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Importance of Power Quality

Reshmi Banerjee
Department of Electrical Engineering, Guru Nanak Institute of Technology, WBUT, Kolkata, W.B., India.

ABSTRACT
Power quality determines the fitness of electric power to consumer devices. Synchronization of the voltage frequency and phase allows electrical systems to function in their intended manner without significant loss of performance or life. The term is used to describe electric power that drives an electrical load and the load's ability to function properly. Without the proper power, an electrical device (or load) 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.
Keywords– Harmonic distortion, Long interruption, Micro interruption, Power conditioning, Power quality, Voltage spikes, Voltage swells.

I. INTRODUCTION

While "power quality" is a convenient term for many, it is the quality of the voltage – rather than power or electric current – that is actually described by the term. Power is simply the flow of energy and the current demanded by a load is largely uncontrollable.

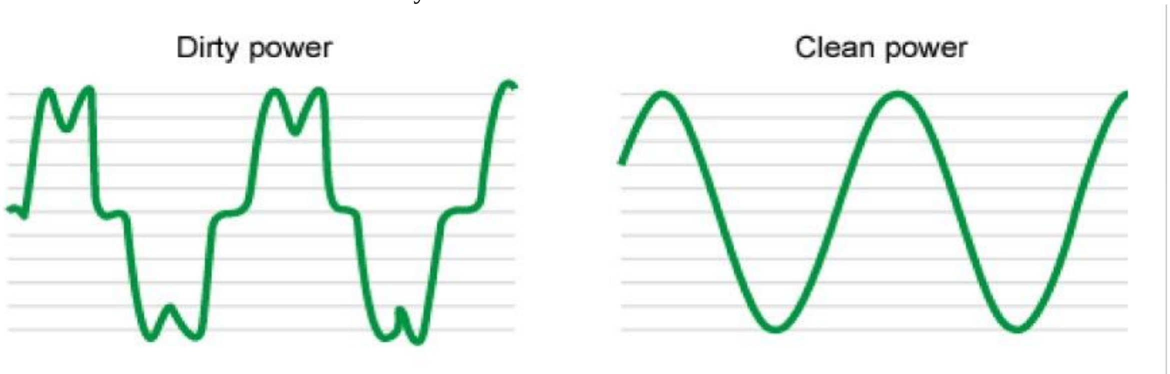

Fig. 1: Difference between clean power and dirty power

The quality of electrical power may be described as a set of values of parameters, such as:

- Continuity of service.
- Variation in voltage magnitude.
- Transient voltages and currents.
- Harmonic content in the waveforms for AC power.

Power conditioning is modifying the power to improve its quality.

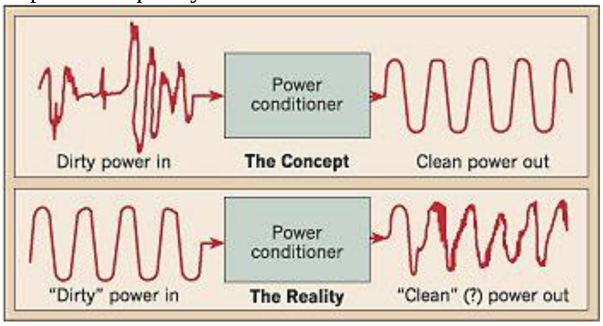

Fig. 2: Power conditioning

An uninterruptible power supply can be used to switch off of mains power if there is a transient (temporary) condition of the line. However, cheaper UPS units create poor quality power themselves, akin to imposing a higher frequency and lower amplitude square wave atop the sine wave. High quality UPS units utilize a double conversion topology which breaks down incoming AC power into DC, charges the batteries, then remanufactures an AC sine wave. This remanufactured sine wave is of higher quality than the original AC power feed.

