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# REVIEW ON POWER QUALITY ISSUES AND ITS SOLUTION FOR BETTER ELECTRICAL RELIABILITY IN POWER SYSTEM.

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**Abstract:**
The demand for electrical energy has expanded rapidly and continues to grow. As a result, the number of power plants has increased dramatically. These electrical distributions have resulted in significant losses due to fluctuating load demands, a lack of reactive power compensation measures, and many more.. The major goal of increasing power quality in transmission lines is to supply continuous electricity with a constant sinusoidal voltage and frequency. However, the power distribution system is primarily made up of non-linear loads, which results in poor power quality. [1]. This review paper discusses the different origins and reasons of poor power quality, as well as practical solutions.

## INTRODUCTION

Due to the constant need for electricity, the use of semiconductor switching equipment, such as diodes and thyristor rectifiers, has rapidly expanded, resulting in a loss of power quality in the transmission lines. Poor power quality concerns in large enterprises have led to massive investments in voltage distortions, harmonics, short and long-term disruptions, and many more. The adoption of linear loads has also reduced power quality. If the electric supply is continuous, with steady voltage and frequency values, the power quality is likewise good. However, in fact, fluctuating electricity needs and problems disrupt the electric power system by deviating from its usual features. The following are the reasons for poor power quality in transmission lines:

i. Due to variation in the supply
ii. Fluctuation in the frequency
iii. When the voltage and current waveforms of the required supply is not constant (i.e. distorted)
iv. Unbalanced loading on the distribution transformers.

Due to increase of these non-linear loads, harmonic component became very significant in the distributed system which led to various problems like distorted voltage waveform, malfunctioning in the system, inaccurate power flow, excessive flow of current and many more. Due to these reasons the efficiency of drawing reactive current has also reduced. [2].

In today's era, the issue of poor power quality has become one of the serious problem for commercial, industrial and domestic consumers. There are appliances used by both commercial or domestic consumers which may not work properly if the voltage level increases or decreases the required value and the chances of damaging the appliances becomes high. This may result in the malfunctioning of the electrical equipment's. In industries, low power quality is one of the serious concerns for automated sensitive production machines [3].

### Nomenclature

The Information Technology Industry Council (ITC), Transient Voltage Suppressors (TVSS), Electromagnetic Interference (EMI), Radio Frequency Interference (RFI), Uninterruptible Power Supply (UPS), Constant Voltage Transformer (CVT)

## 2. MAIN SOURCES, CAUSES AND EFFECTS OF ELECTRICAL POWER QUALITY PROBLEMS:

Power Quality is defined as the any change in voltage, current or frequency deviation that may result in the failure or disoperation of the customer's equipment's. Any Power system should have the capability to provide uninterrupted power supply at smooth sinusoidal voltage without changing the frequency and magnitude. [4].
There are various reasons which lead to degradation of power quality in the transmission lines. Following are the list of causes that leads to poor power quality in the power system:

**Variation of voltage:** Voltage variation can be defined as the deviation of voltage from its actual value. This voltage variation can be for short duration i.e. millisecond to seconds or it may take place for long durations also i.e. for more than a minute. The voltage variation which occurs for short duration occurs mostly as voltage spikes, voltage sags or swell whereas the voltage variation for long duration may occur as voltage fluctuations or voltage interruptions in the power systems. This results in either increase or decrease of the voltage magnitude

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**A. Voltage Sag:** Voltage sag is also known as voltage dips. It is basically decrease or reduction of the magnitude of the supply voltage for a short period of time. When the voltage supply is between 0.1 to 0.9 pu of the nominal voltage for at least one minute, then the chances for voltage dip or sag increases at that moment. These voltage dips takes place due tooccurrence of faults in the line, switching of heavy loads, starting of ant electric machines and many more.

**B. Voltage Swell:** Voltage swell is defined as the sudden increase of the rms voltage level between 1.1 and 1.8 pu for a duration from 0.5 cycle to 1 minute. These voltage swell takes place due to poor regulation of the transformers, due to use of heavy loads. These voltage swell in the power system may lead to damage of the sensitive equipment's loss of data and flickering of light. Some of the symptoms of voltage sag, swell are:

- Fluctuation in the production rate
- Relays and contractors drop out
- Lightening systems starts dimming

**Harmonic Distortions:** When the voltage and current waveforms are not in the sinusoidal shape and vary with different magnitude and phase with the frequencies which are integral multiples of fundamental frequency results in the occurrence of the harmonics in the power system. The addition of harmonics and fundamental frequency results in the distorted waveforms. The formation of harmonics in the power system results in poor power quality. Use of non-linear loads such as UPS, voltage converters, rectifiers results to harmonics which leads to distorted voltage and current waveforms. Usually these harmonics occur in the three phase systems.

