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Study of Power Quality for Northern Grid in India

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Abstract: ***After 2012 blackout [1] there was a severe need for a formal power quality study for Northern Grid, India. In this pater the author has thoroughly studied the present power quality of Northern Grid with respect to voltage fluctuations, transients and harmonics.***

Keywords: Northern Grid. Power quality, product reliability, Harmonics, Voltage Fluctuation

1. Introduction

Power supply is erratic at most places in India, with voltage fluctuating in both directions (up and down) at many places frequently. These voltage fluctuations can damage appliances, thereby causing them to end much before their normal useful life. To meet the needs of India's growing economy, providing reliable, affordable, secure, and sustainable energy requires exploring a range of options including maximizing domestic production, diversifying the fuel mix and the source of supply, and maintaining sufficient reserves, if necessary.

2. Power Quality Issues and Disturbances [2]

Defining power quality and its disturbances is one of the PQ issues. An overview of PQ definitions will be helpful in understanding different PQ events or parameters. In a broad sense power quality may be defined as “any power problem manifested in voltage, current, or frequency deviations that result in failure or disoperation of customer equipment.”[3]

“High Power Quality” has become one of the aims of industrial systems design due to the widespread use of electronic based equipment in nearly every aspect of our modern life. The most significant power quality problems that are responsible for poor power quality and are having detrimental effect on industrial load operation are voltage sags, supply interruptions, harmonics and voltage flickers. Thus electric power quality has become an important issue in the deregulated power systems.

Deregulation is resulting in important structure changes in the utility industry and presents the possibility of improving the system operation efficiency. However, there are some significant impacts of deregulation on power quality which need improved mitigation.

2.1 Harmonics

Harmonics is A sinusoidal component of a periodic waveform having a frequency that is an integral multiple of the fundamental system frequency. The Nonlinear characteristics of devices and loads on the power system give rise to harmonic distortion. Harmonic distortion levels are described by the complete harmonic spectrum with magnitudes and phase angle of each harmonic component. Despite its deficiency as in the Total Harmonic Distortion THD is frequently used as a measure of the degree of harmonic distortion of the system. In a deregulated environment harmonic problems will continue to increase because of the fact that the independent power producers IPP, which are using wind and solar energy to generate power, will depend mainly on inverters to interface with the utility grid leading to the increase of the harmonic distortion.

2.2 Voltage Fluctuation

Voltage fluctuations are changes or swings of the voltage envelope in a systematic manner or a series of random voltage variations and are always referred to as voltage flicker. In addition to its effect on light, it is responsible for reduced life of electronic, incandescent, fluorescent and cathode ray tubes, malfunction of phase locked–loops PLLs, mis-operation of electronic controllers and protection devices. Even under deregulation, voltage fluctuations and flicker will increase due to use of nonlinear and vulnerable devices, and in such environment, the control of the voltage fluctuation should be the responsibility of the Transmission utilities (Transco.) and Distribution Companies (Disco.) such as switch-mode power supplies, television sets, light dimmers, and adjustable-speed drives can also inject provided that industrial customers, especially those utilizing large arc furnaces, control the amount of fluctuation of their load current.

3. Details of Measurement

3.1 Harmonic Measurement

Harmonics in voltage and current were measured and analyzed using Precision Power Analyzer. The system voltage was fed to the recording device directly and the load current was fed to the recording device through CT. The voltage and current waveforms were analyzed up to 25th harmonics using the Fast Fourier Transform (FFT) algorithm.

3.2 Surge Measurement

The voltage signal was captured using digital storage oscilloscope. The oscilloscope was put on trigger mode and whenever surge occurred, data stored inside the oscilloscope. Assure that the electric utility can protect its electrical equipment from overheating, loss of life from excessive harmonic currents, and excessive voltage stress due to excessive harmonic voltage [4].

Each point from IEEE 519 lists the limits for harmonic distortion at the point of common coupling (PCC) or metering point with the utility. The voltage distortion limits are 3% for individual harmonics and 5% THD.