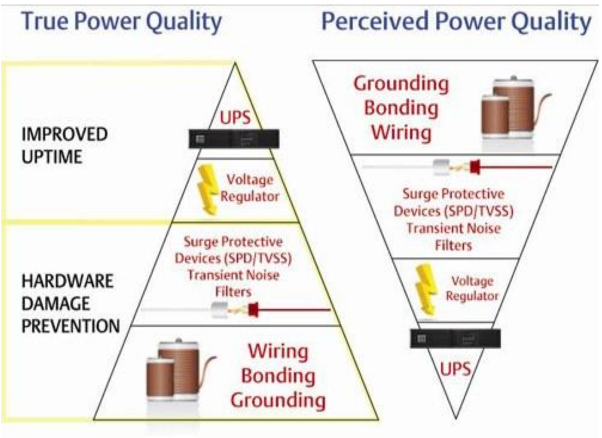

Fig. 3: Power quality

II. METHODOLOGY

Power quality problems can be broadly classified into following categories:

¬ Voltage sags
¬ Micro-interruptions
¬ Long interruptions
¬ Voltage spikes
¬ Voltage swells
¬ Harmonic distortion

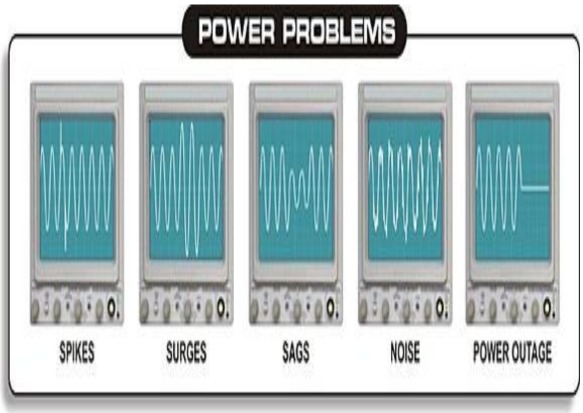

Fig. 4: Power problems

Voltage sags – A decrease of 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.

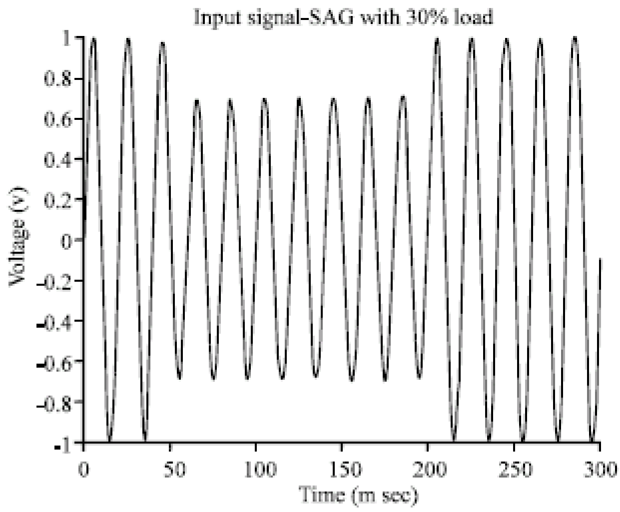

Fig. 5: Voltage sag

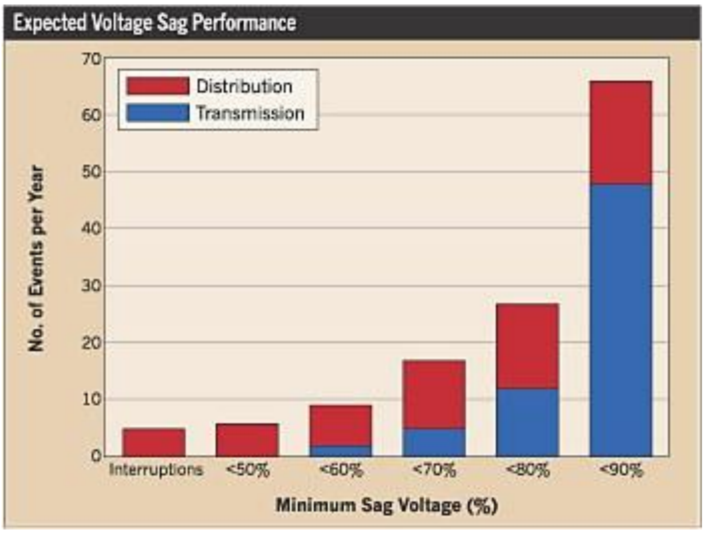

Fig. 6: Expected voltage sag performance

Causes:

- Faults on the transmission or distribution network.
- Faults in consumer’s installation.
- Connection of heavy loads and start-up of large motors.

