Power Quality Issues and Signal Processing Approach

Mr. Mohammad Zubair
ME (EPS) Student
Department of Electrical
Engineering MGI-COET
Shegaon,India.
muhd.zubair2016@gmail.com

Prof. Abhijit P. Padol.
Department of Electrical
Engineering MGI-COET
Shegaon,India.
abhijit.padol@gmail.com

Prof. Pratik W. Choudhary
Department of Electrical
Engineering MGI-COET
Shegaon,India.
c.pratik55@gmail.com

Prof. Piyush S. Dorale
Department of Electrical
Engineering MGI-COET
Shegaon,India.
piyush.dorale@gmail.com

Prof. Aishwarya S. Kakad
Department of Electrical
Engineering MGI-COET
Shegaon,India.
aishkakad@gmail.com

Abstract- This Paper emphases on power quality Issues, Identification, Categorization and Mitigation of Power Quality issues in a Power System. The various techniques for Identification, Categorization of power quality Problems in electrical power system have been proposed so far. This paper presents a full overview of different techniques used for classification of power disturbance. The common method for detection and classification of Power Quality issues like voltage sag, swell, notch, spike, transients etc. using Fourier transform, S-transform and Wavelet transform. Wavelet transform has received greater attention in power quality. Wavelet transform is more than efficient to other transform.

Keywords- *Power quality disturbance, Fourier transform, Wavelet transform and S-transform,comparision*

*****

I. INTRODUCTION

Electrical energy is the most efficient and popular form of energy and the modern society is heavily dependent on the electric supply. The life cannot be imagined without the supply of electricity. At the same time the quality and continuity of the electric power supplied is also very important for the efficient functioning of the end user equipment. Most of the commercial and industrial loads demand high quality uninterrupted power. Power quality is simply the interaction of electrical power with electrical equipment. If electrical equipment operates correctly and reliably without being damaged or stressed, we would say that the electrical power is of good quality. On the other hand, if the electrical equipment malfunctions, is unreliable, or is damaged during normal usage, we would suspect that the power quality is poor. Power Quality is an important issue to power utilities and their customers. The wide use of non-linear loads and other electronics equipment can cause power disturbance which then lead to poor power quality. Poor power quality is normally caused by power line disturbance resulting in failure of End user equipment. To improve the power quality, the Power Quality issues should be detected, localized and classified accurately so that appropriate solution can be suggested to mitigate it. The Power Quality issues are identifying using DWT (Discrete Wavelet Transform) or s-transform. From this we can find the Statistical parameters which are given as input to ANN (Artificial Neural Network) for categorization then most appropriate solution will be given to mitigate it. To overcome the detrimental effects of poor quality, sources and causes of disturbances should be specified before initiating any mitigation action. Therefore continuous monitoring, power quality Issues.

In Signal Processing techniques linking are Fourier Transform, Wavelet Transform and S-Transform. Signal Processing techniques have become most popular technique for identification of power quality disturbance. Wavelet transform, which has the ability to analyze these power quality problems simultaneously in both time and frequency domain is used to extract features of the disturbances by decomposing the signal using multi resolution analysis. These features are used to detect and localize the disturbances. Wavelet transform is a powerful tool for detection and classification of power system disturbances are laborious since they are primary based on visual inspection of waveforms. Recent advances in signal processing and pattern recognition have led to the development of several new classification approaches, which are based on discrete wavelet transform, multiresolution signal decomposition, polynomial approximation, and bispectra analysis [1-.3]

II. POWER QUALITY

It is define as any power problem manifested in voltage current or frequency deviation that results in failure or missed operation of utility or end user equipment. Power quality is simply the interaction of electrical power with electrical equipment. If electrical equipment operates correctly and reliably without being damaged or stressed, we would say that the electrical power is of good quality. On the other hand, if the electrical equipment malfunctions, is unreliable, or is

