# A Review on Power Quality Problems

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*Abstract* — Throughout the previous decade, interest in power quality (PQ) has grown. The power quality (PQ) issue has drawn a lot of attention in the last ten years as a result of the widespread use of power electronics-based and/or microprocessor-controlled loads. On the one hand, these devices cause power quality issues, and on the other, they malfunction as a result of the generated power quality issues. This paper introduces about the power qualities problems and key issues.

***Keywords:*** Power Quality; Power Quality Index; Voltage Sag; Sources of Voltage Sag

## I. INTRODUCTION

Power quality (PQ) has recently drawn increased attention because of the issues and risks it poses to utilities and customers. Signals containing voltage, current, or frequency can exhibit typical PQ issues. Identification of PQ problems is crucial since they raise the cost of maintenance, operation, and monitoring (Abdelsalam et al. 2021). Maintaining the stability, dependability, and power quality of power distribution to the load is essential given the continual development of technology. Hundreds of producing stations and thousands of load centres are interconnected through extensive power transmission and distribution networks in today's sophisticated power systems, which are expected to provide the growing demand for power whenever necessary, with acceptable quality and cost (Sannino et al. 2003). Industrial, commercial, and even residential clients are increasingly affected by PQ issues (Ghosh et al., 2000). The PQ issues may result in severe process disruptions, malfunctioning voltage-sensitive loads, and/or data losses in industries, structures, and hospitals. Today, a network connects a lot of things. Integrated processes result in considerably more significant repercussions when any component fails (Dugan et al., 2007).

## II. OVERVIEW

Concerns over the quality of electric power are growing among both electric utilities and final consumers. Since the late 1980s, one of the most often used keywords in the power sector is "power quality." The expected and potential negative effects on power quality of the introduction of various smart distribution-grid technology and applications were discussed by Bollen et al. in 2017. The technologies and applications covered in the suggested work include demand-side management, enhanced voltage regulation, and microgrids.

### A. Power Quality

Depending on one's frame of reference, there can be many distinct definitions of power quality. Power quality is a broad phrase that encompasses all aspects of voltage and current waveform amplitude, phase, and frequency that occur in a power circuit. Power distribution systems should provide their customers with an uninterrupted flow of energy with smooth sinusoidal voltage at the agreed magnitude level and frequency, but these systems contain a number of nonlinear loads that have a substantial impact on the quality of power supplies. Circumstances that cause power quality and electrical disruptions frequently have an impact on how power systems really operate. Reactive power, which produces phase displacements, harmonic disturbances, and an imbalance in the power distribution among phases in the electrical network, is the primary cause of power losses. Interruptions, transients, quick disturbances, flickering, voltage imbalance, and harmonic distortion are all examples of electrical disturbances.

The rising concern is being caused by four main factors:."

1) Modern load equipment is more sensitive to changes in power quality than older equipment because it has microprocessor-based controllers and power electronic components.
2) As the importance of total power system efficiency has grown, so has the use of devices like shunt capacitors for power factor correction to cut losses and high-efficiency, adjustable-speed motor drives. Because of the rising harmonic levels on power systems, many people are worried about how this may affect system capacities in the future.
3) End consumers are more aware of problems with power quality. Utilities customers are pressuring providers to raise the caliber of the electricity they offer as they become more knowledgeable about problems like outages, sags, and switching transients.
4) Today, a network connects a lot of things. The breakdown of any component results in considerably more significant effects in integrated processes.

Transients, voltage sag and swell, power-line flicker, and resonance are examples of short-term disruptions. Transients are disruptions that can be caused by lightning strikes, static discharges, switching processes, or the on and off of machinery. They only last for a brief period of time until the electrical circuit rapidly resumes stable, damage-free operation. When the voltage level drops for more than a few seconds, it is referred to as undervoltage; otherwise, it is referred to as a voltage sag (Montoya et al. 2018).

