

POWER QUALITY ISSUES, PROBLEMS AND RELATED STANDARDS

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ABSTRACT

The growth in power electronics has impacted many loads that traditionally were considered linear in nature. As a result, the number of nonlinear loads has increased and is expected to increase dramatically in the years ahead. With increasing quantities of non-linear loads being added to electrical systems, it has become necessary to establish criteria for limiting problems from system voltage degradation.

This paper presents the power quality problems, issues and related international standards. The presentation is done with giving a thorough knowledge of harmonics, power quality indices, parameters effecting electric power etc. Latest research work in giving different international standards for different type of power quality problems is also been given. This is important for design engineers and researchers in power quality to know the international standards used for power quality.

INTRODUCTION

The paper and the technology on which it is grounded are largely motivated by the power quality issues. The term power quality is rather general concept. Broadly, it may be defined as provision of voltages and system design so that user of electric power can utilized electric energy from the distribution system successfully, without interference on interruption. Utilities may want to define power quality as reliability. Equipment manufacturers, in turn may define it as a power that enables the equipment to work properly. In other words power quality can be defined as, "Any power problem manifested in voltage, current or frequency deviations that results in failure of or disoperation of customer equipment."

From the utility perspective, Power Quality has been defined as the parameters of the voltage that affect the customer's supersensitive equipment.

From the power user perspective, Power Quality may be defined as any electrical parameter or connection that affects the operation of the equipment. This included all electrical parameters, connections and grounds, whether the source from the utility, local equipment or other users.

From the Power Quality market or industry perspective, it is any product or service that is supplied to users or utilities to measure, treat, remedy, educate engineers or prevent Power Quality issues, problems and related items [6]

This paper critically discusses about the power quality problems, issues and related standards with giving a thorough knowledge of harmonics, power quality indices, parameters effecting electric power etc.

The above said areas are discussed under the following heads:

1. Power quality problems & issues
2. Harmonics and harmonics sequences
3. Power quality indices
4. Power quality standards

1. Power Quality Problems & Issues:

Voltage sags are considered the most common Power Quality problem. These can be caused by the utility or by customer loads. When sourced from the utility, they are most commonly caused by faults on the distribution system. These sags will be from 3 to 30 cycles and can be single or three phase. Depending on the design of the distribution system, a ground fault on 1 phase can cause a simultaneous swell on another phase.

A recent survey of Power Quality experts in Arizona indicates that 50% of all Power Quality problems are related to grounding, ground bonds, and neutral to ground voltages, ground loops, ground current or other ground associated issues. Electrically operated or connected equipment is affected by Power Quality [10, 12, 15, 16].

Determining the exact problems requires sophisticated electronic test equipment. The following symptoms are indicators of Power Quality problems:

1. Piece of equipment misoperates at the same time of day.
2. Circuit breakers trip without being overloaded.
3. Equipment fails during a thunderstorm.
4. Automated systems stop for no apparent reason.
5. Electronic systems fail or fail to operate on a frequent basis.

- Electronic systems work in one location but not in another location.

The commonly used terms those describe the parameters of electrical power that describe or measure power quality are Voltage sags, Voltage variations, Interruptions Swells, Brownouts, Blackouts, Voltage imbalance, Distortion, Harmonics, Harmonic resonance, Interharmonics, Notching, Noise, Impulse, Spikes (Voltage), Ground noise, Common mode noise, Critical load, Crest factor, Electromagnetic compatibility, Dropout, Fault, Flicker, Ground, Raw power, Clean ground, Ground loops, Voltage fluctuations, Transient, Dirty power, Momentary interruption, Over voltage, Under voltage, Non-linear load, THD, Triplens, Voltage dip, Voltage regulation, Blink, Oscillatory transient etc [4, 12, 15].

Power Quality has been an issue since electrical power was invented. It has only become a well published issue in recent years because of the loads it affects. If your favorite TV program is interrupted by the local sewage pump operating on a Variable Speed drive interfering with it, you are aware of a Power Quality problem. When the lights blink and your PC reboots, you are aware of a Power Quality problem. The electrical loads get more sensitive [6].

There are hundreds of manufacturers making thousands of different Power Quality solutions today [7].

