

IEEE Guide for Service to Equipment Sensitive to Momentary Voltage Disturbances

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Abstract: Computers, computer-like products, and equipment using solid-state 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 distribution 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.

Keywords: disturbance analyzers, faults, harmonic distortion, momentary voltage disturbances, noise, power conditioners, sensitive equipment, surge protection, surges

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On page 3, the second item in the list in 3.1.8 has been corrected to read “2 s” rather than “2 min”.

Introduction

(This introduction is not a part of IEEE Std 1250-1995, IEEE Guide for Service to Equipment Sensitive to Momentary Voltage Disturbances.)

This guide was developed out of an increasing awareness of the incompatibility of modern electronics equipment with a normal power system environment. Simply put, much new user equipment is not designed to withstand the surges, faults, and reclosing duty present on typical electric utility distribution systems or within the user's facility.

This guide describes the operating environment of sensitive utilization equipment, identifies potential problem areas, and suggests effective ways to satisfy its special voltage requirements. Cooperation among users, utilities, and equipment designers is needed to ensure both adequate electric service to all users and proper equipment operations. Solutions are presented from the perspectives of both the customer and the utility provider, since the problems users of sensitive equipment experience often originate from either area..

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IEEE Guide for Service to Equipment Sensitive to Momentary Voltage Disturbances

1. Overview

1.1 Scope

This guide describes momentary voltage disturbances (short-duration transients) occurring in ac power distribution and utilization systems, their potential effects on sensitive equipment, and guidance toward mitigation of these effects. Also provided is a description of the operating environment of sensitive utilization equipment as well as information on harmonic distortion limits.

1.2 Problem definition

Computers, computer-like products, and equipment using solid-state 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 distribution systems. In addition to the usual steady-state concerns, designers and users of these types of equipment, as well as suppliers of utilities, are concerned with transients, brief momentary disturbances, and harmonics of these often sensitive loads.

Most voltage problems associated with computers and other sensitive equipment are related to not only high or low steady-state voltage levels, but also to momentary voltage disturbances, such as surges, sags, interruptions, or rapid changes in voltage. The starting of a large motor, for example, can result in voltage sag due to the high inrush current. A fault on the utility lines, even though cleared, can result in a momentary sag, surge, or interruption. Momentary voltage disturbances may result from a wide variety of causes on a utility system or within a user's facility.

Site monitoring with disturbance recorders helps to identify the nature of the problem and the frequency of occurrence. Such information can then be correlated to events on either side of the meter to help identify possible solutions. However, difficulty often arises in matching recorded disturbances to equipment sensitivities.

A variety of power-conditioning equipment is available to buffer the sensitive load from various disturbances (and in some cases, from harmonics) where necessary. Ideally, the power-quality tolerance of the particular sensitive equipment should be analyzed to determine the proper solution; however, this information is often unknown. In addition, the user should be aware of some of the nonlinear characteristics of certain types of conditioning equipment.

1.3 Purpose of guide

Equipment application problems exist today because of certain incompatibilities among the sensitive equipment and various disturbances present on typical power systems. Some of the newer sensitive loads are particularly vulnerable to momentary disturbances. In addition, some of these loads introduce considerable harmonic content into the system and can be detrimental to other equipment in the area. Because of increasing use of computers and other sensitive equipment, such problems will continue to grow unless corrective measures are taken.

The primary purpose of this guide is to assist in identifying potential problems and to suggest effective ways to satisfy sensitive equipment voltage requirements. This discussion should provide insight into the distinction between those voltage-related problems that are controlled by the utility and those that can only be addressed by the user or equipment designer. Cooperation among users, utilities, and equipment designers is needed to ensure both adequate electric service to all users and proper equipment operations. Solutions are presented from the perspectives of both the customer and the utility provider, since the problems users of sensitive equipment experience often originate from either area.

The secondary purpose of this guide is to help provide the designers of sensitive equipment with an understanding of the environment in which their equipment is expected to operate.

2. References

This guide shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply:

ANSI C84.1-1989, American National Standard Voltage Ratings (60 Hz) for Electric Power Systems and Equipment.¹

IEEE Std 100-1992, The New IEEE Standard Dictionary of Electrical and Electronics Terms (ANSI).²

IEEE C62.1-1989 (Reaff 1994), IEEE Standard for Gapped Silicon-Carbide Surge Arresters for AC Power Circuits (ANSI).

IEEE Std C62.41-1991, IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits (ANSI).