ISSN: 2321-8169
65 - 69

damaged during normal usage, we would suspect that the power quality is poor. Aim of electric power system:

to generate electrical energy and to deliver this energy to end-user equipment at an acceptable voltage. Power quality becoming important to electricity consumers at all levels of usage. Power Quality defines the term "power quality," and then discusses several power-quality "events." Power-quality "events" happen during fault conditions, lightning strikes, and other occurrences that adversely affect the line-voltage and/or current waveforms. We shall define these events and their causes, and the possible Ramifications of poor power quality the end-users are now more concerned to protect their sensitive loads from power quality disturbances by installing protection equipment. Power Quality has become an important issue to both power utilities and their customers. The wide use of non-linear loads and electronics equipment can cause power disturbance which then lead to poor power quality. Poor power quality is normally caused by power line disturbance resulting in failure of End user equipment. It is the measure, analysis and improvement of bus voltage (load bus voltage) , to maintain that voltage to be sinusoid at rated voltage and frequency. It is the power that has sinusoidal voltage and current without any distortion and operates at the designed magnitude and frequency. [1-8]

III. POWER QUALITY ISSUES

If the voltage supplied to utilization equipment was always a perfect sine wave of constant frequency and magnitude and the resulting load current tracked the voltage, there would be no power quality problems. Unfortunately, the voltage supplied to utilization equipment is not always perfect and performance problems with the utilization equipment result. Due to poor power quality, an electrical device may malfunction, fail prematurely or not operate at all. There are many ways in which electric power can be of poor quality and many more causes of such poor quality power. Common power quality problems include:

1. Voltage Sag
2. Voltage swell
3. Very short interruptions
4. Long interruptions
5. Harmonic distortion
6. Under voltages and over voltage
7. High-Voltage Spikes
8. Electrical noise.
9. Transients

1. Voltage Sag/Dip:-

A decrease of the normal voltage level between 10 and 90% of the nominal rms voltage at the power frequency, for durations of 0, 5 cycle to 1 minute.

Causes:

Faults on the transmission or distribution network, faults in consumer's installation. Connection of heavy loads and start-up of large motors.It reduce the energy being delivered to the end user .It cause computer to reset, shut down or to fails results in loss of data.

Consequences:

It causes adjustable speed drive to shut down. It causes overheating of the motors. Malfunction of microprocessor-

based. Control systems (PCs, PLCs, ASDs, etc.) that may lead to a process stoppage.Tripping of contactors and electromechanical relays.Disconnection and loss of efficiency in electric rotating machines.

2. Voltage swells:

momentary increase of the voltage, at the power frequency, outside the normal tolerances, with duration of more than one cycle and typically less than a few seconds. very fast variation of the voltage value for durations from a several microseconds to few milliseconds.

Causes:

lightning, switching of lines or power factor correction capacitors. Disconnection of heavy loads.Start/stop of heavy loads, badly dimensioned power sources, badly regulated transformers (mainly during off-peak hours.

Consequences:

Data loss, flickering of lighting and screens, stoppage or damage of sensitive Equipment, if the voltage values are too high.

3. Very short interruptions:

Total interruption of electrical supply for duration from few milliseconds to one or two seconds.Mainly due to the opening And automatic reclosure of protection devices to decommission a faulty section of the network. The main fault causes are insulation failure, lightning and insulator flashover. Consequences of these interruptions are tripping of protection devices, loss of information and malfunction of data processing equipment

4. Long interruptions:

Long interruption of electrical supply for duration greater than 1 to 2 seconds.The main fault causes are Equipment failure in the power system network, storms and objects (trees, cars, etc) striking lines or poles, fire, human error, bad coordination or failure of protection devices. A consequence of these interruptions is stoppage of all equipment

Consequences:

During Interruption the voltage level rapidly decays to zero or to almost zero. Thus no energy is transferred to a component or device. This causes the complete shutdown of equipment and also can lead to damage. It cause computer to reset, shut down or to fails results in loss of data.

5. Harmonic distortion:

Electricity generation is normally produced at constant frequency of 50Hz and generated voltage can be considered practically sinusoidal .When a source of sinusoidal voltage is applied to a nonlinear device or load the resulting current is not perfectly sinusoidal. In the presence of system impendence of this causes a non-sinusoidal voltage drop causing voltage distortion at the load terminals known as Harmonic Distortion.

ISSN: 2321-8169
65 - 69

Voltage or current waveforms assume non-sinusoidal shape. The waveform corresponds to the sum of different sine-waves with different magnitude and phase, having frequencies that are multiples of power-system frequency. Main Causes are Classic sources: electric machines working above the knee of the magnetization curve (magnetic saturation), arc furnaces, welding machines, rectifiers, and DC brush motors. Modern sources: all non-linear loads, such as power electronics Equipment includes ASDs, switched mode power supplies, data processing equipment, high efficiency lighting.