The categories of these solutions are:

- Utility based solutions for the substation level.
- User based solution for whole facility protection.
- User load level solutions for specific loads
- Designed in solutions, built in by the equipment manufacturer to reduce the sensitivity to Power Quality problems.

The issue of electric power quality is gaining importance because of several reasons:

- The society is becoming increasingly dependent on the electrical supply. A small power outage has a great economical impact on the industrial consumers. A longer interruption harms practically all operations of a modern society.
- New equipments are more sensitive to power quality variations.
- The advent of new power electronic equipment, such as variable speed drives and switched mode power supplies, has brought new disturbances into the supply system.
- Deregulation is resulting in structural changes in the utility industry (Traditionally, the generation, transmission, distribution and retail services have been bundled into one regulated company the task of which, among the others, was to be responsible for the quality of power. In a deregulated environment, it is worthwhile

to ask, who will be responsible for the power quality?

- The deregulated environment may reduce the maintenance of and investments into the power system and, hence, reduce the margins in the system.
- Emerging of distributed generation (known also as embedded and dispersed generation) as a side effect of the deregulation. Distributed generation changes the way how the utility grid is operated and introduces new power quality challenges. The end users' awareness in power quality issues has increased.

The nature of electricity as a product is special. Similar to the conventional products its characteristics affect its usefulness to the customer. Different from the conventional products the application of it is one of the main factors that have an influence on its characteristics. The current that the customer's appliance draws from the supply network flows through the impedances of the supply system and causes a voltage drop, which affects the voltage that is delivered to the customer. Hence, both the voltage quality and the current quality are important. It is rather natural to split up the responsibilities so that the power distribution supplier is responsible for the voltage quality and the customer is accountable for the quality of current that he or she is taking from the utility. Table 1 shows the categorization of power system electromagnetic phenomena that affect the power quality [2, 6].

Transients

(i) Impulsive

Categories	Typical spectral content	Typical duration
Nanosecond	5 ns rise time	< 50 ns
Microsecond	1 μsec rise time	50 ns - 1 ms
Millisecond	1 ms rise time	> 1 ms

(ii) Oscillatory

Categories	Typical spectral content	Typical duration	Typical voltage magnitude
Low frequency	< 5 kHz	0.3-50 ms	0-4 p.u.
Medium frequency	5-500 kHz	20 μs	0-8 p.u.
High frequency	0.5-5 MHz	5 μs	0-4 p.u.

Short duration variations

(i) Instantaneous

Categories	Typical duration	Typical voltage magnitude
Interruption	0.5-30 cycles	< 0.1 p.u.
Sag (dip)	0.5-30 cycles	0.1-0.9 p.u.
Swell	0.5-30 cycles	1.1-1.8 p.u.

(ii) Momentary

Categories	Typical duration	Typical voltage magnitude
Interruption	30 cycles - 3 s	< 0.1 p.u.
Sag (dip)	30 cycles - 3 s	0.1-0.9 p.u.
Swell	30 cycles - 3 s	1.1-1.4 p.u.

(iii) Temporary

Categories	Typical duration	Typical voltage magnitude
Interruption	3 s - 1 min	< 0.1 p.u.
Sag (dip)	3 s - 1 min	0.1-0.9 p.u.
Swell	3 s - 1 min	1.1-1.2 p.u.

Long duration variations

Categories	Typical duration	Typical voltage magnitude
Interruption, sustained	> 1 min	0.0 p.u.
Undervoltages	> 1 min	0.8-0.9 p.u.
Overvoltages	> 1 min	1.1-1.2 p.u.
Voltage unbalance	Steady state	0.5%-2%

Waveform distortion

Categories	Typical spectral content	Typical voltage magnitude
DC offset	----	0%-0.1%
Harmonics	0-100th harmonic	0%-20%
Interharmonics	0-6 kHz	0%-2%
Notching	----	----
Noise	Broadband	0%-1%
Voltage fluctuations	< 25 Hz	0.1%-7%

Table 1: Categories and characteristics of power system electromagnetic phenomenon

2. Harmonics and Harmonics Sequences:

In power systems harmonics appear as a waveform distortion of the voltage or the current. The harmonics are generated by nonlinear loads. The sinusoidal voltage applied to the nonlinear load does not result in a sinusoidal current. Further, this nonsinusoidal current will produce a nonsinusoidal voltage drop while flowing through the finite source impedance, and, hence, cause harmonic voltages. Alongside with the harmonics, interharmonics and dc-component may distort the waveform. The spectral component with frequency of f is

