

# Electromagnetic Compatibility (EMC) Requirements for Smart Grid and other Energy Applications

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# Smart Grid Overview

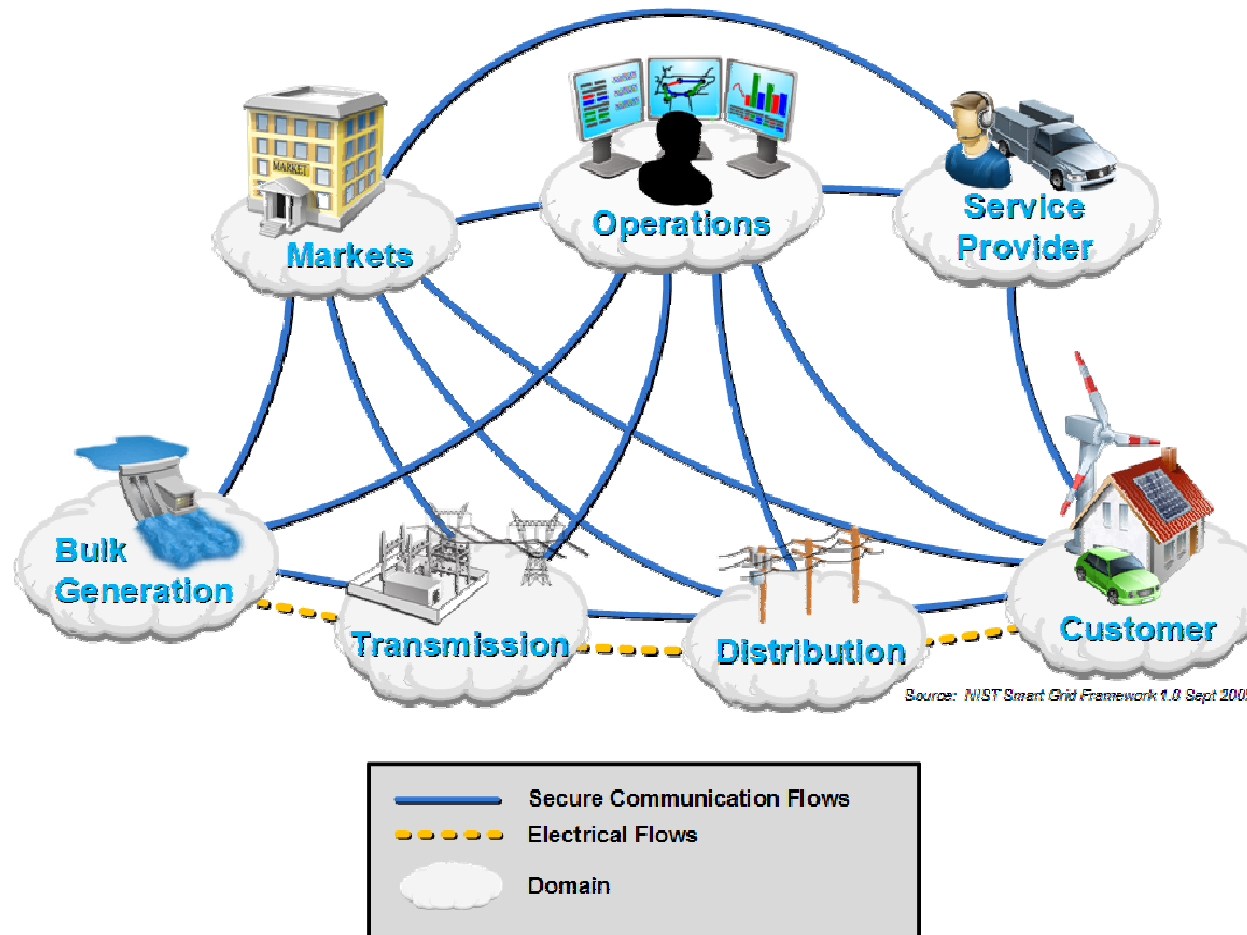
# Smart Grid

- an automated, widely distributed energy delivery network characterized by a two-way flow of electricity and information, capable of monitoring and responding to changes in everything from power plants to customer preferences to individual appliances.”
- “a smart grid is the electricity delivery system (from point of generation to point of consumption) integrated with communications and information technology”

(Note: Other definitions may also be in the eyes of the beholder and multiple definitions may be a result of layers or sub-tiers of interoperability and end use applications but will have commonality once understood.)

