min	0.8–0.9 pu
3.3 Overvoltages		> 1 min	1.1–1.2 pu
4.0 Voltage imbalance		steady state	0.5–2%
5.0 Waveform distortion			
5.1 DC offset		steady state	0–0.1%
5.2 Harmonics	0–100th H	steady state	0–20%
5.3 Interharmonics	0–6 kHz	steady state	0–2%
5.4 Notching		steady state	
5.5 Noise	broad-band	steady state	0–1%
6.0 Voltage fluctuations	< 25 Hz	intermittent	0.1–7%
7.0 Power frequency variations		< 10 s	

II. VIRTUAL INSTRUMENTATION SOFTWARE

Described procedure for disturbance waveforms generation is functionally based on the concept of virtual instrumentation. Virtual instrumentation concept is based on the standard PC, [10].
Block diagram of the virtual instrument, developed by means of graphical programming package LabVIEW, power quality disturbances signal generator are developed in virtual instrumentation software, which gives possibilities for creation of the basic disturbance parameters are as shown in the fig2. The adjustments for the parameter are provided using a number of the control buttons and knobs implemented in the virtual instrument front panel, as shown in fig3, which presented simulated undisturbed

Single-phase voltage waveforms and above waveforms, on instrument front panel are shown control switches, performing selection of the number samples, voltage magnitude and frequency[11].

On this front panel are shown control buttons for regulation of the signal periods number, signal frequency, disturbance start and stop times, voltage swell and sag amplitude levels. Illustrated front panel also performs graphical presentation of the voltage waveforms, including simulation of single-phase voltage swell. Waveforms are generated according to predefined disturbance duration and swell amplitude level.
Simulation of Single-phase waveforms with included voltage sag, performed in LabVIEW environment, is illustrated in Fig 4. Shown voltage signals are simulated with 50 ms disturbance duration and 0.5V sag level. Separated section of the control knobs is applied for selection and regulation of the amplitude voltage levels regarding to the individual high-order harmonics added to the nominal voltage Waveforms.

III.SIMULATION RESULTS

Numbers of signals of each type of power quality disturbances are generated according to selected disturbance duration and sag/ swell amplitude level. Simulation of each type of single phase waveforms are performed in hybrid power quality signal generator in LabVIEW environment and the Block diagram of power quality disturbances signal generator as illustrated in Fig.2.

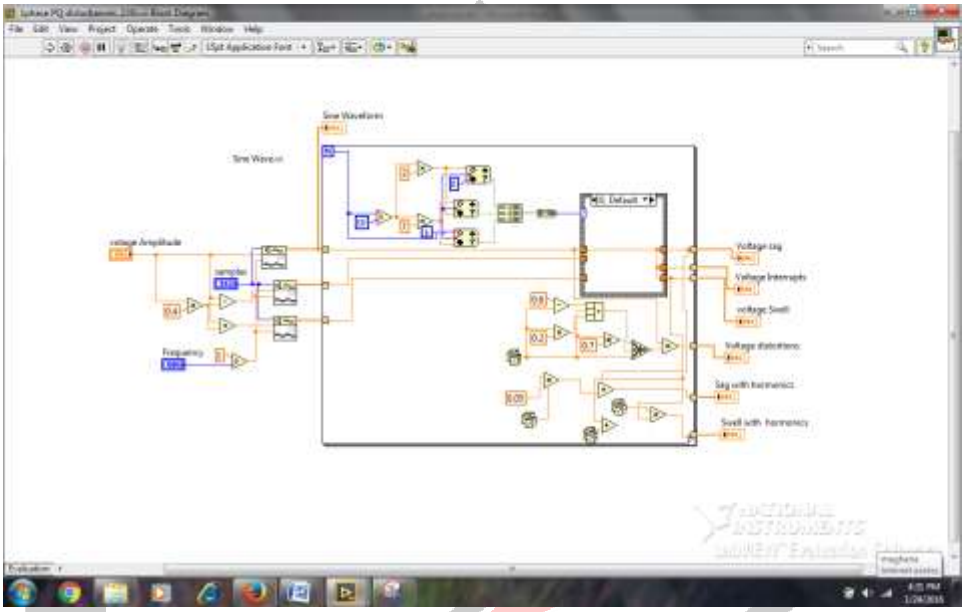
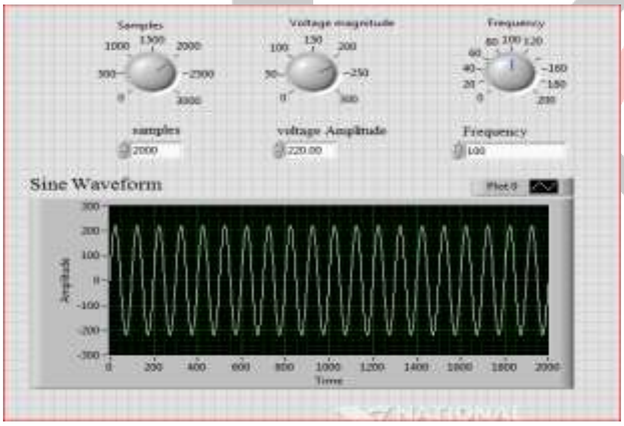