3. Terminology

3.1 Definitions

Whenever possible, the definitions of the terms used in this guide are those found in IEEE Std 100-1992³ or Std 1100-1992 [B7].⁴ In some instances, the IEEE definition in the current dictionary may be either too broad or too restrictive; in such a case, an additional definition is included in this subclause.

3.1.1 clamping voltage: The maximum magnitude of voltage across a surge-protective device during the passage of a specified surge current (e.g., 100 A, 8/20 μ s waveshape).

3.1.2 distortion factor: The ratio of the rms of the harmonic content to the rms value of the fundamental quantity, often expressed as a percent of the fundamental. *Syn:* **total harmonic distortion**. *See also:* **harmonic distortion**.

3.1.3 flicker: A perceptible change in electric light source intensity due to a fluctuation of input voltage.

NOTE—The general meaning of this term could make it applicable to describe the pulsation of luminous flux from a low-inertia source (such as gas discharge lamps) caused by the zero crossings of the supply voltage at twice the power-system frequency. However, in the context of power supply disturbances, the term applies to perceptible, subjective, objectionable, and random or periodic variations of the light output.

¹ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

²IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

³The numbers in brackets correspond to those of the references in clause 2.

⁴The numbers in brackets preceded by the letter B correspond to those of the bibliography in the annex.

3.1.4 ground loop: A potentially detrimental loop formed when two or more points in an electrical system that are nominally at ground potential are connected by a conducting path such that either or both points are not at the same ground potential.

3.1.5 harmonic: A sinusoidal component of a periodic wave having a frequency that is an integral multiple of the fundamental frequency.

3.1.6 harmonic distortion: The mathematical representation of the distortion of a pure sine waveform. *See also:* **distortion factor; total harmonic distortion.**

3.1.7 impulse: A surge of unidirectional polarity, for example, a 1.2/50 μ s voltage surge.

NOTE—This usage conforms to that in IEC documents.

3.1.8 interruption: The complete loss of voltage for a time period. The time-base of the interruption is characterized as follows:

- Instantaneous: 0.5 to 30 cycles
- Momentary: 30 cycles to 2 s
- Temporary: 2 s to 2 min
- Sustained: greater than 2 min

3.1.9 linear load: An electrical load device that, in steady-state operation, presents an essentially constant load impedance to the power source throughout the cycle of applied voltage.

3.1.10 momentary disturbance: A variation in the level of the steady-state supply voltage that results from surges, sags, faults, circuit and equipment switching, or from the operation of circuit breakers or reclosers resulting from their response to abnormal circuit conditions. *See also:* **transient.**

3.1.11 noise: Unwanted electrical signals that produce undesirable effects in the circuits of the control systems in which they occur. (For this guide, “control systems” include sensitive electronic equipment in total or in part.)

3.1.12 nonlinear load: Electrical load that draws current discontinuously or whose impedance varies during the cycle of the input ac voltage waveform.

3.1.13 notch: A transient reduction in the magnitude (absolute value) of the quasi-sinusoidal mains voltage. (The duration is always less than a half-cycle and usually less than a few milliseconds.) *See also:* **sag; undervoltage.**

3.1.14 overvoltage: An rms increase in the ac voltage, at the power frequency, for durations greater than a few seconds. *See also:* **surge; swell.**

3.1.15 permanent fault: One that will persist regardless of how fast the system is de-energized or the number of times that the system is de-energized and re-energized.

3.1.16 power factor, total: The ratio of the total power input in watts to the total voltampere input.

3.1.17 ride-through capability: The ability of equipment to withstand momentary interruptions or sags.

3.1.18 sag: An rms reduction in the ac voltage, at the power frequency, for durations from a half-cycle to a few seconds. *See also:* **notch; undervoltage.**

NOTE—The IEC terminology is *dip*.

3.1.19 SPD: Surge-protective device.

3.1.20 surge: A transient wave of voltage or current. (The duration of a surge is not tightly specified, but it is usually less than a few milliseconds.) *See also:* **overvoltage; swell.**

3.1.21 surge-protective device (SPD): A device intended to either limit transient overvoltages or divert surge currents or both. It contains at least one nonlinear component.

3.1.22 swell: An rms increase in the ac voltage, at the power frequency, for durations from a half-cycle to a few seconds. *See also:* **overvoltage; surge.**

3.1.23 TDD: Total demand distortion.

3.1.24 temporary fault: One that may be self-clearing, or may be cleared if the faulted circuit is rapidly de-energized by opening of a protective device, such as a circuit breaker or recloser.