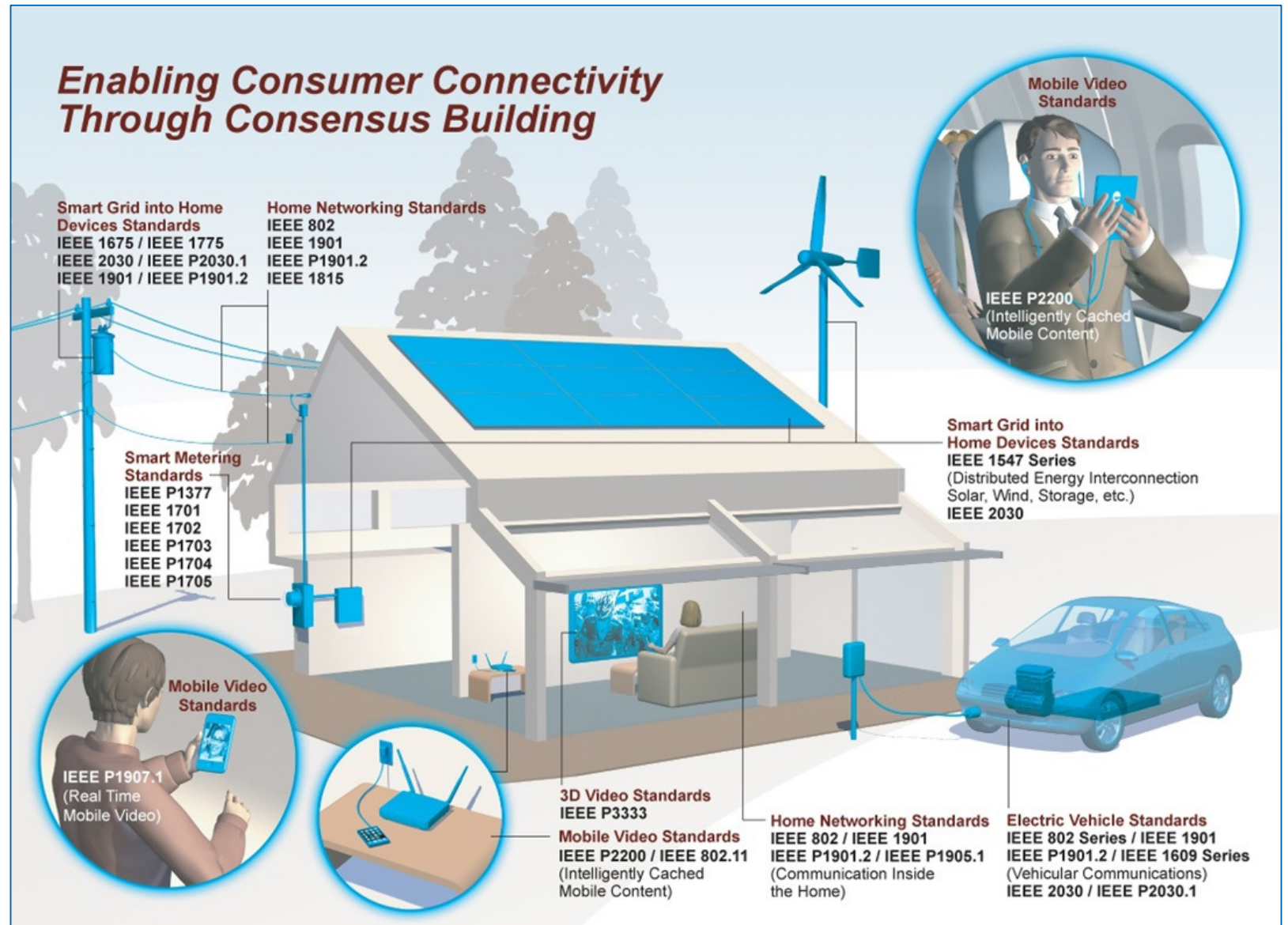
# Smart Grid

- Conceptual Model



# Smart Grid

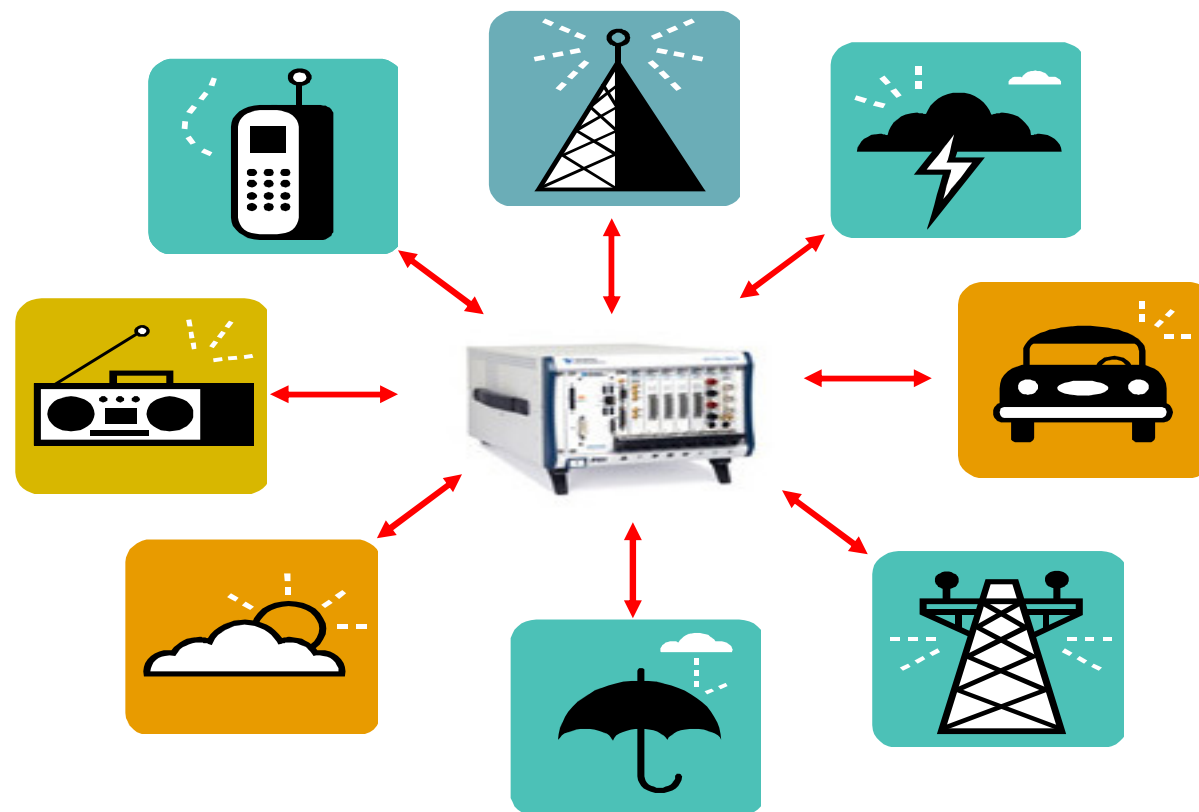
- Standards Overview
  - Viewpoint of the United States
  - Many standards impact the Smart Grid application areas.
  - EMC is addressed in IEEE 2030-2011.



# Smart Grid and EMC

# Smart Grid and EMC

- Electromagnetic Compatibility
  - the capability of electrical and electronic systems, equipment, and devices to operate in their intended electromagnetic environment within a defined margin of safety, and at design levels of performance without suffering or causing unacceptable degradation as a result of electromagnetic interference.



# Smart Grid and EMC

- EMC must be considered to ensure continuous reliable real time operation in the many locations and environments where the Smart Grid equipment will operate. Components and devices are subjected to a wide range of conducted and radiated noise sources that are disruptive to all electronic systems.
- These sources can be categorized as follows:
  - **Conducted noise** from such sources as power line harmonics, surge (from lightning and power system switching transients), and fast transients/bursts (interruption of inductive dc circuits)
  - **Radiated noise** or signals from known transmitters (AM, FM, and TV broadcast transmitters, communications radios, wireless devices, etc.).
  - **High power events** such as geomagnetic storms, intentional EM interference (IEMI) from portable transmitters, and EM pulses associated with high altitude nuclear detonation (HEMP).
  - **Electrostatic discharge events** when a statically charged body (human or inert) comes in contact with a Smart Grid device.



# Smart Grid and EMC

- It is a group effort
  - Manufacturers
    - Design and test products to demonstrate EM immunity per specific standards.
  - Utilities
    - Continue to specify that components meet the EMC requirements in specific standards.
    - Utilities may require additional compliance testing.
  - Electric power customers (especially commercial and industrial)
    - Practice good installation procedures and specify products that have good EMC design.
  - SDOs
    - Continue to develop and update EMC standards where found necessary to reflect the progress in technology and the applicable electromagnetic environments.
  - Government
    - Evaluate national policies and priorities for protection of the electric power infrastructure from electromagnetic interference, especially high-power events like HEMP, IEMI, and geomagnetic storms.

# Smart Grid and EMC in the United States

# Smart Grid and EMC in the United States

- NIST (<http://www.nist.gov/smartgrid/>) has “primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems...”
  - NIST Smart Grid Interoperability Framework, Release 3.0
    - Emphasis on architecture, cybersecurity, risk management, testing and certification, and (of course) standards.
    - EMC included in Section 8.1.1
    - <http://www.nist.gov/smartgrid/framework3.cfm>
  - Smart Grid Interoperability Panel (SGIP)
    - A private entity focused on critical power industry issues most relevant to our stakeholders, which include utilities, regulators, equipment vendors and integrators.
    - <http://www.sgip.org/>

# Smart Grid and EMC in the United States

- Emissions Standards

- There are none!
- 46 CFR Part 15B

- 15.103 Exempted devices

- (b) A digital device used exclusively as an electronic control or power system utilized by a public utility or in an industrial plant. The term public utility includes equipment only to the extent that it is in a dedicated building or large room owned or leased by the utility and does not extend to equipment installed in a subscriber's facility.



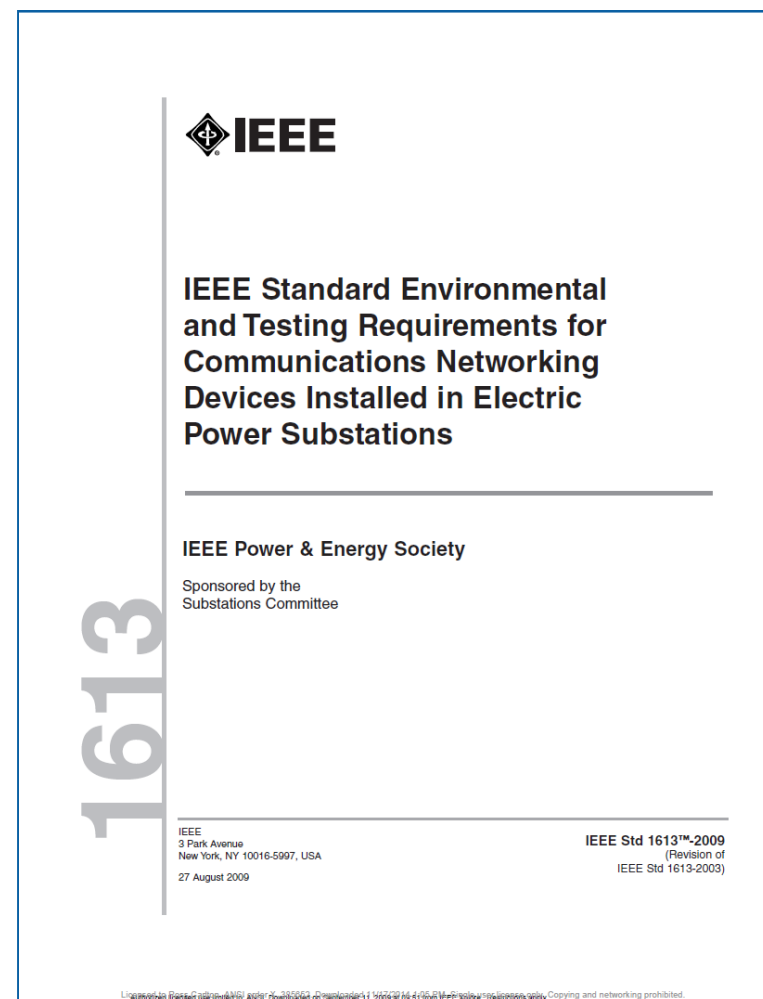
# Smart Grid and EMC in the United States

- Immunity Standards
  - Relays and Relay Systems
    - IEEE C37.90-2005 “IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus” (CW Surge)
    - IEEE C37.90.1-2012 “IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus” (EFT, DOW Surge)
    - IEEE C37.90.2-2004 “IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers” (Radiated RF Fields)
    - IEEE C37.90.3-2001 “IEEE Standard Electrostatic Discharge Tests for Protective Relays” (ESD)
  - Communications Networking Devices
    - IEEE 1613-2009 “IEEE Standard Environmental and Testing Requirements for Communications Networking Devices Installed in Electric Power Substations”
    - IEEE 1613.1-2013 “IEEE Standard Environmental and Testing Requirements for Communications Networking Devices Installed in Transmission and Distribution Facilities”

