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INSPECTION OF VOLTAGE SAGS AND VOLTAGE SWELLS INCIDENT IN POWER QUALITY PROBLEMS- A REVIEW

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Abstract - *Maintain a power quality is very important subject latterly due to non-linear loads. Any power problem in voltage, current and frequency that results in failure of equipments. Nowadays every industries using advance technology for manufacturing and process unit. Every software or any other industries required high reliability and pure quality of power supply. In power quality voltage sags and voltage swells are occur more than other like harmonics. The intention of this paper is to understand the power quality phenomena in distribution systems where power quality problem occur more.*

Keywords: *voltage sag, voltage swell, current, power quality, frequency, distribution system.*

1. INTRODUCTION

Generation, transmission and distribution are main function blocks of the electrical power system. Distribution system is directly connected to customers from bulk power systems. Distribution system locates at customer's side, so power quality maintains is most important in distribution system [1].Power Quality (PQ) related issues are most anxious nowadays. The large use of electronic equipment like energy-efficient lighting, programmable logic controllers (PLC), and adjustable speed drives (ASD) and other home appliances where mostly electronics devices are use. Electronic devices change load nature and that cause power quality issues. Due to their non-linearity in property all these loads produce disturbances in the system waveform [2]. This disturbance in the system increases the financial losses with the adverse effect on productivity and competitiveness.

Non-linear loads often shift the phase angle between the load current and voltage requires reactive power to serve them and cause low power factor. This low power factor also produce power quality problem. There is lot of power quality problems such as voltage sag, voltage swell, momentary interruption, harmonics distortion, frequency deviation, noise etc. In this paper it focused on power quality problems. Among them two power quality problems have been identified to major concern to the customers are voltage sags, swells and harmonics.

Many techniques are used to overcome the problem of voltage sag and swell like Flexible AC Transmission System (FACTS) for transmission system. When problem occur on distribution side then its affect the transmission line also. FACTS improve the power transfer capabilities and stability margins [3]. The custom power devices which mostly used to reduce voltage sag and swell are Dynamic Voltage Restorer (DVR), Distributed Static Compensator (D-STATCOM) and Solid State Transfer Switch (SSTC)[4].

2. POWER QUALITY

According to Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE 1100 define as [5] "the concept of powering and grounding sensitive electronic equipment in a manner suitable for the equipment". Intermixing loads can cause power quality related problems in any facility. An Electrical Power Research Survey (EPRS) found poor wiring and grounding in the end user's facilities cause 80% of all power quality problems. When non sensitive and sensitive loads are connected to the same circuit they often interact with one another. For more explanation purpose, when a large motor on an elevator or an air conditioner starts, it causes a heavy inrush current that causes a voltage sag and swell.

For economic operation of a power system, the level of power quality should be required maintained properly. Power quality is a vast concept concerning optimization. The adverse effects due to over voltage, also the losses incurred due the under voltage have to be seriously harmonics in the system which have their own adverse effects including power factor reduction.

"Any power related problem manifested in voltage, current or frequency deviation that result customer equipment is disoperation". This definition can be used to measurement of power quality is taken from the end user customer.

3. PERCENTAGE OF ABNORMAL CONDITIONS

The most common types of abnormal condition are voltage sag and swell, harmonics etc. Among these, voltage sage account for the highest percentage of occurrences in equipment [6].

- Voltage sags = 31 %
- Harmonics = 18 %

- Asymmetrical voltage = 18 %
- Short outage = 13 %
- Voltage swells = 13 %
- Voltage transient = 7 %

4. VOLTAGE SAGS

Voltage sag is come under the short duration voltage variation which caused either fault condition. In this type temporary voltage reduction at different nodes in circuit and this is harmful to the end side appliances. Voltage sag is also called voltage dip. The IEC electro- technical vocabulary, IEC 60050 [7], define "sudden reduction of the voltage at any point in the electrical power system, followed by voltage recovery after a short time interval, from half cycle to a few seconds". And according to IEEE Standard 1159 [8] defines as "a decrease of the RMS voltage to 0.1-0.9pu for a duration of 0.5-1 cycle minute". Where RMS is defined as, it is a mathematical term which is used to measure the voltage.
For understanding purpose, when large load on any circuit start instantly that time this heavy load draw large power in the circuit and that time there is chance to occur the voltage sag. When voltage sag occurs in circuit magnitude of voltage decrease and low level of voltage affect the distribution as well as transmission line.

According to time duration and voltage magnitude, sag is classified as:

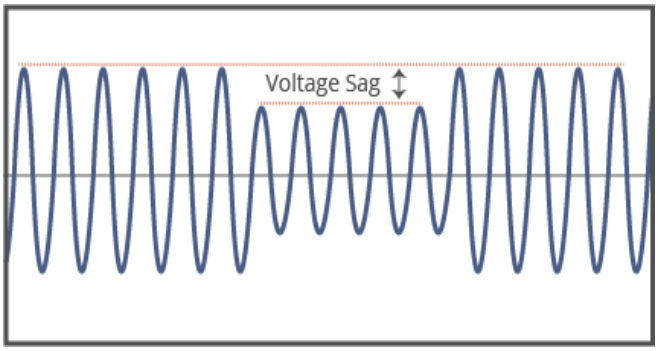

Fig. 1: An Example of Voltage Sag.

1) Instantaneous Sag: When r.m.s voltage decreases to between 0.1 and 0.9 per unit for time duration of 0.008333 second to 0.5 second .This type of sag is occur very fast and this instant change of voltage is harmful to the end users devices.

