



# Understanding Power Quality Standards

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# Objectives of presentation

Understanding Power Quality, Power Quality Standards, EC Codes, Guidebooks for managing Power Quality

# References


The Malaysian Grid Code
The Malaysian Distribution Code
TNB's Electricity Supply Application Handbook (ESAH)

| | |
|---|---|
| IEEE P1366 | Guide for Electric Distribution Reliability Indices. |
| IEEE 1100 | Recommended Practice for Powering and Grounding Sensitive Electronic Equipment, |
| IEEE 1159 | Recommended Practice For Monitoring Electric Power Quality |
| IEEE 519 | Harmonic mitigation |
| IEC 60364 | Electrical Installations of Buildings |
| IEC 61000-2-X | EMC |
| IEC 61000-3-X | EMC |
| IEC 61000-4-X | EMC |
| SEMI STD | SEMI F42/47/49/50 |
| ENGR | Engineering Recommendation |
| EN 50160 | Electromagnetic Environment |

# Presentation contents

- Understanding Normal Utility Grade Power
- Power Quality Standards
  - Definition of Power Quality
  - Mitigation of Power Quality
- PQ & EMC Requirement for Electrical Wiring
- Management of EMC according to Malaysian Grid & Distribution Codes
- TNB's Power Quality Requirement
- TNB's Power Quality Guidebooks


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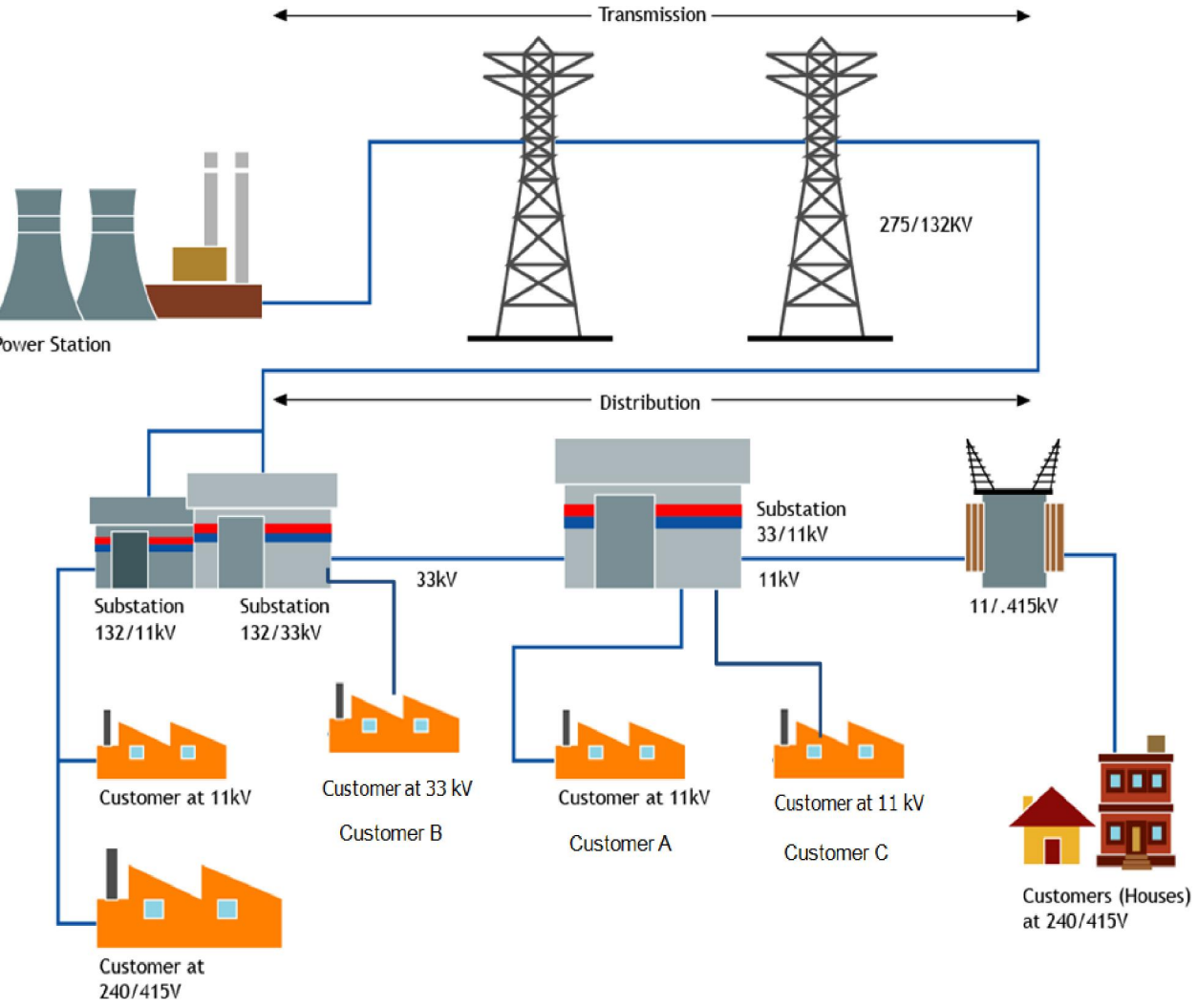
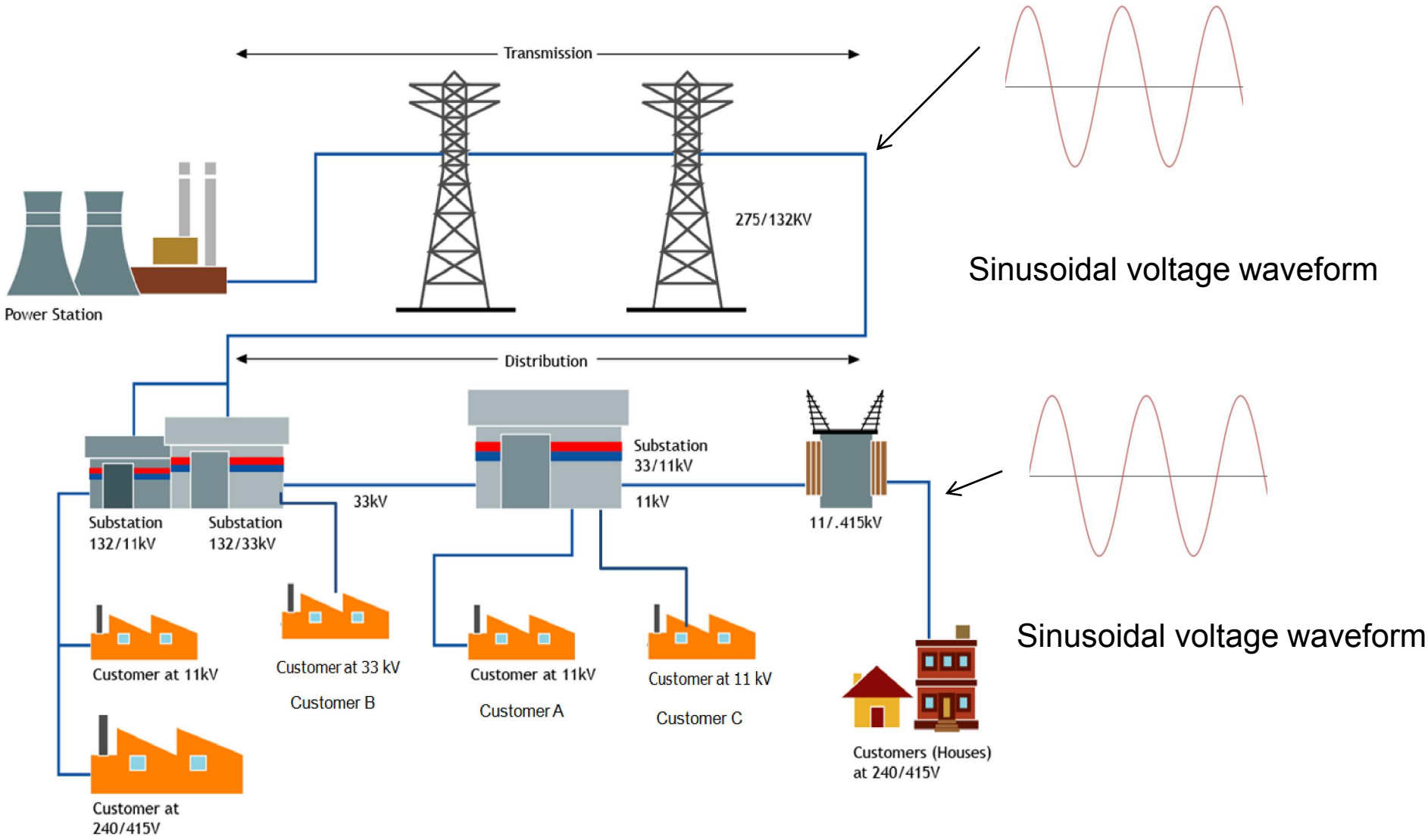
# Understanding Normal Utility Grade Power

# Power System Connection In Peninsular Malaysia

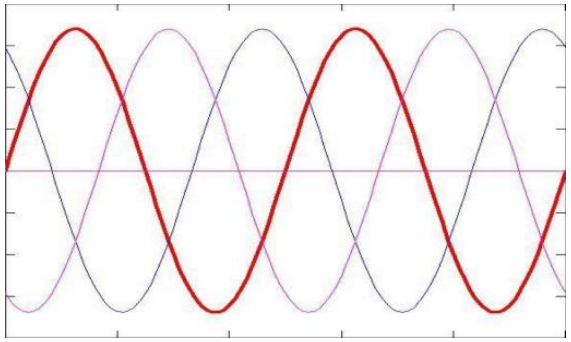



| MD ranges of individual customer | Supply voltage |
|---|---|
| Up to 12 kVA | 230V |
| 12kVA to 100kVA | 400V |
| 100kVA to 1000kVA | 400V |
| 1000kVA to 5000kVA | 11kV |
| 1000kVA to 10000kVA | 22kV |
| 5000kVA to 25000kVA | 33kV |
| Above 25000kVA | 132kV , 275 kV |

# Power utility provides normal utility grade power

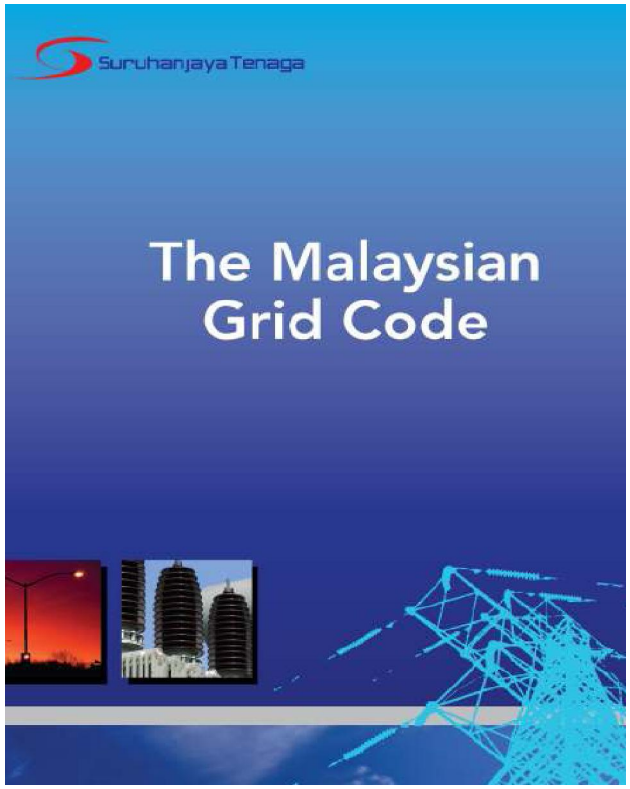


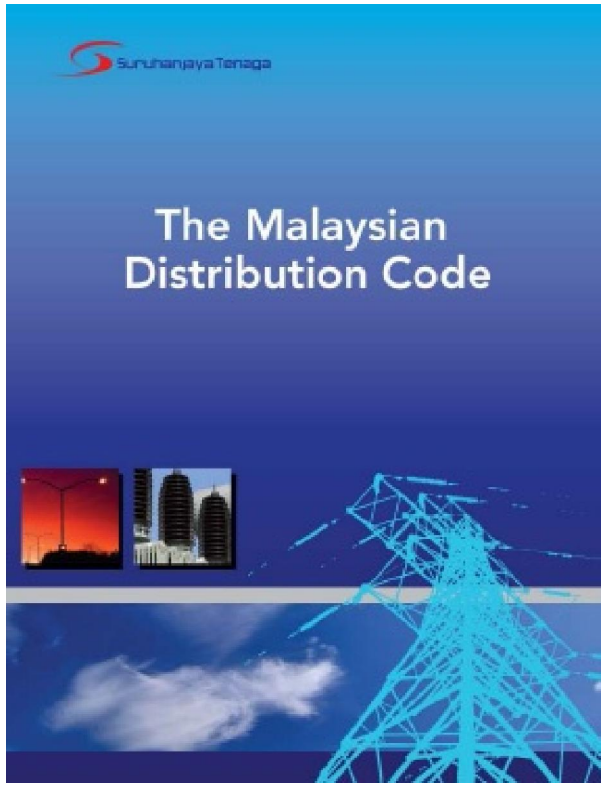
# Steady State Voltage & Frequency Regulations



Sinusoidal voltage waveform

Frequency = 50 Hz (+/- 1 %)



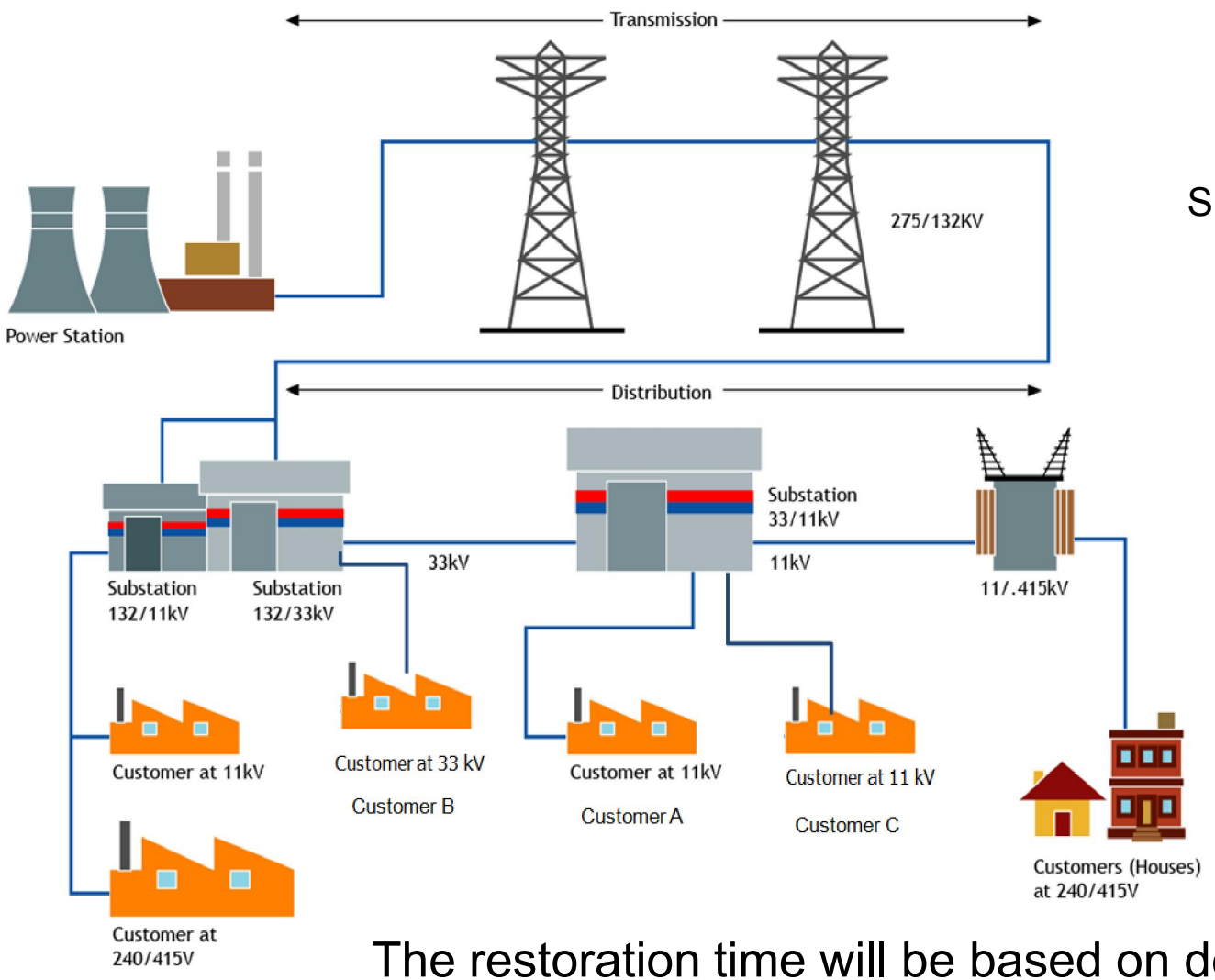

Voltage regulations (Normal)

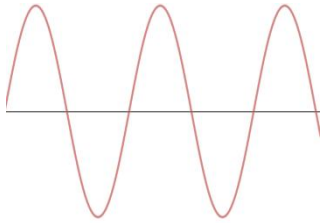
| Voltage level | % variations |
|---|---|
| 400 Volt & 230 Volt | +10 % to – 6 % |
| 6.6, 11, 22 & 33 kV | ± 5 % |
| 132 kV &275 kV | - 5 % to +5 % |
| 500 kV | ± 5 % |

Voltage regulations (Contingency)

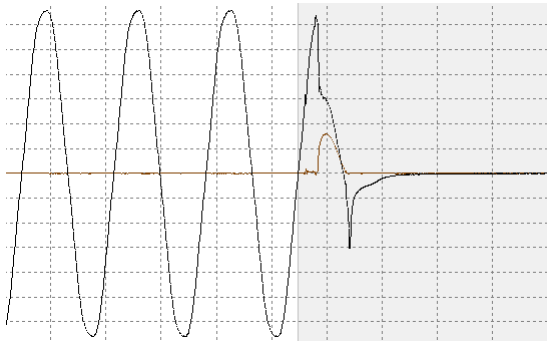
| Voltage level | % variations |
|---|---|
| 400 Volt & 230 Volt | ± 10 % |
| 6.6, 11, 22 & 33 kV | ± 10 % |
| 132 kV & 275 kV | ± 10 % |
| 500 kV | - 10 % to 10 % |

# Standard Power Reliability & Security



Sinusoidal voltage waveform



Power Outages

The restoration time will be based on defined security levels

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Energy Commission

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# Power Quality Standards

## Definition of Power Quality

# Symptoms: Power Outage vs. Power Quality

Symptom of Power Outage
No Electricity for more than 60 s

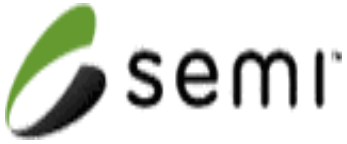
## Symptoms of Power Quality

- Lights blinking
- Sudden Equipment maloperation
- Sudden tripping of circuit breakers
- Premature equipment failure
- Poor performance & unexpected shutdowns
- Lost data in electronics
- Capacitor bank failure
- High ground current
- Others

# POWER QUALITY STANDARDS

- IEC
- IEEE
- SEMI
- ENGINEERING RECOMMENDATIONS





# Definitions of Power Quality

**IEC 61000 Series:**
**Power Quality (PQ):**

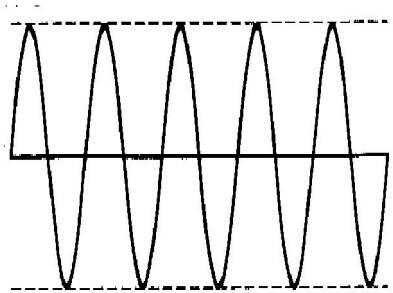
"The ability of a device, equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment "

**IEEE 1159:2009,**
**IEEE 1100:2005**

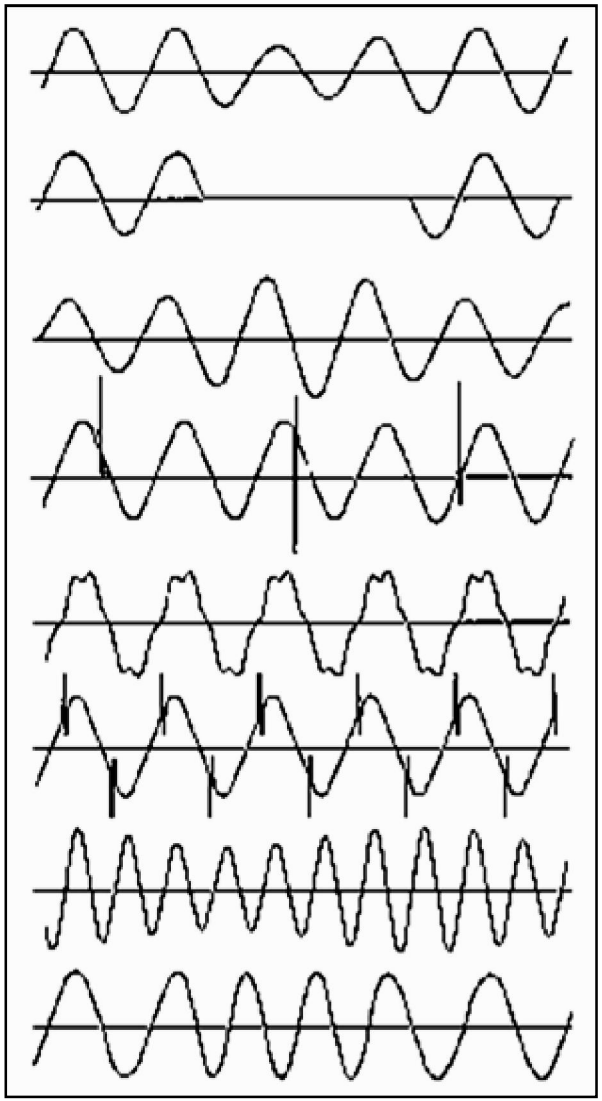
**power quality (PQ):**

The concept of powering and grounding electronic equipment in a manner that is suitable to the operation of that equipment and compatible with the supply system and other connected equipment.