# Smart Grid and EMC in the United States

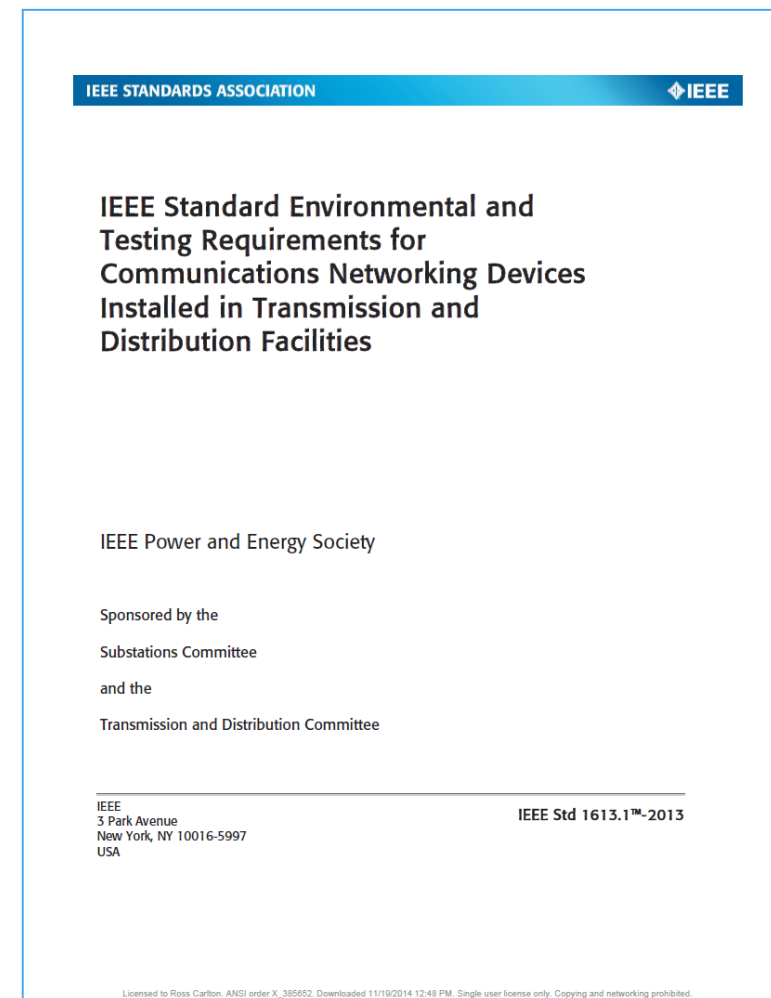
- IEEE 1613-2009

- Applicable to communications networking devices and communications ports in protective relays installed in electric power substations
- Requirements
  - Surge Withstand Capability per IEEE C37.90.1-2002
    - Damped Oscillatory Wave - 2.5 kV at 1 MHz
    - Electrical Fast Transients – 4 kV at 2.5 kHz
  - Radiated RF Susceptibility per IEEE C37.90.2-2004
    - 20 V/m, 80-1000 MHz, 80% AM w/ 1 kHz tone
  - Electrostatic Discharge (ESD) per IEEE C37.90.3-2001
    - Contact Discharge: 2, 4, 8 kV
    - Air Discharge: 4, 8, 15 kV
- Shortcomings
  - Simply a repackaging of the above three standards.
  - Non-standard method for RF Susceptibility and limited frequency range.
  - Non-standard transverse coupling method for EFT.
  - Other disturbances common to the environment are not accounted for.



# Smart Grid and EMC in the United States

- IEEE 1613.1-2013
  - Amendment to IEEE 1613
  - Applicable to communications networking devices installed in transmissions and distribution facilities
    - Broadened to extend outside substations (smart meters)
  - Locations
    - Zone A - located within a boundary or fenced area, such as a generating station or a transmission or distribution substation (more severe)
    - Zone B – external to those areas (less severe)
  - Requirements
    - Adds new tests based on IEC standards



# Smart Grid and EMC in the United States

- IEEE 1613.1-2013

Test	Standard	Enclosure	Power Port	Signal Port	Notes
EFT	IEEE C37.90.1	N/A	Zone A – None Zone B – 2kV	Zone A – None Zone B – None	Transverse mode test on DC terminals >48V only.
DOW	IEEE C37.90.1	N/A	Zone A – None Zone B – 2kV	Zone A – None Zone B – None	
RF RI	IEEE C37.90.2	20V/m, 80-1000MHz, AM 10V/m, 1-3.8GHz, AM 5 V/m, 1-6GHz, PM	N/A	N/A	
ESD	IEEE C37.90.3	Zone A – 8kV CD, 15kV AD Zone B – 4kV CD, 8kV AD	N/A	N/A	
Surge	IEC 61000-4-5	N/A	Zone A - 2kV DM, 4kV CM Zone B – 1kV DM, 2kV CM	Zone A - 1kV DM, 2kV CM Zone B - 0.5kV DM, 1kV CM	
RF CI	IEC 61000-4-6	N/A	Zone A – 10Vrms Zone B – 3Vrms	Zone A – 10Vrms Zone B – 3Vrms	
MF RI	IEC 61000-4-8	Zone A – 100/1000A/m Zone B – 30/300A/m	N/A	N/A	
DOMF	IEC 61000-4-10	Zone A – 100A/m Zone B – 30A/m	N/A	N/A	
LF CI	IEC 61000-4-16	Zone A – 30/300Vrms Zone B – 10/100Vrms	N/A	N/A	



# Smart Grid and EMC in the World

# Smart Grid and EMC in the World

- The IEC (<http://www.iec.ch/smartgrid>) provides a centralized repository for global Smart Grid activities.
- SG 3 (Strategic Group) on Smart Grid, set up by the IEC SMB (Standardization Management Board), provides advice on fast-moving ideas and technologies likely to form the basis for new International Standards or IEC TCs in the area of Smart Grid technologies.
- IEC Smart Grid Standardization Roadmap
  - The design and operation of a Smart Grid shall conform to the requirements set out in the EMC compatibility standards 61000-2-2 (LV) and 61000-2-12 (MV).
  - Apply existing product family standards or, if none exist, the generic standards of the 61000-6-x family.

# Smart Grid and EMC in the World

- Standards

- Relays and Relay Systems

- IEC 60255-26:2013 {Ed 3.0} “Measuring relays and protection equipment – Part 26: Electromagnetic compatibility requirements”

- Communications Networking Devices

- IEC 60870-2-1:1995 {Ed 2.0} “Telecontrol equipment and systems - Part 2: Operating conditions - Section 1: Power supply and electromagnetic compatibility”
    - IEC 61850-3:2013 {Ed 2.0} “Communication networks and systems in substations Part 3: General requirements”

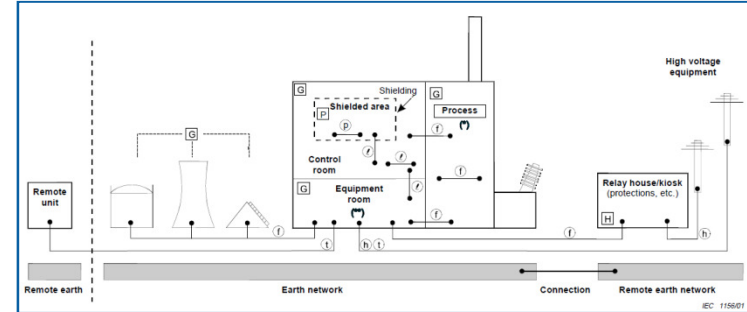
- Electrical and Electronic Equipment

- ! • IEC 61000-6-2:2005 {Ed 2.0} “Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments”
    - IEC 61000-6-4:2006 {Ed 2.0} “Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Emissions for industrial environments”
    - ! • IEC/TS 61000-6-5:2001 {Ed 1.0} “Electromagnetic compatibility (EMC) – Part 6-5: Generic standards – Immunity for power station and substation environments”

# International EMC Requirements

# International EMC Requirements

- Overview
  - Harmonization
    - Requirements are moving towards harmonization.
    - Significant achievements have been made.
    - Significant gaps still exist.
  - A product's EMC requirements must be assessed on a case by case basis.
    - Requirements are driven by
      - The particular application
      - The operational environments
      - Installation techniques
    - Determining requirements is a process



Port	Phenomenon	Basic standard	Test value	Performance criteria
Enclosure	Electrostatic discharge (ESD)	IEC 61000-4-2	4 kV/8 kV contact/air	B
	EM field	IEC 61000-4-3	10 V/m (80 MHz to 1 GHz) 3 V/m (1.4 GHz to 2 GHz) 1 V/m (2.0 GHz to 2.7 GHz)	A

Test	Environmental phenomena	Frequency range	Limit values	Basic standard
14.1	conducted emission	0.15 to 0.5 MHz	quasi peak 79 average 66	CISPR 22
		0.5 to 5 MHz	quasi peak 73 average 60	
		5 to 30 MHz	quasi peak 73 average 60	

Test	Environmental phenomena	Basic standard IEC	Local	In field	Connections <sup>1</sup>	To HV equipment	Telecommunication	Remarks			
2.1	Main frequency voltage	IEC 61300-4-16	-	-	4	30 V continuous 300 V for 1 s	4	30 V continuous 300 V for 1 s	4	30 V continuous 300 V for 1 s	-
2.2	Surge 1,250 μs line to ground line to line	IEC 61000-4-5	3 1	1 kV 0.5 kV	3 2	2 kV 1 kV	4 3	4 kV 2 kV	4	4 kV <sup>2</sup> 2 kV <sup>2</sup>	For balanced lines and short distance data bus see table A.1 in IEC 61000-4-5
2.3	Damped oscillatory wave connection made differential mode	IEC 61300-4-12	-	-	2	1 kV 0.5 kV	3	2.5 kV 1 kV	3	2.5 kV <sup>2</sup> 1 kV	Test is performed at 1 MHz (higher frequencies are under consideration to cover GB)
2.4	Fast transient/burst	IEC 61000-4-4	3	1 kV	4	2 kV	x	4 kV	x	4 kV	Repetition rate of 2.5 - 10% used at 4 kV
2.5	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	3	10 V	3	10 V	3	10 V	3	10 V	10 V = 140 dB(μV)

Test	Environmental phenomena	Frequency range	Average limits	Peak limits	Basic standard
17.1	radiated emission	1 000 to 3 000 MHz	56	76	CISPR 22
		3 000 to 6 000 MHz	60	80	CISPR 22

# International EMC Requirements

- Comparison
  - Relays and Relay Systems
    - IEC 60255-26:2013 {Ed 3.0} “Measuring relays and protection equipment – Part 26: Electromagnetic compatibility requirements”
  - Communications Networking Devices
    - IEC 61850-3:2013 {Ed 2.0} “Communication networks and systems in substations Part 3: General requirements”
  - Electrical and Electronic Equipment
    - IEC 61000-6-2:2005 {Ed 2.0} “Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments”
    - IEC 61000-6-4:2006 {Ed 2.0} “Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Emissions for industrial environments”
    - IEC 61000-6-5:201x {Ed 1.0} “Electromagnetic compatibility (EMC) – Part 6-5: Generic standards – Immunity for power station and substation environments”

# International EMC Requirements

- Definitions

- Locations

- Power station - an installation whose purpose is to generate electricity and which includes civil engineering works, energy conversion equipment and all the necessary ancillary equipment (i.e. control room, equipment room and process area)
    - Substation (of a power system) - a part of an electrical system, confined to a given area, mainly including ends of transmission or distribution lines, electrical switchgear and control gear, buildings and transformers (i.e. control building, relay house and switchyard area).
    - Protected – within a shielded room with power and I/O filtering.