Harmonic;

If $f = nf_{fund}$, where n is an integer > 0

DC-component;

If $f = 0$ ($f = nf_{fund}$, where $n = 0$)

Interharmonic;

If $f = nf_{fund}$, where n is an integer > 0

Subharmonic;

If $f > 0$ and $f < f_{fund}$, where f_{fund} is the fundamental power system frequency. The interharmonics and subharmonics are also referenced in IEC Std 60050-551-20 (2001). In power systems the harmonics have an interesting property called the sequence. Natural sequences are shown in Table 2. The sequence indicates the phase sequence of the phase quantities.

The fundamental component is of positive sequence, meaning that phase a is leading phase b, which is leading phase c. The phase order is then a-b-c. The phase order of a negative sequence component is a-c-b. With zero-sequence components all phase quantities are similar and the phase order can not be defined. If a space-vector is constructed from a harmonic sequence it is noticed that positive sequence components rotate into the positive direction and negative sequence components into the negative direction. The zero-sequence component does not contribute to the space-vector at all [4,6,9].

Order	Sequence	Order	Sequence
1	Positive	6	Zero
2	Negative	7	Positive
3	Zero	8	Negative
4	Positive	9	Zero
5	Negative	10	Positive

Table 2: Natural sequences of characteristic current harmonics of converters

Transients may be impulsive or oscillatory in nature. Impulsive transients are typically caused by lightnings and high oscillatory transients as a response of a local system to the impulsive transient. A low frequency oscillatory transient may be a result of a capacitor switching. Short duration variations are typically caused by faults or energization of large loads which require high starting currents. Long duration under- or overvoltages usually result in switching of large load or generation unit or a capacitor bank. An incorrect transformer tap setting may also be a cause of such a situation. Voltage unbalance may be caused by excess of poorly balanced single phase loads or blown fuses in one phase of a capacitor bank. Waveform distortions are caused by nonlinear loads in the power systems. A half-wave rectification may cause dc-offset. Harmonics are originating from many sources, in which typically power electronics are involved, but may also be produced by nonlinearly magnetizing inductances. Interharmonics are mainly caused by cycloconverters and arcing devices. Notching is a periodic voltage disturbance typically caused by commutations of power electronic device. Notching could be regarded as harmonics with high orders, but is typically considered as a special case. Voltage fluctuation may be caused by rapidly varying loads or generation. Certain voltage fluctuations are often called flicker, because of the visible effect to incandescent lamps. Power frequency variations may be caused by power system faults or disconnection or connection of

large load or generation unit.

3. Power Quality Indices:

3.1 General harmonic indices

A complete description of a given distortion is the spectrum, but it is not very practical for rough comparisons and assessments. Hence, several harmonic indices have been developed to measure and characterize harmonic distortions with a single figure [4, 6]. The most common harmonic index is the total harmonic distortion (THD).

$$THD = \frac{\sqrt{\sum_{h=2}^{h \max} X_h^2}}{X_1}$$

X_1 is the fundamental wave RMS value and X_h is the RMS value of the harmonic component h . The THD is calculated up to the harmonic h_{\max} , which is typically 40 or 50, but in some cases, if it is known that harmonics higher than that exist, it is justified to calculate the THD, e.g., up to the 200th harmonic. It is advisable to report the number of harmonics taken into the calculation. The THD may be calculated with either the RMS values or the peak-values. There exists a connection between the THD and the waveform's true RMS value X_{rms} as:

$$X_{rms} = X_1 \sqrt{1 + THD^2}$$

provided that no harmonics exist above h_{\max} and the waveform is periodic with a fundamental wave period. The THD is:

$$THD = \sqrt{\left(\frac{X_{rms}}{X_1}\right)^2 - 1}$$

The THD may be calculated for the voltage or the current. It is a measure that quantifies "how close the waveform is to pure sine". The smaller the THD the closer the wave-shape approximates sine. Typical rule-of-thumb values for acceptable waveforms are a 5% THD for the current and a 2% THD for the voltage in the customer's point of connection. There exists also an alternative definition of the THD, which is sometimes called distortion index (DIN)

$$DIN = \frac{\sqrt{\sum_{h=2}^{h_{\max}} X_h^2}}{\sqrt{\sum_{h=1}^{h_{\max}} X_h^2}} = \frac{\sqrt{\sum_{h=2}^{h_{\max}} X_h^2}}{X_{rms}}$$