Consequences are increased probability in occurrence of resonance, neutral overload in 3-phase systems, overheating of all cables and equipment, loss of efficiency in electric machines, electromagnetic interference with communication systems, and errors in measures when using average reading meters, nuisance tripping of thermal protections.

6. Under voltages and over voltage:

Under voltages and overvoltage’s are abnormally high or low voltages that last a minute or more. Under voltages are more common than overvoltage’s and are caused by a variety of things, including the utility supply and overloaded circuits. Utility “brownouts” are an example of an under voltage condition. Pro longed under voltage conditions can seriously damage motors, relays, ballasts, transformers, and other electromechanical devices by overheating them. Under voltages can also affect manufacturing work in process, such as timed drying using resistance heating as well as cause electronic equipment to malfunction. Sustained overvoltage in a facility can shorten insulation life in electrical equipment and reduce the operating life of incandescent lamps and other similar equipment. As with voltage sags and swells, the effects of sustained over- and overvoltage can often be mitigated using power conditioners and UPSs. Excessive network loading, loss of generation, incorrectly set transformer taps and voltage regulator malfunctions, causes under voltage. Loads with a poor power factor or a general lack of reactive power support on a network also contribute. Under voltage can also indirectly lead to overloading problems as equipment takes an increased current to maintain power output.

7. High-Voltage Spikes:

High-voltage spikes occur when there is a sudden voltage peak of up to 6,000 volts. These spikes are usually the result of nearby lightning strikes, but there can be other causes as well. The effects on vulnerable electronic systems can include loss of data and burned circuit boards. Possible Solutions are using Surge Suppressors, Voltage Regulators, Uninterruptable Power Supplies, and Power Conditioners. Resonance, neutral overload in 3-phase systems, overheating of all cables and equipment, loss of efficiency in electric machines, electromagnetic interference with communication systems, and errors in measures when using average reading meters, nuisance tripping of thermal protections.

8. Electrical noise:

Electrical noise typically does not affect electrical equipment, but it can play havoc with electronic equipment causing data errors and other problems. Electrical noise can be caused by a variety of things, including electromagnetic interference (EMI) from arcing electrical equipment, such as dirty brushes on motors, microwave devices, and electric discharge lighting. Electrical noise typically rides on the voltage sine wave, resulting in a distorted voltage waveform. Sensitive electronic equipment can be protected from electrical noise by filters, isolation transformers, power conditioners, UPS, and other similar equipment.

9. Transients:

The transients are the momentary changes in voltage and current signals in the power system over a short period of time. These transients are categorized into two types impulsive, oscillatory. The impulsive transients are unidirectional whereas the oscillatory transients have swings with rapid change of polarity.

Causes:

There are many causes due to which transients are produced in the power system. They are arcing between the contacts of the switches, Sudden switching of loads, Poor or loose connections, Lightening strokes

Consequences:

Electronics devices are affected and show wrong results Motors run with higher temperature, Failure of ballasts in the fluorescent lights, Reduce the efficiency and lifetime of equipment [1-8]

