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Future Power Quality Issues

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Abstract: ***The power system or the main grid capacity to provide a clean and steady supply of electricity is known as the power quality. Due to the bulk usage of the electronic equipment, the progress of electric power utilization and rising non- linear loads on electrical system network may leads to many power quality related issues. The power quality becomes the major issue due to increase in losses and heat, over loading of the power system etc. All electrical equipment such as motors, generators, transformers, computers, home appliances fails when it exhibits power quality issues. This paper summarizes the various power quality problems such as variation of voltage, transient, harmonics etc.***

Index Terms**: *frequency variation, harmonics distortions, power quality, voltage sag, voltage swell.***

I. INTRODUCTION

The industry for electric power consists of three main stages, such as generation of electricity, transmission of electricity and distribution of electricity to the consumer. The mixture of non-uniformity in climate situation, demand and further several quantities may leads to difficulties in the system to transfer electrical energy from the production side to the consumption side. Power quality is considered as a significant concern for both the establishment of power supply and for the consumers. It is the ability to supply a clean and steady power to the system. It is available as noise free pure sine wave and always within a suitable voltage and frequency tolerance. Therefore any issues that is related to power quality is considered as the major concern over distribution side and also in the industry side nowadays. Due to the high usage of electronic tools, such as information technology devices, power electronic equipment's like adjustable speed drives, programmable logical controls, power efficient lighting etc., leads to an effective variation in the electric loads nature. These loads have a non-linearity nature due to this they cause disturbances in the voltage forms which is a one of the negative impact. There is an increase in power quality issues due to the phenomena of switching which leads into an oscillatory transient in the power system. Power quality issues leads to problems such as failure of electrical equipment, high electricity bills, wastage of energy, and obstruction with communications systems and also the shutdown of the entire plants.

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II. POWER QUALITY ISSUES

Power quality is referred as ability of the grid or the power system to provide pure and steady supply to the devices. It has become as significant concern due to the high sensitivity of the modern and digital control instruments to deterioration of power quality. The power is to be provided to the consumer in clean sinusoidal wave form at a frequency of 50Hz that does not contain any power quality related issues.

Now days, electronic devices are facing a lot of problems due to the low quality of power such as the malfunctioning of tools, damage of the electrical equipment's etc. and these may likely effect the sensitivity of the electrical gadgets. The major power quality issues are voltage dips, voltage unbalance, flickering, harmonics distortions, frequency variation, very long and short interruptions, electrical noise, under voltages, voltage swell, voltage fluctuations etc.

A. Voltage Sag

It is the decrease in the rms voltages within 10 to 90 percent of the original voltage for a duration normally of less than one minute. The frequency of occurrence is between a few ten to hundred times per annum. In the case of modern industrial plants the various devices are used for different process such as process controllers and adjustable speed drive etc., which are highly responsive to decrease in the rms voltages within 10 to 90 percent of the original voltage for a duration less than one minute and it leads to critical power quality problem to industrial customers. The factors which cause sag of voltage are:

- When the electric motors are starting than running at their rated speed, it takes more current.
- Starting of large electric motor is one of the major causes of voltage sags.
- There will be voltage sag, until the protective switch gear operates during the line to ground fault.
- In households, starting up of refrigerators, air-conditioners, or furnace fans leads to voltage sag.
- Sudden changing of electrical loads
- Energization of transformers.

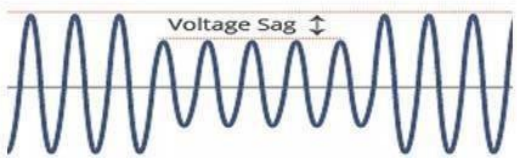

Fig.1 Illustration of voltage sag

B. Short-Duration Voltage Variation

Short duration variation of voltage is the deviation in voltage for duration of not more than 1 minute at power frequency. These variations are resultant of energization of heavy loads which need a high starting current, irregular movable connection at electrical wiring or by any failure conditions. The fault can cause interruptions or swells (voltage rise) based on the system conditions and fault location. This condition can be isolated or near to point of interest. In both cases, the result of actual fault condition on the voltage is of short time variation and this problem remains till the protective devices gets started to remove the fault.