DIN is frequently used in the European literature but rarely in the United States. The advantage of this formulation is that it is always between zero and one. The THD goes infinitely large as the distortion increases. For small distortions, however, both definitions give approximately the same result [4, 6, 8, 9]. The THD is defined for signals, which are periodic with the fundamental wave period. However, in practical power engineering the signal may have subharmonics, interharmonics, or distortion above h_{\max} to which the harmonic analysis is extended. Usually, the THD is used as the measure of the power quality in case of interharmonics and subharmonics, even though it is, strictly speaking, not defined for these signals, if the power frequency is used as the fundamental frequency. This is understandable because the majority of the power analyzers calculate it automatically and many standards refer to it. Also, very often the practical signal is well approximated by the power frequency fundamental wave periodic signal and the calculated THD is a meaningful quantity. Sometimes, however, the opposite is true. The THD denotes the ratio of the energy content of the harmonics to that of the fundamental component [4].

THD' = (Total Signal Energy - Fundamental Wave Signal Energy) / Fundamental Wave Signal Energy

Where the fundamental frequency (and hence also the fundamental wave period) is defined by the power frequency. THD is calculated as:

$$THD = \frac{\sqrt{X_{rms}^2 - X_1^2}}{X_1}$$

In a periodic case, evidently, THD = THD'. In IEC Std 61800-4 (2002) THD is called total distortion ratio, and it is noted that it may be approximated with THD if interharmonics are disregarded due to their low amplitude. Further, it is noted that assessment of THD and THD' lead typically to the same result in case of a voltage, but there may be significant differences in case of a current.

The RMS value of an aperiodic signal $x(t)$ may be calculated as:

$$X_{rms} = \sqrt{\frac{1}{T_{end}} \int_0^{T_{end}} x(t)^2 dt}$$

Where T_{end} is the time horizon. In practical power engineering, T_{end} should be chosen as an integer multiple of the power frequency cycle time because the amplitudes of the interharmonic and subharmonic components are typically far lower than the power frequency component.

The THD is not always a very good measure of the detrimental effect of the current. Especially in variable speed drives, the THD of the line current may be very high in light loads but within the acceptable limits in full load. Despite the high THD value under light load condition the absolute magnitudes of the harmonics are low and do not harm the power system. With a line converter the THD may approach infinity when the fundamental current approaches zero while some harmonics are present because of the switching action of the converter bridge. This misleading property may be avoided by relating the harmonics to the nominal or the maximum current instead of the fundamental wave of the present current waveform. This is known as the total demand distortion (TDD).

$$TDD = \frac{\sqrt{\sum_{h=2}^{h_{\max}} I_h^2}}{I_n}$$

4. Power Quality Standards:

Power quality is a worldwide issue, and keeping related standards current is a never-ending task. It typically takes years to push changes through the process. One of the most important developments in the power quality arena is the increased emphasis on coordinating IEEE standards with international standards developed by the International Electrotechnical Committee [1, 3, 5, 8, 14, 15].

Most of the ongoing work by the IEEE in harmonic standards development has shifted to modifying Standard 519-1992. So let's take a closer look at some of the recent developments within these two organizations [8].

The Power Quality Standards Coordinating Committee, SCC-22, sponsored a task force to pull together a list of power quality terms and definitions. However, as the task force began compiling the definitions from various IEEE and IEC standards, they found many confusing or conflicting terms. Despite this hurdle, they tried to identify official

definitions and provide examples of properly used terms. Accurate comparisons of power quality levels from one facility and system to another require consistent methodology. Existing IEEE Standard 1159 provides only general guidelines and definitions, so its group is actively developing more specific procedures for systems monitoring. Standard 1159.3 is actually based on the development of a Power Quality Data Interchange Format (PQDIF). The format is a means for exchanging power quality monitoring information between different applications. It will allow software developers to design applications that analyze power quality problems independently from the manufacturers of the monitoring equipment [1]. As for the IEC, there are some specific standards related to the monitoring requirements for each type of power quality phenomena. For example, IEC Standard 61000-4-7 deals with the requirements for monitoring and measuring harmonics, while IEC Standard 61000-4-15 describes the instrumentation and procedures for monitoring flicker. IEC Standard 61000-4-30 have some future plans on providing overall recommendations for monitoring all types of power quality phenomena while still referring to other specific standards where appropriate. IEEE is currently adopting this standardized approach as well [3].