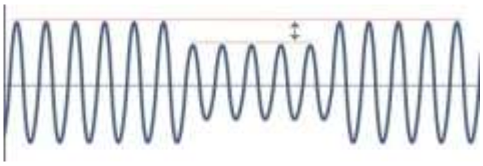

Fig. 1 Voltage Sag/Dip

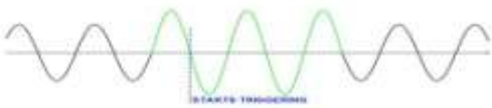

Fig. 2 Voltage Swell

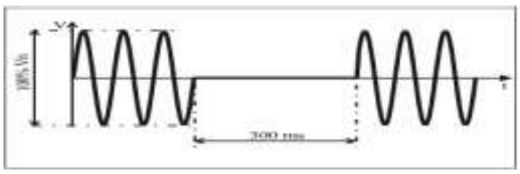

Fig. 3 Very short interruptions

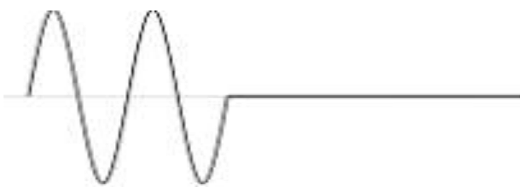

Fig.4 Long interruptions

 ISSN: 2321-8169
65 - 69

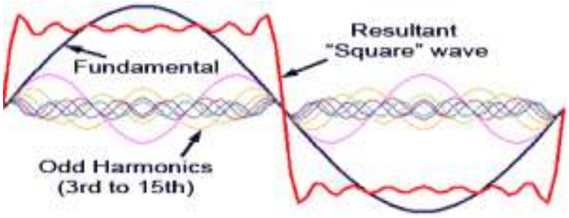

Fig.5 Harmonic distortion

Fig.6 Under voltages and over voltage

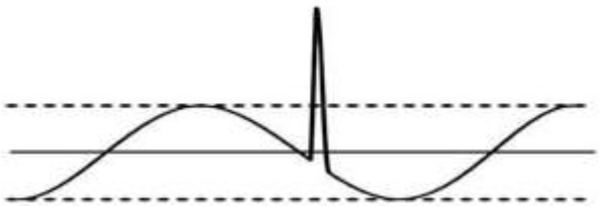
Fig.7 High-Voltage Spikes

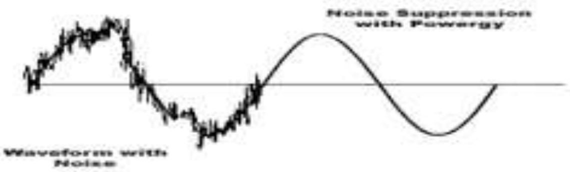

Fig.8 Electrical noise

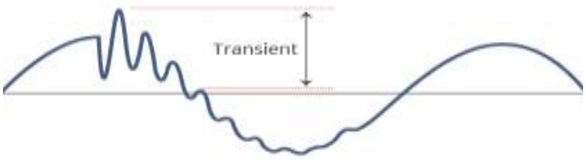

Fig.9 Transients

IV. SIGNAL PROCESSING TECHNIQUES

Signal processing involves techniques that improve our understanding of information contained in received ultrasonic data. Normally, when a signal is measured with an oscilloscope, it is viewed in the time domain (vertical axis is amplitude or voltage and the horizontal axis is time). For many signals, this is the most logical and intuitive way to view them. Simple signal processing often involves the use of gates to isolate the signal of interest or frequency filters to smooth or reject unwanted frequencies. When the frequency content of the signal is of interest, it makes sense to view the signal graph in the frequency domain. In the frequency domain, the vertical axis is still voltage but the horizontal axis is frequency.

The frequency domain display shows how much of the signal's energy is present as a function of frequency. For a simple signal such as a sine wave, the frequency domain representation does not usually show us much additional information. However, with more complex signals, such as the response of a broad bandwidth transducer, the frequency domain gives a more useful view of the signal.

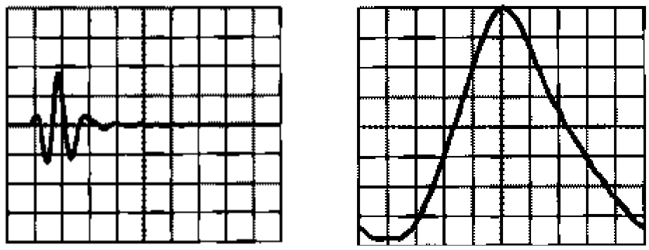
Fig.10 Time Domain Frequency Domain (Magnitude)

Signal Processing methods including Fourier Transform, Wavelet Transform and S-Transform have become most common tools in detection and classification of power quality problems. Different signal-processing methods have been applied for classifying different types of Distribution system. The most broadly used are the Fast Fourier transforms (FFT) and the Short Time Fourier Transforms (STFT) .Fourier transform have restraint of constant bandwidth of window size so using Fourier Transform study of non-stationery signal is not conceivable. So STFT (Gabor develop new method is known as Gabor Transform).[7-11]

A) Fourier Transform:

The Fourier Transform is one of the old technique and most powerful tools in signal processing. This transform plots the signal in time domain to a frequency domain wherever certain useful properties about the signal can be seen. Fourier Transform *F (jω)* of f (t) is given as

$$F\,(j\,\omega) = \int_{-\infty}^{\infty} f(t)e^{-jwt}\,dt \qquad (1)$$

B) Wavelet Transform:

Wavelet transform is also a mathematical tool for signal analysis. Wavelet analysis is very efficient where the signal being analyzed has transients, discontinuities or distortions in the voltage and current waveforms. The basic concept of wavelet analysis is to select an appropriate wavelet function called "mother wavelet" and then perform analysis using shifted and dilated version of this wavelet.
The wavelet transform of a continuous signal *f(t)* is:

$$F(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} f(t)\psi\left(\frac{t-b}{a}\right)dt \qquad (2)$$

C) S – TRANSFORM:

S-transform (ST) is combined the Wavelet transform and short time Fourier transforms, it overcomes the drawbacks of Wavelet transform and short time Fourier transforms. S-transform has a significant property is that it syndicate a frequency dependent resolution of the time-frequency space and absolutely referenced local phase information. S-Transform (ST) has the capability to detect the fault in the influence of noise due to which it is very popular in detecting power system faults and power quality disturbances.[9]

The generalized S transform is given by:

The S-transform of a signal h (t) is defined as

$$S(f,\tau)=\int_{-\infty}^{\infty} h(t)g(f,\tau-t)e^{-j2\pi ft}dt \qquad (3)$$

Where the Gaussian modulating function is given as

$$g(f,\tau)=\frac{|f|}{\sqrt{2\pi}}e^{-\left(t^2/2\rho^2\right)} \qquad (4)$$

V. COMAPARISON BETWEEN DIFFERENT TRANSFORMS

Using Fourier Transform we can study the signal only in Time domain and Frequency domain separately. We cannot analyze combine study of signal in both domains. STFT uses constant window to analyze the signal in both domain at a time. Wavelet transform is advance technique in which shifted and dilated version of mother wavelet used and coefficient is calculated. S transform is a combination of Fourier and wavelet transform.

VI. CONCLUSION

In this paper different types of power quality disturbances are discussed. Signal processing methods are the conventional methods to analyze the power quality disturbance. Among the above mentioned signal processing techniques Wavelet is most commonly used method as Fourier have limitations. Recently developed S-Transform is also more popular and efficient technique in these days.

REFERENCES

[1] Devendra Mittal, Classification of Power Quality Disturbances in Electric Power System: A Review. ISSN:2278-1676 Volume 3, Issue 5 (Nov- Dec. 2012), PP 06-14

[2] S.Khokhar, A.A.Mohd Zin, A.S.Mokhtar,Automatic Classification ofPowerQuality Review.DOI:10.1109/SCOReD.2013.7002625

[3] Nantian Huang, Review of Power-Quality Disturbance Recognition Using S-transform, 978-0-7695-3728-3/09 $25.00 © 2009 IEEE DOI 10.1109/CASE.2009.96

[4] Anurag Agarwal, Sanjiv Kumar, A Research Review of Power Quality Problems in Electrical Power System, MIT International Journal of Electrical and Instrumentation Engineering, Vol. 2, No. 2, Aug. 2012, pp. (88-93)

[5] R.k.Rojin ,A Review Of Power Quality Problems And Solutions In Electrical Power System, IJAREEIE,Vol. 2, Issue 11, November 2013

[6] Yamini arora, A Review Of Power Quality Problems And SolutionsInternational Journal of Emerging Trends in Engineering and Development, Issue 4, Vol.5 (Aug.- Sep. 2014)

[7] P. M. Balasubramaniam, Power Quality Issues, Solutions and Standards: ATechnology Review Journal of Applied Science and Engineering, Vol. 18, No. 4, pp. 371_380 (2015)

[8] ZWE-LEE GAING,Implementation of Power Disturbance Classifier Using Wavelet-Based Neural Networks.2013IEEE Bologna power tech Conference, june 23th-26th, bologna,Italy

[9] Masoud Karimi, Hossein Mokhtari, and M. Reza Iravani, Wavelet Based On-Line Disturbance Detection for Power Quality Applications, IEEE Transactions On Power Delivery, Vol. 15, No. 4, October 2000

[10] Balasaheb R. More, Power Quality Disturbances Using Wavelet Transform, International Journal of Electrical Engineering and Technology (IJEET), ISSN 0976 – 6545(Print), ISSN 0976 – 6553(Online) Volume 5, Issue 6, June (2014), pp. 49

[11] F. Zhao and R. Yang, "Power-Quality Disturbance Recognition using S-Transform", IEEE Trans.On Power Delivery, vol. 22, No. 2, pp. 944-950,April 2007.