# Power Quality/Voltage Disturbances



Normal voltage waveforms



Voltage Dips / Sags

Momentary Interruptions

Swells

Transients

Harmonic Distortion

Notches

Voltage fluctuations

Frequency Deviations

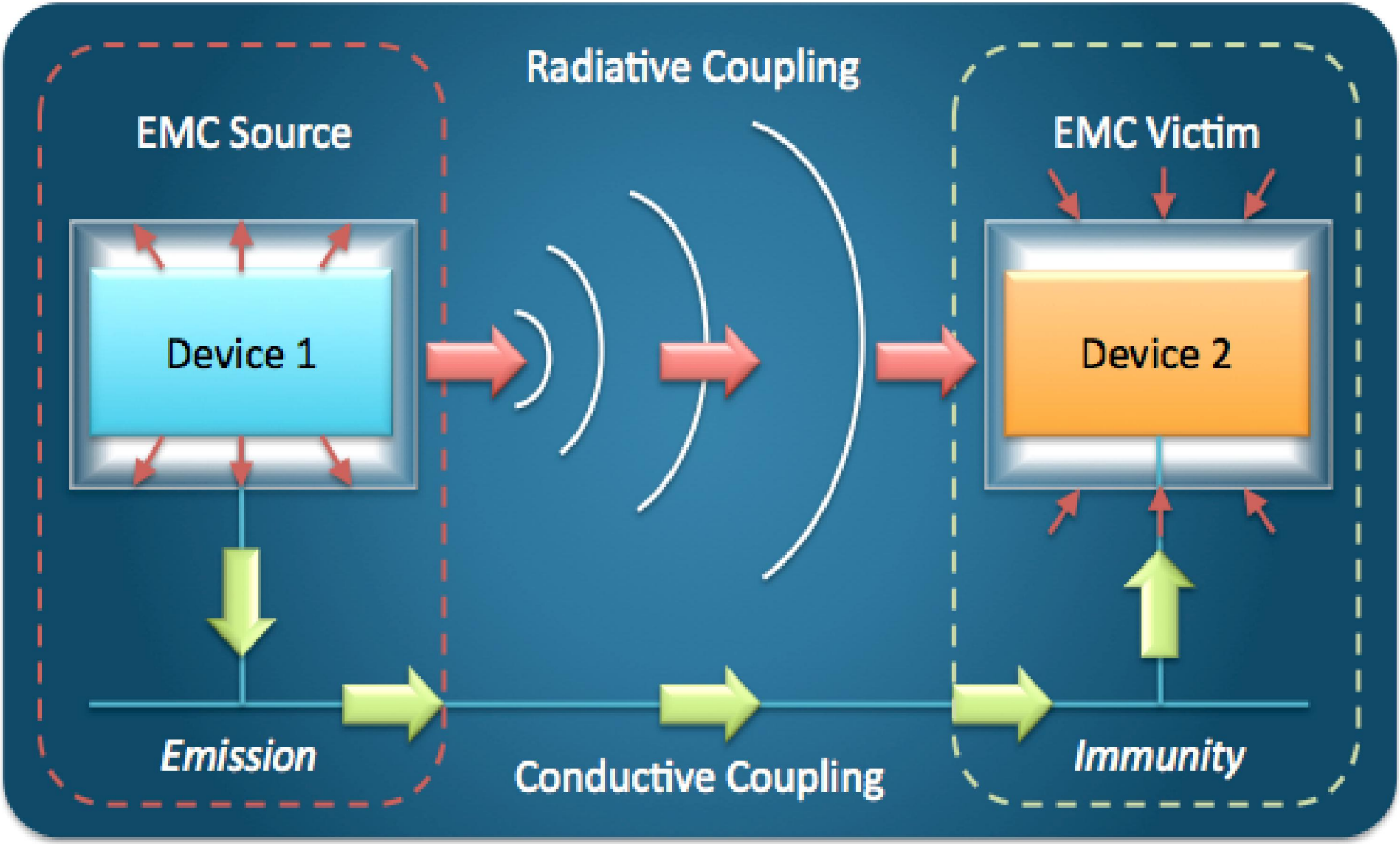
# POWER QUALITY STANDARDS

- IEC
- IEEE
- SEMI
- ENGINEERING RECOMMENDATIONS

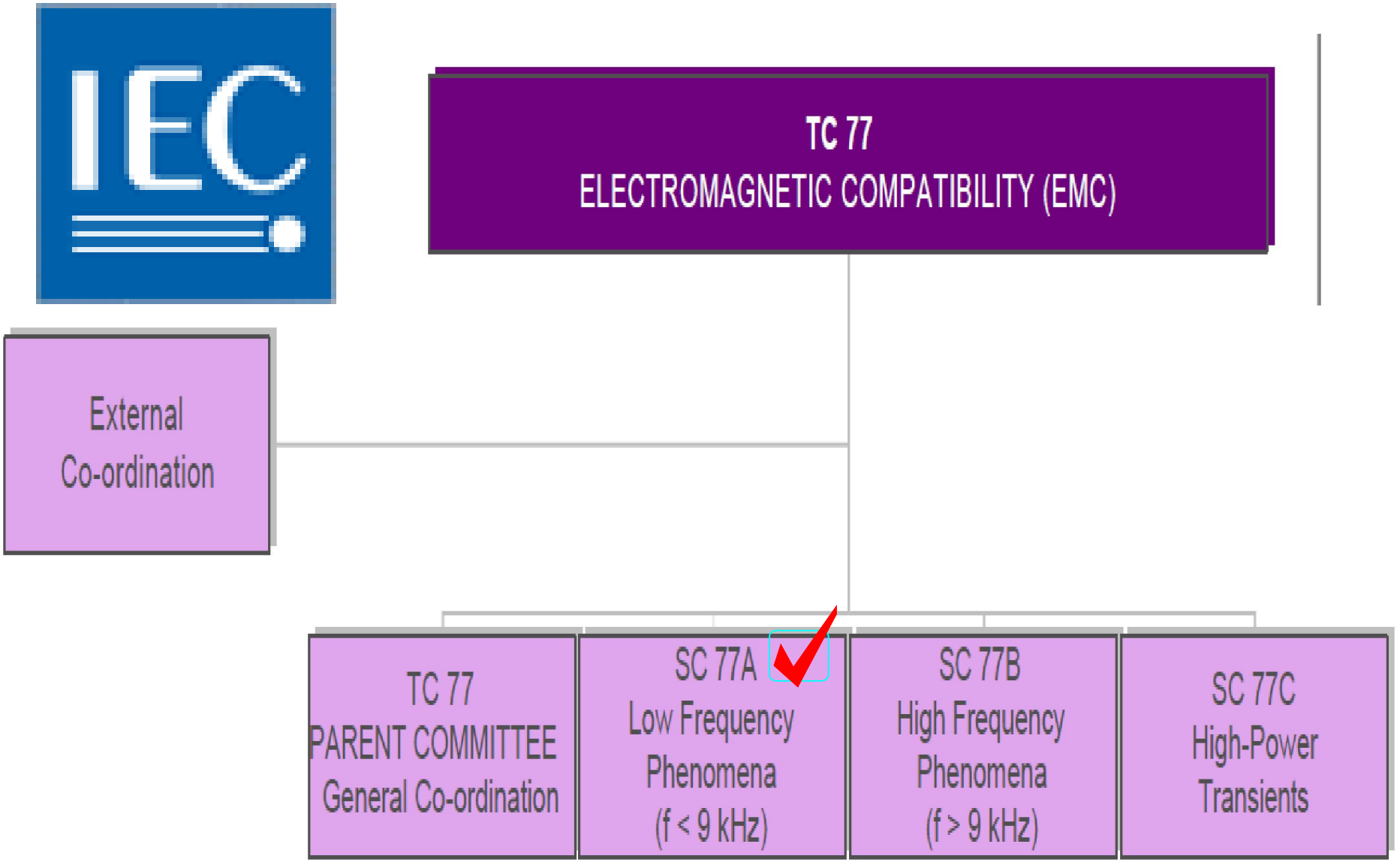
**According to IEC, Electrical Power Quality is a compatibility problem between the source and load, not perfection of source…..**

- Power Quality or Electromagnetic compatibility (EMC) itself is defined as: "the ability of an equipment or system to function satisfactorily in its electromagnetic (EM) environment (immunity) without introducing intolerable electromagnetic disturbances to anything in that environment (emission)“.

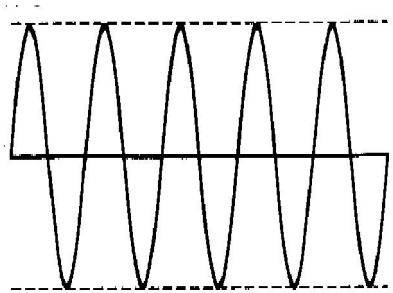
# Concept of Electromagnetic Compatibility



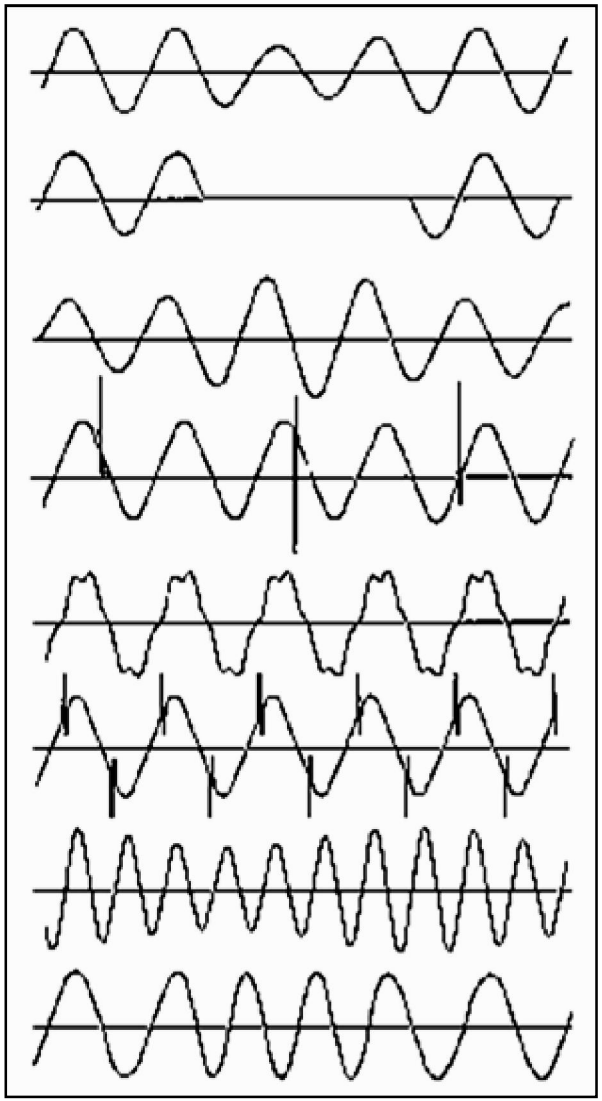
# Categories of EMC phenomena.



# Low Frequency Disturbances (< 9 kHz) are Power Quality Disturbances



Normal voltage waveforms



Voltage Dips / Sags

Momentary Interruptions

Swells

Transients

Harmonic Distortion

Notches

Voltage fluctuations

Frequency Deviations

# CATEGORIES OF POWER QUALITY DISTURBANCES

**Steady state Power Quality Variations**

- Harmonics distortion
- Flickers
- Voltage variations – unbalance
- Frequency variations

**Power Quality Disturbances**

- Voltage sag/Voltage swell
- Transients
- Momentary interruption

## IEC 61000

### Part 1: General

- the safety function requirements (what the function does); and
- the safety integrity requirements (the likelihood of a safety function being performed satisfactorily).

### Part 2: Environment

- Description of the environment
- Classification of the environment
- Compatibility levels

### Part 3: Limits

- Emission limits
- Immunity limits (insofar as they do not fall under the responsibility of product committees)

### Part 4: Testing and measurement techniques

- Measurement techniques
- Testing techniques

### Part 5: Installation and mitigation guidelines

- Installation guidelines
- Mitigation methods and devices

### Part 6: Generic standards

# IEC Standards that define Electromagnetic Environment

## LF conducted distubances

**IEC/TR 61000-2-1**
Electromagnetic compatibility (EMC) - Part 2: Environment - Section 1: Description of the environment - Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems

**IEC 61000-2-2**
Electromagnetic compatibility (EMC) - Part 2-2: Environment - Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems

**IEC 61000-2-4**
Electromagnetic compatibility (EMC) - Part 2-4: Environment - Compatibility levels in industrial plants for low-frequency conducted disturbances

**IEC/TR 61000-2-6**
Electromagnetic compatibility (EMC) - Part 2: Environment - Section 6: Assessment of the emission levels in the power supply of industrial plants as regards low-frequency conducted disturbances

**IEC/TR 61000-2-8**
Electromagnetic compatibility (EMC) - Part 2-8: Environment - Voltage dips and short interruptions on public electric power supply systems with statistical measurement results

**IEC 61000-2-12**
Electromagnetic compatibility (EMC) - Part 2-12: Environment - Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems

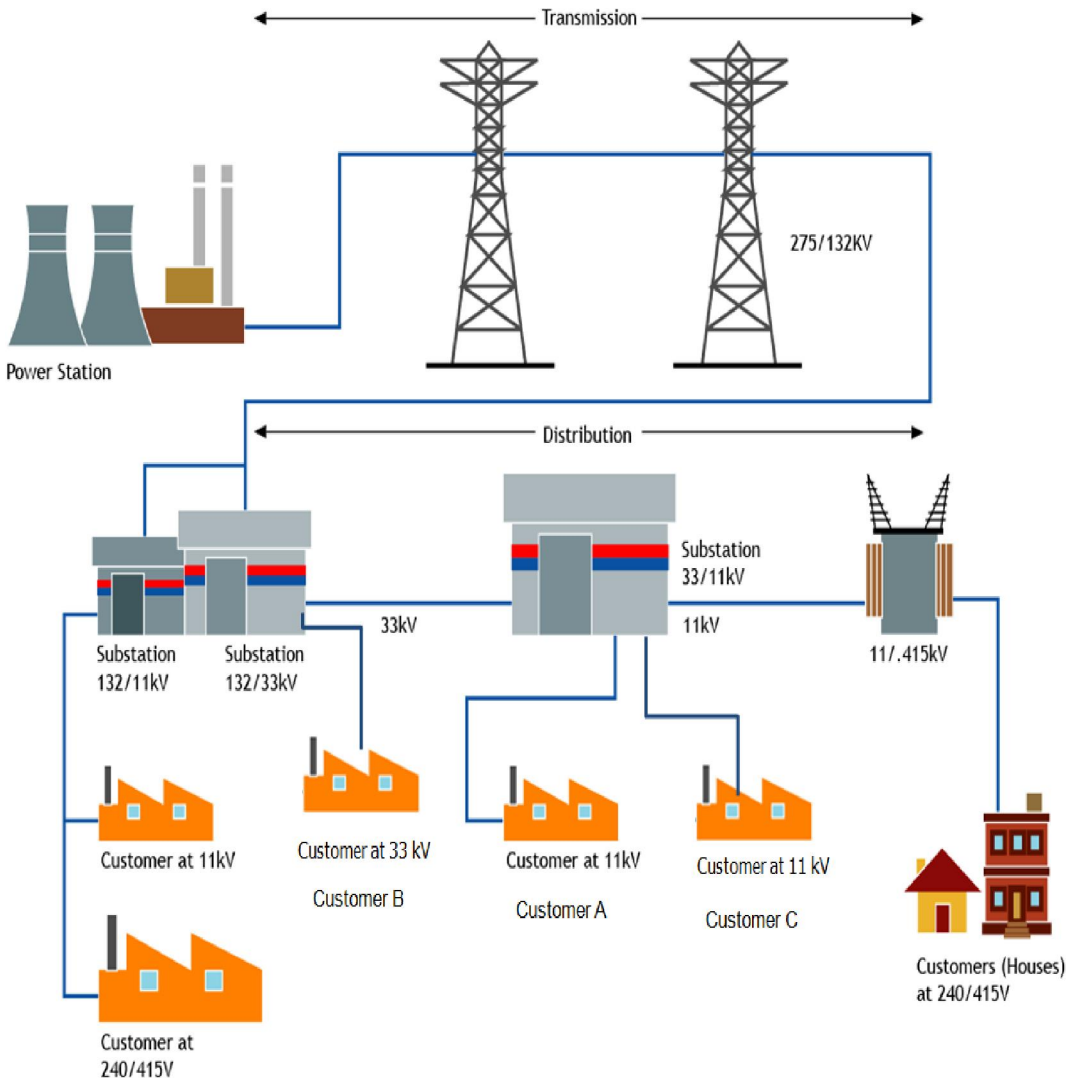
**IEC/TR 61000-2-14**
Electromagnetic compatibility (EMC) - Part 2-14: Environment - Overvoltages on public electricity distribution networks

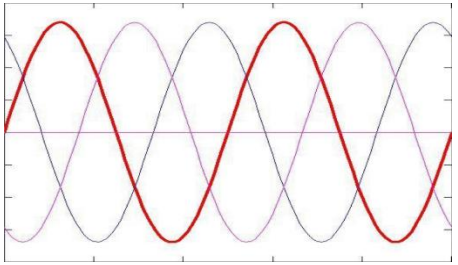
**IEC/TR 60725**
Consideration of reference impedances and public supply network impedances for use in determining disturbance characteristics of electrical equipment having a rated current = < 75 A per phase

## LF radiated disturbances

**IEC/TR 61000-2-7**
Electromagnetic compatibility (EMC) - Part 2: Environment - Section 7: Low frequency magnetic fields in various environments

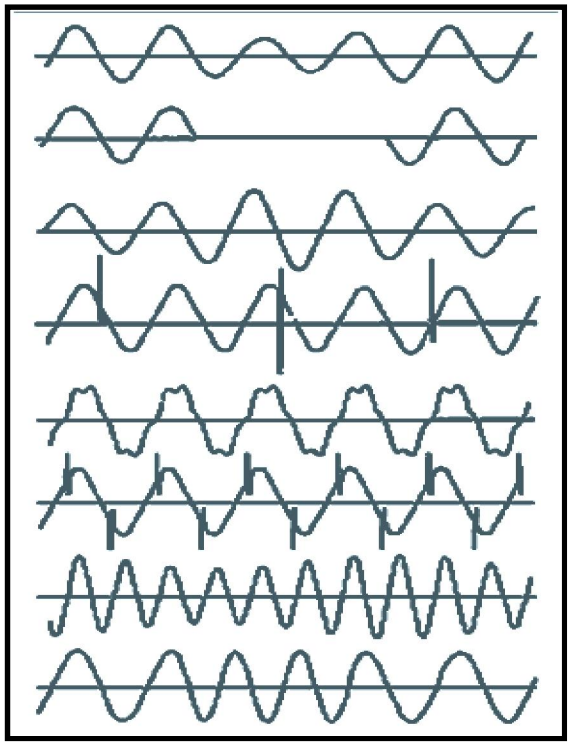
# IEC 61000-2-4 : Electromagnetic Environment



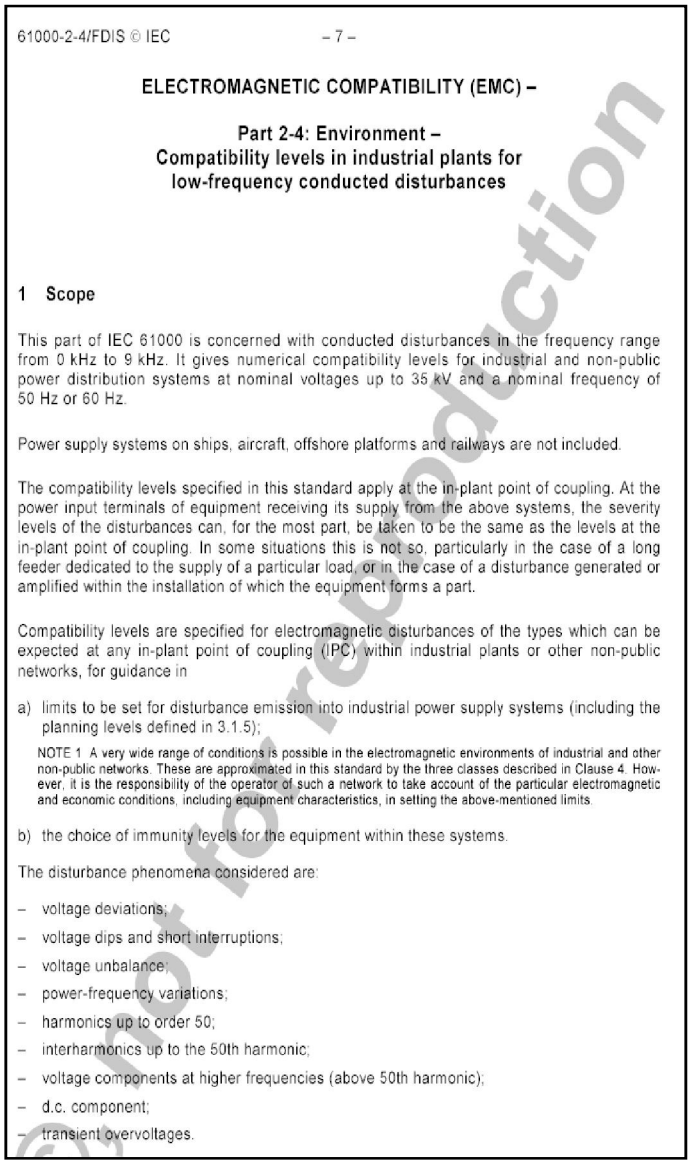
Sinusoidal voltage waveform

Nonsinusoidal voltage waveforms



# IEC 61000-2-4 : Electromagnetic Environment

| Supply Voltage Phenomenon | Acceptable limits | Measurement Interval |
|---|---|---|
| Grid frequency | 49.5Hz to 50.5Hz | 10 s |
| Slow voltage changes | 230Volt ± 8% | 10 min |
| Voltage Sags or Dips (≤1min) | 100 times (Rural / Overhead system)<br>10-100 times (Urban/Underground system) | 10 ms |
| Short Interruptions (≤ 3min) | 10 to 100 times per year (under 1% of nominal) | 10 ms |
| Transient over-voltages (line-to-ground) | Mostly < 6kV | N/A |
| Voltage unbalance | 2% | 10 min |
| Harmonic Voltages | 8% Total Harmonic Distortion | 10 min |



61000-2-4/FDIS © IEC – 7 –

**ELECTROMAGNETIC COMPATIBILITY (EMC) –**

**Part 2-4: Environment –**
**Compatibility levels in industrial plants for low-frequency conducted disturbances**

**1 Scope**

This part of IEC 61000 is concerned with conducted disturbances in the frequency range from 0 kHz to 9 kHz. It gives numerical compatibility levels for industrial and non-public power distribution systems at nominal voltages up to 35 kV and a nominal frequency of 50 Hz or 60 Hz.