Voltage Swell

This issue is a reverse of the voltage sag which is a rapid rise in nominal source voltage. It can be termed as the quick rise in the rms voltage level within 110 to 180 percentage of the nominal voltage for duration of less than one minute. Voltage swell is usually related with system fault and is appears like the voltage dip, however is not so much common. It is actually for the ungrounded or floating delta type system since there is a rapid variation in the ground reference system and lastly may results to voltage increase on ungrounded phase. The fault that may occur at various positions of a four wire, multi-grounded feeders exhibit various changing grades of the voltage swells on non-faulted phases. Due to faults on the system sources some interruptions are occurred, and these interruptions can be headed by dip of voltage.

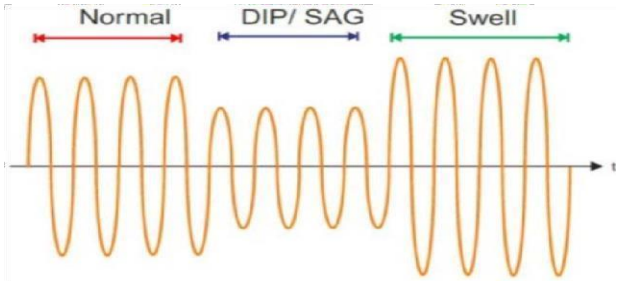

Fig.2 Voltage swell and dip

Interruption

A decrease in the load current or supply voltage to less than 10% for duration of time which is not more than 1 min is defined as the interruption. Interruption may be occur due to failures of devices, control malfunctions and power system faults. Since the magnitude of voltage is constantly less than 10% of the nominal value, the interruption are generally measured by their duration. When a fault occurs, the duration of interruption can be explained, using the functioning time of the utility safety equipment's. Interruption that may cause by the non-permanent fault can be reduced to less than 30 cycles by the immediate reclosing of the safety devices. The delay in the reclosing of protective devices may sometimes leads to momentary or temporary interruptions. There will be an irregular time span of interruption due to malfunctioning of the equipment or movable connections.

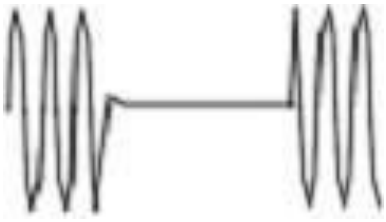

Fig.3 Interruption

C. Voltage Fluctuations

It is termed as efficient or random differences in the magnitude of supply voltage. Variations in the magnitude of voltage cannot be more than 90% to 110% of the nominal value. If the loads show quick and nonstop difference in the magnitude of load current, it may causes variation in the voltage and is defined as flicker. However, the little variations in magnitude that happening at a specific frequencies leads to a result which is termed as the "lamp flicker".

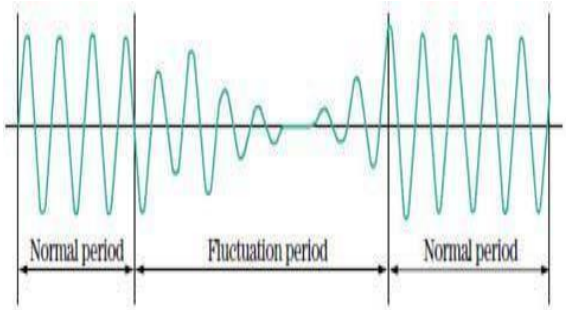

Fig.4 Voltage fluctuation

The fluctuation of the luminance or spectral distribution of the light source with time induces an impression of instability of visual sensation and is described by the lamp flicker. Arc is considered to be one of the main cause of voltage fluctuation on distribution system and utility transmission.

D. Voltage Unbalance

Voltage unbalance means that the variation of voltage in three phase system, which the magnitude of voltages or the phase angle differences between them are not to be same. Existence of this issue on the negative sequence is dangerous to complete three phase loads even it affect resistive load also.

The blown fuse that present in one of the phase of a three phase bank can also be a reason for the unbalanced voltage.

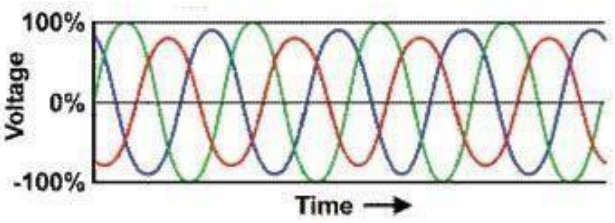

Fig.5 Voltage unbalance

E. Frequency variations

It means that variation in frequency from the standard utility frequency of 50Hz. Frequency is directly associated with the generators revolving speed. Dynamic unbalance between the load and generation causes a small difference in the range of frequencies. The size of shift of the frequencies and its period are based upon the features of the load, also the response of the generation control system to changes in the load. For the typical steady state operation of electric system frequency variation that moves exterior of established limits occurred due to the faults on the mass transmission of power, a heavy block of load being detached, or huge sources of generation is going off-line.