Figure 2. Block diagram of power quality disturbances signal generator.



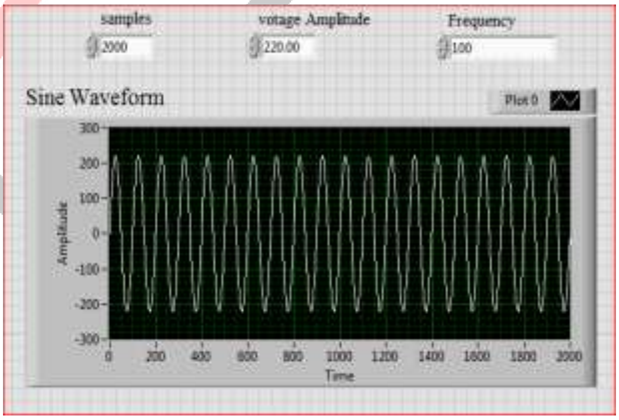
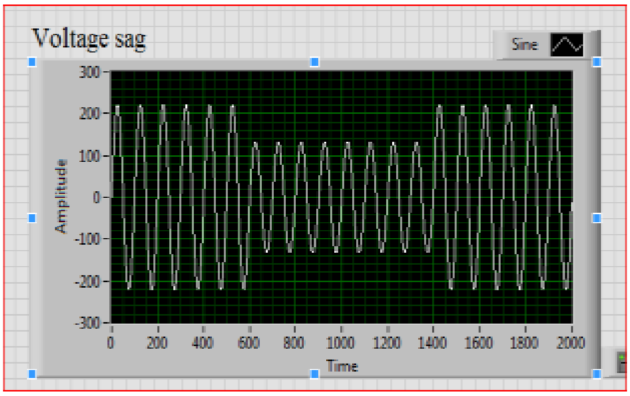


Fig3.Front panel of PQD signal generator. Fig4.Simulated PQD waveforms of Fundamental sine waveform.

Fig3 show simulated voltage signals of 220V magnitude of 10 milli-second disturbance duration of front panel of power quality disturbance signal generator for pure sine waveform and fig 4 shows the pure sine wave form with number of samples , voltage magnitude and frequency ranges.



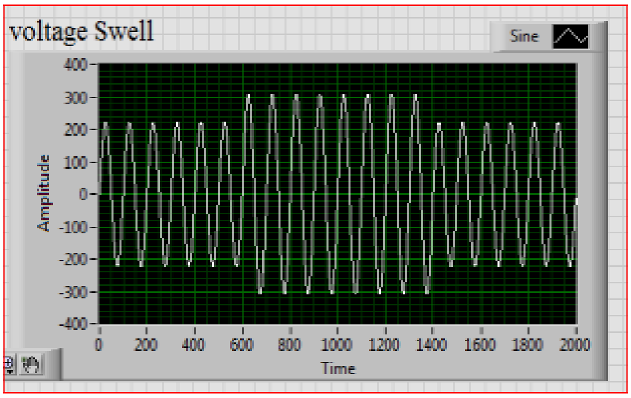
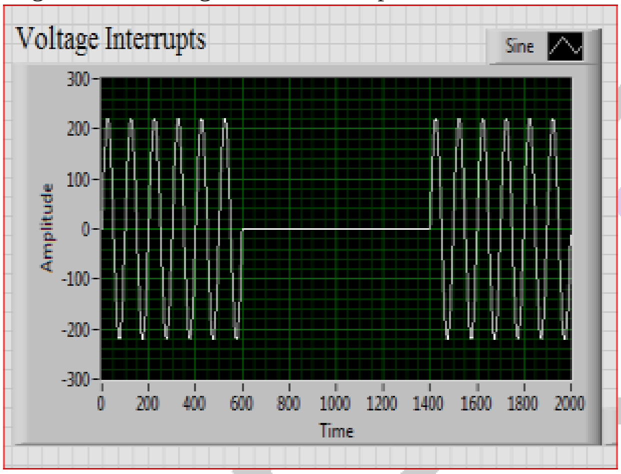


Figure5. Simulated PQD waveforms of Voltage Sag. Figure 6. Simulated PQD waveforms of Voltage Swell.