Power supply systems on ships, aircraft, offshore platforms and railways are not included.

The compatibility levels specified in this standard apply at the in-plant point of coupling. At the power input terminals of equipment receiving its supply from the above systems, the severity levels of the disturbances can, for the most part, be taken to be the same as the levels at the in-plant point of coupling. In some situations this is not so, particularly in the case of a long feeder dedicated to the supply of a particular load, or in the case of a disturbance generated or amplified within the installation of which the equipment forms a part.

Compatibility levels are specified for electromagnetic disturbances of the types which can be expected at any in-plant point of coupling (IPC) within industrial plants or other non-public networks, for guidance in

a) limits to be set for disturbance emission into industrial power supply systems (including the planning levels defined in 3.1.5);

NOTE 1 A very wide range of conditions is possible in the electromagnetic environments of industrial and other non-public networks. These are approximated in this standard by the three classes described in Clause 4. However, it is the responsibility of the operator of such a network to take account of the particular electromagnetic and economic conditions, including equipment characteristics, in setting the above-mentioned limits.

b) the choice of immunity levels for the equipment within these systems.

The disturbance phenomena considered are:

- voltage deviations;
- voltage dips and short interruptions;
- voltage unbalance;
- power-frequency variations;
- harmonics up to order 50;
- interharmonics up to the 50th harmonic;
- voltage components at higher frequencies (above 50th harmonic);
- d.c. component;
- transient overvoltages.

# IEC standards that define measurement Technique/Emission

| LF conducted disturbances |
| --- |
| **IEC 61000-4-7**<br>Electromagnetic compatibility (EMC) - Part 4-7: Testing and measurement techniques - General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto |
| **IEC 61000-4-15**<br>Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Section 15: Flickermeter - Functional and design specifications |

## Emission

### LF conducted disturbances

**IEC 61000-3-2**
Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤16 A per phase)

**IEC 61000-3-3**
Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection

**IEC/TS 61000-3-4**
Electromagnetic compatibility (EMC) - Part 3-4: Limits - Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A

**IEC/TS 61000-3-5**
Electromagnetic compatibility (EMC) - Part 3-5: Limits - Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 75 A

**IEC/TR 61000-3-6**
Electromagnetic compatibility (EMC) - Part 3-6: Limits - Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems

**IEC/TR 61000-3-7**
Electromagnetic compatibility (EMC) - Part 3-7: Limits - Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems

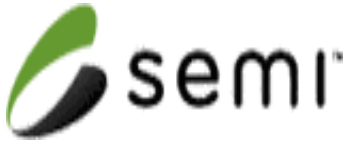
**IEC 61000-3-8**
Electromagnetic compatibility (EMC) - Part 3: Limits - Section 8: Signalling on low-voltage electrical installations - Emission levels, frequency bands and electromagnetic disturbance levels

**IEC 61000-3-12**
Electromagnetic compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase

# POWER QUALITY STANDARDS

- IEC
- IEEE
- SEMI
- ENGINEERING RECOMMENDATIONS





# Power quality phenomena

- The term *power quality* refers to a wide variety of electromagnetic phenomena that characterize the voltage and current at a given time and at a given location on the power system.

- IEEE uses the electromagnetic compatibility approach to describe power quality phenomena. The electromagnetic compatibility approach has been accepted by the international community in International Electrotechnical Commission (IEC) standards produced by IEC Technical Committee 77.

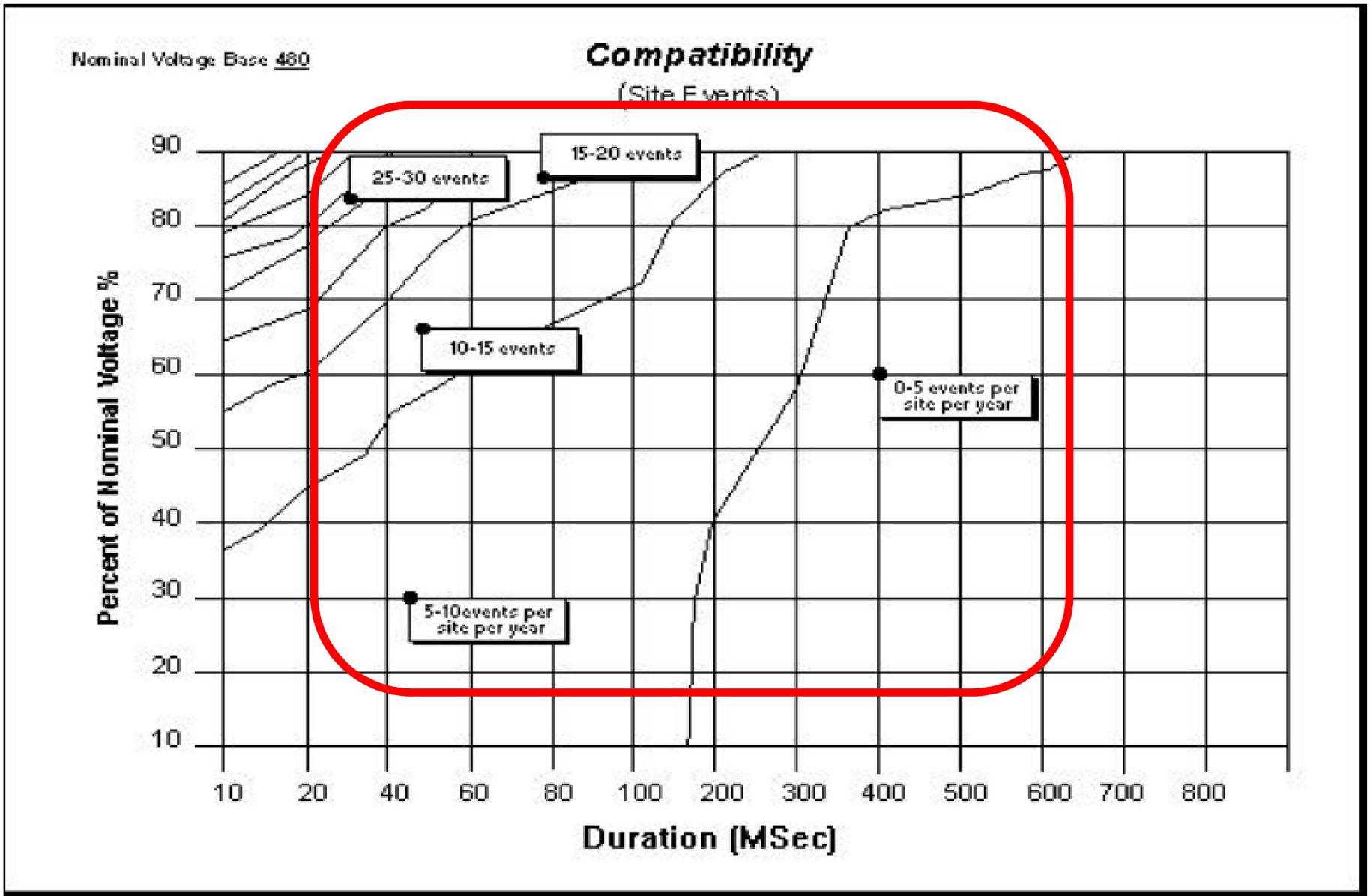
# Principal phenomena causing electromagnetic disturbances

| Group | Examples |
|---|---|
| Conducted low-frequency phenomena | Harmonics, interharmonics |
| | Signal systems (power line carrier) |
| | Voltage fluctuations |
| | Voltage dips and interruptions |
| | Voltage imbalance |
| | Power-frequency variations |
| | Induced low-frequency voltages |
| | DC in AC networks |
| Radiated low-frequency phenomena | Magnetic fields |
| | Electric fields |
| Conducted high-frequency phenomena | Induced continuous wave (CW) voltages or currents |
| | Unidirectional transients |
| | Oscillatory transients |
| Radiated high-frequency phenomena | Magnetic fields |
| | Electric fields |
| | Electromagnetic fields |
| | Continuous waves |
| | Transients |
| Electrostatic discharge phenomena (ESD) | — |
| Nuclear electromagnetic pulse (NEMP) | — |

# POWER QUALITY STANDARDS

- IEC
- IEEE
- SEMI
- ENGINEERING RECOMMENDATIONS

# SEMI F50 : Electromagnetic Environment for voltage sags



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# Power Quality Standards

## Mitigation of Power Quality

# POWER QUALITY STANDARDS

- IEC
- IEEE
- SEMI
- ENGINEERING RECOMMENDATIONS

# Understanding EMC Testing

EMC Testing is necessary in ensuring that a device, equipment or system does not emit electromagnetic disturbances more than the levels determined in limits established by regulatory / standard bodies, and …

at the same time it is able to withstand an expected level of electromagnetic disturbances from various sources of transient phenomena and continuous radio frequency phenomena that are present in its intended electromagnetic environment.

## LF conducted disturbances

**IEC 61000-4-11**
Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests

**IEC 61000-4-13**
Electromagnetic compatibility (EMC) - Part 4-13: Testing and measurement techniques - Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests

**IEC 61000-4-14**
Electromagnetic compatibility (EMC) - Part 4-14: Testing and measurement techniques - Voltage fluctuation immunity test for equipment with input current not exceeding 16 A per phase

**IEC 61000-4-16**
Electromagnetic compatibility (EMC) - Part 4-16: Testing and measurement techniques - Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz

**IEC 61000-4-17**
Electromagnetic compatibility (EMC) - Part 4-17: Testing and measurement techniques - Ripple on d.c. input power port immunity test

**IEC 61000-4-27**
Electromagnetic compatibility (EMC) - Part 4-27: Testing and measurement techniques - Unbalance, immunity test for equipment with input current not exceeding 16 A per phase

**IEC 61000-4-28**
Electromagnetic compatibility (EMC) - Part 4-28: Testing and measurement techniques - Variation of power frequency, immunity test for equipment with input current not exceeding 16 A per phase

**IEC 61000-4-29**
Electromagnetic compatibility (EMC) - Part 4-29: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations on d.c. input power port immunity test

**IEC 61000-4-30**
Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods

**IEC 61000-4-34**
Electromagnetic compatibility (EMC) - Part 4-34: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with mains current more than 16 A per phase

## LF radiated disturbances

**IEC 61000-4-8**
Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test

## HF conducted disturbances

**IEC 61000-4-4**
Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test

**IEC/TR 61000-4-5**
Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test

**IEC/TR 61000-4-6**
Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields

**IEC/TR 61000-4-12**
Electromagnetic compatibility (EMC) - Part 1-5: General - High power electromagnetic (HPEM) effects on civil systems

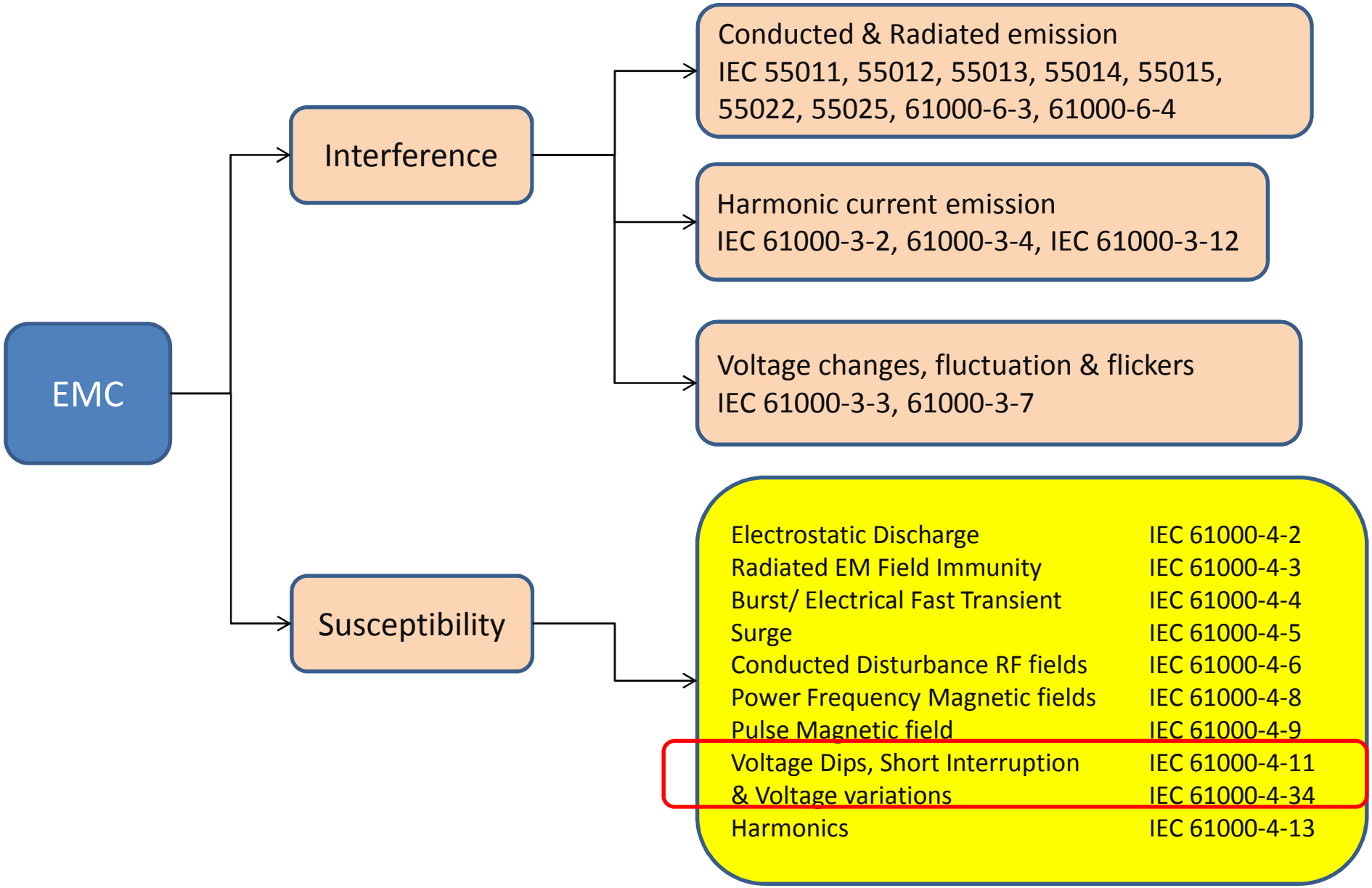
IEC 61000-4-18

## HF radiated disturbances

**IEC 61000-4-3**
Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test

**IEC 61000-4-9**
Electromagnetic compatibility (EMC) - Part 4-9: Testing and measurement techniques - Pulse magnetic field immunity test

# Summary of EMC Testing



# IEC standards for Evaluating Equipment Sensitivity against voltage dips

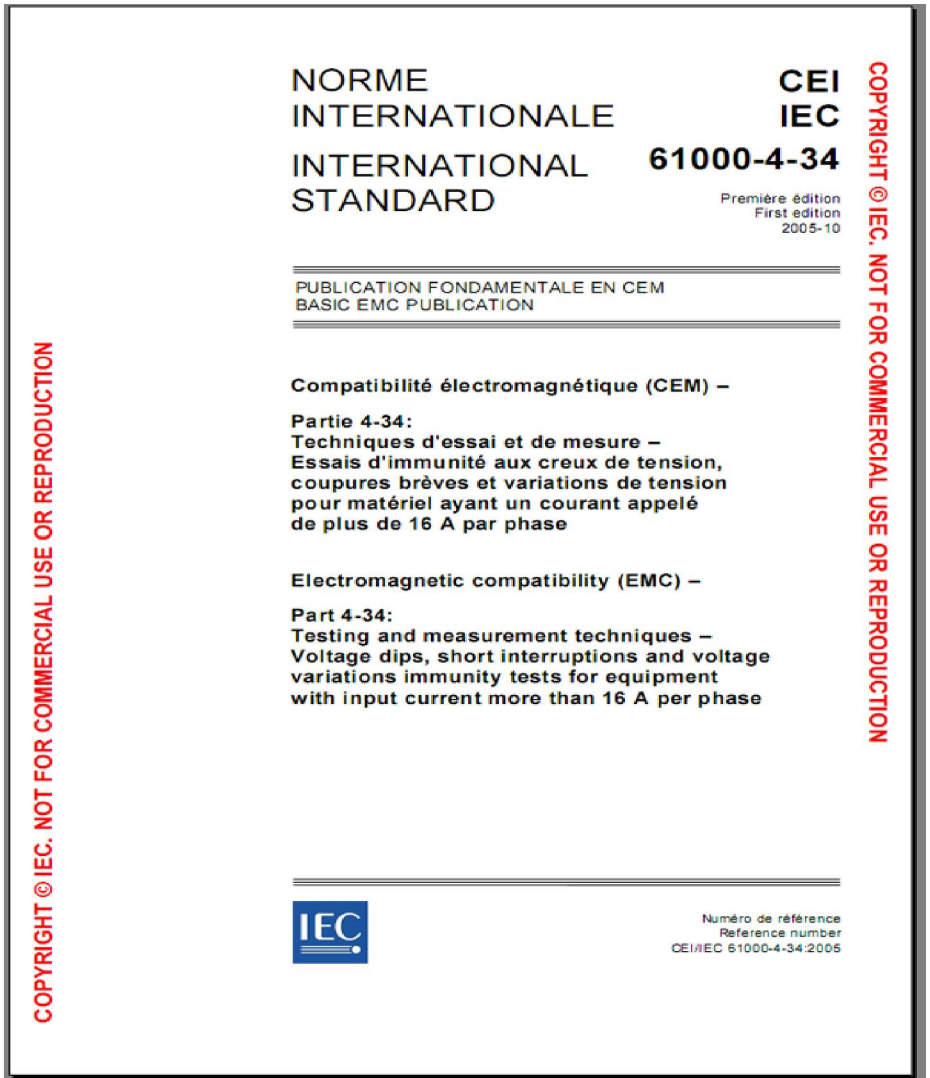
IEC 61000-4-34 Low Frequency Phenomena (International Electrotechnical Commission)

IEC 61000-4-11 is Intended to be used for Equipment LESS Then 16A

IEC 61000-4-34 is Intended to be used for Equipment GREATER Then 16A

The Intent of IEC 61000-4-11 and -34 is to define Voltage Dip Test Levels, not for Specific Types of Equipment, but Attempts to Define the Environment of the Equipment

IEC 61000-4-34 applies to Equipment over 16A and IEC 61000-4-11 for Equipment Under 16A



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INTERNATIONAL STANDARD

CEI
IEC
61000-4-34

Première édition
First edition
2005-10

PUBLICATION FONDAMENTALE EN CEM
BASIC EMC PUBLICATION

Compatibilité électromagnétique (CEM) –

Partie 4-34:
Techniques d'essai et de mesure –
Essais d'immunité aux creux de tension, coupures brèves et variations de tension pour matériel ayant un courant appelé de plus de 16 A par phase

Electromagnetic compatibility (EMC) –

Part 4-34:
Testing and measurement techniques –
Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current more than 16 A per phase

IEC

Numéro de référence
Reference number
CEI/IEC 61000-4-34:2005


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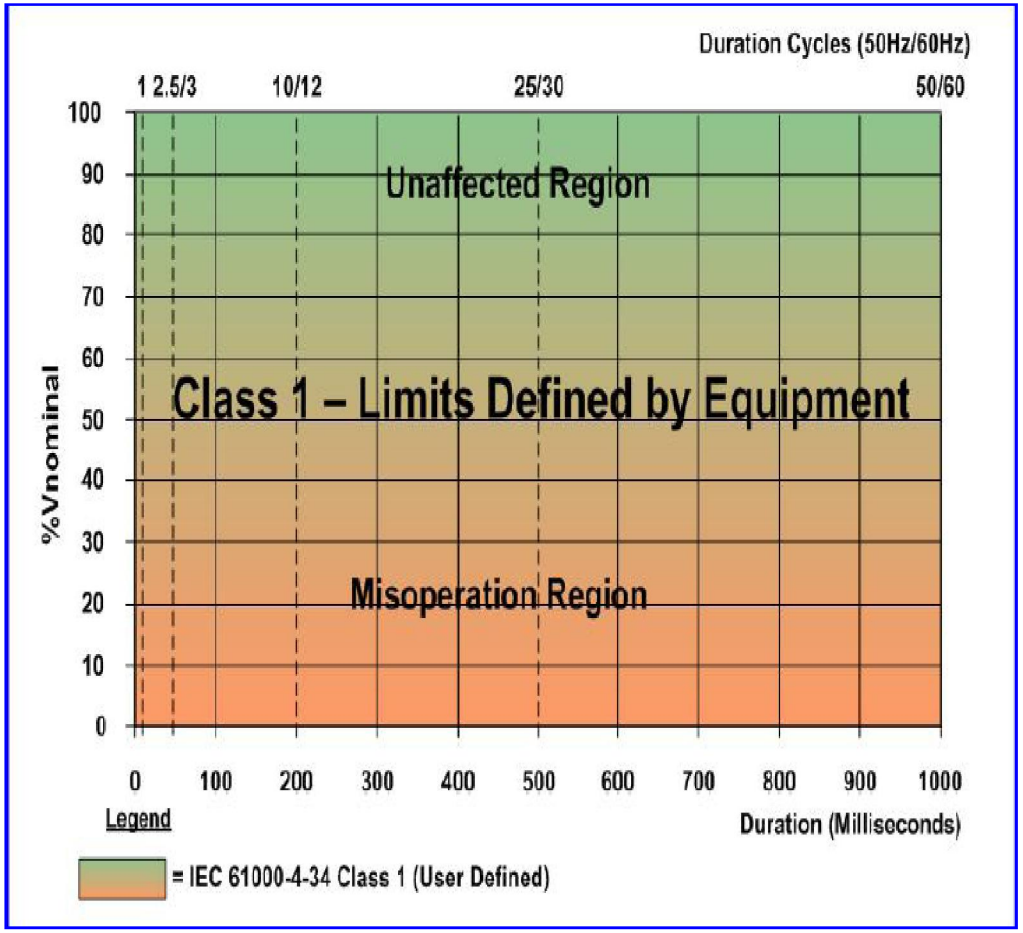
# IEC 61000-4-11 / 34 Class 1

**Class 1 -** This class applies to protected supplies and has compatibility levels lower than public network levels. It relates to the use of equipment very sensitive to disturbances in the power supply for instance the instrumentation of technological laboratories, some automation and protection equipment, some computers, etc.