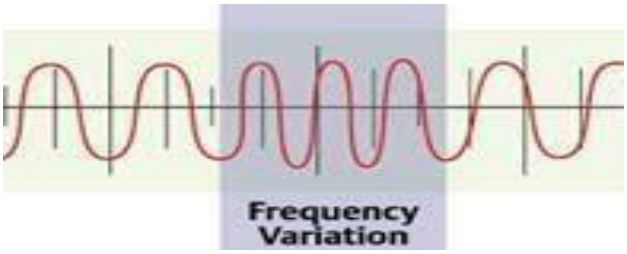

Fig.6 Frequency variation

F. Long Duration Voltage Variation

It is termed as a deviation in the voltage for more than1 min at power frequencies. These voltage variation can be over voltage or it may be under voltage. The change of loads on the system and the switching operation of the system are considered to be the cause of the under voltage and over voltage rather than the faults on the systems. These changes are usually represented as the plots of root mean square voltage versus time.

Over Voltage

An increase in voltage which is more than 110% for duration greater than 1 min at the power frequency is termed as over voltages. Over voltages are typically the results of load switching for e.g. energizing a capacitor bank or the switching off heavy loads. The over voltages are outcomes of incorrect tap settings on transformers, the system might be too feeble for the preferred voltage regulation or the voltage controls are insufficient.

Under Voltage

A decrease in voltage which is below 90% for duration more than 1min at the power frequency is termed as under voltage. The switching off capacitor banks or switching on load can be a reason for the under voltage in the system and it will continue till the voltage regulation equipment brings the voltage back within the suitable tolerance range. The overloaded circuit may also cause under voltages.

Sustained Interruptions

The long-duration voltage variation in which supply voltage falls to zero for duration more than 1 min is considered as sustained interruptions. Sustained interruptions usually exist as permanent and it requires human involvement to repair the system for re-establishment. It is mainly due to storms, trees striking poles, failure of customer equipment in the power system or improper coordination of protection devices. As a result, these disturbances may leads to the complete power cut of the consumer equipment's.

G. Transients

An undesirable and momentary variation in voltage or current or both is termed as transients. Transient can be also defined as a part of variation that occurred at variables which vanishes for the duration of changeover from the steady state working condition to another. It is basically divided into two, impulsive and oscillatory. Effects in motors:

- It will cause the motor to run at high temperatures
- Equipment failure due to degradation in the insulation of the motors winding
- Increasing in the motor's losses and its operating temperature effects in electrical equipment
- Degrades the contacting surfaces of the protective devices
- Increasing in the hysteresis losses, transformer efficiency is reduced

Impulsive transient

Impulsive transients are rapid non-powerfrequency variation in the steady-state condition of currents, voltages or both, which is unidirectional in polarity. It is characterized by their rise time and decay time, which can also be exposed by their own spectral content. Example, a 1.2 X 50 µs, 2000 volt (V) impulsive transients will increases to its peak value (2000 V) from zero in 1.2 µs and it decreases 1000 V in 50 µs.

Lighting is the general cause of impulsive transients. Current impulsive transient caused by lighting is shown in the figure 7. Owing to large frequencies, the shape of impulsive transient can changed fast through the circuit components and contain various features when observed from dissimilar portions of the system. When it is observed from dissimilar portions of the system, it may significantly have dissimilar characteristics or features (for e.g. when observed from one building to another). The large frequencies will permit the damping of the impulsive transients by the resistive components of the system.