**Interruption in the supply:** One of the main reasons for poor quality of power is interruption in the voltage supply. The interruption in the supply voltage may lead to loss of data's or information's, tripping of protecting devices, etc. The interruption of the supply are of two types: long interruptions and short interruptions. The short interruption may take place due to poor maintenance of the electrical equipment's, lightening or insulator flashover whereas the long interruption takes place due to failure of the equipment's, natural conditions like storms or objects such as trees , cars etc., failure of protecting devices and many more leading to loss of power in transmission lines.

**Frequency Fluctuation**: the change of frequency from normal stable frequency (50 or 60 Hz) is called frequency variation. As we know that power requirement at the receiving side must be same as the power at sending end, if the demand is high than the generation, the frequency tend to increase. Frequency fluctuation may lead to faults in the transmission lines, shutting down of large generators, etc. if the frequency fluctuation increases beyond the value of ± 5% resulting in the collapse of the system.

**Over Voltage & Under Voltage:** If the nominal rms voltage becomes greater than the 1.1 pu for more than one minute of the time duration then that phenomena is called over voltage. The occurrence of over voltage and under voltage is due to various reasons such as: use of large loads, inappropriate tap settings of the transformers, lack of proper control of voltage, faults in the distribution lines and many more. Whereas in case of under voltage takes place when the nominal voltage decreases by 0.9 p.u for longer duration that is for more than a minute [6].

**Brownouts and blackouts:** Brownout means steady lower voltage state. Brownout generally occurs during peak summer time when the demand of the electric power is high and it becomes difficult to meet the requirements of the consumer. Whereas blackouts means zero –voltage condition that will last for at least more than two cycles. Both brownout and blackout leads to power failure, data loss, , equipment failure and many more. The possible solutions to these problems can be use of Uninterruptable Power Supplies, Voltage Regulators and Power Conditioners.

Thus there are many other reasons for poor power quality such as occurrence of noise, voltage unbalance and many more. In order to overcome these issues related to poor power quality in the industry several methods were adopted to improve the quality of power

## METHODS FOR POWER IMPROVEMENT

**Grounding & Bonding Integrity:** Poor earthing in power system is one of the major causes for poor power quality. Grounding is one of the most important concerns in the electrical systems. Proper grounding of electrical system will not only protect the does not only protect the electrical devices but also plays an important role by upgrading the system. There is a difference between the functions of the grounded conductor and the equipment's used for grounding systems i.e. safety ground. The grounded conductors also known as neutral which are basically a current carrying conductor connected to the ground. Grounding of the conductor will reduce the voltage potential present in the equipment's. Whereas, to protect the electrical systems from super – imposed voltages safety grounds are being used..

**Power Disturbances**: In the present era, the common disturbances occurring in electrical power system are occurrences of voltage fluctuations and noise which directly affects any electrical equipment's. These disturbances may occur in

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different forms such as voltage sag, voltage swell, over and under voltages, harmonics frequency variations and many more. The Information Technology Industry Council (ITC) has introduced various devices which will help to improve the power quality in the electrical systems. According to ITC these instruments should have the capability to tolerate the voltage disturbances without any interruption. This paper explains different types of power conditioning equipment's which are being used to protect the equipment's from power disturbances and thus also helps in improving the power quality.

**Transient Voltage Suppressors (TVSS):** These equipment's are used to clamp the transient impulses i.e. the spikes to a safe level for the electronic loads. These protects the equipment's from various transient conditions. It is a device that is used to brace the transient voltages and reduce the excessive voltage by incorporating nonlinear resistances by avoiding the voltage to reach the appliances. They are installed between the sensitive equipment's and the power. One of the main advantage of TVSS is that, these equipment's are not that costly.

**Filters:** Filters are used to provide protection against low-voltage or high-frequency noises. Filters are used to protect the equipment's by allowing the flow of only required frequency whereas it avoids or blocks the flow of unwanted signals. They are designed in such a manner that they only allow the fundamental frequency to pass and rejects the higher frequency such as electromagnetic interference (EMI) and radio frequency interference (RFI). They are designed with resistors, capacitors, inductor which creates low impedance path for the wanted fundamental frequency and high impedance path for unwanted frequencies [5].