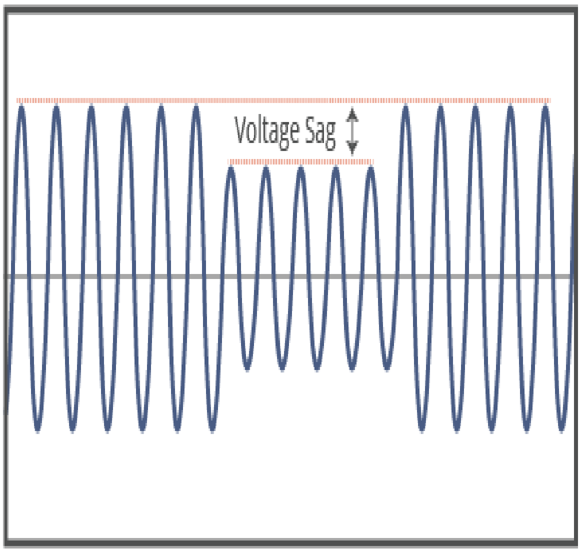

Fig. 7: Characteristic of voltage sag

Micro-interruptions – Total interruption of electrical supply for duration from few milliseconds to one to two seconds.
Causes:
¬ Opening and automatic reclosure of protection devices.
¬ Insulation failure, lightning and insulator flashover.

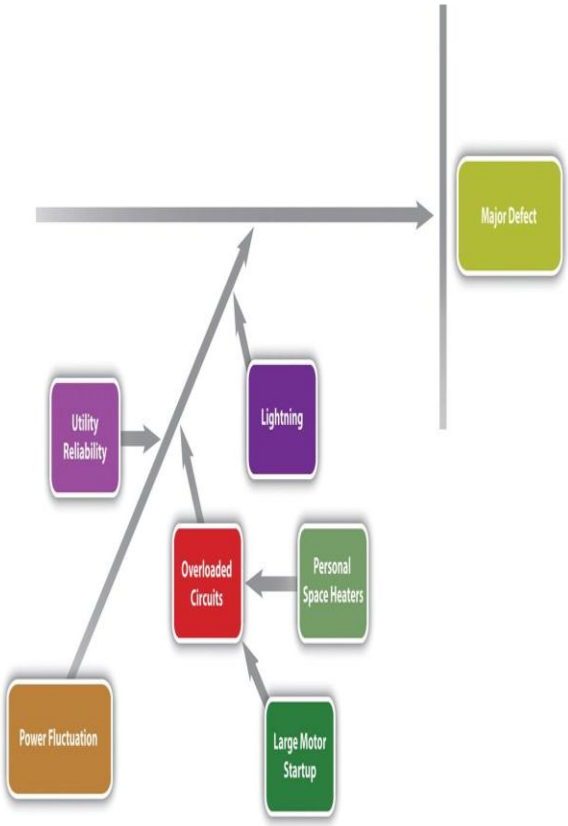

Fig. 8: Lightning

Long interruptions – Total interruption of electrical supply for duration greater than 1 to 2 seconds.
Causes:
- 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.

Voltage spikes – Very fast variation of the voltage value for durations from a several microseconds to few milliseconds.