- Voltages

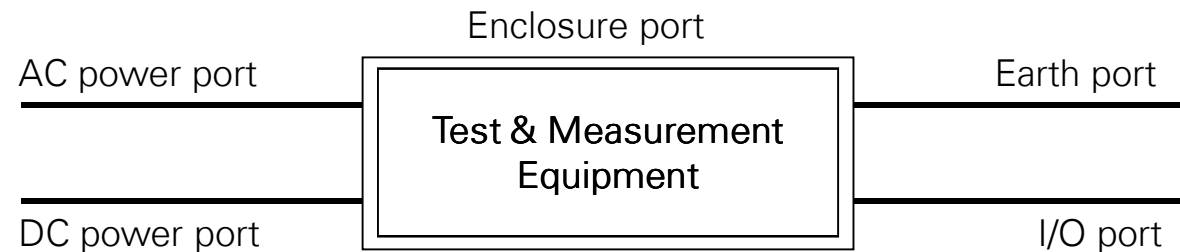
- Low voltage (LV) refers to a.c. voltages  $\leq 1$  kV
    - Medium voltage (MV) refers to a.c. voltages between 1 kV and 30-100 kV
    - High voltage (HV) refers to any a.c. voltage above MV levels

# International EMC Requirements

- Definitions

- Port

- A port is an interface between the equipment and the external electromagnetic environment



- The enclosure port is the physical boundary of the equipment through which electromagnetic fields may radiate or impinge on.
      - A power port is the connection to a conductor or cable carrying the primary electrical power needed for the operation (functioning) of equipment
      - An I/O port is any connection to input, output, or bidirectional measurement, control, data or communications signals (i.e. any function not associated with power or earth).
      - The earth port is a port connected to local earth for functional (not safety) purposes.

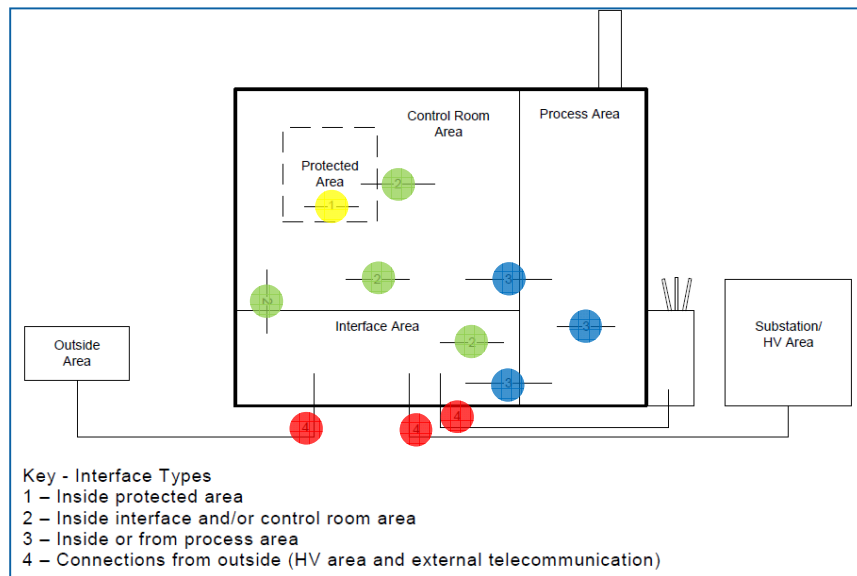


# International EMC Requirements

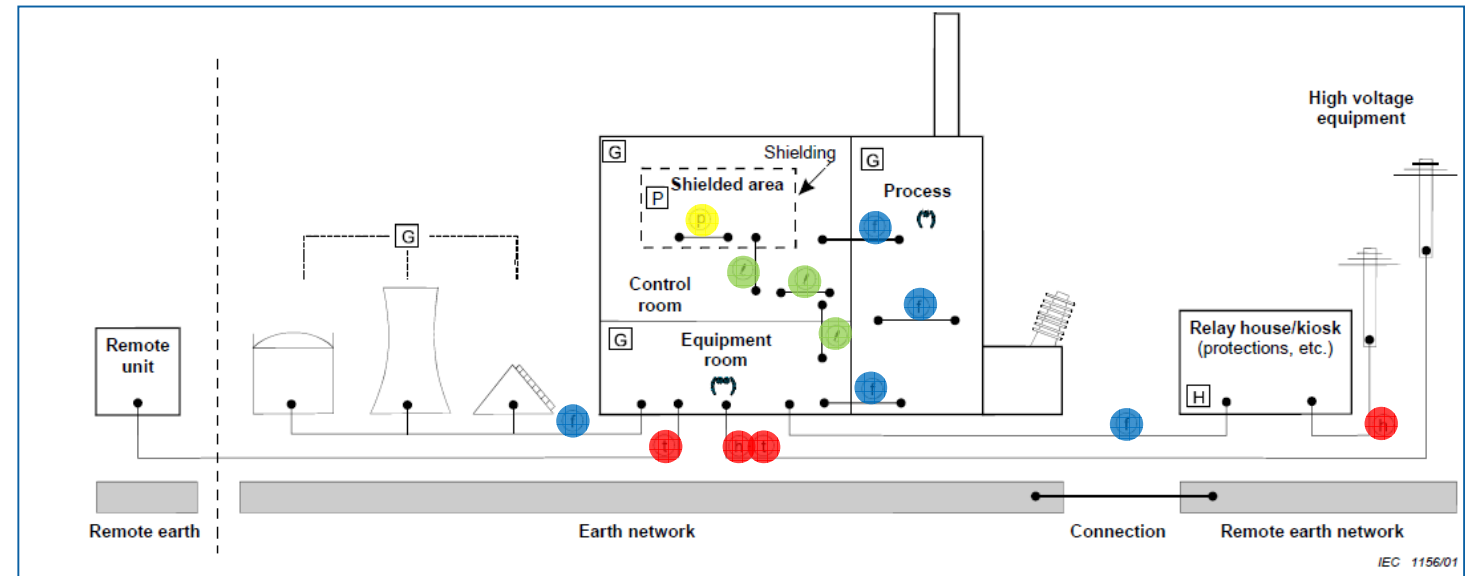
- Definitions

- I/O Port Types for Power Stations and Substations

- The difference in definitions makes comparisons difficult.



IEC 61000-6-5



IEC 1156/01

\* Boiler, generator, turbine, switchgear, MV substations, etc.      \*\* Control apparatus, electric relays, transducer relays, etc.  
 Type of location for enclosure, power supply and functional earth ports