NOTE Class 1 environments normally contain equipment which requires protection by such apparatus as uninterruptible power supplies (UPS), filters, or surge suppressers.

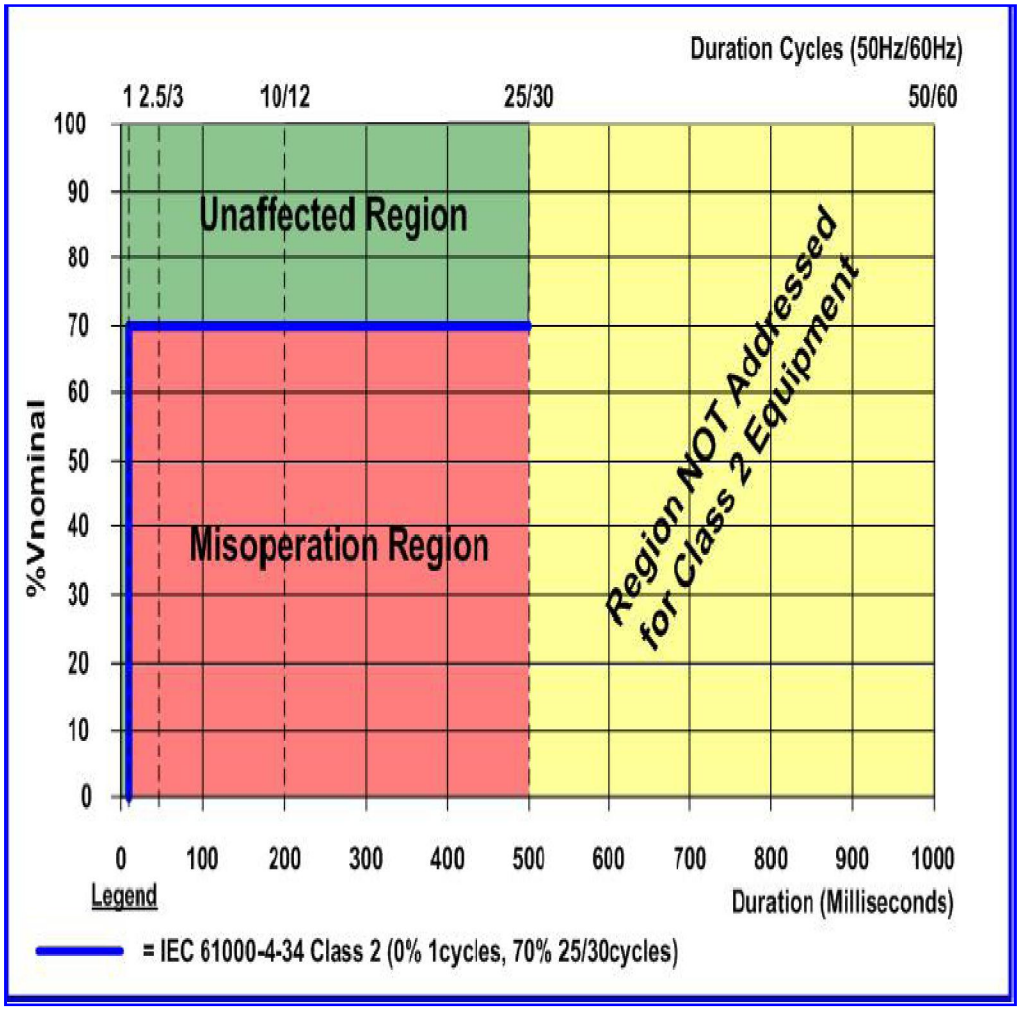



IEC 61000-4-11/34 Class 1

# IEC 61000-4-11 / 34 Class 2

Class 2 - This class applies to points of common coupling (PCC's for consumer systems) and points of common internal point of coupling (IPC's) in the industrial environment in general.

The compatibility levels in this class are identical to those of public networks; therefore components designed for application in public networks may be used in this class of industrial environment.



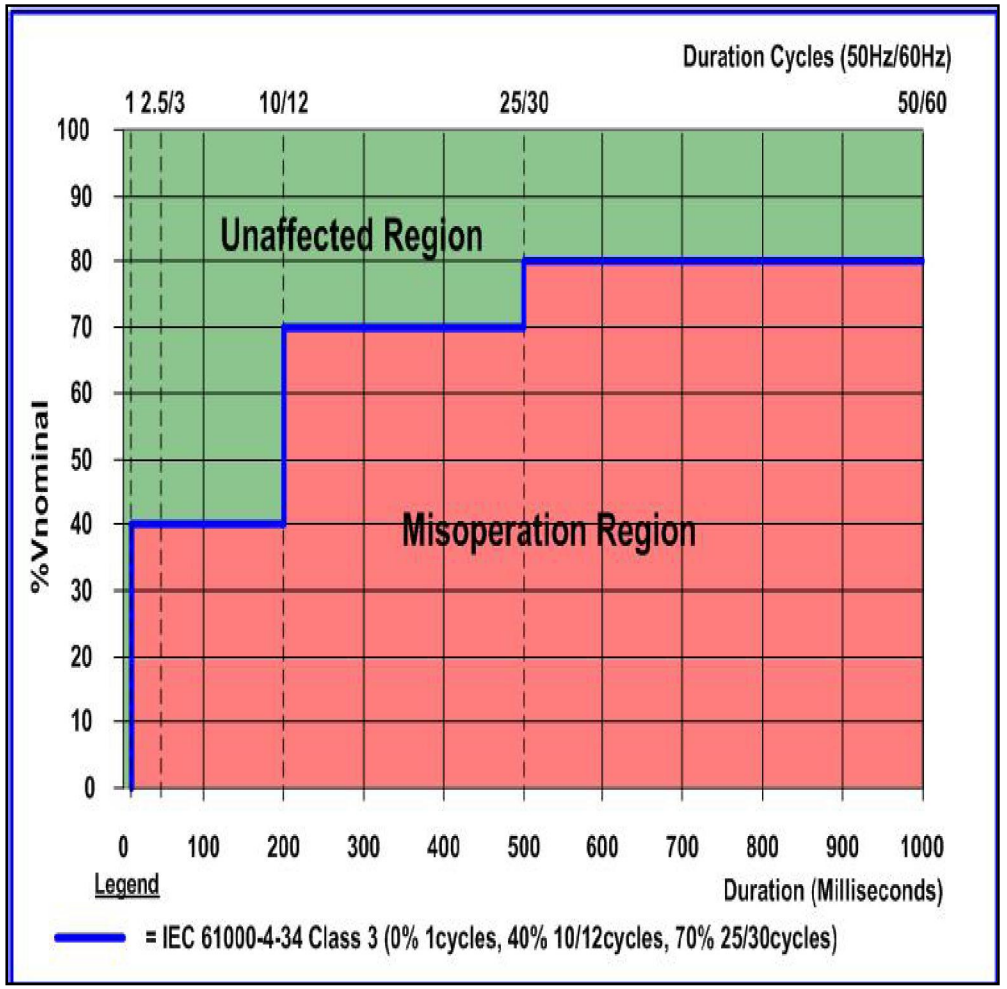

IEC 61000-4-11/34 Class 2

# IEC 61000-4-11 / 34 Class 3

Class 3 - This class applies only to IPC's in industrial environments. It has higher compatibility levels than those of class 2 for some disturbance phenomena.

For instance, this class should be considered when any of the following conditions are met:

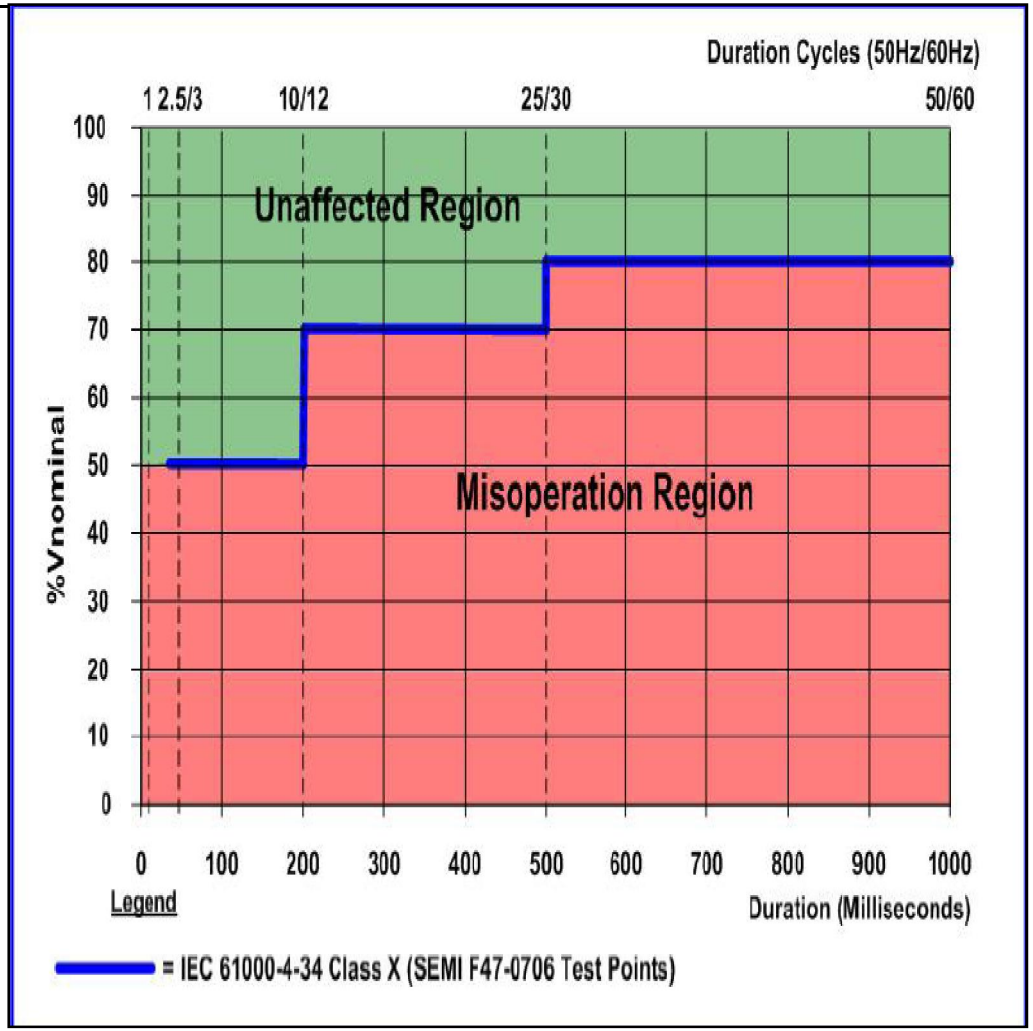
- a major part of the load is fed through converters;
- welding machines are present;
- large motors are frequently started;
- loads vary rapidly




IEC 61000-4-11/34 Class 3

# IEC 61000-4-11 / 34 Class X (4)

Class X – User Defined and in case of SEMI F47-0706, the test Points are Defined in the SEMI F47 Standard




IEC 61000-4-11/34 Class X

# IEC 61000-2-8 PROPOSES MITIGATION MEASURES FOR VOLTAGE SAG



INTERNATIONAL ELECTROTECHNICAL COMMISSION

## ELECTROMAGNETIC COMPATIBILITY (EMC)

## PART 2-8 : ENVIRONMENT-
## Voltage dips and short interruptions on public electric power supply systems with statistical measurement results.

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Technical Report IEC 61000-2-8 has been prepared by subcommittee 77A: Low frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

It has the status of a basic EMC publication in accordance with IEC guide 107.

The text of this standard is based on the following documents:

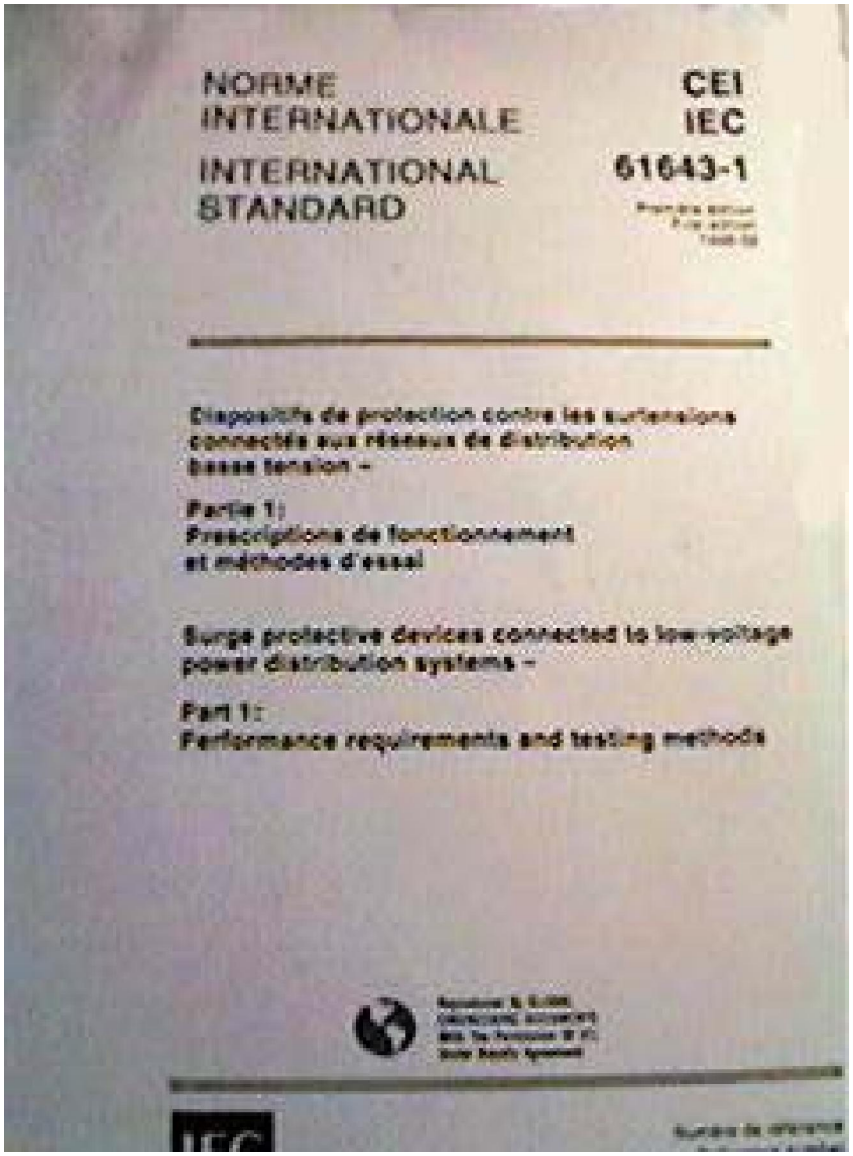
| FDIS | Report on voting |
|---|---|
| 77A/XX/FDIS | 77AXX/XX/RVD |

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3

# IEC 61643-1-1998

## IEC Standard on Surge Protection

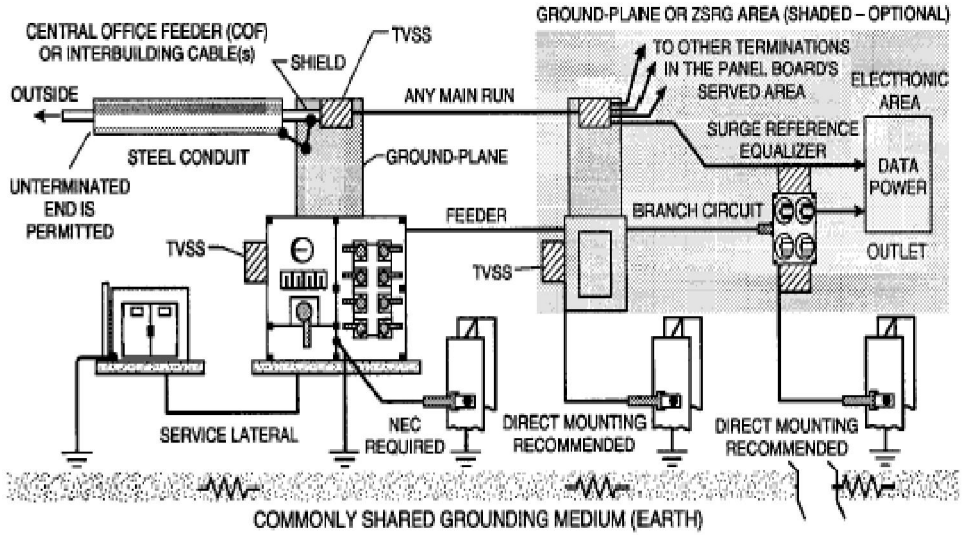

NORME INTERNATIONALE
CEI IEC
INTERNATIONAL STANDARD
61643-1

Dispositifs de protection contre les surtensions connectés aux réseaux de distribution basse tension –

Partie 1:
Prescriptions de fonctionnement et méthodes d'essai

Surge protective devices connected to low-voltage power distribution systems –

Part 1:
Performance requirements and testing methods

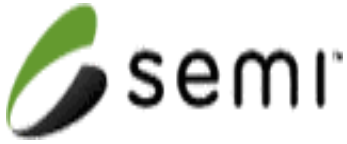




# POWER QUALITY STANDARDS

- IEC
- IEEE
- SEMI
- ENGINEERING RECOMMENDATIONS

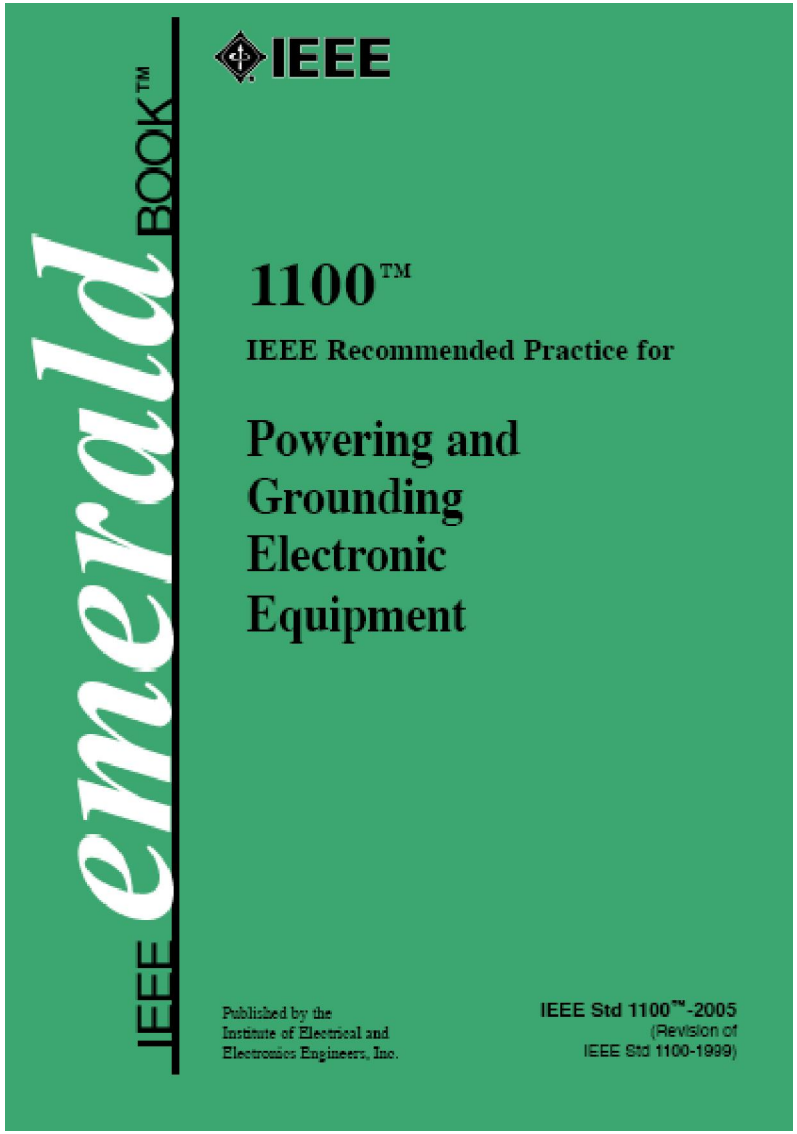




# Overview of IEEE 1000: 2005

- IEEE 1100 describes the many types of power correction devices that accept electrical power in whatever form it is available and modify the power to improve the quality or reliability required for electronic & voltage sensitive equipment.