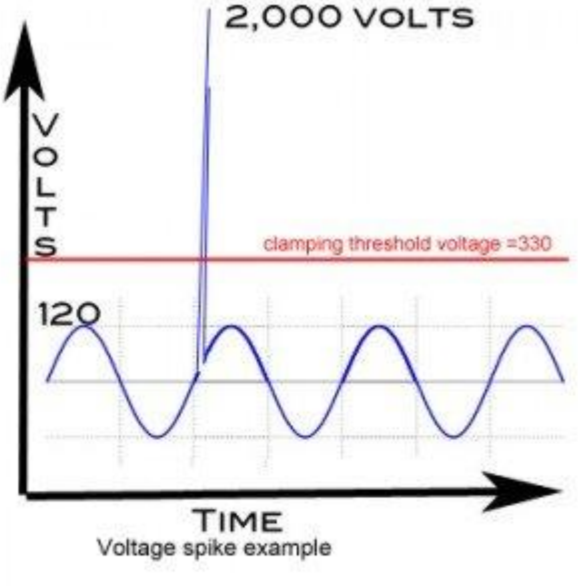

Fig. 9: Voltage spike example

Causes:
¬ Lightning.
¬ Switching of lines or power factor correction capacitors.
¬ Disconnection of heavy loads.

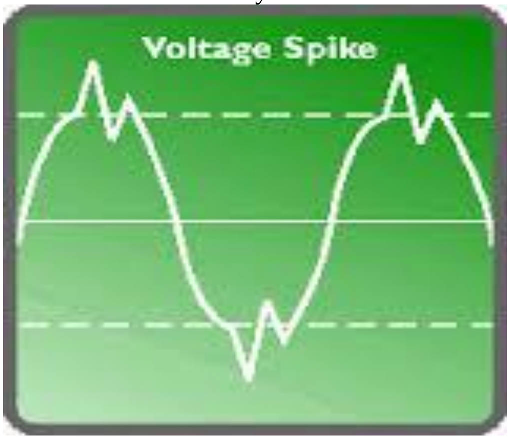

Fig. 10: Voltage spike

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.

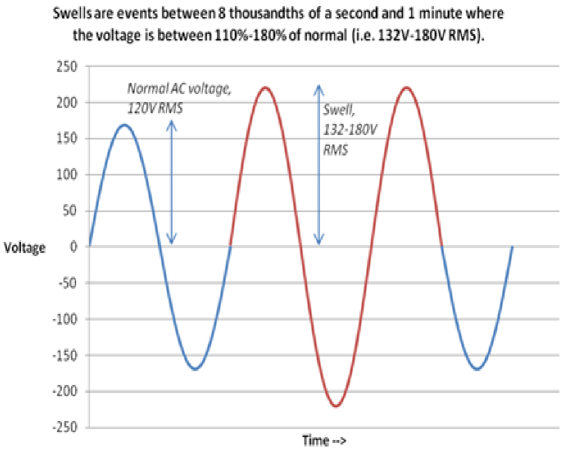

Fig. 11: Characteristic of voltage spike

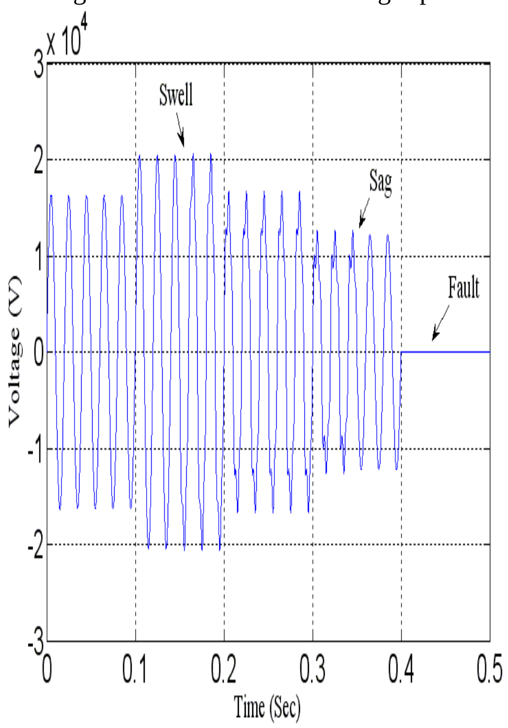

Fig. 12: Characteristic comparison between swell, sag and fault

Causes:

- Start/stop of heavy loads.
- Poorly dimensioned power sources.
- Poorly regulated transformers.