In order to remove the harmonics and improve the poor power quality different filters can be used such as: passive harmonic filters, active harmonic filters, line-reactors, electronic feedback filters and many more.

**Isolation Transformers**: As the name suggests, Isolation Transformers are used to provide a degree of isolation and filtering by reducing the electrical noise. This reduction is done by physically separating the primary and secondary through magnetic isolation. They are basically used to lessen the common mode of noises. These transformers are not able to reduce the power outages and voltage fluctuations.

**Voltage Regulators:** Voltage regulators are used to improve the voltage swell, voltage sag and brownouts. Voltage regulators maintain output voltage at nominal voltage under all but the most severe input voltage variations. Voltage regulators are normally installed where the input voltage fluctuates, but total loss of power is uncommon. There are three basic types of regulators:

**A. Tap Changers:** Tap changers are designed to adjust the varying input voltages by automatically transferring taps on a power transformer. One of the important advantages of tap changers is its efficiency which is more than the voltage regulation technology. There are various other advantages also such as high overloading current capability, comprises of wide range of inputs and good noise isolation. Whereas, these tap changer equipment's have some disadvantages also i.e. occurrence of noise at the time of changing taps and there is no correction in the waveform [5].

**B. Buck Boost:** They uses the same technology as the tap changers with a difference that transformer is not isolated. They have the capability to withstand high in-rush currents and have high efficiency. One of its major disadvantages is that at the time of changing taps, noises are created, they also have poor noise isolation and there is no correction in the waveform.

**C. Constant Voltage Transformer (CVT):** The CVT is a static regulator that is used to maintain constant voltage at the output at the time large varying input voltages. The Constant Voltage Transformers in order to have proper voltage generally avoid two phenomena's i.e.: saturation of core and occurrence of resonance. When the resonance occurs, the current starts increasing and that leads to saturation of the magnetic core of the transformer. After the saturation of the magnetic core the transformer produces the constant voltage at the output as the magnetic flux is constant. The advantages of constant voltage transformer are precise voltage at the output, proper isolation of noise and limiting of current for overload protection. Since these transformers are static so very little maintenance is required. Whereas, the disadvantages are its huge size, and less efficiency.

**Uninterruptible Power Supply (UPS):** UPS systems are used to provide protection at the time complete power interruption. UPS are being designed to supply continuous uninterrupted power in case of any small or large interruption so that the power transfer does not get affected These UPS systems are also used to protection from sags, brownouts, surges, etc. There are basically three major UPS technologies used each providing different levels of protection to the system:

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**A. Off-Line UPS:** Off-line UPS systems are low in cost and they are very useful applications in personal computers, programmable logic controllers and peripherals. Off-line UPS systems supply the load directly from the electrical utility with a limited conditioning. These systems are used to supply power from the battery at the time of interruption, voltage swells, voltage sags, spikes, etc. They also act as noise suppressor. One of the major advantage of this type of system is that its efficiency is very high and has very high reliability as compared to others. The main disadvantage is that protection from low voltages and high voltages are limited and depends on the capacity of the battery. Other disadvantages are poor voltage regulation at the output and large duration of transfer time taken. [6].

**A. Line-Interactive UPS**: These types of systems have high efficiency and can provide good battery back-up. These systems are used in those areas where the chances of occurrence of voltage fluctuation is high. The characteristic of line-interactive systems that differentiates it from others is that they have the capacity regulate voltage at the output without affecting the battery. They have very high voltage and the mai disadvantages are large duration of time taken and difficulty in comparing competing units. The output waveform in these types systems can be either a sine wave or step-sine wave depending on the manufacturer and model.

**B. True On-Line UPS:** These types of systems are used to provide good protection of power and availability of power. They are also known as double conversion is unique in that the power is converted from AC utility to DC for battery charging and to power the inverter. The DC value is converted back to AC to power the critical load. The main advantages of these types of systems are its use to remove the voltage fluctuations. Voltage regulation is achieved by continuously regenerating a clean sine wave. The main disadvantages of these types of systems are its less efficiency and higher audible noise [6].

## CONCLUSION

In this article, we have examined various methods to improve nutritional quality. It is known that high quality electricity is needed to meet the constant demand of consumers. Sometimes the voltage at the receiving end is not the same as the voltage at the sending end. Certain measures must be implemented in the power system to avoid such large losses. There are also many other techniques that help improve stream quality. Among the various measures, the correct choice of less sensitive equipment plays an important role in improving the quality of electricity. If even the most powerful equipment suffers, other measures must be taken, such as the installation of recovery technologies, distributed generation or ballast to avoid power quality problems.

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