4.1 IEEE 519

IEEE 519-1992, Recommended Practices and Requirements for Harmonic Control in Electric Power Systems, established limits on harmonic currents and voltages at the point of common coupling (PCC), or point of metering [1.3].

The limits of IEEE 519 are intended to:

- 1) Assure that the electric utility can deliver relatively clean power to all of its customers;
- 2) Assure that the electric utility can protect its electrical equipment from overheating, loss of life from excessive harmonic currents, and excessive voltage stress due to excessive harmonic voltage. Each point from IEEE 519 lists the limits for harmonic distortion at the point of common coupling (PCC) or metering point with the utility. The voltage distortion limits are 3% for individual harmonics and 5% THD.

The heaviest electrical users have the most stringent harmonic limits. However, as the size of the user load decreases with respect to the size of the system, the user can inject a larger percentage of harmonic current into the utility system. This protects other users on the same feeder as well as the utility, which is required to furnish a certain quality of power to its customers. Note that all of

the harmonic limits in IEEE 519 are based on a customer load mix and location on the power system. The limits are not applied to particular equipment, although, with a high amount of nonlinear loads, it is likely that some harmonic suppression may be necessary. As the load mix changes, it is often necessary to reevaluate the limits of IEEE 519.

4.1.1 IEEE Standard for Current Harmonics :

IEEE-519

- **General Distribution Systems [120V- 69 kV]**

I_{sc}/I_L	h<11	11 h<17	17 h<23	23 h<25	TDD (%)
<20	4.0	2.0	1.5	0.6	5
20-50	7.0	3.5	2.5	1.0	8
50-100	10	4.5	4.0	1.5	12
100-1000	12	5.5	5.0	2.0	15
>1000	15	7.0	6.0	2.5	20

- **General Sub-transmission Systems [69 kV-161 kV]**

I_{sc}/I_L	h<11	11 h<17	17 h<23	23 h<25	h 35	TDD (%)
<50	2.0	1.0	0.75	0.3	0.15	2.5
50	3.0	1.5	1.15	0.45	0.22	3.75

Above current distortion limits are for odd harmonics. Even harmonics are limited to 25% of the odd harmonic limits [1,3,5]. For all power generation equipment, distortion limits are those with $I_{sc}/I_L < 20$. I_{sc} is the maximum short circuit current at the point of coupling "PCC". I_L is the maximum fundamental frequency 15-or 30-minutes load current at PCC. TDD is the Total Demand Distortion (=THD normalized by I_L)

4.1.2 IEEE STANDARD FOR VOLTAGE HARMONICS

IEEE-519 - Voltage Distortion Limits

Bus voltage	Individual V_b (%)	THDV(%)
V <69 kV	3.0	5.0
69 V <161 kV	1.5	2.5
V 161 kV	1.0	1.5

4.2 IEC 61000-3-2 and IEC 61000-3-4 (formerly 1000-3-2 and 1000-3-4)

4.2.1 IEC 61000-3-2 (1995-03)

It specifies limits for harmonic current emissions applicable to electrical and electronic equipment having an input current up to and including 16 A per phase, and intended to be connected to public low-voltage distribution systems. The tests according to this standard are type tests [3, 5, 8].

4.2.2 IEC/TS 61000-3-4 (1998-10)

It specifies to electrical and electronic equipment with a rated input current exceeding 16 A per phase and intended to be connected to public low-voltage ac distribution systems of the following types:

- nominal voltage up to 240 V, single-phase, two or three wires;
- nominal voltage up to 600 V, three-phase, three or four wires;
- nominal frequency 50 Hz or 60 Hz

These recommendations specify the information required to enable a supply authority to assess equipment regarding harmonic disturbance and to decide whether or not the equipment is acceptable for connection with regard to the harmonic distortion aspect. The European standards, IEC 61000-3-2 & 61000-3-4, placing current harmonic limits on equipment, are designed to protect the small consumer's equipment. The former is restricted to 16 A; the latter extends the range above 16 A.