Fig 5 shows the amplitude of voltage sag up to 60% of its rated voltage for time duration from 600 to 1400 samples Similarly for magnitude of voltage swell varied up to 130% of its rated voltage for time duration from 600 to 1400 samples as shown fig 6.



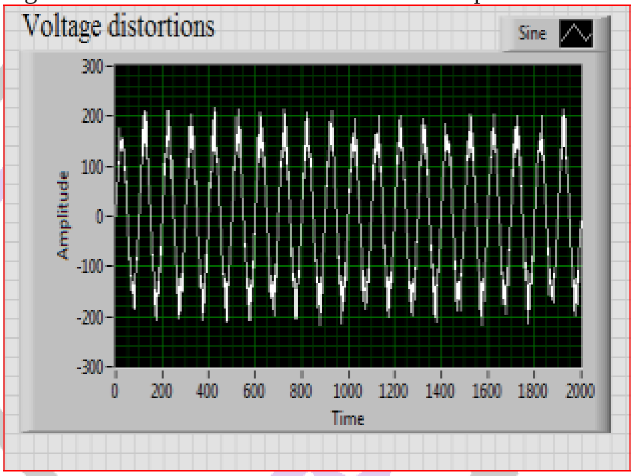
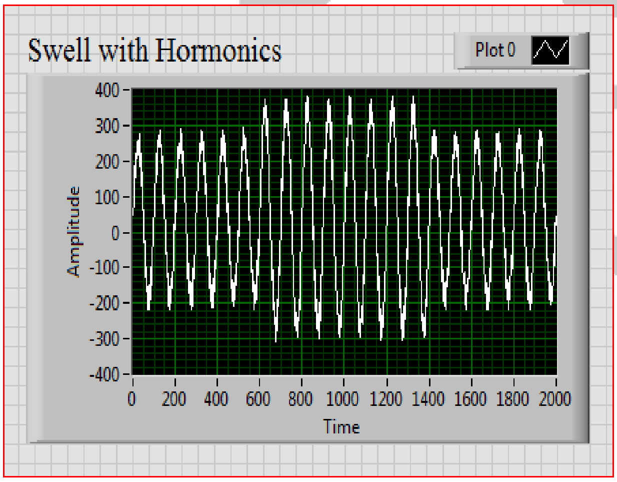


Fig7. Simulated PQD waveforms of Voltage Interrupts. Fig 8. Simulated PQD waveforms of Voltage disturbance

and further voltage Interruption for a time duration from 600 to 1400 samples are as shown in fig7.voltage distortion for continues signal are as shown in the fig8.



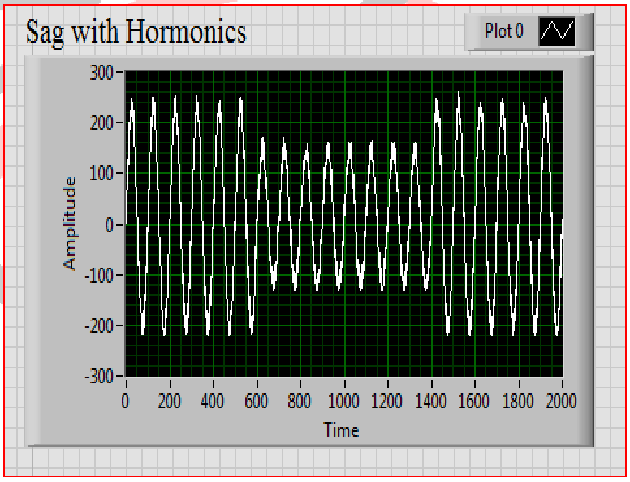


Fig9. Simulated PQD waveforms of Voltage swell with Harmonics. Fig10. Simulated PQD waveforms of Voltage sags with Harmonics.

Fig 9 shows the voltage Swell with harmonics varied up to 130% of its rated voltage for time duration from 600 to 1400 samples and Fig 10 shows voltage sag with harmonics up to 60% of its rated voltage for time duration from 600 to 1400 samples.

IV.CONCLUSION

The classification of power quality disturbances are developed using virtual instrumentation, which is designed in Lab VIEW programming environment for simulation and generation of the PQ disturbances. Power quality disturbances are generated by adjusting the parameter for single phase voltage wave form by control switches and knobs on the Front panel of Lab View. PQ disturbances analysis can be done successfully on new software tools.

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