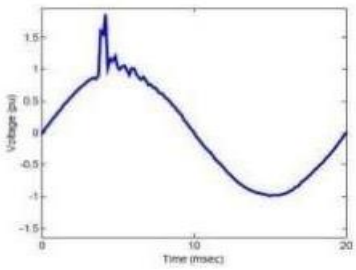

Fig.7 Impulsive transient

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Oscillatory transient

Oscillatory transients are termed as the rapid non-power frequency variation in the steady-state condition of voltage, current or both, and also contain positive and negative polarity standards. The polarity will change due to the instantaneous values of voltages or current includes in this type of transient. It can be explained by its own spectral content, duration, and magnitude. Spectral content were subclasses into large, average, and small frequency. Large frequency transients are oscillatory transients with primary frequency component, which are above 500 kHz and the normal duration calculated in microseconds. These are consequence of a local system in response to an impulsive transient. Transients with a primary frequency component within 5 and 500 kHz and a period measured in the tens of microseconds are defined as a medium-frequency transient. Oscillatory transient currents, which is in the tens of kHz caused by back to back capacitor are shown in fig 8.

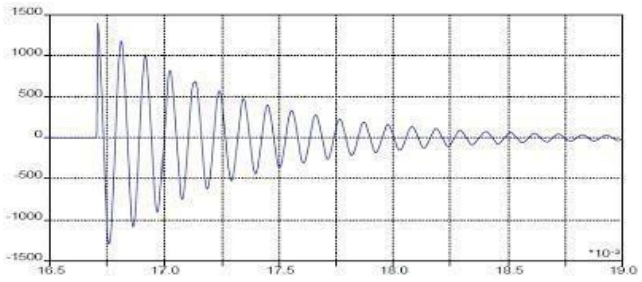

Fig. 8 Oscillatory transient current produced by back to back capacitor switching

Transient with primary frequency component less than 5000 Hz and period from 0.0003 to 0.0005sec is termed as small frequency transient. This phenomenon commonly experience on utility sub transmission and distribution systems and it is caused by several other types of event. This category involves energization of capacitor bank, which produces an oscillatory voltage transient with a primary frequency between 3, 00,000 to 9, 00,000 Hz. The peak magnitude approaches 2 Pu, but it is normally 1.3 to 1.5 Pu having period between 0.5 and 3 cycles depends on system damping fig. 9. It is probable to categorize transients according to their modes. Depending on its appearance between line, neutral and ground, or between line and neutral, the transients in a three-phase system with separate neutral conductor can be either normal or common mode.

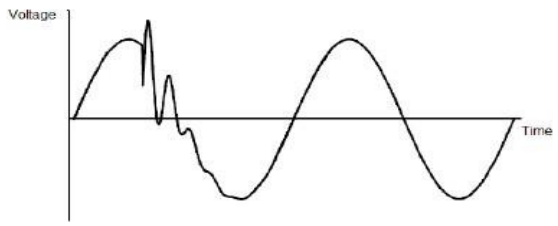

Fig.9 Low frequency oscillatory transient occurred by capacitor bank

H. Power Factor Variation

The ratio of real and apparent power (product of voltage and current) is termed as Power Factor. There will be a distortion of the pure sinusoidal waveform due to the use of semiconductor devices in various electrical power system networks and these are said to be known as the nonlinear loads. Due to this nonlinear load, there will be a lot of fluctuations in the waveforms of voltage and current and is not giving a perfect sinusoidal waveform. In these positions, the real power is lesser than apparent power and also gives a low power factor. If power factor becomes high, lot of issues will occur in the load side along with the entire circuit. When the power factor becomes poor, it causes various problems like larger KVA rating of the apparatus, increase in the load current, poor voltage regulation, heavier conductor size, efficiency becomes poor, and more copper loss. If the power factor becomes very low, the current flowing through the circuit is higher than that of the load. The cost of the equipment will increase and also large wires required in the whole system, if the power factor becomes poor.

I. Distortion in Waveform

The steady state divergence of power frequency from a perfect sine wave is termed as waveform distortion. The following are considered to be the most important types of waveform distortion.

DC Offset

DC offset is defined as the occurrence of dc voltage or current in an AC power system network. DC offset arises because of the asymmetry or due to the geomagnetic trouble of electronic power converters. The another source of DC offsets are the life extenders of incandescent light bulb, which consists of diodes that reduces the rms voltage applied to the bulb with the help of half-wave rectification.

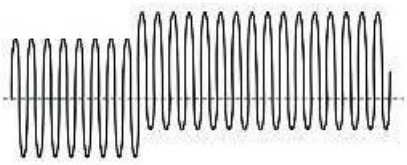

Fig.10 DC offset

The presence of DC in an AC network has dangerous effect on transformer core biasing, during their typical operation. It increases the heat and decreases the transformer life. Sometimes there will be an electrolytic erosion of connectors and grounding electrodes due to DC.