- IEEE 1100 recommends proper grounding practices to minimize equipment maloperation, high ground current, etc



| POWER QUALITY CONDITION | | POWER CONDITIONING TECHNOLOGY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | TRANSIENT VOLTAGE SURGE SUPPRESSOR | EMI/RFI | ISOLATION TRANSFORMER | VOLTAGE REGULATOR (ELECTRONIC) | VOLTAGE REGULATOR (FERRORESONANT) | MOTOR GENERATOR | STANDBY POWER | UNINTERRUPTIBLE POWER SUPPLY | STANDBY ENGINE GENERATOR |
|  TRANSIENT VOLTAGE SURGE | COMMON MODE | | | | | | | | | |
| | NORMAL MODE | | | | | | | | | |
|  NOISE | COMMON MODE | | | | | | | | | |
| | NORMAL MODE | | | | | | | | | |
|  NOTCHES | | | | | | | | | | |
|  VOLTAGE DISTORTION | | | | | | | | | | |
|  SAG | | | | | | | | | | |
|  SWELL | | | | | | | | | | |
|  UNDERVOLTAGE | | | | | | | | | | |
|  OVERVOLTAGE | | | | | | | | | | |
|  MOMENTARY INTERRUPTION | | | | | | | | | | |
|  LONG-TERM INTERRUPTION | | | | | | | | | | |
|  FREQUENCY VARIATION | | | | | | | | | | |

IEEE Std 519-1992
(Revision of IEEE Std 519-1981)
Second Printing 15 June 2004

# IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

Sponsor
Transmission and Distribution Committee
of the
IEEE Power Engineering Society

and

Static Power Converter Committee
of the
IEEE Industry Applications Society

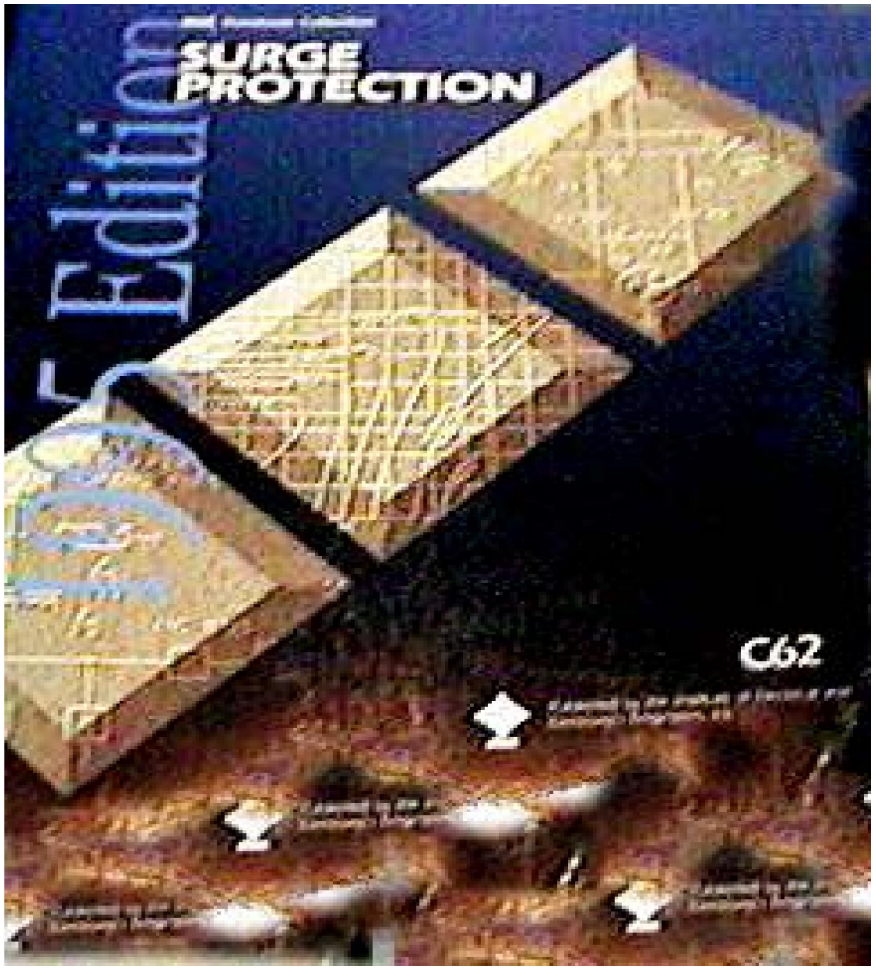
Approved June 18, 1992

IEEE Standards Board

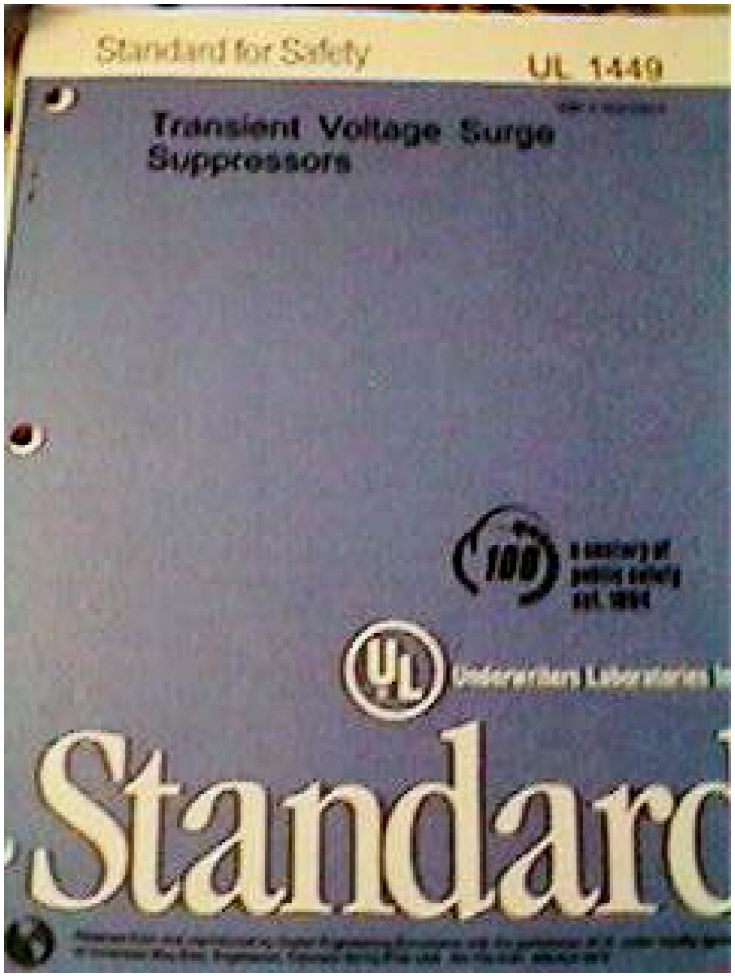
Approved January 4, 1993

American National Standards Institute

# IEEE SURGE SUPPRESSION STANDARDS




**IEEE C62.-1991**

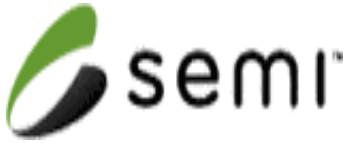



**UL 1449-1985**

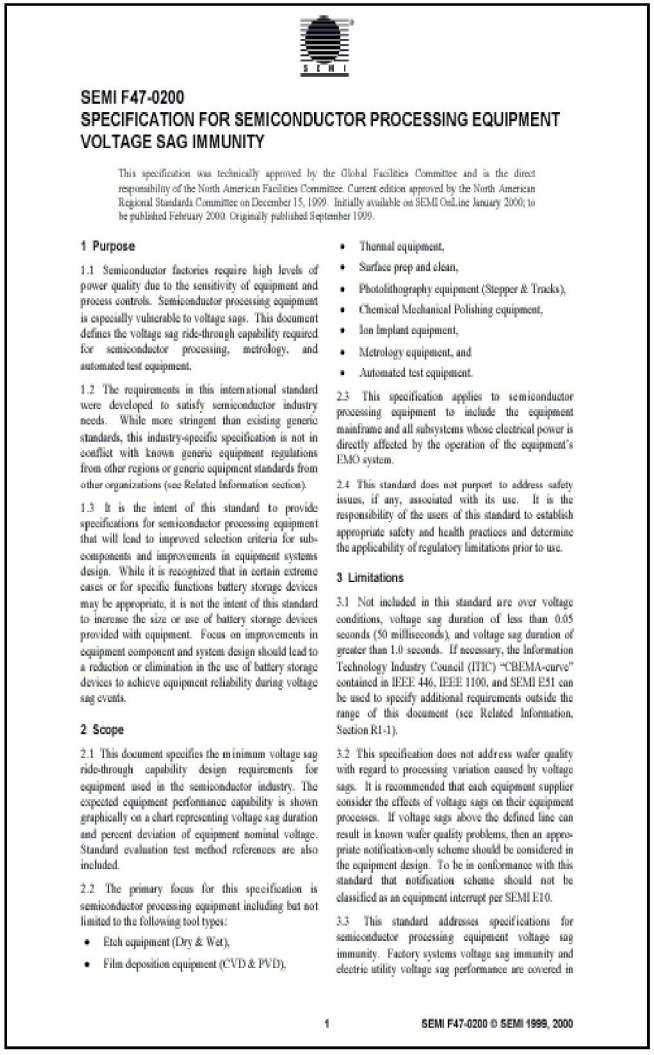
# POWER QUALITY STANDARDS

- IEC
- IEEE
- SEMI
- ENGINEERING RECOMMENDATIONS






# SEMI Standards for Managing Voltage Sags



SEMI F47-0200
SPECIFICATION FOR SEMICONDUCTOR PROCESSING EQUIPMENT VOLTAGE SAG IMMUNITY

This specification was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 15, 1999. Initially available on SEMI OnLine January 2000; to be published February 2000. Originally published September 1999.

1 Purpose

1.1 Semiconductor factories require high levels of power quality due to the sensitivity of equipment and process controls. Semiconductor processing equipment is especially vulnerable to voltage sags. This document defines the voltage sag ride-through capability required for semiconductor processing, metrology, and automated test equipment.

1.2 The requirements in this international standard were developed to satisfy semiconductor industry needs. While more stringent than existing generic standards, this industry-specific specification is not in conflict with known generic equipment regulations from other regions or generic equipment standards from other organizations (see Related Information section).

1.3 It is the intent of this standard to provide specifications for semiconductor processing equipment that will lead to improved selection criteria for sub-components and improvements in equipment systems design. While it is recognized that in certain extreme cases or for specific functions battery storage devices may be appropriate, it is not the intent of this standard to increase the size or use of battery storage devices provided with equipment. Focus on improvements in equipment component and system design should lead to a reduction or elimination in the use of battery storage devices to achieve equipment reliability during voltage sag events.

2 Scope

2.1 This document specifies the minimum voltage sag ride-through capability design requirements for equipment used in the semiconductor industry. The expected equipment performance capability is shown graphically on a chart representing voltage sag duration and percent deviation of equipment nominal voltage. Standard evaluation test method references are also included.

2.2 The primary focus for this specification is semiconductor processing equipment including but not limited to the following tool types:

- Etch equipment (Dry & Wet),
- Film deposition equipment (CVD & PVD),
- Thermal equipment,
- Surface prep and clean,
- Photolithography equipment (Stepper & Tracks),
- Chemical Mechanical Polishing equipment,
- Ion Implant equipment,
- Metrology equipment, and
- Automated test equipment.

2.3 This specification applies to semiconductor processing equipment to include the equipment mainframe and all subsystems whose electrical power is directly affected by the operation of the equipment's EMO system.

2.4 This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Limitations

3.1 Not included in this standard are over voltage conditions, voltage sag duration of less than 0.05 seconds (50 milliseconds), and voltage sag duration of greater than 1.0 seconds. If necessary, the Information Technology Industry Council (ITIC) "CBEMA-curve" contained in IEEE 446, IEEE 1100, and SEMI E51 can be used to specify additional requirements outside the range of this document (see Related Information, Section R1-1).

3.2 This specification does not address wafer quality with regard to processing variation caused by voltage sags. It is recommended that each equipment supplier consider the effects of voltage sags on their equipment processes. If voltage sags above the defined line can result in known wafer quality problems, then an appropriate notification-only scheme should be considered in the equipment design. To be in conformance with this standard that notification scheme should not be classified as an equipment interrupt per SEMI E10.

3.3 This standard addresses specifications for semiconductor processing equipment voltage sag immunity. Factory systems voltage sag immunity and electric utility voltage sag performance are covered in

1 SEMI F47-0200 © SEMI 1999, 2000

**SEMI F47: Voltage sag immunity**

SEMI F42-0600
TEST METHOD FOR SEMICONDUCTOR PROCESSING EQUIPMENT VOLTAGE SAG IMMUNITY

This test method was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on March 2 and April 30, 2000. Initially available on SEMI OnLine May 2000; to be published June 2000. Originally published June 1999.

1 Purpose

1.1 The purpose of this document is to define the test method used to characterize the susceptibility of semiconductor processing, metrology, and automated test equipment to voltage sags.

2 Scope

2.1 This document defines the testing procedures and test equipment required to characterize the susceptibility of equipment to voltage sags by showing voltage sag duration and magnitude performance data for the equipment.

NOTE 1: Characterizing equipment voltage sag immunity allows for the identification of tolerances, if any, that may exist between the tested equipment immunity and any one or more voltage sag performance specifications.

equipment and procedures meets regulatory requirements in each location.

4 Referenced Standards

4.1 SEMI Standard

SEMI S2 — Safety Guidelines for Semiconductor Manufacturing Equipment

4.2 IEEE Standard[1]

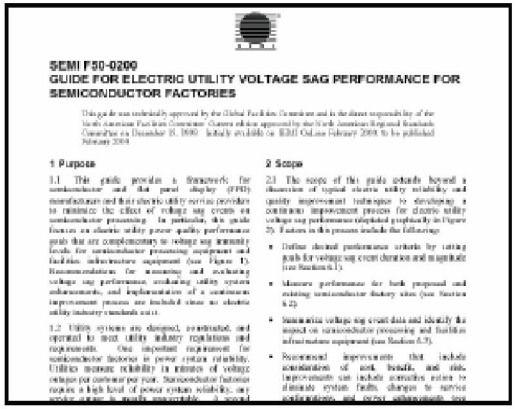
IEEE 1250 — Guide for Service to Equipment Sensitive to Momentary Voltage Disturbances

NOTE 2: As listed or revised, all documents cited shall be the latest publications of adopted standards.

5 Terminology

5.1 Definitions

**SEMI F42 – Test Methodology (Superseded by SEMI F47-0706)**



SEMI F50-0200
GUIDE FOR ELECTRIC UTILITY VOLTAGE SAG PERFORMANCE FOR SEMICONDUCTOR FACTORIES

This guide was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 15, 1999. Initially available on SEMI OnLine February 2000. To be published February 2000.

1 Purpose

1.1 This guide provides a framework for semiconductor and flat panel display (FPD) manufacturers and their electric utility service providers to minimize the effect of voltage sag events on semiconductor processing. In particular, this guide focuses on electric utility power quality performance goals that are complementary to voltage sag immunity levels for semiconductor processing equipment and facilities infrastructure equipment (see Figure 1). Recommendations for measuring and evaluating voltage sag performance, combining utility system enhancements, and implementation of a continuous improvement process are included since no electric utility industry standards exist.

1.2 Utility systems are designed, constructed, and operated to meet utility industry regulations and requirements. One important requirement for semiconductor factories is power system reliability. Utilities measure reliability in minutes of voltage outage per customer per year. Semiconductor factories require a high level of power system reliability, and

2 Scope

2.1 The scope of this guide extends beyond a discussion of typical electric utility reliability and quality improvement techniques to developing a continuous improvement process for electric utility voltage sag performance (displayed graphically in Figure 2). Factors in this process include the following:

- Define desired performance criteria by setting goals for voltage sag event duration and magnitude (see Section 6.1).
- Measure performance for both proposed and existing semiconductor factory sites (see Section 6.2).
- Summarize voltage sag event data and identify the impact on semiconductor processing and facilities infrastructure equipment (see Section 6.3).
- Recommend improvements that include considerations of risk, benefit, and risk. Improvements can include alternative system to eliminate system faults, changes to system configuration, and power enhancement and

**SEMI F50- Guide for Electric Utilities**

SEMI F49-0200
GUIDE FOR SEMICONDUCTOR FACTORY SYSTEMS VOLTAGE SAG IMMUNITY

This guide was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 15, 1999. Initially available on SEMI OnLine February 2000; to be published February 2000.

1 Purpose

1.1 A guide defining a systems approach to power conditioning is needed for semiconductor and flat panel display (FPD) facilities. Semiconductor and FPD factories require high levels of power quality due to the sensitivity of equipment and process controls. Semiconductor and FPD processing equipment is especially vulnerable to voltage sags. The facility electrical system distributes power to process equipment, support equipment, and facility infrastructure equipment. Facility electrical distribution systems should be designed to integrate the voltage sag susceptibility of all the equipment with the power quality supplied by the utility. Installing effective and efficient facilities power conditioning requires identification of appropriate conditioning technologies and properly applying the conditioning equipment.

1.2 Utilizing recommendations in this guide should result in effective power conditioning of the facility

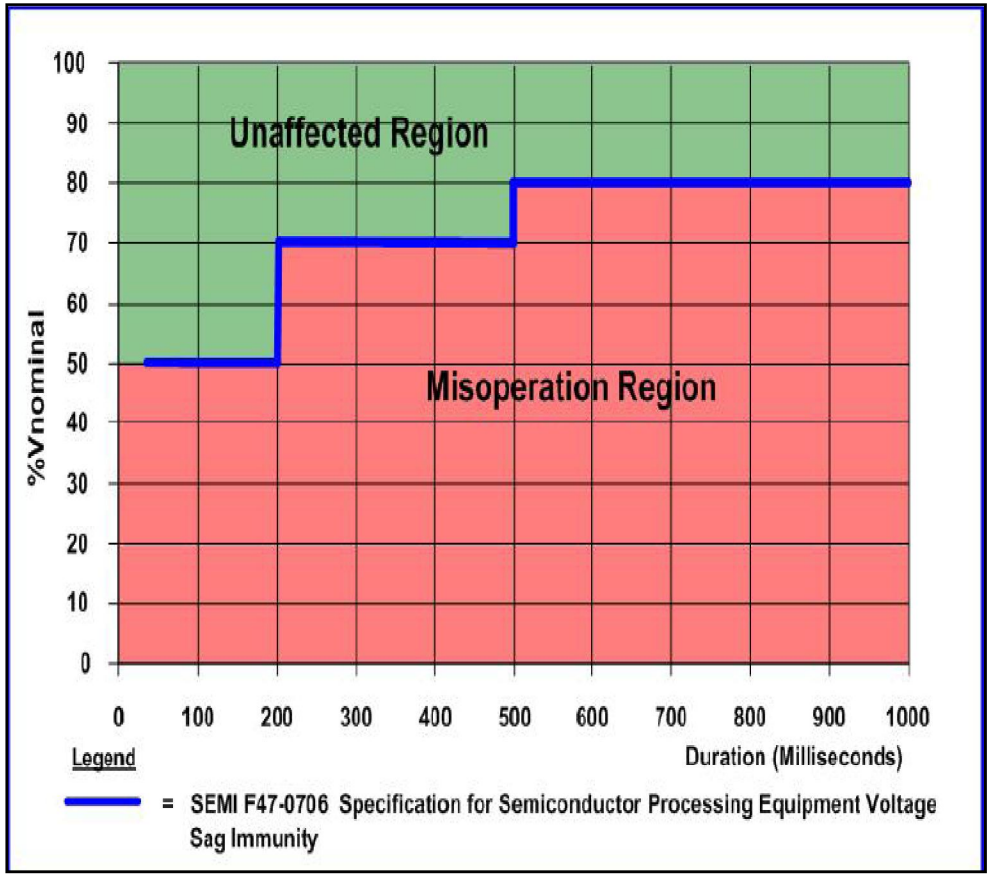
- Quantifying process equipment performance (see Section 7.5).
- Quantifying support equipment and facilities infrastructure equipment performance (see Section 7.4).
- Utility power monitoring strategies (see Section 7.3).
- Measurement and modeling strategies (see Section 7.6).
- Power enhancing and conditioning strategies for use in the facilities electrical distribution system (see Section 7.7).

2.4 This guide does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this guide to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

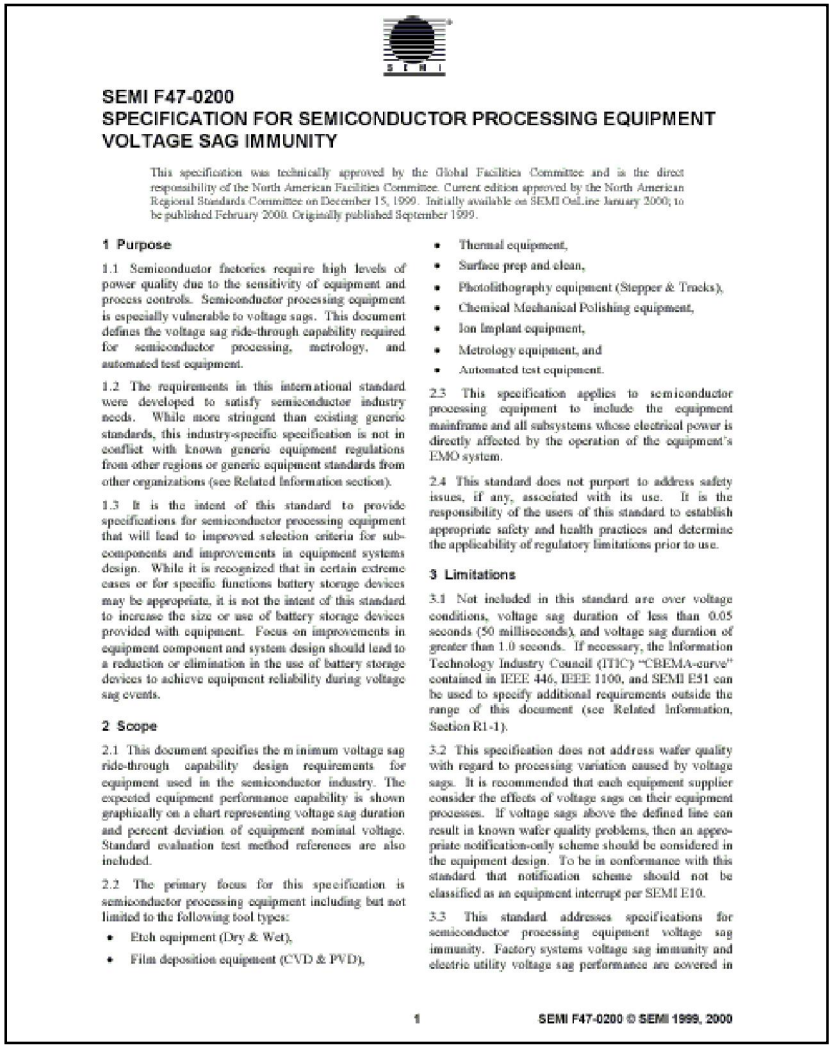
**SEMI F49- Guide for Semiconductor Factory Systems**


**International SEMATECH Technology Transfer # 99063760B-TR**

# Technical Standard for Evaluating Equipment Sensitivity for voltage sags




SEMI F47-0706



**SEMI F47-0200**
**SPECIFICATION FOR SEMICONDUCTOR PROCESSING EQUIPMENT VOLTAGE SAG IMMUNITY**

This specification was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 15, 1999. Initially available on SEMI OnLine January 2000; to be published February 2000. Originally published September 1999.