Noise, harmonic distortion, and voltage imbalance and notching are examples of long-term disturbances. While voltage notching is a periodic disturbance that occurs during the regular functioning of power electronic devices when the current flows from one phase to another, voltage unbalance can be induced by either single-phase or unbalanced three-phase loads. Harmonic distortion, which is frequently brought on by nonlinear loads like variable-speed drives, is characterized by sporadic changes in the pure sinusoidal waveform (Montoya et al. 2018).

 

### *B. Classifications of Power Quality Problems*

Custom power was presented by N.G. Hingorani in 1995 as an application of the FACTS idea to distribution systems in order to improve PQ and increase the dependability of the power supply (Hingorani, 1995).

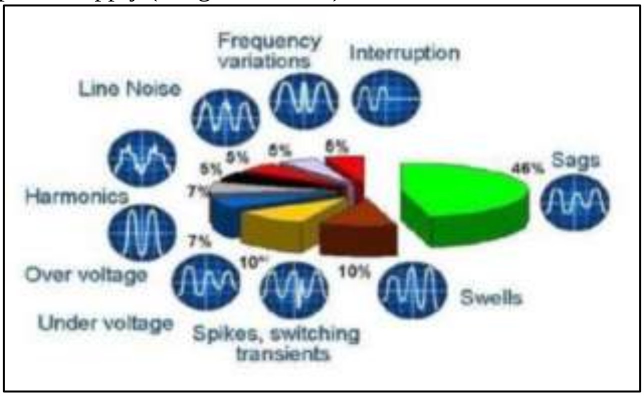


Fig 1.1: Classification of Power Quality Problems

| | Category | Time Duration | Voltage Magnitude |
|---|---|---|---|
| 1 | Transients | | |
| 1.1 | Impulsive | | |
| | Nanosecond | <50 nsec | |
| | Microsecond | 50nsec-1msec | |
| | Millisecond | >1msec | |
| 1.2 | Oscillatory | | |
| | Low Frequency | | 0-4 pu |
| | Medium Frequency | | 0-8 pu |
| | High Frequency | | 0-4 pu |
| 2 | Long Duration Variations | | |
| 2.1 | Instantaneous | | |
| | Interruption | 0.5-30 cycles | <0.1 pu |
| | Sag | 0.5-30 cycles | 0.1-0.9 pu |
| | Swell | 0.5-30 cycles | 1.1-1.8 pu |
| 2.2 | Momentary | | |
| | Interruption | 30 cycles-3 sec | <0.1 pu |
| | Sag | 30 cycles-3 sec | 0.1-0.9 pu |
| | Swell | 30 cycles-3 sec | 1.1-1.4 pu |
| 2.3 | Temporary | | |
| | Interruption | 3 sec- 1 min | <0.1 pu |
| | Sag | 3 sec- 1 min | 0.1-0.9 pu |
| | Swell | 3 sec- 1 min | 1.1-1.2 pu |
| 3 | Long Duration Variations | | |
| 3.1 | Interruption | >1 min | 0 pu |
| 3.2 | Overvoltages | >1 min | 0.8-0.9 pu |
| 3.3 | Undervoltages | >1 min | 1.1-1.2 pu |
| 4 | Waveform Distortions | | |
| 4.1 | DC offset | Steady State | 0-0.1% |
| 4.2 | Harmonics | Steady State | 0-20% |
| 4.3 | Inter-harmonics | Steady State | 0-2% |
| 4.4 | Noise | Steady State | 0-1% |
| 5 | Voltage Fluctuation | Intermittent | 0.1-7% |
| 6 | Power Frequency Variations | >10% | |
| 7 | Voltage Unbalance | Steady State | 0.5-2% |

Table 1.1: Category wise IEEE 1159 Disturbance Classifications Power Quality Problems

One of the most frequent power quality issues today is voltage sags or dips. These are transient drops in one, two, or all three phases of the power system's rms voltage (MacGregor et al. 1998).