Inter-harmonics

These are termed as the voltage or current having frequency components which are not an integer multiple of the fundamental frequency. The major causes of these waveform distortion are cyclo-converters, static frequency converters, induction furnaces, arcing devices etc.

PLC signals are also measured as inter-harmonics. The varying inter-harmonics frequencies with natural frequencies of the system resulting in quite severe resonances.

Notching

Periodic trouble in voltage occurred during the standard process of power electronics devices when current is commutated from one phase to another phase can be termed as notching. Notching is happening continuously so it can be distinguished by the harmonic spectrum of the affected voltage. The effects due to notching are loss of system data, system halts etc. For example voltage from three-phase converter which produces dc current is shown in figure 11.

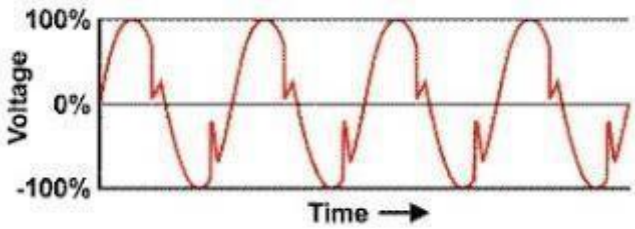

Fig. 11 Notching

Noise

In power system the large frequencies signals of the waveform are superimposed is termed as noise. Loads with arcing devices, switching electric supplies, solid-state rectifiers, power-electronics equipment's etc., are the major sources of noise. These problems can become more intense with unsuitable grounding which flops to carry out noise from the system. It can also disturb electronic devices such as microcomputers, programmable controllers etc.

Harmonics

It is termed as an integer multiple of the fundamental frequency. In linear load, the current drawn will be perfect and it gives a clean sine waveform. Any type of deviation will not occur in this type of linear loads. The levels of harmonic distortion are explained through total harmonic spectrum with magnitude and phase angles of each single harmonic component. Once the harmonics level is raised, it will disturb the loads that are connected with another devices. The issues that are produced by the presence of harmonics are failure of the equipment, equipment heating and also create an electromagnetic interference with the communication circuits. The diodes, thyristors are considered to be the dominating valves of power electronics in the past days. With these semiconductors, due to the process for commutating the flow of current, harmonics of very low order are generated. The generation of harmonics in line commutated rectifiers and converters is imperious a little multiples of the fundamental frequency. The propagation of emission has been transferred to higher frequencies due to establishment of the transistors which is considered to be a self-commutated valve. Sometimes there may be emission in the range of high frequencies because of the fast improvement of energy saving equipments in our homes. Disturbances of supraharmonics are becoming an increasing interest in the industry, especially with the growth of distributed and embedded generation. Instead of having an increased emission at higher frequencies, designers need to design the product that satisfies emission limits at the harmonic frequencies. Some examples of device that have high frequency emission are:

- Oscillations over commutation notches [up to 10 kHz]
- Industrial size converters [9 -150 kHz]
- Electric vehicles chargers [15 kHz 100 kHz]
- Photovoltaic inverters [4 kHz - 20 kHz]
- Power line communication [9 - 95 kHz]
- Household devices [2 - 150 kHz]
- Road lights [up to 20 kHz]

III. CONCLUSION

Power quality plays an important role in the modern society. Almost all the electrical equipments get failed is because of the power quality issues. Every consumers demand for the proper functioning of the electrical equipments along with good quality of the power. To solve these problems, the better way is to restore the technology, selection of equipments with less sensitivity and also the use of the interfacing devices. The considerable power quality problems are voltage sag, voltage swell, fluctuations of voltage, voltage unbalance, flickering, harmonic distortions, voltage dips, variations in frequency, very short interruptions, electrical noise, under voltages, very long interruptions, etc... Harmonics is one of the major power quality issue and is termed as the integer multiple of fundamental frequency. The propagation of emission has been transferred to higher frequencies due to establishment of the transistors which is considered to be a self-commutated valve. Sometimes there may be emission in the range of high frequencies because of the fast improvement of energy saving equipments in our homes. Disturbances of supraharmonics are becoming an increasing interest in the industry, especially with the growth of distributed and embedded generation. Now days, a broad area of researches are proceeding at a huge number of places, yet information related to supraharmonics remains confined.

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