**1 Purpose**

1.1 Semiconductor factories require high levels of power quality due to the sensitivity of equipment and process controls. Semiconductor processing equipment is especially vulnerable to voltage sags. This document defines the voltage sag ride-through capability required for semiconductor processing, metrology, and automated test equipment.

1.2 The requirements in this international standard were developed to satisfy semiconductor industry needs. While more stringent than existing generic standards, this industry-specific specification is not in conflict with known generic equipment regulations from other regions or generic equipment standards from other organizations (see Related Information section).

1.3 It is the intent of this standard to provide specifications for semiconductor processing equipment that will lead to improved selection criteria for sub-components and improvements in equipment systems design. While it is recognized that in certain extreme cases or for specific functions battery storage devices may be appropriate, it is not the intent of this standard to increase the size or use of battery storage devices provided with equipment. Focus on improvements in equipment component and system design should lead to a reduction or elimination in the use of battery storage devices to achieve equipment reliability during voltage sag events.

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2.2 The primary focus for this specification is semiconductor processing equipment including but not limited to the following tool types:

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- Thermal equipment,
- Surface prep and clean,
- Photolithography equipment (Stepper & Tracks),
- Chemical Mechanical Polishing equipment,
- Ion Implant equipment,
- Metrology equipment, and
- Automated test equipment.

2.3 This specification applies to semiconductor processing equipment to include the equipment mainframe and all subsystems whose electrical power is directly affected by the operation of the equipment's EMO system.

2.4 This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

**3 Limitations**

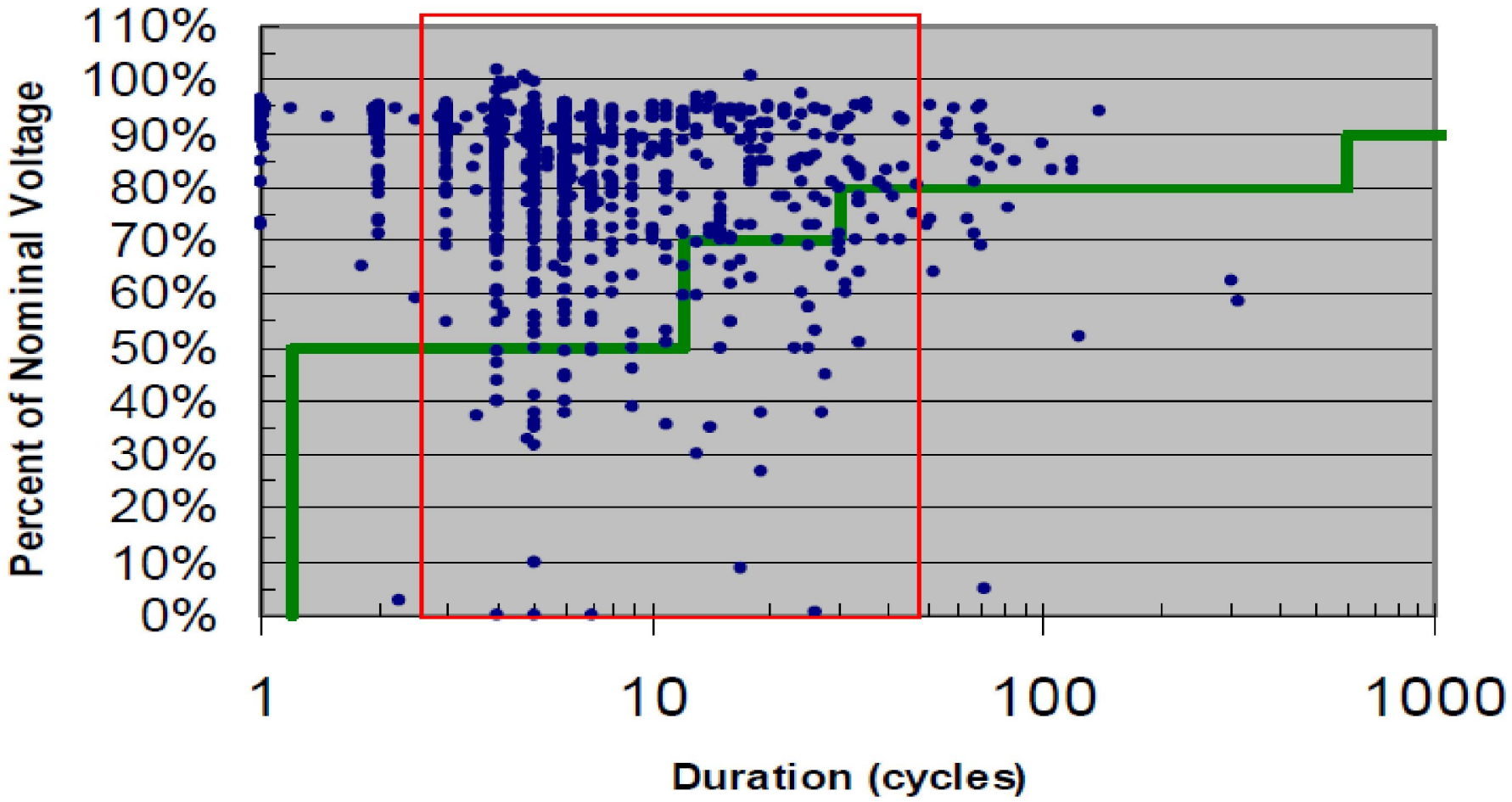
3.1 Not included in this standard are over voltage conditions, voltage sag duration of less than 0.05 seconds (50 milliseconds), and voltage sag duration of greater than 1.0 seconds. If necessary, the Information Technology Industry Council (ITIC) "CBEMA-curve" contained in IEEE 446, IEEE 1100, and SEMI E51 can be used to specify additional requirements outside the range of this document (see Related Information, Section R1-1).

3.2 This specification does not address wafer quality with regard to processing variation caused by voltage sags. It is recommended that each equipment supplier consider the effects of voltage sags on their equipment processes. If voltage sags above the defined line can result in known wafer quality problems, then an appropriate notification-only scheme should be considered in the equipment design. To be in conformance with this standard that notification scheme should not be classified as an equipment interrupt per SEMI E10.

3.3 This standard addresses specifications for semiconductor processing equipment voltage sag immunity. Factory systems voltage sag immunity and electric utility voltage sag performance are covered in

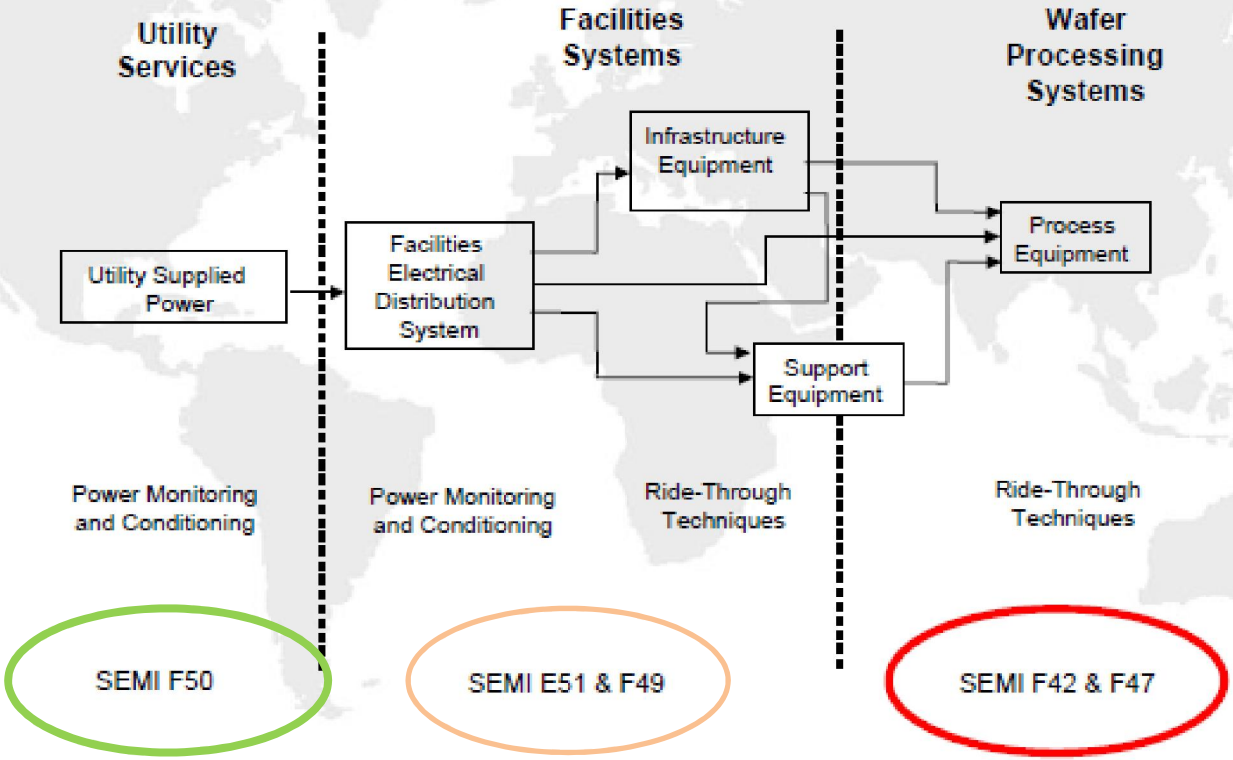
# SEMI F47 0706

Note: All the blue dots signified voltage sags recorded at 15 number of semiconductor plants in USA



# SEMI F47 System approach

## SEMI standards address voltage dips at different levels








PSL Power Standards Lab

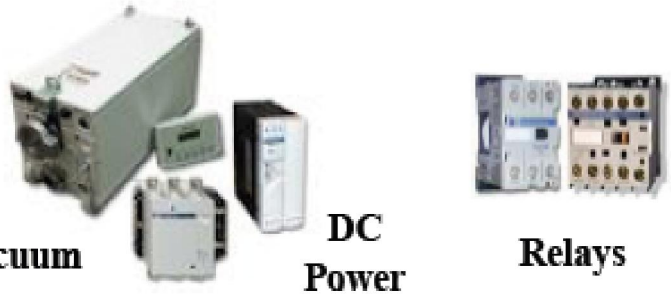
# SEMI F47 Compliance Strategies

- Use "Selective Power Conditioners" on susceptible loads

CVT DPI DySC CoilLock Low Voltage Ride Through Module

- Embed the Solution through proper design, configuration and component selection strategies

**These equipment exceed SEMI F47**



Vacuum Pumps Contactors DC Power Supplies Relays

- Utilize a *Combination* of both strategies

Suruhanjaya Tenaga
Energy Commission

TENAGA NASIONAL

# PQ & EMC Requirement for Electrical Wiring

# MALAYSIAN STANDARD

MS 1936:2007

## ELECTRICAL INSTALLATIONS OF BUILDING – GUIDE TO MS IEC 60364

ICS: 91.140.50, 29.020

Descriptors: guide electrical installation, buildings



DEPARTMENT OF STANDARDS MALAYSIA

# MALAYSIAN STANDARD

MS 1979:2011 (BM)

## PEMASANGAN ELEKTRIK DALAM BANGUNAN - KOD AMALAN

ICS: 91.140.50; 29.020

Perihal: amalan, pemasangan elektrik, bangunan, rumah kediaman, tempat tinggal



DEPARTMENT OF STANDARDS MALAYSIA

# INTERNATIONAL STANDARD

**IEC 60364-1**

Fifth edition
2005-11

## Low-voltage electrical installations –

## Part 1:
## Fundamental principles, assessment of general characteristics, definitions

*This English-language version is derived from the original bilingual publication by leaving out all French-language pages. Missing page numbers correspond to the French-language pages.*

Reference number
IEC 60364-1:2005(E)

# NORME INTERNATIONALE

# INTERNATIONAL STANDARD

**CEI IEC 60364-4-44**

Edition 1.1
2003-12

Edition 1:2001 consolidée par l'amendement 1:2003
Edition 1:2001 consolidated with amendment 1:2003

## Installations électriques des bâtiments –

## Partie 4-44
## Protection pour assurer la sécurité – Protection contre les perturbations de tension et les perturbations électromagnétiques

## Electrical installations of buildings –

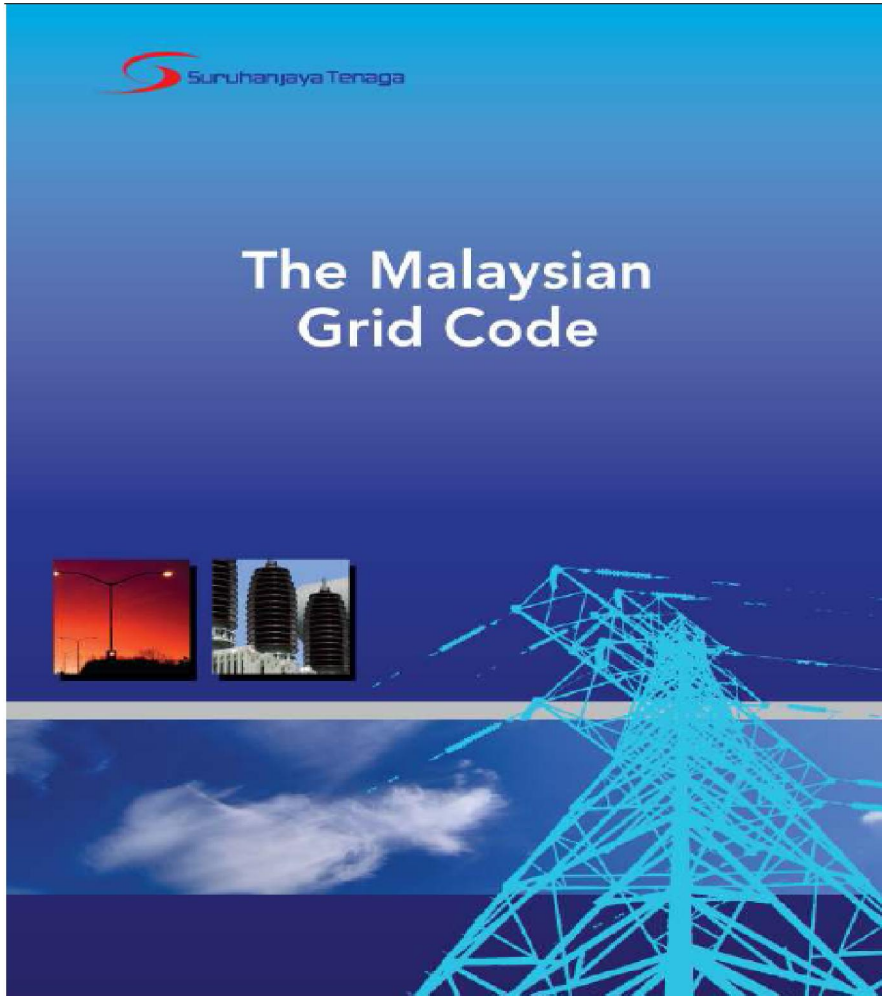
## Part 4-44:
## Protection for safety – Protection against voltage disturbances and electromagnetic disturbances

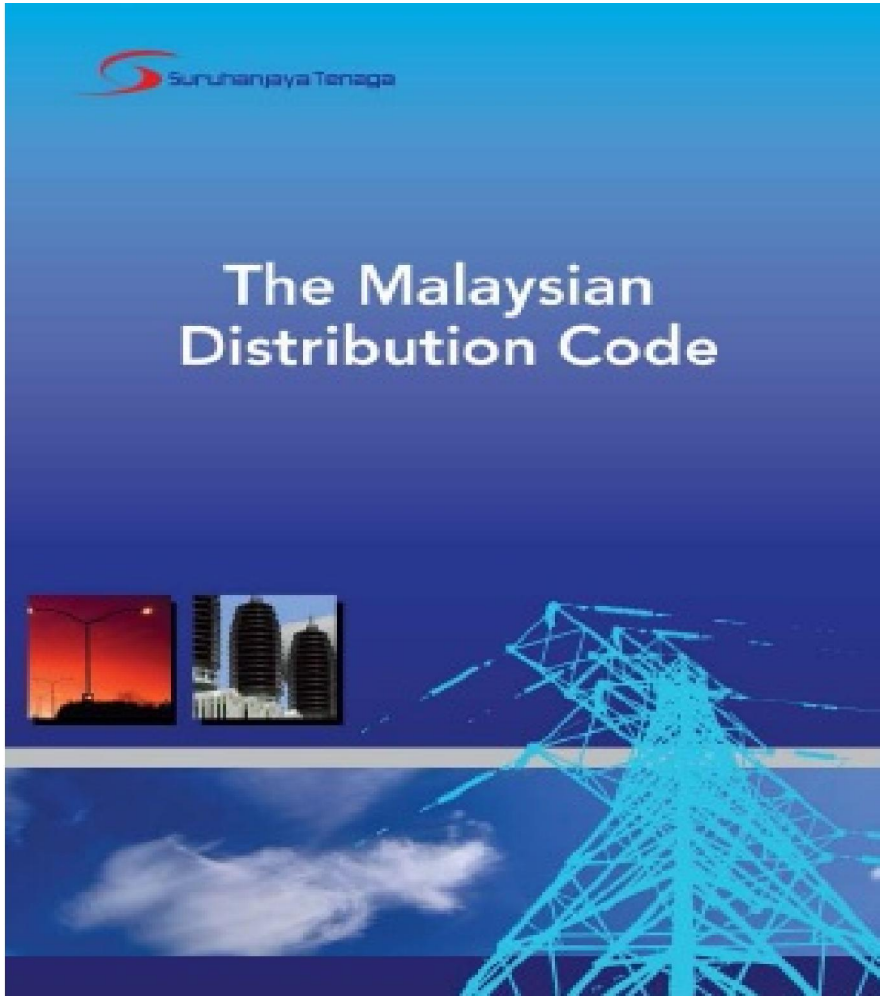
Numéro de référence
Reference number
CEI/IEC 60364-4-44:2001+A1:2003



# Management of EMC according to Malaysian Grid & Distribution Codes

# The Malaysian Codes address the existence of voltage disturbances and EMC requirement for Power Quality



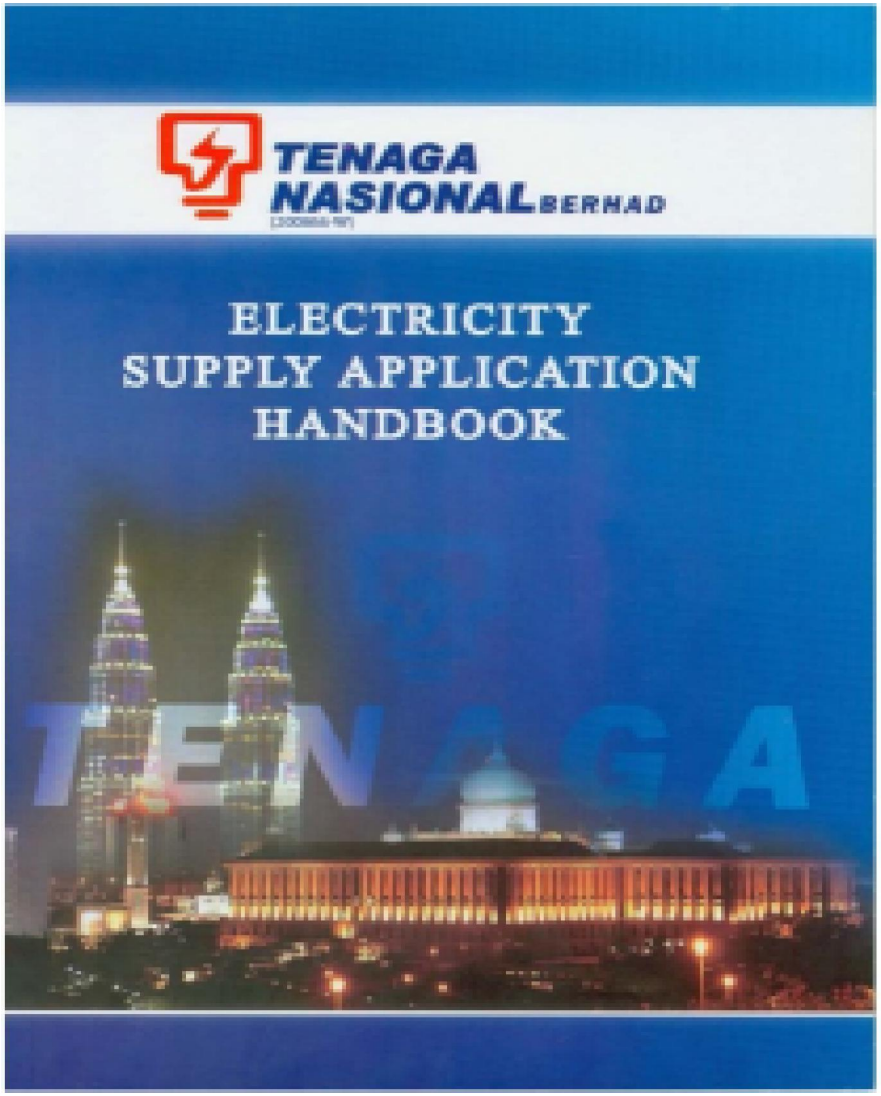



Suruhanjaya Tenaga
Energy Commission

TENAGA NASIONAL

# TNB's Power Quality Requirement

# Electricity Supply Application Handbook address the power quality requirement




TENAGA NASIONAL BERHAD *Electricity Supply Application Handbook*

## Vision

**To be among the leading corporations in energy and related businesses globally**

## Mission

**We are committed to excellence in our products and services**

## Shared values

**Our share values provide us with a principle that will shape our business ethics and operations**

- **Customer first**
- **Business excellence**
- **Integrity**
- **Caring**

## 1.3 POWER QUALITY

### 1.3.1 Power Quality Requirement

1.3.1.1 TNB supplies electricity by the alternating current (ac) system with system frequency of 50 Hz with specified regulated voltage levels. The ranges of voltage regulations available are explained in section 2.1 of this guideline.