3.1.25 THD: Total harmonic distortion.

3.1.26 total demand distortion (TDD): The total rms current distortion in percent of maximum demand current.

3.1.27 total harmonic distortion (THD): The ratio of the rms value of the sum of the squared individual harmonic amplitudes to the rms value of the fundamental frequency of a complex waveform. *Syn:* **distortion factor.**

3.1.28 transient: Any disturbance with a duration of less than a few cycles. *See also:* **notch; sag; surge; swell.**

3.1.29 undervoltage: An rms decrease in the ac voltage, at the power frequency, for durations greater than a few seconds. *See also:* **notch; sag.**

3.1.30 voltage distortion: Any deviation from the nominal sine wave of the ac line voltage.

3.2 Differing usage of technical terms

Some of the terms used to describe voltage disturbances are defined differently by utility engineers and by manufacturers and users of disturbance analyzers and power conditioners [B25]. Table 1 defines the terms, and figure 1 illustrates the waveforms, as they are commonly understood by these two groups.

Table 1—Voltage terminology differences

Term	Utility meaning	Monitoring equipment manufacturer or user meaning
Impulse	Unidirectional surge	Same
Momentary interruption	Complete loss of line voltage for a duration of 30 cycles to 2 min, while automatic equipment is acting to resolve an abnormal circuit condition	Complete loss of line voltage for a duration of a half-cycle or more
Notch	An impulse that subtracts from the fundamental frequency wave	Same
Sustained interruption	The complete loss of line voltage for a duration greater than 2 min	Complete loss of line voltage for a duration of half-cycle or more
Sag	Momentary undervoltage at fundamental frequency lasting from a half-cycle to a few seconds	Same
Surge	Unidirectional surge	Momentary overvoltage at fundamental frequency lasting from a half-cycle to a few seconds
Swell	Momentary overvoltage at fundamental frequency lasting from a half-cycle to a few seconds	Same