4.3 IEEE Standard 141-1993, Recommended Practice for Electric Power Distribution for Industrial Plants

A thorough analysis of basic electrical-system considerations is presented. Guidance is provided in design, construction, and continuity of an overall system to achieve safety of life and preservation of property; reliability; simplicity of operation; voltage regulation in the utilization of equipment within the tolerance limits under all load conditions; care and maintenance; and flexibility to permit development and expansion [3, 8, 17].

4.4 IEEE Standard 142-1991, Recommended Practice for Grounding of Industrial and Commercial Power Systems

This standard presents a thorough investigation of the problems of grounding and the methods for solving these problems. There is a separate chapter for grounding sensitive equipment [3, 17].

4.5 IEEE Standard 242-1986, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

This standard deals with the proper selection, application, and coordination of the components which constitute system protection for industrial plants and commercial buildings [3, 17].

4.6 IEEE Standard 446-1987, Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications

This standard is recommended engineering practices for the selection and application of emergency and standby power systems. It provides facility designers, operators and owners with guidelines for assuring uninterrupted power, virtually free of frequency excursions and voltage dips, surges, and transients [8, 9, 17].

4.7 IEEE Standard 493-1997, Recommended Practice for Design of Reliable Industrial and Commercial Power Systems

The fundamentals of reliability analysis as it applies to the planning and design of industrial and commercial electric power distribution systems are presented. Included are basic concepts of reliability analysis by probability methods, fundamentals of power system reliability evaluation, economic evaluation of reliability, cost of power outage data, equipment reliability data, and examples of reliability analysis. Emergency and standby power, electrical preventive maintenance, and evaluating and improving reliability of the existing plant are also addressed [8, 9, 17].

4.8 IEEE Standard 1100-1999, Recommended Practice for Powering and Grounding Sensitive Electronic Equipment

Recommended design, installation, and maintenance practices for electrical power and grounding (including both power-related and signal-related noise control) of sensitive electronic processing equipment used in commercial and industrial applications [8, 9, 17]

4.9 IEEE Standard 1159-1995, Recommended Practice for Monitoring Electric Power Quality

Monitoring of electric power quality of AC power systems, definitions of power quality terminology, impact of poor power quality on utility and

customer equipment, and the measurement of electromagnetic phenomena are covered [7, 12, 17].

4.10 IEEE Standard 1250-1995, Guide for Service to Equipment Sensitive to Momentary Voltage Disturbances

Computers, computer-like products, and equipment using solidstate power conversion have created entirely new areas of power quality considerations. There is an increasing awareness that much of this new user equipment is not designed to withstand the surges, faults, and reclosing duty present on typical distributions systems. Momentary voltage disturbances occurring in ac power distribution and utilization systems, their potential effects on this new, sensitive, user equipment, and guidance toward mitigation of these effects are described. Harmonic distortion limits are also discussed [13, 17].

4.11 IEEE Standard 1346-1998 Recommended Practice for Evaluating Electric Power System Compatibility with Electronic Process Equipment

A standard methodology for the technical and financial analysis of voltage sag compatibility between process equipment and electric power systems is recommended. The methodology presented is intended to be used as a planning tool to quantify the voltage sag environment and process sensitivity. It shows how technical and financial alternatives can be evaluated. Performance limits for utility systems, power distribution systems, or electronic process equipment are not included [8, 17].

4.12 SEMI F-47-1999, Standard for Definition and Measurement of Equipment Reliability, Availability, and Maintainability defines the sag ride through capability [17].

4.13 SEMI F-42-1999, Test Method for Semiconductor Processing Equipment Voltage Sag Immunity defines the test methodology to confirm compliance to the standard [17].

4.14 Standards related to Voltage Sag and Reliability

Personnel at many utilities monitor voltage sags and calculate indices for system sag performance the same way they do for system reliability. The distribution voltage quality standard i.e. IEEE Standard P1564 gives the recommended indices and procedures for characterizing voltage sag performance and comparing performance across

different systems. Undoubtedly, this standardized approach will be extremely useful. Individual customers can use the voltage sag performance information to evaluate the economics of various alternatives for improving system performance. You can find this evaluation procedure described in IEEE Standard 1346-1998.