**G** Normal location in power stations and MV substations – examples are control room, equipment room and process area.

**H** Normal location in HV substations – examples are control building, relay house and switchyard area.

**P** Protected location, if any – example is a shielded area in the control room.

Type of signal port connections

**l** Local – examples are connections within a control room or equipment room.

**f** Field – examples are connections between process and equipment room.

**h** HV equipment – examples are connections to circuit breakers, voltage/current transformers, etc.

**t** Telecommunication – examples are connections to power line carrier or remote terminal units.

**p** Protected, if any – examples are connections inside a shielded room.

IEC 61850-3

# International EMC Requirements

- Emissions

Test	Test Port	Test Conditions	IEC 61000-6-4:2007 - Emission standard for industrial environments			IEC 60255-26:2013 (Ed 3.0) - Measuring relays and protection equipment - Part 26: Electromagnetic compatibility requirements			IEC 61850-3:2013 - Communications networks and systems in substations			
			Test Method Standard	Test Levels	Notes	Test Method Standard	Test Levels	Notes	Test Method Standard	Test Levels	Notes	
Conducted RF Emissions	AC Power Mains	150 kHz - 500 kHz	CISPR 16-2-1:2003, 7.4.1 (defines arrangement)	66 dBuV/m AV	Class A	CISPR 22:2008 (Ed 6.0)	66 dBuV/m AV	Class A	CISPR 22:2008 (Ed 6.0)	66 dBuV/m AV	Class A	
		500 kHz - 30 MHz		79 dBuV/m QP			79 dBuV/m QP			79 dBuV/m QP		
		150 kHz - 500 kHz	CISPR 16-1-2:2003, 4.3 (defines AMN)	60 dBuV/m AV	60 dBuV/m AV		60 dBuV/m AV					
		500 kHz - 5 MHz		73 dBuV/m QP	73 dBuV/m QP		73 dBuV/m QP					
	5 MHz - 30 MHz											
	DC Power Mains	150 kHz - 500 kHz				CISPR 11:2010 (Ed 5.1)	66 dBuV/m AV	Class A	CISPR 22:2008 (Ed 6.0)	66 dBuV/m AV	Class A	
		500 kHz - 30 MHz			60 dBuV/m AV		60 dBuV/m AV					
		150 kHz - 500 kHz			73 dBuV/m QP		73 dBuV/m QP	73 dBuV/m QP				
		500 kHz - 5 MHz										
	5 MHz - 30 MHz											
	I/O, Signal, Control & Functional Earth	150 kHz - 500 kHz										
		500 kHz - 30 MHz										
I/O, Signal & Control (connected to mains)	150 kHz - 500 kHz											
	500 kHz - 30 MHz											
Communication	150 kHz - 500 kHz	CISPR 22:2008 (Ed 6.0)	84-74 dBuV AV	Class A				CISPR 22:2008 (Ed 6.0)	84-74 dBuV AV	Class A		
	500 kHz - 30 MHz		97-87 dBuV, QP			97-87 dBuV, QP			97-87 dBuV, QP			
	150 kHz - 500 kHz	74 dBuV, AV	74 dBuV, AV	74 dBuV, AV								
	500 kHz - 30 MHz	87 dBuV, QP	87 dBuV, QP	87 dBuV, QP								
Radiated RF Emissions	Enclosure	30 MHz - 230 MHz	CISPR 16-2-3 (latest)	40 dBuV/m QP @ 10 m	Class A	CISPR 11:2010 (Ed 5.1)	40 dBuV/m QP @ 10 m	Class A	CISPR 22:2008 (Ed 6.0)	40 dBuV/m QP @ 10 m	Class A	
		230 MHz - 1 GHz		47 dBuV/m QP @ 10 m			47 dBuV/m QP @ 10 m			47 dBuV/m QP @ 10 m		
		1 GHz - 3 GHz					56 dBuV/m AV @ 3 m			56 dBuV/m AV @ 3 m		56 dBuV/m AV @ 3 m
		3 GHz - 6 GHz					76 dBuV/m QP @ 3 m			76 dBuV/m QP @ 3 m		76 dBuV/m QP @ 3 m
		30 MHz - 230 MHz					60 dBuV/m AV @ 3 m			60 dBuV/m AV @ 3 m		60 dBuV/m AV @ 3 m
		230 MHz - 1 GHz					80 dBuV/m QP @ 3 m			80 dBuV/m QP @ 3 m		80 dBuV/m QP @ 3 m
		1 GHz - 3 GHz										
		3 GHz - 6 GHz										

# International EMC Requirements

- Emissions

Test	Test Port	Test Conditions	IEC 61000-6-4:2007 - Emission standard for industrial environments			IEC 60255-26:2013 (Ed 3.0) - Measuring relays and protection equipment - Part 26: Electromagnetic compatibility requirements			IEC 61850-3:2013 - Communications networks and systems in substations		
			Test Method Standard	Test Levels	Notes	Test Method Standard	Test Levels	Notes	Test Method Standard	Test Levels	Notes
Conducted RF Emissions	AC Power Mains	150 kHz - 500 kHz	CISPR 16-2-1:2003, 7.4.1 (defines arrangement)	66 dBuV/m AV	Class A	CISPR 22:2008 (Ed 6.0)	66 dBuV/m AV	Class A	CISPR 22:2008 (Ed 6.0)	66 dBuV/m AV	Class A
		500 kHz - 30 MHz		79 dBuV/m QP			79 dBuV/m QP			79 dBuV/m QP	
		150 kHz - 500 kHz	CISPR 16-1-2:2003, 4.3 (defines AMN)	60 dBuV/m AV	60 dBuV/m AV		60 dBuV/m AV				
		500 kHz - 5 MHz		73 dBuV/m QP	73 dBuV/m QP		73 dBuV/m QP				
	DC Power Mains									66 dBuV/m AV	Class A
										79 dBuV/m QP	
		I/O, Signal, Control & Functional Earth								60 dBuV/m AV	
		I/O, Signal & Control (connected to mains)								73 dBuV/m QP	
		Communication								84-74 dBuV AV	Class A
										97-87 dBuV, QP	
									74 dBuV, AV	Class A	
									87 dBuV, QP	Class A	
Radiated RF Emissions	Enclosure	500 kHz - 30 MHz									
		30 MHz - 230 MHz	CISPR 16-2-3 (latest)	40 dBuV/m QP @ 10 m	Class A	CISPR 11:2010 (Ed 5.1)	40 dBuV/m QP @ 10 m	Class A	CISPR 22:2008 (Ed 6.0)	40 dBuV/m QP @ 10 m	Class A
		230 MHz - 1 GHz		47 dBuV/m QP @ 10 m	Class A		47 dBuV/m QP @ 10 m	Class A		47 dBuV/m QP @ 10 m	Class A
		1 GHz - 3 GHz					56 dBuV/m AV @ 3 m	Class A		56 dBuV/m AV @ 3 m	Class A
		3 GHz - 6 GHz					76 dBuV/m QP @ 3 m			76 dBuV/m QP @ 3 m	
		30 MHz - 230 MHz					60 dBuV/m AV @ 3 m	Class A		60 dBuV/m AV @ 3 m	Class A
		230 MHz - 1 GHz					80 dBuV/m QP @ 3 m			80 dBuV/m QP @ 3 m	
		1 GHz - 3 GHz									
3 GHz - 6 GHz											

**Conducted RF Emissions**  
 AC Power: Meet Class A levels using CISPR 11/22.  
 DC Power: Meet Class A levels using CISPR 11/22.  
 Telecom Ports: Meet Class A levels using CISPR /22.

**Radiated RF Emissions**  
 Meet Class A levels using CISPR 11/22.

# International EMC Requirements

- Immunity
  - Enclosure Port

			IEC 61000-6-2		IEC 61000-6-5:CD (2014)		IEC 60255-26:2013		IEC 61850-3:2013	
			2005	CD (2015)	PS	SS	Zone B	Zone A	PS & MV SS	HV SS
Power Frequency Magnetic Field Immunity	IEC 61000-4-8	Continuous	30 A/m	30 A/m	100 A/m	100 A/m	30 A/m	30 A/m	100 A/m	100 A/m
		1 second	-	-	1 kA/m	1 kA/m	300 A/m	300 A/m	1 kA/m	1 kA/m
Radiated RF Field Immunity	IEC 61000-4-3	80 MHz to 1 GHz, 80% AM (1 kHz)	10 V/m	10 V/m	10 V/m	10 V/m	10 V/m	10 V/m	10 V/m	10 V/m
		1.0 GHz to 2.7 GHz, 80% AM (1 kHz)	3 V/m	3 V/m	3 V/m	3 V/m	10 V/m	10 V/m	10 V/m	10 V/m
		2.7 GHz to 6.0 GHz, 80% AM (1 kHz)	1 V/m	3 V/m	1 V/m	1 V/m	-	-	-	-
Electrostatic Discharge	IEC 61000-4-2	Contact Discharge	4 kV	4 kV	6 kV	6 kV	6 kV	6 kV	6 kV	6 kV
		Air Discharge	8 kV	8 kV	8 kV	8 kV	8 kV	8 kV	8 kV	8 kV

- Power frequency magnetic field immunity is harmonized between 61000-6-5 and 61850-3 with lesser levels for 60255-26.
- Radiated RF field immunity is harmonized below 1 GHz but varies above 1 GHz.
- ESD is harmonized between all three Energy standards.

# International EMC Requirements

- Immunity
  - No consistent harmonization between standards.
  - Comparison of all the standards is difficult.
  - Immunity discussion will focus on the new version of the generic standard covering immunity requirements for power station and substation environments

IEC 61000-6-5:201x {Ed 1.0}

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- Immunity
  - No consistent harmonization between standards.
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IEC 61000-6-5:201x {Ed 1.0}

**Warning! There are significant differences between IEC 61000-6-5 and other existing standards.**

# IEC 61000-6-5:201x {Ed 1.0}

## IEC 61000-6-5:201x {Ed 1.0}

- This document covers the EMC immunity for equipment used in power stations and in MV and HV Substations
- The existing document is a TS and was published in 2001
- It has been decided to upgrade this document to contain up-to-date environment information (from 61000-2-5) and to make it an International Standard
  - The CDV was circulated in early 2014 and it at FDIS stage
- When completed this generic standard will apply to all equipment not covered by a product EMC standard
  - According to IEC Guide 107, product committees will have the choice of using this generic standard or developing a specific product EMC standard



## IEC 61000-6-5:201x {Ed 1.0}

- Several EMC product standards have been published by IEC technical committees dealing with different application areas in the generation, transmission and distribution of electricity and related telecommunication systems, including
  - switchgear and control gear (TC 17),
  - instrument transformers (TC 38),
  - nuclear instrumentation (TC 45),
  - power systems management and associated information exchange (TC 57),
  - industrial-process measurement and control – system aspects (SC 65A),
  - measuring relays and protection equipment (TC 95)

# IEC 61000-6-5:201x {Ed 1.0}

- Characterization of the electromagnetic phenomena
  - Continuous phenomena are typically sinusoidal or modulated sinusoids.
  - High-occurrence transient phenomena are byproducts of normal power grid operation.
  - Low-occurrence transient phenomena are byproducts of abnormal power grid operation or the impact of natural electromagnetic environmental effects.