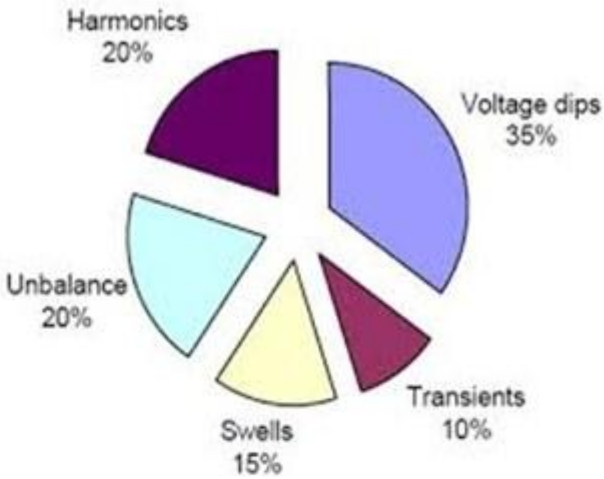

Fig. 13: Percentage of harmonics, swells, transients and voltage dips

Harmonic distortion – 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.

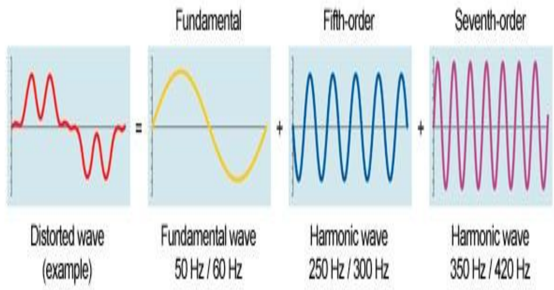

Fig. 14: Harmonics

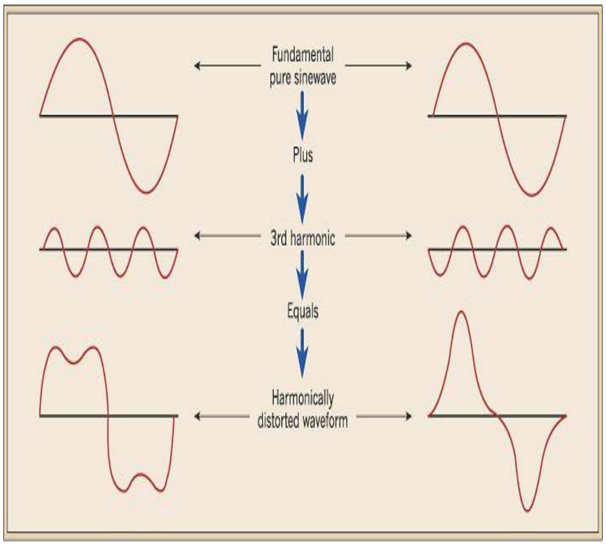

Fig. 15: Harmonically distorted waveform

Causes:

- Electric machines working above the knee of the magnetization curve (magnetic saturation), arc furnaces, welding machines, rectifiers and DC brush motors.
- All non-linear loads, such as power electronics equipment.