All of the harmonic limits in IEEE 519 are based on a customer load mix and location on the power system. The limits are not applied to particular equipment, although, with a high amount of nonlinear loads, it is likely that some harmonic suppression may be necessary.[5]

Below current distortion limits are for odd harmonics. Even harmonics are limited to 25% of the odd harmonic limits [1,3,5]. For all power generation equipment, distortion limits are those with I SC/I L<20.I SC is the maximum short circuit current at the point of coupling "PCC".I frequency 15-or 30-minutes load current at PCC.

Table 1: The reading of Individual harmonic content when current found maximum of entire measurement.

Harmonic Order	*I in %*	*I in A*	*VPN in %*
1	100	10.52	100
2	0.16	0.02	0.02
3	5.48	0.58	0.25
4	0.13	0.01	0.05
5	4.3	0.45	1.46
6	0.1	0.01	0.03
7	3.23	0.34	0.39
8	0.19	0.02	0.09
9	1.54	0.16	0.37
10	0.06	0.01	0.04
11	1.07	0.11	0.1
12	0.05	0.01	0.01
13	0.43	0.04	0.4
14	0.04	0	0.03
15	0.11	0.01	0.03
16	0.06	0.01	0.02
17	0.1	0.01	0.11
18	0.05	0	0.02
19	0.05	0.01	0.04
20	0.01	0	0.02
21	0.21	0.02	0.19
22	0.03	0	0.02
23	0.11	0.01	0.09
24	0.03	0	0.01
25	0.05	0.01	0.09

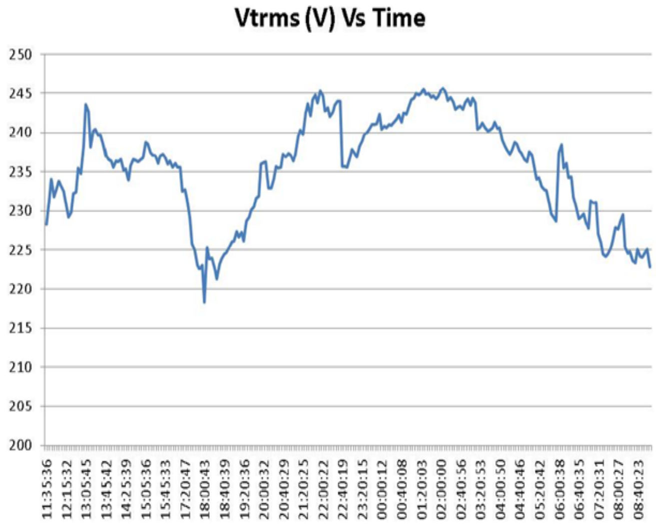
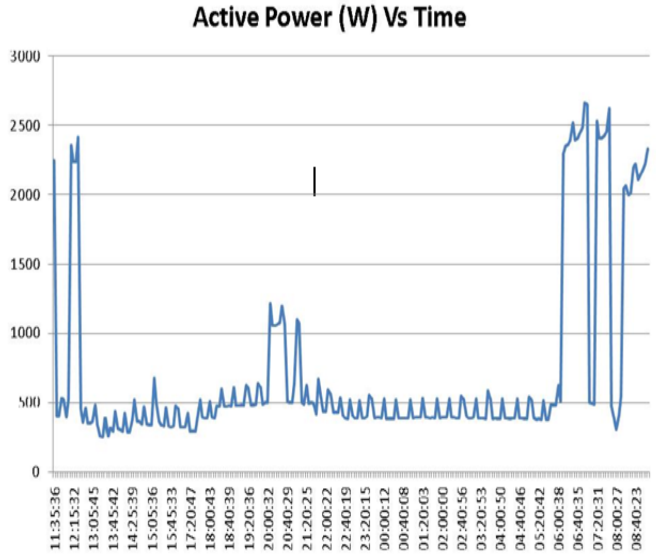