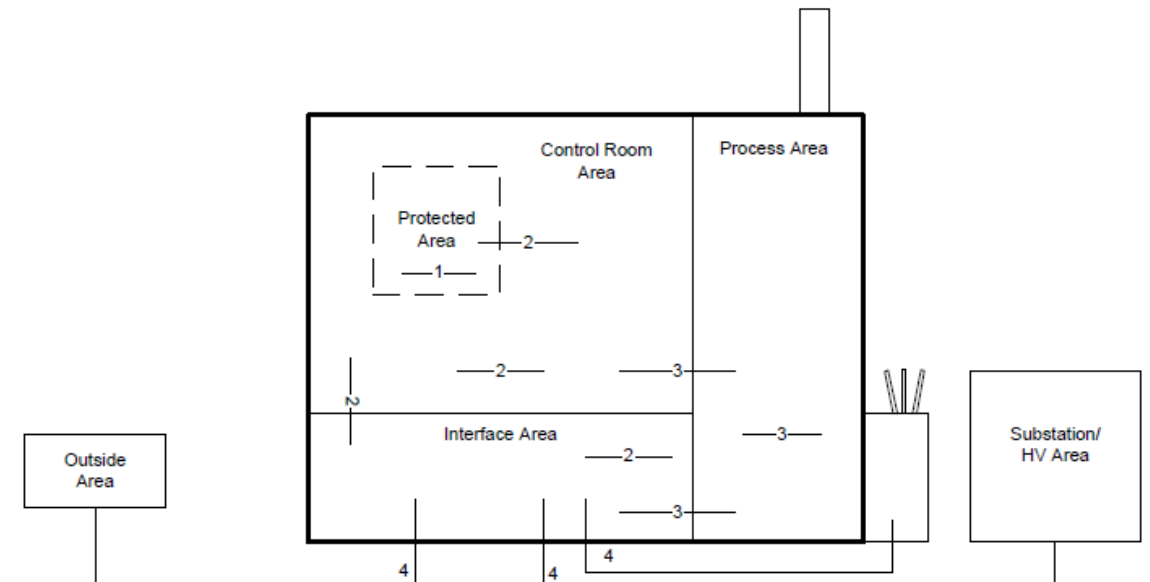
Continuous phenomena	Transient phenomena with high occurrence	Transient phenomena with low occurrence
Voltage variations: – a.c. power supply – d.c. power supply <sup>a</sup>	Voltage dips (duration ≤0,02 s): – a.c. power supply – d.c. power supply	Voltage dips (duration >0,02 s): – a.c. power supply – d.c. power supply
Harmonics, interharmonics <sup>a</sup>	Voltage fluctuations	Voltage interruptions: – a.c. power supply – d.c. power supply
Signalling voltages <sup>a</sup>	Fast transient/burst	Short duration power frequency variation <sup>a,b</sup>
Ripple on d.c. power supply	Damped oscillatory/ring wave	Surge
Power frequency variation <sup>a</sup>	Damped oscillatory magnetic field	Short duration power frequency voltage
Conducted disturbances in the range 2 to 150 kHz <sup>a</sup>	Electrostatic discharge	Short duration power frequency magnetic fields (according to IEC 61000-4-8)
Conducted disturbances in the range 1,6 to 30 MHz <sup>a</sup>		Radiated pulsed disturbances
Power frequency magnetic field (according to IEC 61000-4-8)		
Radiated, radio frequency electromagnetic field		
Conducted disturbances, induced by radio-frequency fields		
Mains frequency voltage (according to IEC 61000-4-16)		

<sup>a</sup> Not covered in this standard by dedicated immunity requirements.

<sup>b</sup> In case of islanded systems (e.g. not connected to a public network), the characterization of the phenomenon changes from "low occurrence" to "high occurrence".

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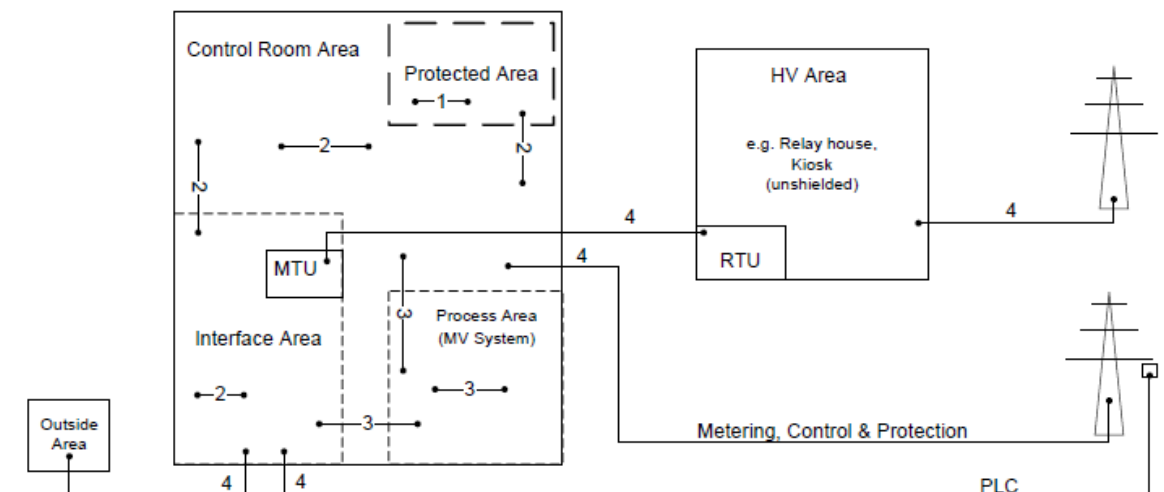
- Power Station interface types
  - Process Area contains e.g. boiler, generator, turbine, switchgear, large drives, converters, etc.
  - Control Room Area contains e.g. control systems, computers, fire fighting systems, UPS, etc.
  - Protected Area contains e.g. special sensitive equipment like routers, special computers, etc.
  - Interface Area contains e.g. equipment and systems connected to the outside with measures like surge protection and bonding of cable shields.
  - Outside Area can contain additional process equipment or environmental metering, signaling, etc.
  - High Voltage Area contains e.g. circuit breakers, bus bars, disconnectors, metering etc.



- Key - Interface Types
- 1 – Inside protected area
  - 2 – Inside interface and/or control room area
  - 3 – Inside or from process area
  - 4 – Connections from outside (HV area and external telecommunication)

# IEC 61000-6-5:201x {Ed 1.0}

- Air Insulated Substation interface types
  - Control Room Area can be a dedicated house or only a relay house that contains control systems, computers, fire fighting systems, UPS, etc.
  - Relay House / Kiosk contains protection relays, marshalling kiosks for PTs/CTs.
  - Protected Area contains e.g. special sensitive equipment like routers, special computers, etc.
  - Process Area contains mainly MV systems (if available) with circuit breakers and MV-busbars.
  - Interface Area contains equipment and systems connected to the outside with measures like surge protection and bonding of cable shields.
  - High Voltage Area contains circuit breakers, bus bars, disconnectors, metering, UPS, etc.
  - Outside Area are e.g. control centers.

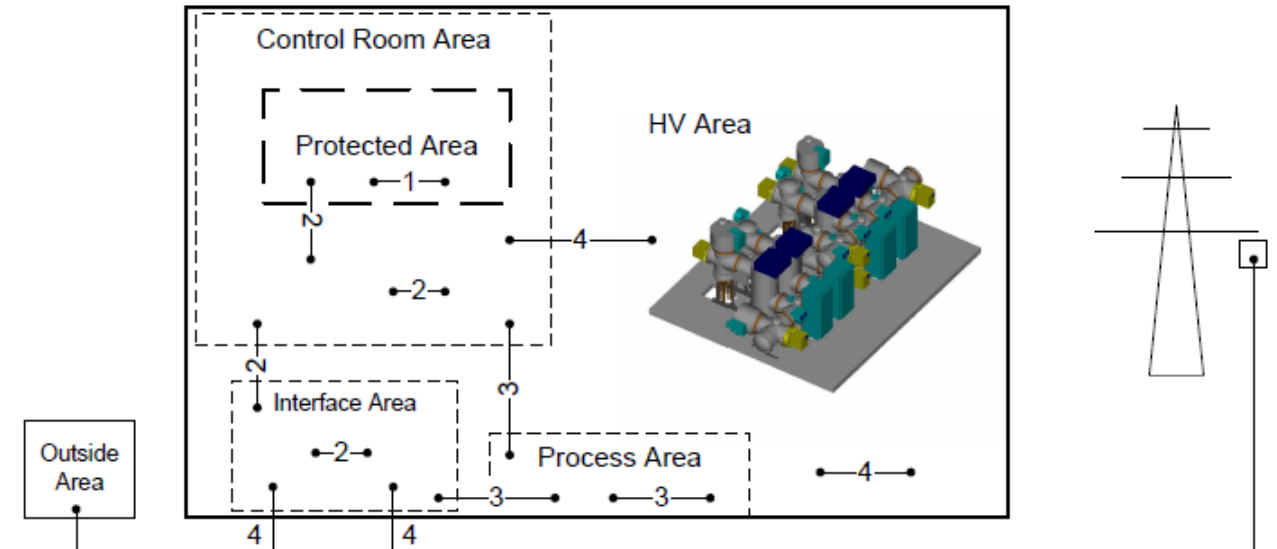


Key - Interface Types

- 1 - Inside protected area
- 2 - Inside interface and/or control room area
- 3 - Inside or from process area
- 4 - Connections from outside (HV and external telecommunication)

# IEC 61000-6-5:201x {Ed 1.0}

- Gas Insulated Substation interface types
  - Control Room Area contains control systems, computers, fire fighting systems, UPS, etc.
  - Process Area contains mainly MV systems with circuit breakers and MV-busbars.
  - Protected Area contains e.g. special sensitive equipment like routers, special computers, etc.
  - Interface Area contains equipment and systems connected to the outside with measures like surge protection and bonding of cable shields.
  - Outside Area are e.g. control centers.
  - HV Area contains GIS, earthing bus bars, transformers, etc.