A form of undervoltage condition known as voltage interruptions lasts for a time typically longer than 0.5 seconds but not more than 60 seconds. In contrast to a sag event, a voltage interruption always has a voltage magnitude of less than 0.1 pu. Depending on how long the disruption lasts, interruptions are again divided into brief and temporary categories.Voltage sags are the opposite of voltage swells (instantaneous or momentary overvoltage events). The duration of these overvoltage conditions on the power system ranges from 0.5 cycles to 3 seconds, and the related voltage magnitude is between 110 and 180 percent of the nominal power frequency voltage value.

### *C. Voltage Sag*

Voltage sags are described as any "sudden fall of the voltage at a point in the electrical system, followed by voltage recovery after a short period of time, from half a cycle to a few seconds" in the IEC electro technical language, IEC 60050- 604, 1998 (Dugan et al., 2007).

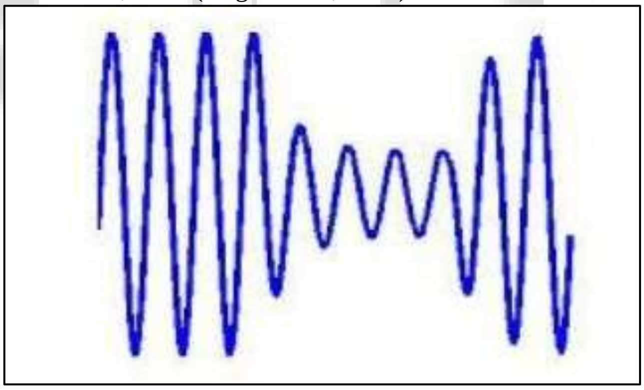

Fig. 1.2: Voltage Sag Waveform

#### *1) Sources of Voltage Sag*

Voltage sags can also be brought on by the energization of high loads or the starting of powerful motors, albeit they are typically related to system breakdowns. The following list of factors can induce voltage drops in a power system:

a) Voltage sag due to faults
b) Voltage sags due to induction motor starting
c) Voltage sags due to transformer energizing

### *D. Key Issues and Challenges in Classification of PQ Disturbances*

It is challenging to classify PQ disturbances accurately because it depends on a number of different elements. The following are some of the main problems and obstacles to automatic PQ disturbance classification.

 

- The majority of classification methods that have been suggested are for solitary disturbances. Hence, attempts for multiple disturbance classification must be made. Several methods are currently available for multi-class SVM. The suitability of these methods for classifying PQ disturbances can be evaluated.
- Most research used simulated data for training and testing. As a result, the creation of a thorough standard PQ database, comparable to those of many other signal processing domains, is also required for testing and comparing state-of-the-art approaches.
- Prior to coming up with solutions, the technological and economic constraints must be taken into account. Additionally, the solutions must be assessed from a system viewpoint, meaning that potential fixes must be found at all system levels, from utility supply to the equipment that affects end users.
- There is some literature on the automatic classification of PQ events based on the disturbance's root cause. Without mentioning the underlying cause, the majority of the methods deal with the PQ event type. For instance, it would be helpful to know whether a voltage sag was brought on by a heavy load switching, a line-to-ground failure, or for any other reason, in the case of a voltage sag occurrence. For a deeper understanding of PQ occurrences, the effort should be expanded to cause-based classification rather than phenomenon-based classification.

## III. CONCLUSION

It has been determined from the review that Harmonics and transient disturbances frequently have a significant negative impact on electric power quality, which is currently of interest to many power utilities throughout the world. Power quality is turning into a significant and difficult issue for the power engineers as a result of the rising use of various power electronic devices in modern power systems. There is no one methodology that can accurately identify and categories the power qualities issues and evaluate them. Power quality disruptions should be minimized or removed, regardless of their origin. If this isn't done, there may be more facility downtime, less productivity, more equipment maintenance, or more frequent equipment replacement.

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