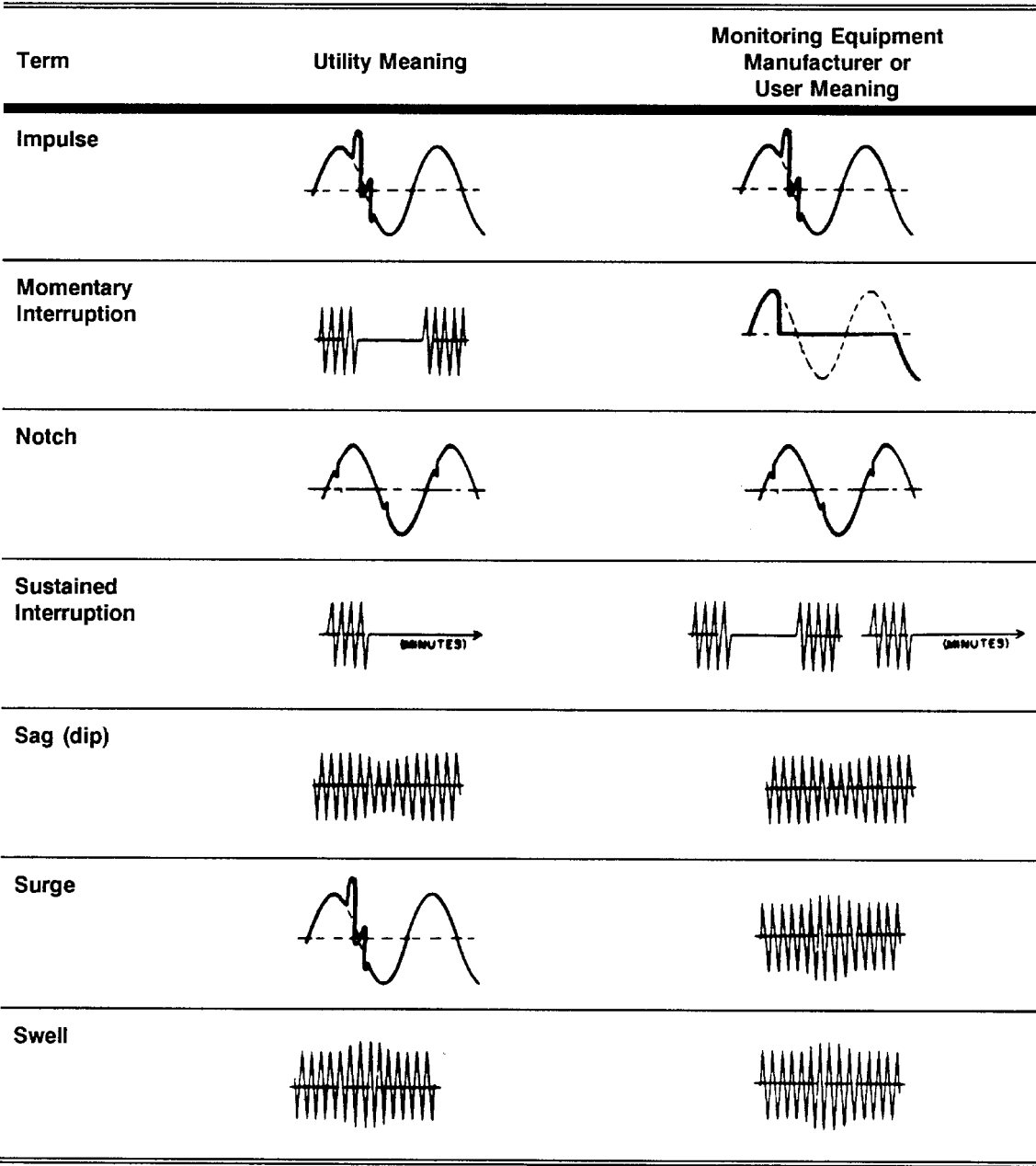


Figure 1—Voltage terminology differences

Power quality is a broadly used term that has been applied to voltage, service availability, and even harmonic content. Except for clause 1, this guide has purposely avoided the use of this term.

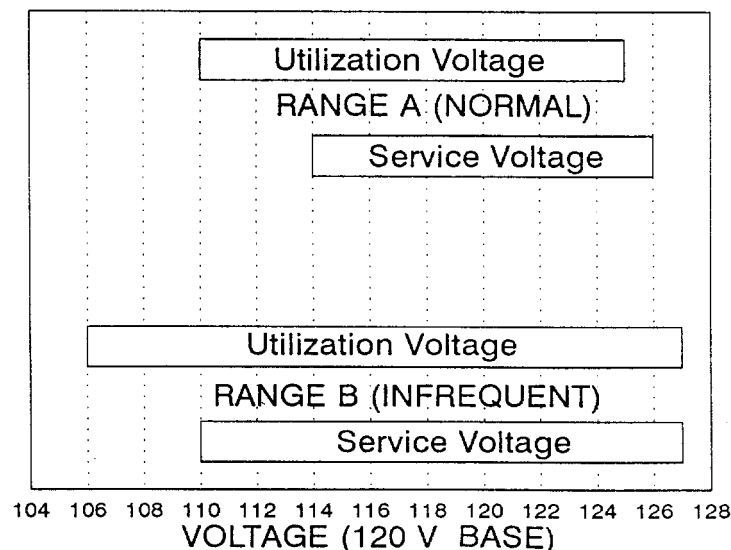
Voltage quality is a term used to describe the relative amount of voltage disturbances or variations—particularly interruptions, sags, surges, and harmonics—as measured at a specific point. This usage of the term, applied from a utility viewpoint, refers to the quality level measured at the point of service; from the customer viewpoint, it refers to the quality level measured at the point of utilization. At the point of utilization, a customer’s perception of poor voltage quality may result from disturbances elsewhere on the customer’s system, from a nearby customer, or from the utility system. Specific voltage quality requirements, from the customer viewpoint, can differ from one customer to another, and depend on the special needs of the equipment involved.

4. Electrical environment

4.1 Steady-state voltage

Over the years, electric utility companies, equipment manufacturers, and end-users have cooperated in establishing standards for operating voltage limits that have resulted in satisfactory operation without excessive demands upon the design of the power supply or the utilization equipment. As a result of this cooperative effort, the American National Standards Institute (ANSI) has developed and published ANSI C84.1-1989. This standard is concerned with the range of steady-state voltage levels and is not related to momentary disturbances.

Figure 2 illustrates the standard voltage range for service (meter) and utilization (load) voltages from ANSI C84.1-1989. The customer’s utilization voltage is based on the utility meeting the service requirements plus an additional allowance for voltage drop in the customer’s wiring.



Source: ANSI C84.1-1989. Reprinted with permission from the American National Standards Institute, © 1989.

Figure 2—Voltage ranges