1.3.1.2 TNB shall supply electricity to the main incoming terminals or point of common couplings (PCC) between the consumers and TNB with voltage sag performance as indicated in **standards IEC 61000-2-4** and **IEC/TR 61000-2-8.**

1.3.2.1 TNB specifies requirement that the consumer's must comply with in order to limit the impact of the potential short duration voltage and frequency fluctuations.

1.3.2.2 The requirements are:-

Table 1-4: TNB Power Quality Requirements

| Type Of Disturbance | Indices | Acceptable permissible values at point of common coupling (PCC) | Reference Document |
|---|---|---|---|
| Voltage Step Change | ΔV % | 1% - Frequent starting/switching and/or disconnection of load. | **UK's Engineering Recommendation P28** |
| | | 3 % - Infrequent single starting/ switching or disconnection of Load – once in two hours or more hours. | |
| | | 6 % - Starting/switching once or twice a year. | |
| Voltage Fluctuation and Flicker | Absolute Short Term Flicker Severity ($P_{st}$) | 1.0 (at 132kV and below) | **UK's Engineering Recommendation P28** |
| | | 0.8 (Above 132kV) | |
| | Absolute Long Term Flicker Severity ($P_{lt}$) | 0.8 (at 132kV and below) | |
| | | 0.6 (Above 132kV) | |
| Harmonic Distortion[2] | Total Harmonic Distortion Voltage (THDV) % | 5 % at ≤ 400 Volt | **Engineering Recommendation ER G5/4** |
| | | 4 % at 11kV to 22kV | |
| | | 3% at 33kV | |
| | | 3% at 132kV | |
| Voltage Unbalance | Negative Phase Sequence Voltage % | 2% for 1 minute | **UK's Engineering Recommendation P29** |

1.3.2.3 It is the responsibility of the consumer to ensure that his/her voltage sensitive equipment is able to function continuously through unanticipated voltage sags, caused when the system is subject to external interference such as lightning, 3rd party cable damage, other consumer's equipment fault, TNB equipment fault etc.

1.3.2.4 The consumer must select modern equipment that is able to ride through many of these voltage sags. Consumers should ask their equipment manufacturers whether their equipment can function properly during the voltage sag conditions illustrated in the **European Standard EN 50160**, **IEC Standard 61000-2-2** and **IEC Standard IEC 61000-2-4**. If the equipment does not have any immunity to voltage sags, then the consumer should request from the manufacturers on measures to immune the equipment against voltage sags.

1.3.2.5 The recommended standards to refer for evaluating equipments' sensitivities and identifying immunity solutions to voltage sags, short interruption and voltage variations are **IEC Standard 61000-4-11** and **IEC Standard 61000-4-34**.

1.3.2.6 Guidelines on some immunity measures against voltage sags can be referred to TNB Power Quality Guidebook at http://www.tnb.com.my/tnb/con_quality.htm

### 1.3.3 Declaration to Power Quality Requirement

1.3.3.1 The consumer is required to declare his equipment compatibility and compliance with regards to the required power quality standard using the **Power Quality Compliance Declaration Form** in **Appendix 8**.

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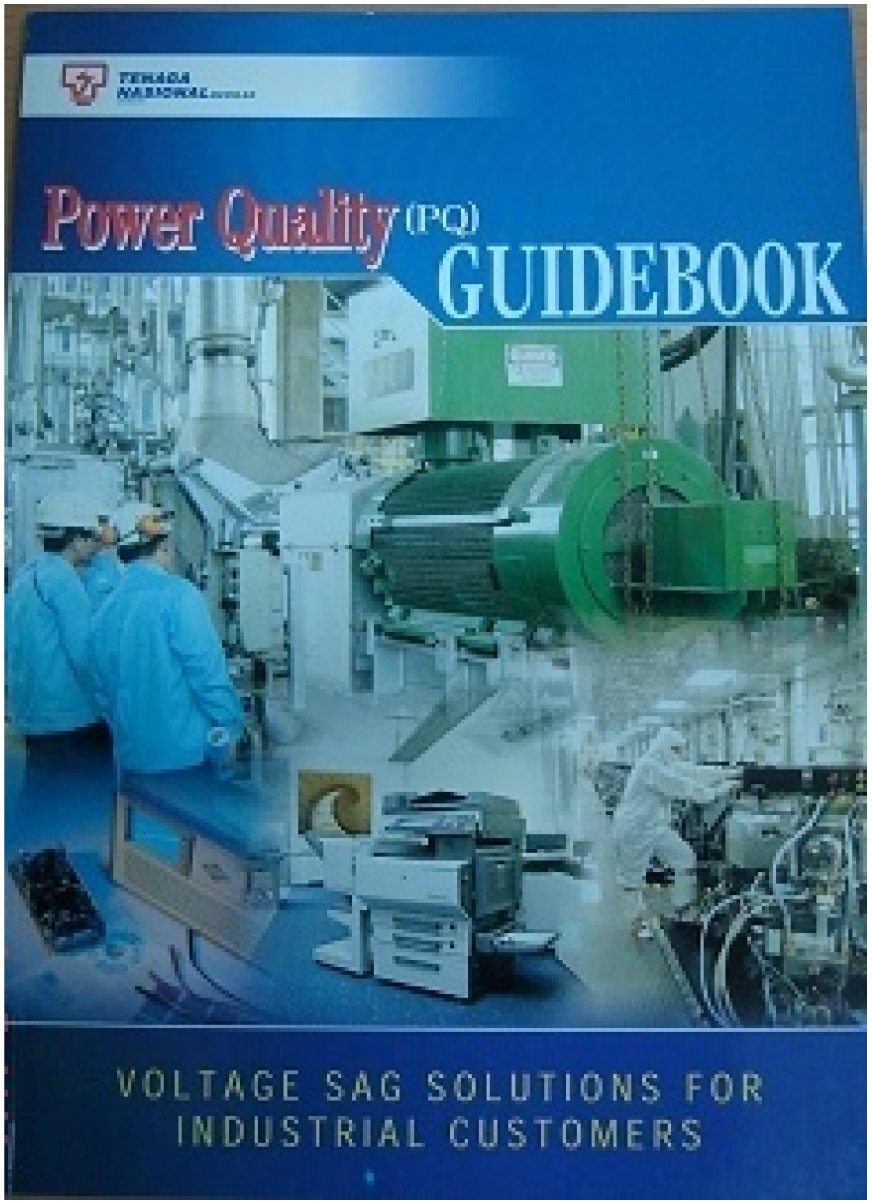
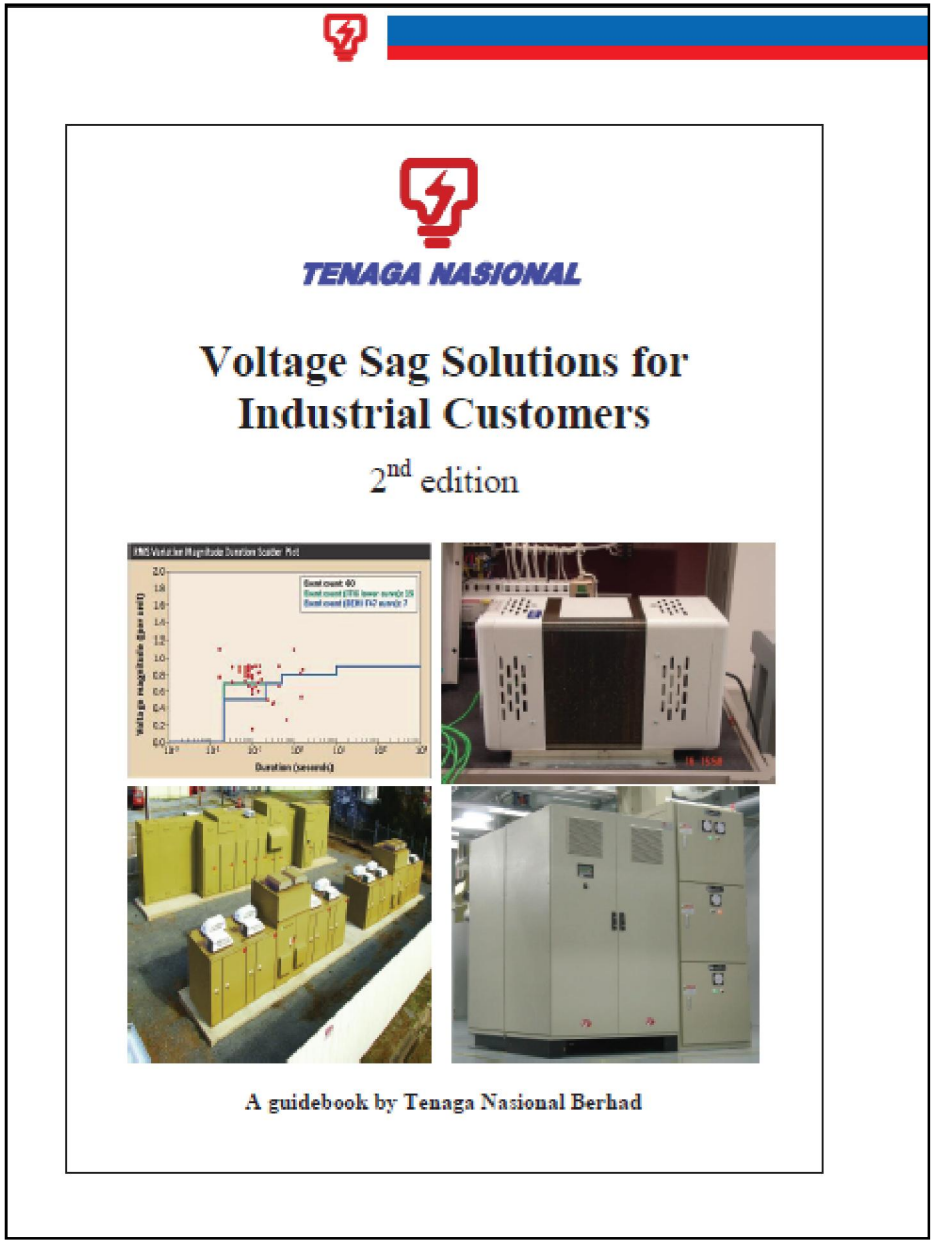
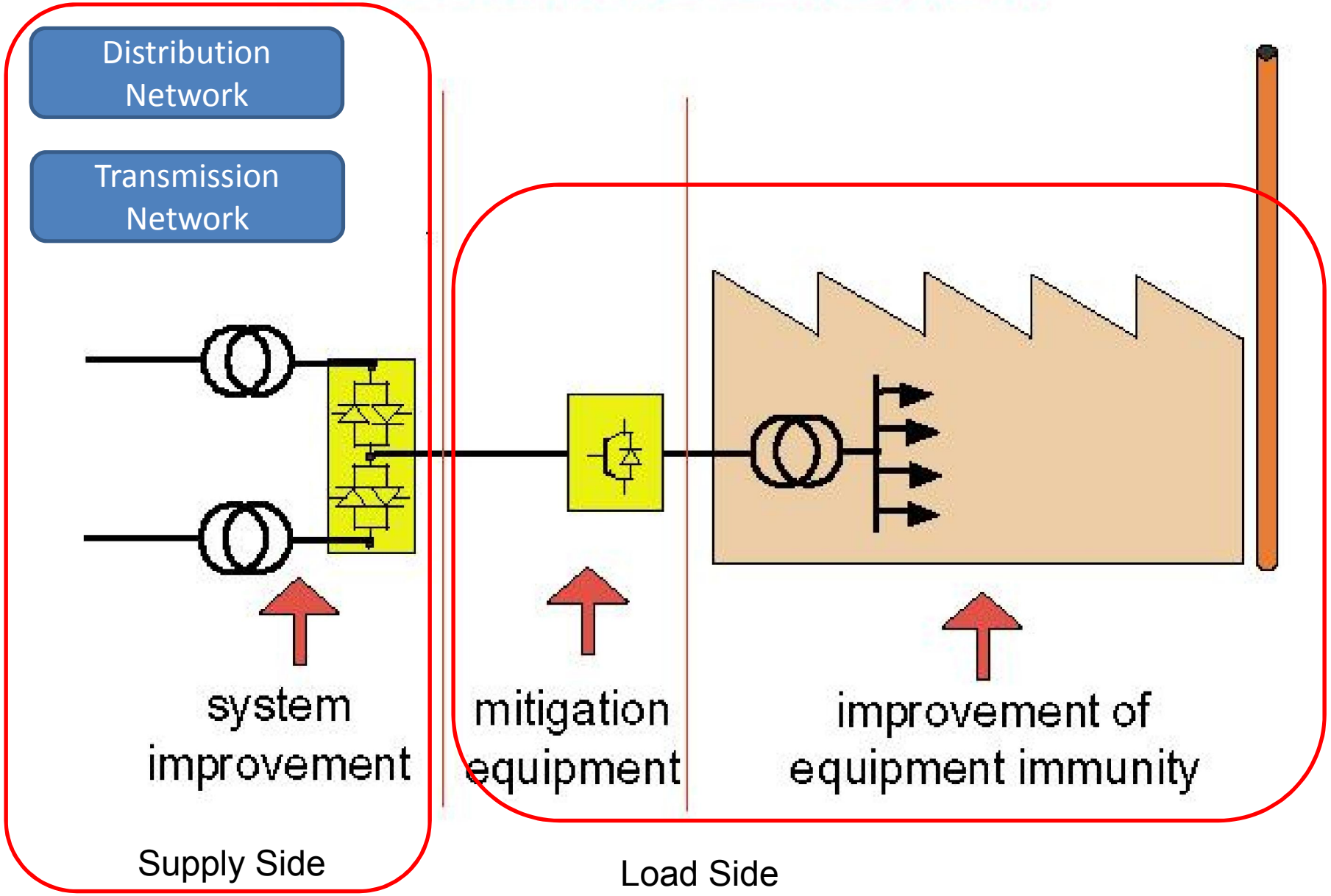
# TNB's Power Quality Guidebooks

# TNB GUIDEBOOKS ON VOLTAGE SAG SOLUTIONS

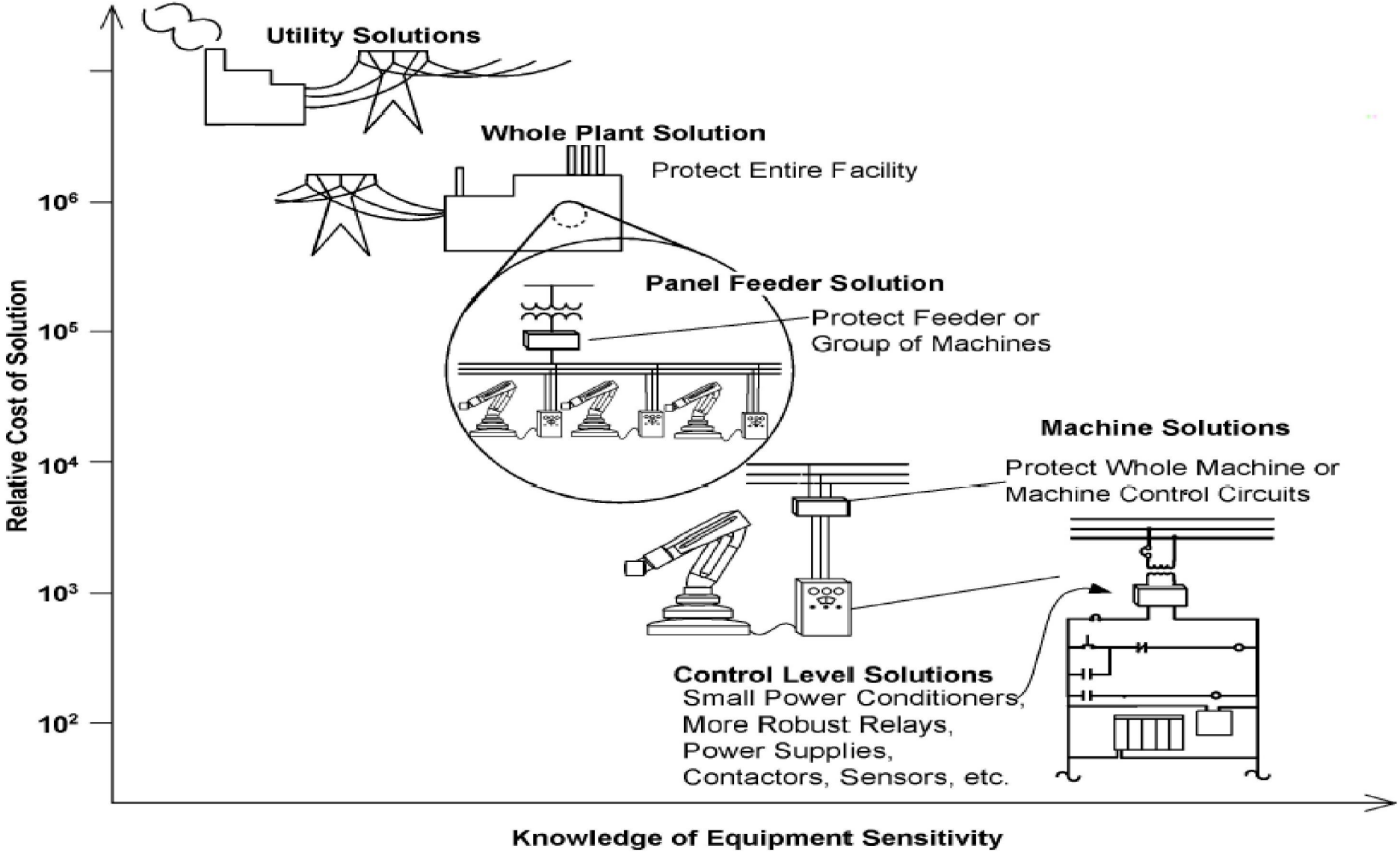


# improving power quality for sensitive customers



# Categories for Voltage Sag Solutions



# EMC Embedded Solutions for Voltage Sags

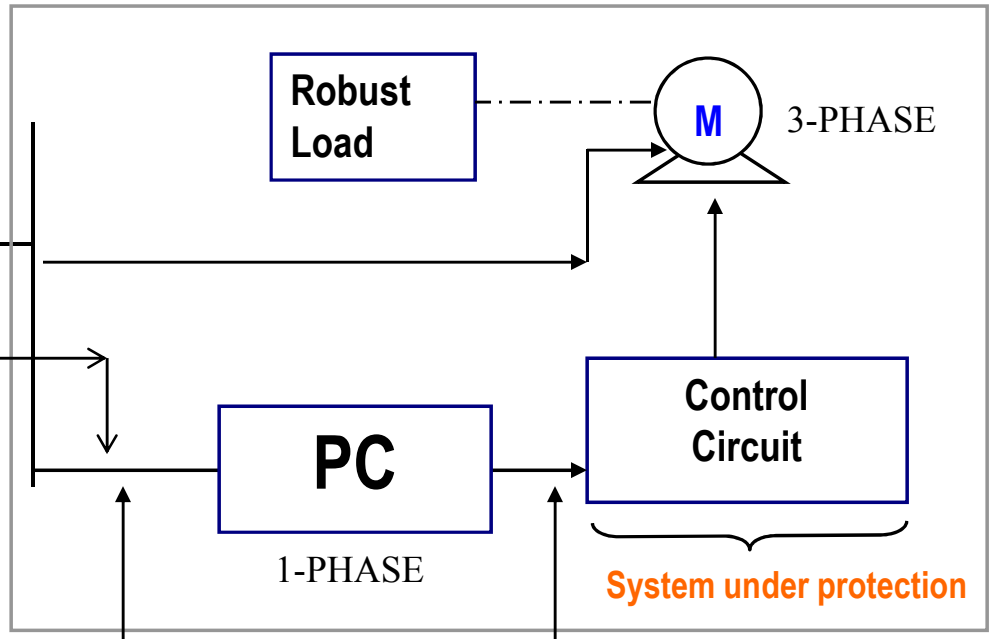
## Simple 8 solutions

- Tip #1: Use DC supply (if applicable)
- Tip #2: Wire load devices in a phase-to-phase configuration
- Tip #3: Identify & improve sensitive ice cube relays
- Tip #4: Do not use phase monitoring relays or undervoltage relays (UVR) in the interlock circuit, VCB etc.
- Tip #5: Install auto restart schemes (if applicable)
- Tip #6: Use a SEMI F47/IEC61000 compliance power supply
  - Range #1 (95V-250V (Japan and Europe),
  - Range #2, 110V-270V (North America and Australia)
- Tip #7: Employ Delay tripping for Motors, Contactors, UVR etc (Voltage 70%, t=2 to 3 seconds)

Tip #8: VFD calibration instead of scalar to set DFC (direct fly start) ere flying start is automatic

# Control Level Solution for control systems:

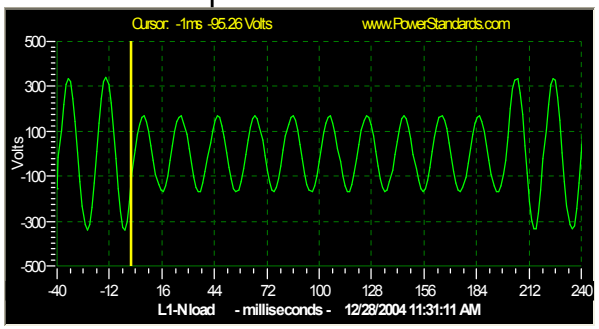
## Improvement in UVR, improvement in control program settings, auto restart, built in immunity & application of single phase Power Conditioner (PC)