A new IEC Standard 61000-2-8 titled "Environment —Voltage Dips and Short Interruptions" has come recently. Its purpose is to describe the expectations and characterizations of system performance. This standards warrants considerable discussion within the IEEE to avoid conflicting methods of characterizing system performance in different parts of the world [5].

4.15 Standards related to Harmonics

Harmonic standards development by the IEEE has shifted to modifying Standard 519-1992. Discussion at the IEEE winter power meeting focused on appropriate limits for harmonic levels inside customer facilities. IEEE Standard 519-1992 provides recommended limits for harmonic levels at the point of common coupling (PCC) between the customer and the power system (i.e., the location where other customers could be supplied). The recommended voltage distortion limit for the PCC is 5% for the total harmonic distortion (THD) and 3% for individual harmonics[5].

The revision to Standard 519 is considering higher limits for inside the facility and making these limits frequency-dependent. The limits specified in IEC for low-voltage systems allow a THD of 8% and include limits for individual harmonic components, which decrease with frequency. "The Guide for Applying Harmonic Limits on Power Systems," is recently in process to be added up in IEEE Standard 519A. Other activities in the harmonics area is to add up the "Working on single-phase harmonic limits and interharmonics issues" in the existing standard. The harmonic filter up, which is part of the capacitor subcommittee, has recently completed a harmonic filter design guide known as IEEE Standard P1531. A new task force on active filters has been formed under the sponsorship of the IEEE harmonics group.

4.16 Standards related to Flicker

Developments in voltage flicker standards demonstrate how the industry can successfully coordinate IEEE and IEC activities. IEC Standard 61000-4-15 defines the measurement procedure and monitor requirements for

characterizing flicker. Recent updates to this standard include the response characteristics of incandescent lights on 120V, 60 Hz systems, which permit using the same monitoring equipment to characterize flicker on power systems in North America. The IEEE flicker task force working on Standard P1453 is set to adopt the IEC standard as its own [5].

4.17 Standards related to Custom Power

IEEE Standard P1409 is currently developing an application guide for custom power technologies to provide enhanced power quality on the distribution system. This is an important area for many utilities that may want to offer enhanced power quality services [5, 7].

4.18 Standards related to Distributed Generation

The new IEEE Standard P1547 provides guidelines for interconnecting distributed generation with the power system [5, 15, 16]. This standard has been on a fast track and should be balloted shortly. It specifies requirements for the full range of interconnection issues and references appropriate standards for individual power quality issues where appropriate.

Many researches are going on to develop the standards for different problems occur in power quality research. They are following [3, 5]:

- (i) Harmonics and other low-frequency disturbances: This area focuses on limits and methods of measurement for harmonics and interharmonics.
- (ii) Voltage fluctuations (flicker) and other low-frequency disturbances: This area focuses on setting limits for voltage fluctuations caused by customer equipment and methods of appropriate measurement.
- (iii) Low-frequency immunity tests: This area focuses on testing procedures that evaluate equipment immunity from power quality variations.
- (iv) Electromagnetic interference related to the network frequency: This area is focusing the full range of power quality phenomena on the network and the interaction issues associated with end users of electricity.
- (v) Power quality measurement methods: This area is currently focusing on IEC 61000-4-30, an overall guide defining the requirements for power quality monitoring equipment.

It's difficult to keep up with the wide variety of power quality standards and guides under development. The best way to stay on top of things is to participate in the process. As power quality

professionals, we have the opportunity to increase our participation in these working groups and better coordinate the efforts of the IEC and IEEE [3, 5, 11].

CONCLUSION

This paper presented a brief and critical discussion about power quality problems, issue and related international standards. The following recommended standards for equipment is developed to help preserve voltage integrity by limiting harmonic current injection of single-phase loads which are likely to appear in increasing numbers in power distribution systems. By addressing harmonic current distortion at the individual sources, system problems may be avoided. The harmonic current limits established in the standards are proposed with the intent of minimizing the impact on existing equipment design. Coordination with existing industry practices and international harmonic standards is also considered in this paper. This paper should help research workers, users and suppliers of electrical power to gain a guideline about the power quality.

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