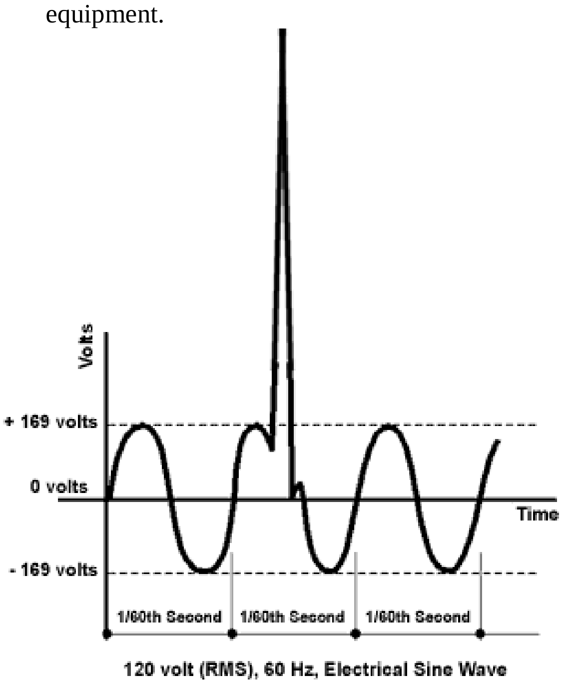

Fig. 16: Electrical sine wave

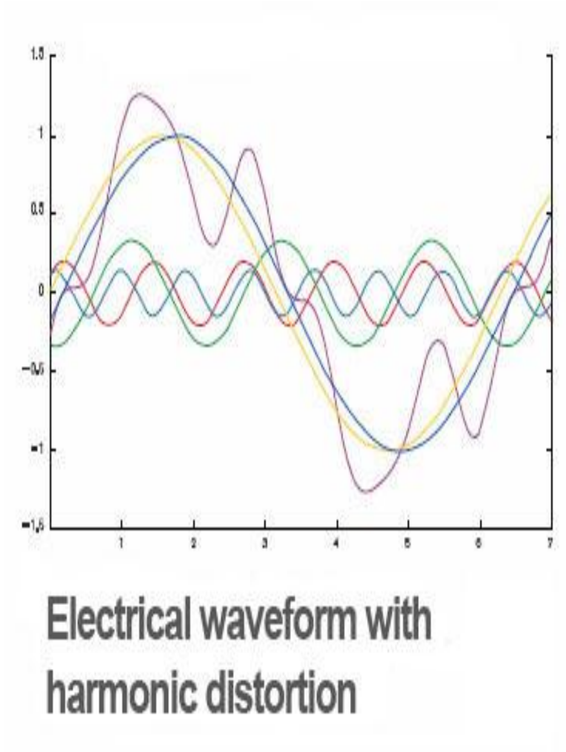

Fig. 17: Electrical waveform with harmonic distortion

III. III. RESULT

- Malfunction of microprocessor based control systems that may lead to a process stoppage.
- Disconnection and loss of efficiency in electric rotating machines.
- Tripping of protection devices.
- Loss of information and malfunction of data processing equipment.
- Stoppage of sensitive equipment.
- Destruction of components and of insulation materials.
- Data processing errors or data loss.
- Electromagnetic interference.
- Flickering of lightning and screens.
- Damage or stoppage or damage of sensitive equipment.
- Increased probability of occurrence of resonance.
- Nuisance tripping of thermal protections.
- Increase in the losses.
- Loss of efficiency in electric machines (e.g. 5^{th} harmonic).

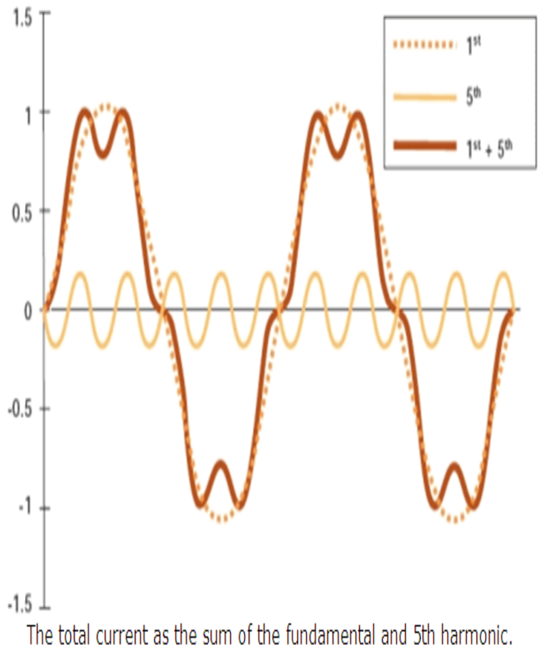

Fig. 18: Effect of 5^{th} harmonic

IV. CONCLUSION

A surge protector or simple capacitor or varistor can protect against most over voltage conditions, while a lightning arrester protects against severe spikes. Electronic filters can remove harmonics. For economic operation of a power system, the level of power quality should be properly maintained. Power quality is a vast concept concerning optimization. The adverse effects due to over voltages, also the losses incurred due to the under voltages have to be seriously dealt.

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