- Key - Interface Types
- 1 - Inside protected area
  - 2 - Inside interface and/or control room area
  - 3 - Inside or from process area
  - 4 - Connections from outside (HV and external telecommunication)

# IEC 61000-6-5:201x {Ed 1.0}

- Performance Criteria

- Performance criterion A: The equipment shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the equipment is used as intended
- Performance criterion B: The equipment shall continue to operate as intended after the test.
- Performance criterion C: Temporary loss of function is allowed, provided the function is self-recoverable or can be restored by the operation of the controls.

Suggested performance criteria for some representative functions

Functions <sup>a</sup>	Functional requirements versus electromagnetic phenomena		
	Continuous phenomena	Transient phenomena with high occurrence	Transient phenomena with low occurrence
Protection and teleprotection <sup>b</sup>	A	A	A
On-line processing and regulation	A	A	A
High speed communication	A	A	A
Metering	A	A	A
Command and control	A	A	B - Short delay <sup>d</sup>
Supervision	A	A	B - Temporary loss, self recovered <sup>e</sup>
Man-machine interface	A	A	C - Stop and reset <sup>f</sup>
Alarm	A	A - Short delay <sup>g</sup> , temporary wrong indication	
Data transmission and telecommunication <sup>c</sup>	A	A - No loss, possible bit error rate degradation <sup>h</sup>	B - Temporary loss <sup>h</sup>
Data acquisition and storage	A	B - Temporary degradation <sup>e, i</sup>	
Measurement	A	B - Temporary degradation, self recovered <sup>l</sup>	
Off-line processing	A	B - Temporary degradation <sup>i</sup>	C - Temporary loss and reset <sup>l</sup>
Passive monitoring	A	B - Temporary degradation	C - Temporary loss
Self-diagnosis	A	B - Temporary loss, self recovered <sup>k</sup>	

# IEC 61000-6-5:201x {Ed 1.0}

- Enclosure port

Power Station

Test	Environmental phenomena	Basic standard	Test specifications <sup>a</sup> Remarks
1.1	Power frequency magnetic field <sup>b</sup>	IEC 61000-4-8	100 A/m (continuous) <sup>c</sup> 1 kA/m for 1 s
1.2	Radiated, radio frequency electromagnetic field	IEC 61000-4-3	80 MHz to 1,0 GHz 10 V/m <sup>d</sup> 80 % AM (1 kHz)
1.3	Radiated, radio frequency electromagnetic field	IEC 61000-4-3	1 GHz to 2,7 GHz 3 V/m <sup>d</sup> 80 % AM (1 kHz)
1.4	Radiated, radio frequency electromagnetic field	IEC 61000-4-3	2,7 GHz to 6 GHz <sup>e</sup> 1 V/m <sup>d</sup> 80 % AM (1 kHz)
1.5	Electrostatic discharge	IEC 61000-4-2	6 kV (contact discharge) <sup>f</sup> 8 kV (air discharge) <sup>f</sup>
<sup>a</sup> Applicable performance criteria are defined in Table 2. <sup>b</sup> Applicable only to equipment containing devices susceptible to magnetic fields (e.g. Hall elements, magnetic field sensors) <sup>c</sup> In case of CRT monitors which are used in protected areas, the test level 3 A/m (continuous) shall be applied. <sup>d</sup> The test level specified is the r.m.s. value of the unmodulated carrier. <sup>e</sup> The test needs to be performed in those frequency ranges only which are given in Table 11. <sup>f</sup> See basic standard for applicability of contact and/or air discharge tests.			

Substation

Test	Environmental phenomena	Basic standard	Test specifications <sup>a</sup> Remarks
1.1	Power frequency magnetic field <sup>b</sup>	IEC 61000-4-8	100 A/m (continuous) <sup>c</sup> 1 kA/m for 1 s
1.2	Radiated, radio frequency electromagnetic field	IEC 61000-4-3	80 MHz to 1,0 GHz 10 V/m <sup>d</sup> 80 % AM (1 kHz)
1.3	Radiated, radio frequency electromagnetic field	IEC 61000-4-3	1 GHz to 2,7 GHz 3 V/m <sup>d</sup> 80 % AM (1 kHz)
1.4	Radiated, radio frequency electromagnetic field	IEC 61000-4-3	2,7 GHz to 6 GHz <sup>e</sup> 1 V/m <sup>d</sup> 80 % AM (1 kHz)
1.5	Electrostatic discharge	IEC 61000-4-2	6 kV (contact discharge) <sup>f</sup> 8 kV (air discharge) <sup>f</sup>
<sup>a</sup> Applicable performance criteria are defined in Table 2. <sup>b</sup> Applicable only to equipment containing devices susceptible to magnetic fields (e.g. Hall elements, magnetic field sensors) <sup>c</sup> In case of CRT monitors which are used in protected areas, the test level 3 A/m (continuous) shall be applied. <sup>d</sup> The test level specified is the r.m.s. value of the unmodulated carrier. <sup>e</sup> The test needs to be performed in those frequency ranges only which are given in Table 11. <sup>f</sup> See basic standard for applicability of contact and/or air discharge tests.			

# IEC 61000-6-5:201x {Ed 1.0}

- Signal ports

Power Station

Test	Environmental phenomena	Basic standard	Test specifications		
			Interface type		
			2	3	4
2.1	Fast transient/burst	IEC 61000-4-4	2 kV 5 kHz or 100 kHz	4 kV 5 kHz or 100 kHz	4 kV 5 kHz or 100 kHz
2.2	Surge <sup>a</sup>	IEC 61000-4-5	1 kV (1,2/50 µs) line to ground	2 kV (1,2/50 µs) line to ground	2 kV (10/700 µs) line to ground
			0,5 kV (1,2/50 µs) line to line	1 kV (1,2/50 µs) line to line	1 kV (10/700 µs) line to line
2.3	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	150 kHz to 80 MHz 10 V <sup>b</sup> 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V <sup>b</sup> 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V <sup>b</sup> 80 % AM (1 kHz)
2.4	Mains frequency voltage <sup>c</sup>	IEC 61000-4-16	10 V continuous 100 V for 1 s	10 V continuous 100 V for 1 s	30 V continuous 300 V for 1 s

Substation

Test	Environmental phenomena	Basic standard	Test specifications		
			Interface type		
			2	3	4
2.1	Fast transient/burst	IEC 61000-4-4	2 kV 5 kHz or 100 kHz	4 kV 5 kHz or 100 kHz	4 kV 5 kHz or 100 kHz
2.2	Surge <sup>a</sup>	IEC 61000-4-5	1 kV (1,2/50 µs) line to ground	2 kV (1,2/50 µs) line to ground	2 kV (10/700 µs) line to ground
			0,5 kV (1,2/50 µs) line to line	1 kV (1,2/50 µs) line to line	1 kV (10/700 µs) line to line
2.3	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	150 kHz to 80 MHz 10 V <sup>b</sup> 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V <sup>b</sup> 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V <sup>b</sup> 80 % AM (1 kHz)
2.4	Mains frequency voltage <sup>c</sup>	IEC 61000-4-16	30 V continuous 300 V for 1 s	30 V continuous 300 V for 1 s	30 V continuous 300 V for 1 s

NOTE: Red boxes highlight differences in test requirements between power stations and substations.



# IEC 61000-6-5:201x {Ed 1.0}

- Signal ports

Power Station

2.5	Conducted common mode disturbances <sup>c</sup>	IEC 61000-4-16	10 V – 1 V 15 Hz – 150 Hz  1 V 150 Hz – 1,5 kHz  1 V – 10 V 1,5 kHz – 15 kHz  10 V 15 kHz – 150 kHz	10 V – 1 V 15 Hz – 150 Hz  1 V 150 Hz – 1,5 kHz  1 V – 10 V 1,5 kHz – 15 kHz  10 V 15 kHz – 150 kHz	no test
2.6	Damped oscillatory wave	IEC 61000-4-18	no test	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz)	2,5 kV (common mode, 1 MHz) <sup>d</sup> 1 kV (differential mode, 1 MHz) <sup>d</sup>
See Figure 2 for information about interface types. Signal port includes lines used for functional earth port. Applicable performance criteria are defined in Table 2.					
<sup>a</sup>	No line-to-line test needed for symmetrical lines and shielded cables as well as data busses shorter than 10 m.				
<sup>b</sup>	The test level specified is the r.m.s. value of the unmodulated carrier.				
<sup>c</sup>	The test level specified is the r.m.s. value.				
<sup>d</sup>	Applicable only to connections to power line carrier.				