Figure 1: Variation in rms voltage with respect to time



. **Figure 2:** Variation in Active Power with respect to time

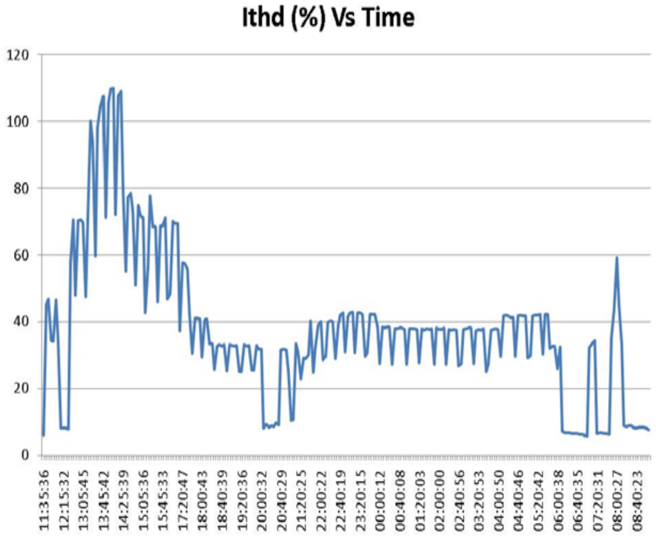


Figure 3: Variation in current THD (%) with respect to time

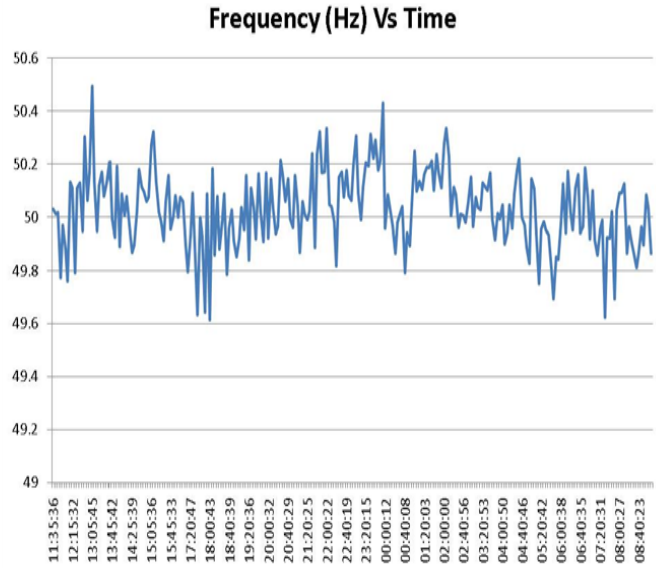


Figure 4: Variation in Frequency with respect to time

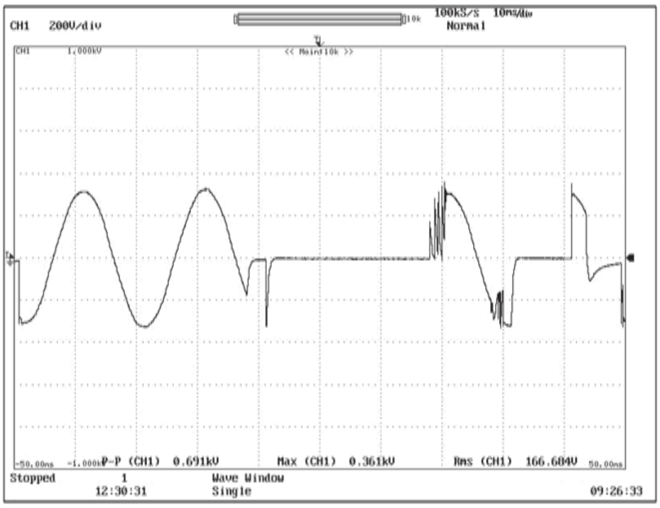


Figure 5: Voltage waveform by oscilloscope

4. Conclusion

The first sign of a power-quality problem is a distortion in the voltage waveform of the power source from a sine wave, or in the amplitude from an established reference level, or a complete interruption. The disturbance can be caused by harmonics in the current or by events in the main voltage supply system. The disturbance can go for a fraction of a cycle (milliseconds) to great durations (seconds to hours) in the voltage supplied by the source.

The aim for method for correction is to make the power source meet an international standard. Power quality problems can basically start at four levels of the system that delivers electric power, first one, includes Power plants and the entire area transmission system. The second one are Transmission lines, major substations whereas third one includes distribution substations, primary, and secondary power lines, and distribution transformers and last and fourth one includes service equipment and building wiring.

In addition, the problems can be caused by the equipment supplied with electric power—for example, power-electronic converters. Redundancy at all levels of the electric-power system reduces the incidence and duration of line-voltage disturbances.

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