2) Momentary Sag: Momentary sag is said when the r.m.s voltage decreases to between 0.1 and 0.9 per unit for the time 0.5 second to 3 seconds.

3) Temporary Sag: Temporary sag is said when the r.m.s voltage decreases to between 0.1 and 0.9 per unit for duration of 3 to 60 seconds.

4.1. TYPES OF VOLTAGE SAG

Based on the phases affected during the sag, the voltage sag has been classified as

1. **Single Phase Sags***:* The frequently occurring voltage sags are single phase events which are basically due to a phase to ground fault occurring somewhere on the system. On other feeders from the same substation this phase to ground fault appears as single phase voltage sag. Typical causes are lightning strikes, tree branches, animal contact etc. It is common to see single phase voltage sags to 30% of nominal voltage or less in industrial plants.
2. **Phase to Phase Sags:** The two phases or phase to phase sags are caused by tree branches, adverse weather, animals or vehicle collision with utility poles. These types of sags typically appear on other feeders from the same substation.
3. **Three Phase Sags:** These sags are caused by switching or tripping of a three phase circuit breaker, switch or reclosed which will create three phase voltage sag on other lines fed from the same substation. Symmetrical three phase sags arise from starting large motors and they account for less than 20% of all sag events and are usually confined to an industrial plant or its immediate.

4.2. GENERAL CAUSES OF VOLTAGE SAGS

1) Voltage sag can occur by faults such as lightning. More than 70% are lighting faults on the transmission or distribution system or by switching of loads with large amounts of initial starting or inrush current such as motor, transformers and large dc power supply [9].
2) Voltage sag due to motor starting is symmetrical since the induction motors are balanced three phase loads. When three phase motor is not properly constructed then sag problem can be occur.
3) Pollution also increases the problem of sag. Salt spray build up on power line insulators over time in coastal areas, even many miles inland, can cause flash over especially in stormy weather.
4) Animals particularly squirrel and snakes occasionally find their way onto power lines or transformers and can cause a short circuit either phase to phase or phase to ground. Large birds, geese and swans, fly into power lines and cause similar faults.

5. VOLTAGE SWELLS

Voltage Swell is defined by IEEE 1159 as increase in the RMS voltage level to 110% to 180% of nominal, at the power frequency for duration of 0.5 cycles to one minute. It is a short duration voltage variation phenomena, which is

the general categories of power quality problems [10]. A swell is defined as an increase to between 1.1 and 1.8 p.u. rms voltage at the network fundamental frequency with duration from 0.5 cycles to one minute. The term momentary overvoltage is also used as a synonym for swell. Switching off a large inductive load or energizing a large capacitor bank is typical system maneuvers that cause swells.

Although not as common as voltage sags, swells are also usually associated to system faults. The severity of a voltage swell during a fault condition is a function of the fault location, system impedance, and grounding. During a single phase-to ground fault on an impedance grounded system, i.e. with some zero sequence impedance, the non-faulted phase-to-ground voltages can increase up to three times the per-unit value (in the case of a non-grounded or high impedance grounded system). The difference in the zero- and positive-sequence impedance causes a change in the non-faulted phases, not only in magnitude but also in phase. For voltage swells the start threshold is equal to 110% of the reference voltage. The end threshold is usually set 1 - 2% of the reference voltage below the start threshold. In other words, the duration of a voltage swell is measured from when one phase rises above 110% of the reference voltage until all three phases have again fallen below 108% - 109% of the reference voltage.

5.1. GENERAL CAUSES OF VOLTAGE SWELLS

Voltage swells are usually associated with system fault condition- just like voltage sags but are much less common. This is particularly true for ungrounded or floating delta system, the sudden change in ground reference result in a voltage swell in phase.

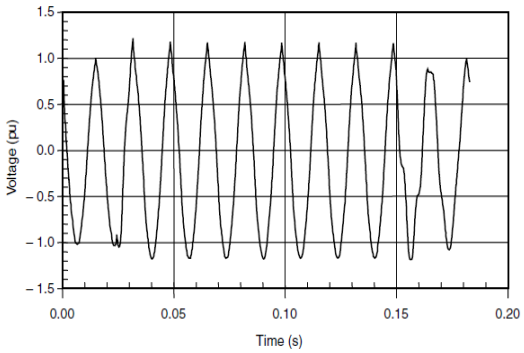

Fig. 2: An Example of Voltage Swell.

6. CONCLUSION

Nowadays, quality and reliability of electrical power is one of the most important topics in power industry. There are number of power quality problems and power quality issues and each of them might have varying and diverse causes. Power quality problems that a customer may encounter classified depending on voltage waveform is being distorted.

There are transients, short time variations (sags, swells, and interruption), long duration variations (under voltages, over voltages), voltage imbalance, waveform distortion, voltage fluctuations and power frequency variations.

Among them, three power quality problems have been identified to be of major concern to the customers are voltage sags, swells and harmonics, but this project is focusing on voltage sags and swells. Voltage sags are huge problems for many industries, and it is probably the most pressing power quality problem nowadays. Voltage sags may cause tripping and large torque peaks in electrical machines. Generally, voltage sags are short duration reductions in rms voltage caused by faults in the electric supply system and the starting of large loads, such as motors. Voltage sags are also generally created on the electric system when faults occur due to lightning, which are accidental shorting of the phases by trees, animals, birds, human error such as digging underground lines or automobiles hitting electric poles, and failure of electrical equipment. Sags and swells also may be produced when large motor loads are started, or due to operation of certain types of electrical equipment such as welders, arc furnaces, smelters, etc.

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