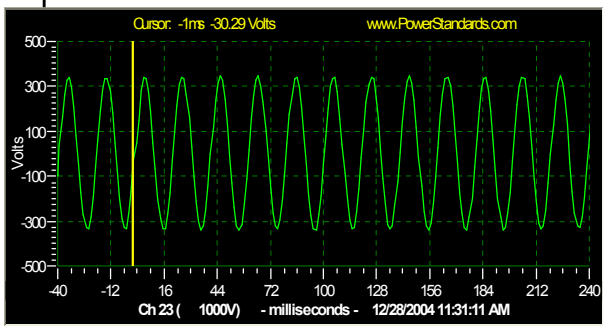


Please evaluate the undervoltage relay (UVR)
In the control system

Power conditioner

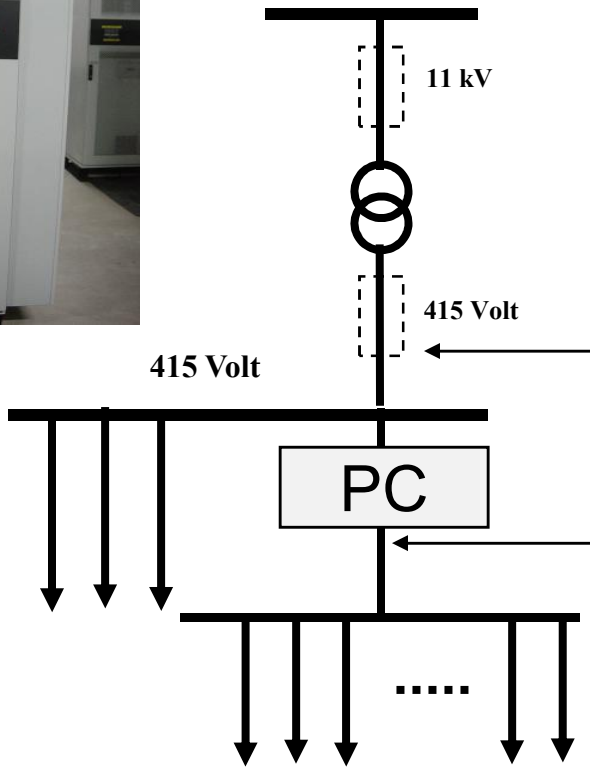



No Power conditioner

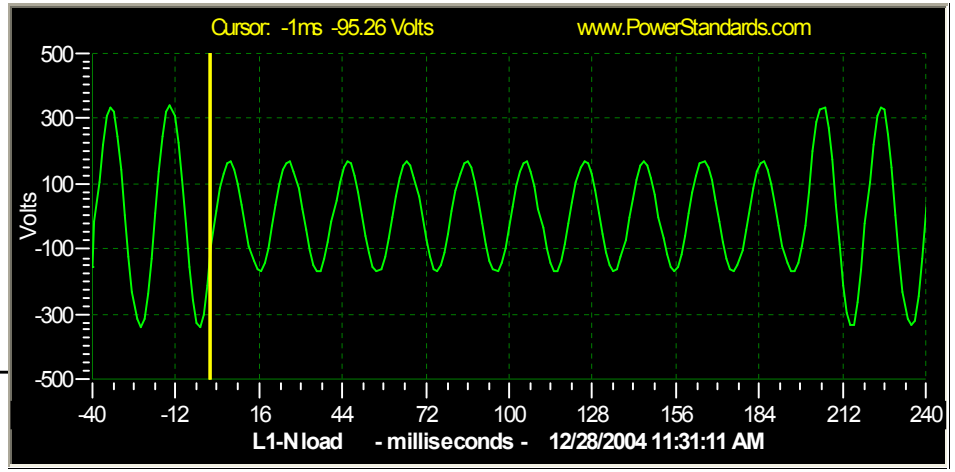



With Power conditioner

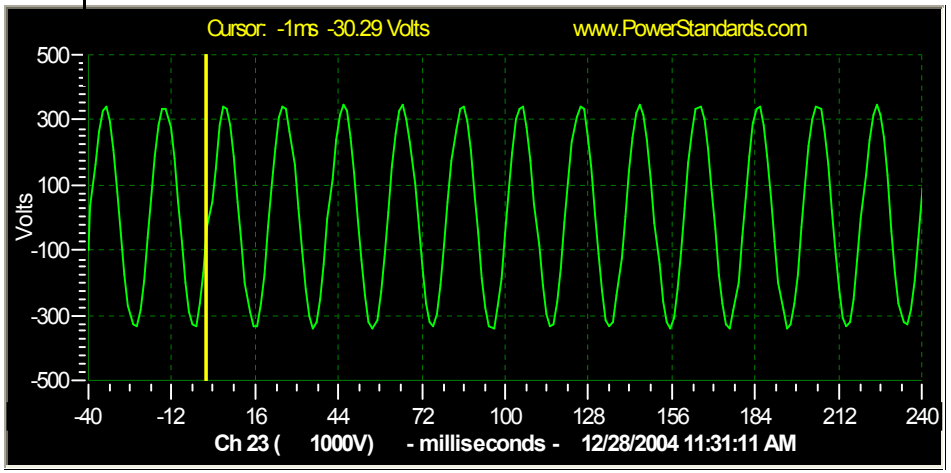
# Machine or Panel Level Solutions




PC: Power Conditioner

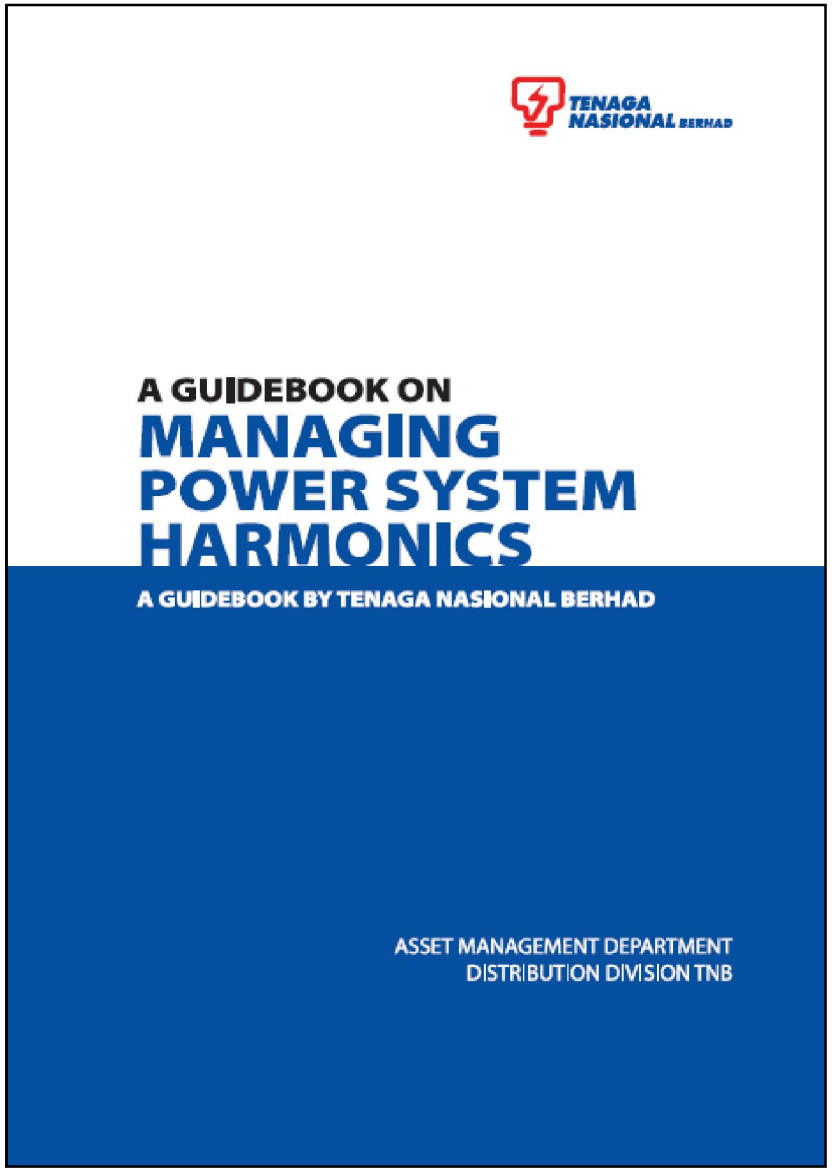



No Power conditioner




With Power conditioner

# TNB Guidebook on Managing Harmonics



# Types of harmonic mitigation

A. AC Line reactors

B. Passive harmonic filters

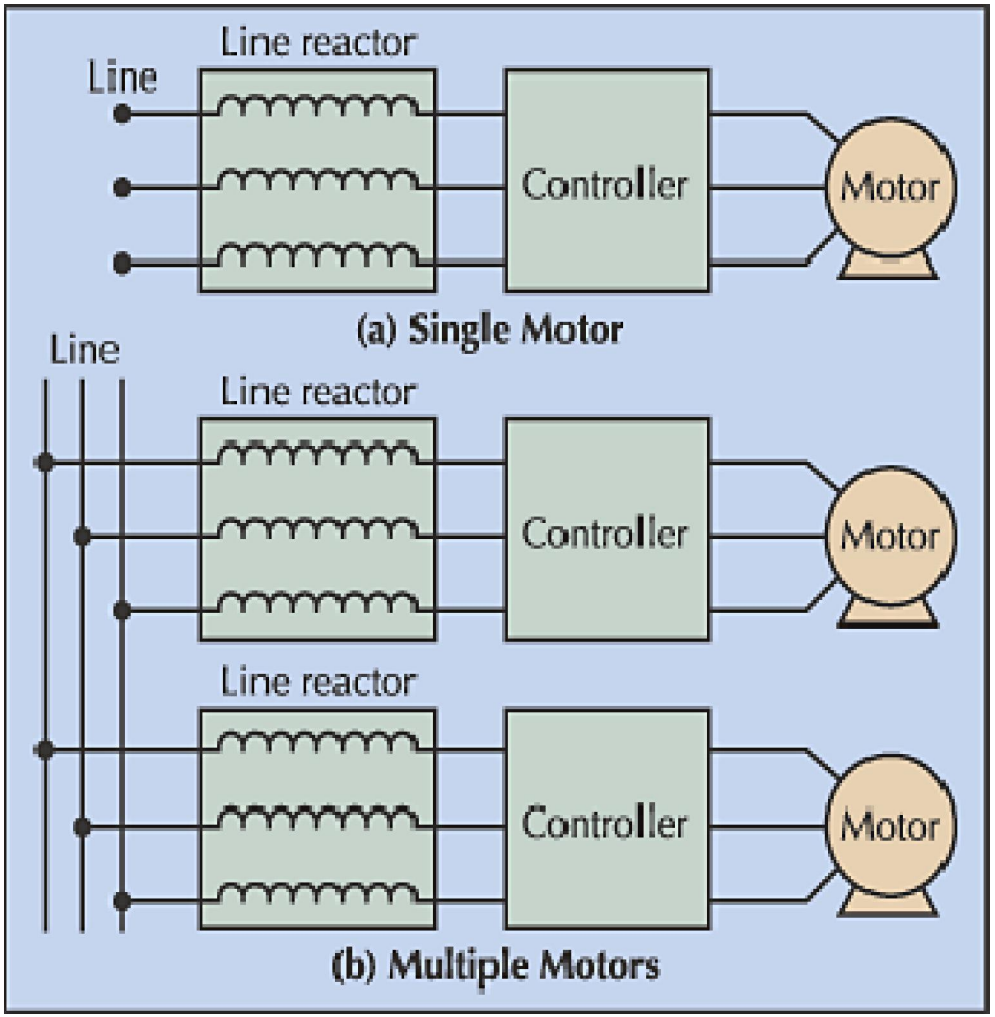
- Series – single phase filters – 3rd harmonic filters (Zero Sequence)
- Shunt – Tuned filter – 5th, 7th, 11th, 13th harmonic filter
- Low pass broad band harmonic filters

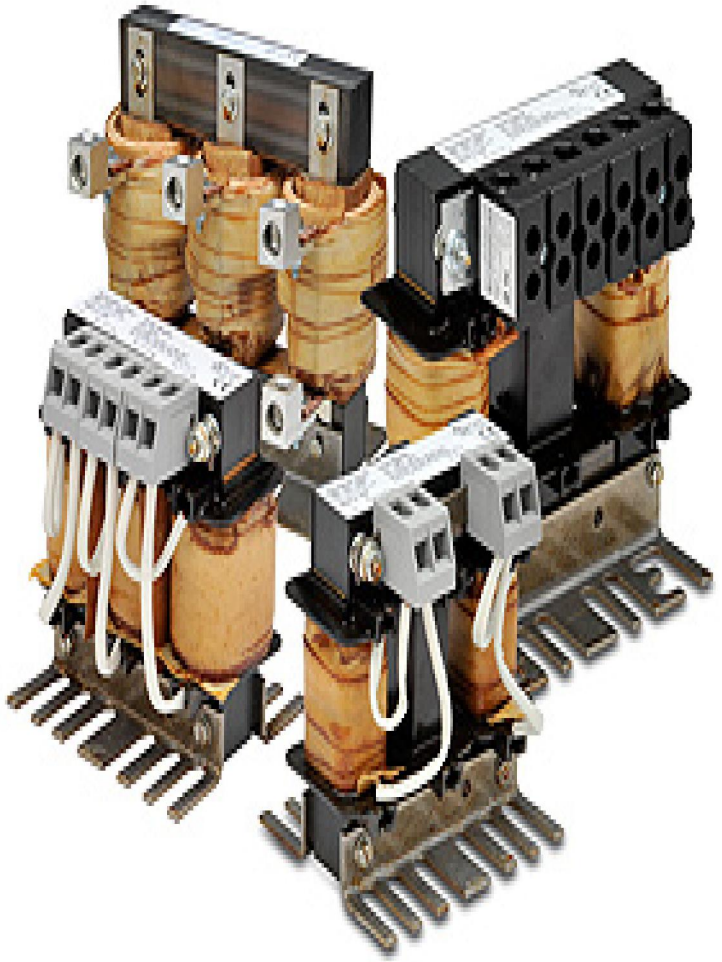
C. Active harmonic filters

D. Isolation transformers

E. Others

# AC LINE REACTORS



Passive Harmonic Filter

Active Harmonic Filter

# Zero Sequence Filter


# Isolation Transformer

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# SUMMARY

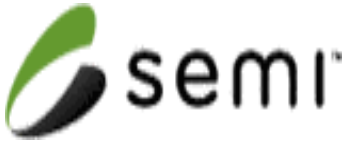
# According to IEC & IEEE, Electrical Power Quality is a compatibility problem between the source and load, not perfection of source…..

- Power Quality or Electromagnetic compatibility (EMC) itself is defined as: "the ability of an equipment or system to function satisfactorily in its electromagnetic (EM) environment (immunity) without introducing intolerable electromagnetic disturbances to anything in that environment (emission)“.

# POWER QUALITY STANDARDS

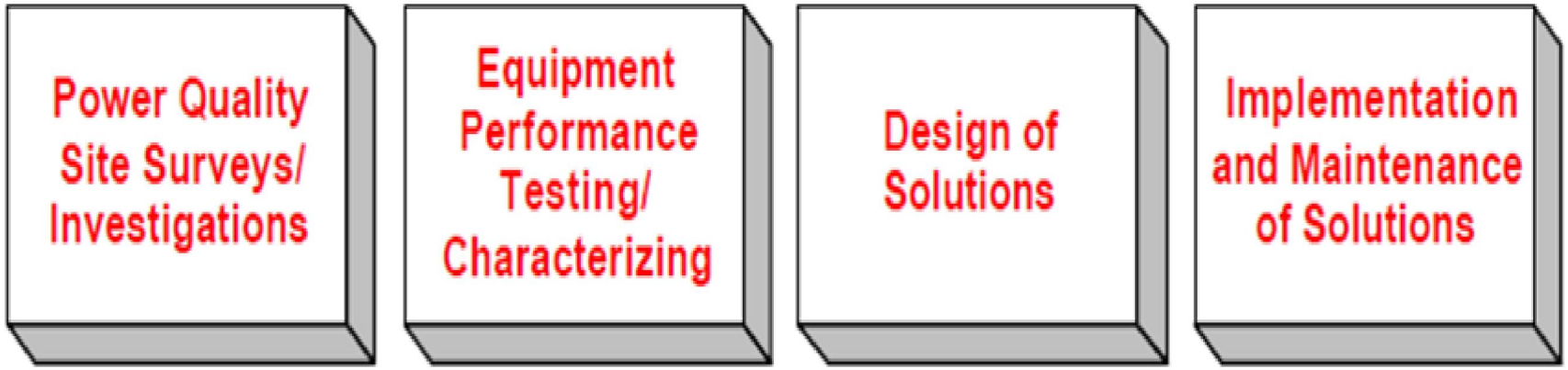
- IEC
- IEEE
- SEMI
- ENGINEERING RECOMMENDATIONS



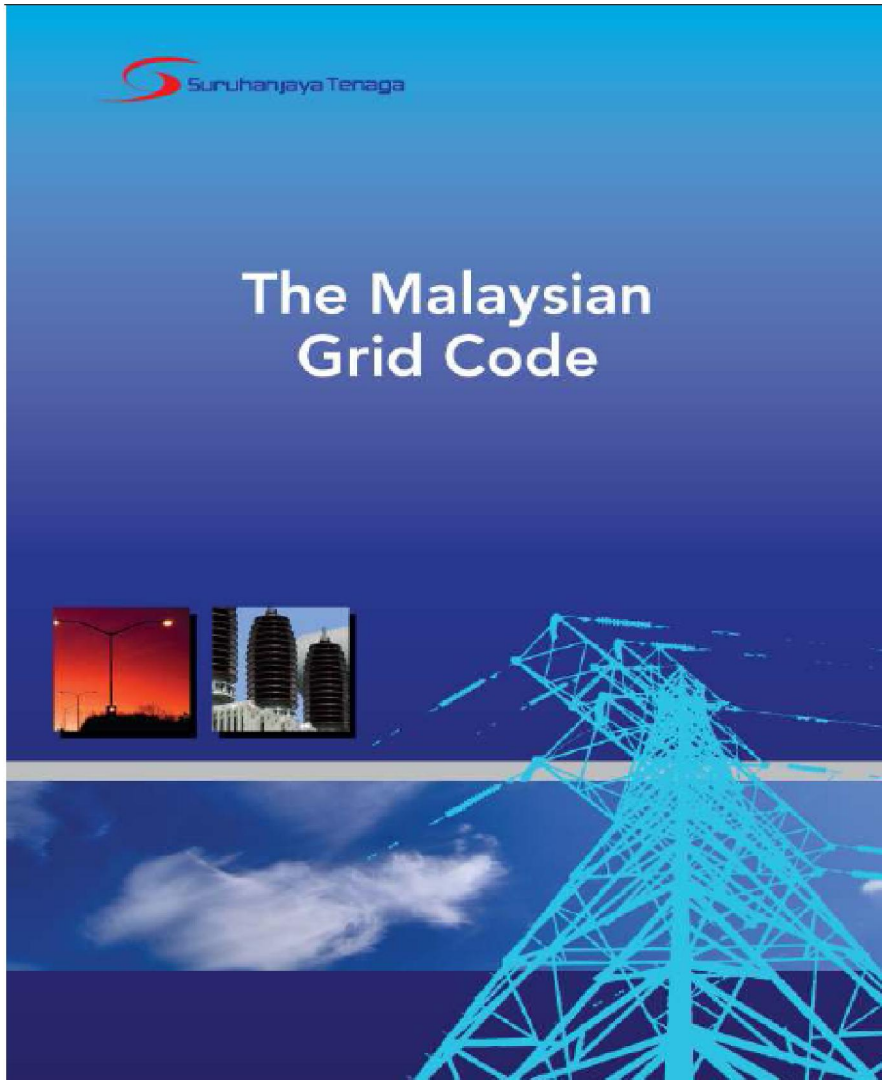


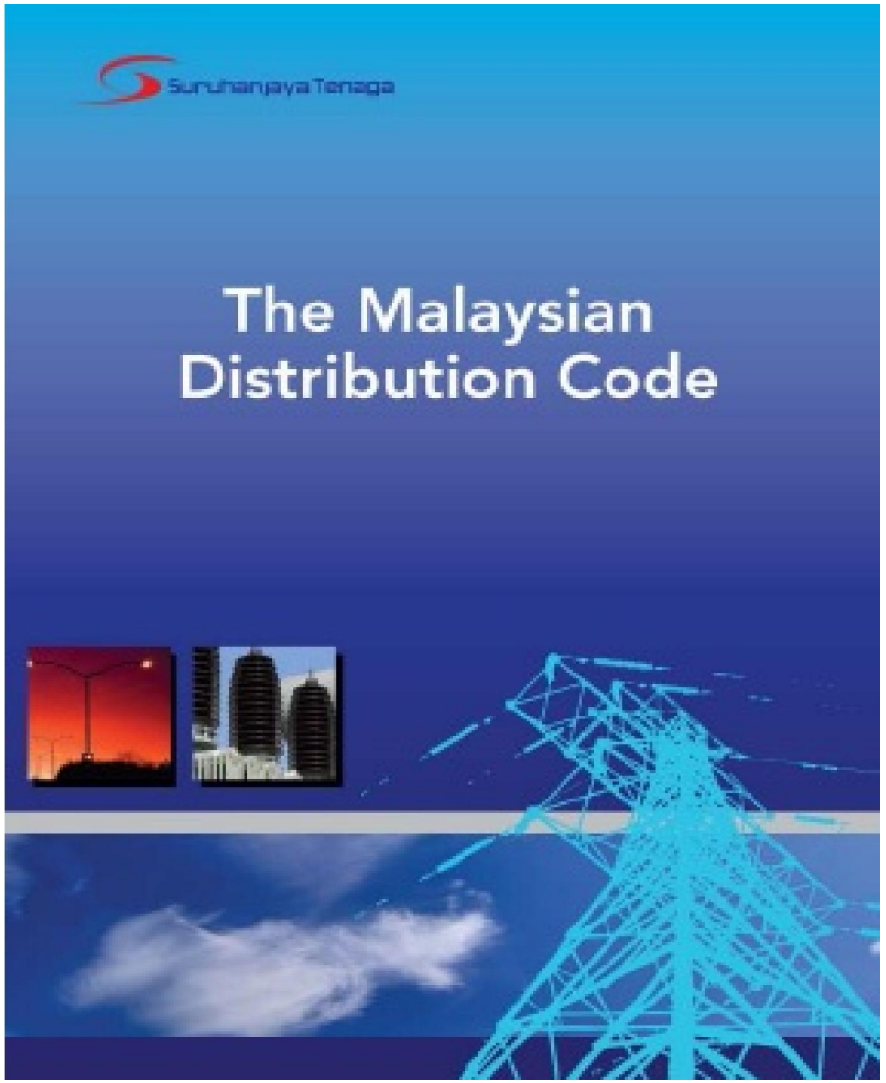
# Planning/Design Stage


# Solving Power Quality Problems



# The Malaysian Codes highlight the EMC responsibility for both power utility & customers



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# THANK YOU