Substation

2.6	Damped oscillatory wave	IEC 61000-4-18	1 kV (common mode, 1 MHz) 0,5 kV (differential mode, 1 MHz)	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz)	2,5 kV (common mode, 1 MHz) <sup>d</sup> 1 kV (differential mode, 1 MHz) <sup>d</sup>
See Figure 3 and Figure 4 for information about interface types. Signal port includes lines used for functional earth port. Applicable performance criteria are defined in Table 2.					
<sup>a</sup>	No line-to-line test needed for symmetrical lines and shielded cables as well as data busses shorter than 10 m.				
<sup>b</sup>	The test level specified is the r.m.s. value of the unmodulated carrier.				
<sup>c</sup>	The test level specified is the r.m.s. value.				
<sup>d</sup>	Applicable only to connections to power line carrier.				

NOTE: Red boxes highlight differences in test requirements between power stations and substations.

# IEC 61000-6-5:201x {Ed 1.0}

- A.C. Power Input and Output ports

Power Station

Test	Environmental phenomena	Basic standard	Test specifications		
			Interface type		
			2	3	4
3.1	Fast transient/burst	IEC 61000-4-4	2 kV 5 kHz or 100 kHz	4 kV 5 kHz or 100 kHz	4 kV 5 kHz or 100 kHz
3.2	Surge	IEC 61000-4-5	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground
			1 kV (1,2/50 μs) line to line	1 kV (1,2/50 μs) line to line	1 kV (1,2/50 μs) line to line
3.3	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	150 kHz to 80 MHz 10 V <sup>a</sup> 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V <sup>a</sup> 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V <sup>a</sup> 80 % AM (1 kHz)
3.4	Voltage dips and voltage interruptions <sup>b</sup>	IEC 61000-4-11 <sup>c</sup>	ΔU = 30 % for 1 period	ΔU = 30 % for 1 period	ΔU = 30 % for 1 period
		IEC 61000-4-34 <sup>d</sup>	ΔU = 60 % for 50 periods <sup>e</sup> ΔU = 100 % for 5 periods ΔU = 100 % for 50 periods <sup>e</sup>	ΔU = 60 % for 50 periods <sup>e</sup> ΔU = 100 % for 5 periods ΔU = 100 % for 50 periods <sup>e</sup>	ΔU = 60 % for 50 periods <sup>e</sup> ΔU = 100 % for 5 periods ΔU = 100 % for 50 periods <sup>e</sup>

Substation

Test	Environmental phenomena	Basic standard	Test specifications		
			Interface type		
			2	3	4
3.1	Fast transient/burst	IEC 61000-4-4	2 kV 5 kHz or 100 kHz	4 kV 5 kHz or 100 kHz	4 kV 5 kHz or 100 kHz
3.2	Surge	IEC 61000-4-5	2 kV (1,2/50 μs) line to ground	4 kV (1,2/50 μs) line to ground	4 kV (1,2/50 μs) line to ground
			1 kV (1,2/50 μs) line to line	2 kV (1,2/50 μs) line to line	2 kV (1,2/50 μs) line to line
3.3	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	150 kHz to 80 MHz 10 V <sup>a</sup> 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V <sup>a</sup> 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V <sup>a</sup> 80 % AM (1 kHz)
3.4	Voltage dips and voltage interruptions <sup>b</sup>	IEC 61000-4-11 <sup>c</sup>	ΔU = 30 % for 1 period	ΔU = 30 % for 1 period	ΔU = 30 % for 1 period
		IEC 61000-4-34 <sup>d</sup>	ΔU = 100 % for 5 periods	ΔU = 100 % for 5 periods	ΔU = 100 % for 5 periods

NOTE: Red boxes highlight differences in test requirements between power stations and substations.

# IEC 61000-6-5:201x {Ed 1.0}

- A.C. Power Input and Output ports

Power Station

3.5	Damped oscillatory wave	IEC 61000-4-18	no test	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)
See Figure 2 for information about interface types. For equipment with input current rating > 16 A, the tests should be limited to the power port of electronic units/modules, etc. Applicable performance criteria are defined in Table 2.					
<sup>a</sup>	The test level specified is the r.m.s. value of the unmodulated carrier.				
<sup>b</sup>	Not applicable to low voltage a.c. output power ports.				
<sup>c</sup>	Applicable to equipment with mains current ≤ 16 A per phase.				
<sup>d</sup>	Applicable to equipment with mains current more than 16 A per phase.				
<sup>e</sup>	Applicable only to power ports directly connected to public low-voltage supply network.				

Substation

3.5	Damped oscillatory wave	IEC 61000-4-18	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)
See Figure 3 and Figure 4 for information about interface types. For equipment with input current rating > 16 A, the tests should be limited to the power port of electronic units/modules, etc. Applicable performance criteria are defined in Table 2.					
<sup>a</sup>	The test level specified is the r.m.s. value of the unmodulated carrier.				
<sup>b</sup>	Not applicable to low voltage a.c. output power ports.				
<sup>c</sup>	Applicable to equipment with mains current ≤ 16 A per phase.				
<sup>d</sup>	Applicable to equipment with mains current more than 16 A per phase.				

NOTE: Red boxes highlight differences in test requirements between power stations and substations.

# IEC 61000-6-5:201x {Ed 1.0}

- D.C. Power Input and Output ports

Power Station

Test	Environmental phenomena	Basic standard	Test specifications		
			Interface type		
			2	3	4
4.1	Fast transient/burst	IEC 61000-4-4	2 kV 5 kHz or 100 kHz	4 kV 5 kHz or 100 kHz	4 kV 5 kHz or 100 kHz
4.2	Surge	IEC 61000-4-5	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground
			1 kV (1,2/50 μs) line to line	1 kV (1,2/50 μs) line to line	1 kV (1,2/50 μs) line to line
4.3	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	150 kHz to 80 MHz 10 V <sup>a</sup> 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V <sup>a</sup> 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V <sup>a</sup> 80 % AM (1 kHz)
4.4	Mains frequency voltage <sup>b</sup>	IEC 61000-4-16	10 V continuous 100 V for 1 s	10 V continuous 100 V for 1 s	30 V continuous 300 V for 1 s
4.5	Ripple on d.c. power supply	IEC 61000-4-17	10 % U <sub>n</sub>	10 % U <sub>n</sub>	10 % U <sub>n</sub>

Substation

Test	Environmental phenomena	Basic standard	Test specifications		
			Interface type		
			2	3	4
4.1	Fast transient/burst	IEC 61000-4-4	2 kV 5 kHz or 100 kHz	4 kV 5 kHz or 100 kHz	4 kV 5 kHz or 100 kHz
4.2	Surge	IEC 61000-4-5	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground	2 kV (1,2/50 μs) line to ground
			1 kV (1,2/50 μs) line to line	1 kV (1,2/50 μs) line to line	1 kV (1,2/50 μs) line to line
4.3	Conducted disturbances, induced by radio-frequency fields	IEC 61000-4-6	150 kHz to 80 MHz 10 V <sup>a</sup> 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V <sup>a</sup> 80 % AM (1 kHz)	150 kHz to 80 MHz 10 V <sup>a</sup> 80 % AM (1 kHz)
4.4	Mains frequency voltage <sup>b</sup>	IEC 61000-4-16	30 V continuous 300 V for 1 s	30 V continuous 300 V for 1 s	30 V continuous 300 V for 1 s
4.5	Ripple on d.c. power supply	IEC 61000-4-17	10 % U <sub>n</sub>	10 % U <sub>n</sub>	10 % U <sub>n</sub>

NOTE: Red boxes highlight differences in test requirements between power stations and substations.

# IEC 61000-6-5:201x {Ed 1.0}

- D.C. Power Input and Output ports

Power Station

4.6	Damped oscillatory wave	IEC 61000-4-18	no test	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)
4.7	Voltage dips and voltage interruptions <sup>c</sup>	IEC 61000-4-29	$\Delta U = 30\%$ for 0,1 s $\Delta U = 60\%$ for 0,1 s $\Delta U = 100\%$ for 0,05 s	$\Delta U = 30\%$ for 0,1 s $\Delta U = 60\%$ for 0,1 s $\Delta U = 100\%$ for 0,05 s	$\Delta U = 30\%$ for 0,1 s $\Delta U = 60\%$ for 0,1 s $\Delta U = 100\%$ for 0,05 s
<p>See Figure 2 for information about interface types.</p> <p>For equipment with input current rating &gt; 16 A, the tests should be limited to the power port of electronic units/modules, etc.</p> <p>Applicable performance criteria are defined in Table 2.</p>					
<sup>a</sup>	The test level specified is the r.m.s. value of the unmodulated carrier.				
<sup>b</sup>	The test level specified is the r.m.s. value.				
<sup>c</sup>	Not applicable to low voltage d.c. output power ports.				

Substation

4.6	Damped oscillatory wave	IEC 61000-4-18	no test	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)	2,5 kV (common mode, 1 MHz) 1 kV (differential mode, 1 MHz) 1 kV (differential mode, 10 MHz)
4.7	Voltage dips and voltage interruptions <sup>c</sup>	IEC 61000-4-29	$\Delta U = 30\%$ for 0,1 s $\Delta U = 60\%$ for 0,1 s $\Delta U = 100\%$ for 0,05 s	$\Delta U = 30\%$ for 0,1 s $\Delta U = 60\%$ for 0,1 s $\Delta U = 100\%$ for 0,05 s	$\Delta U = 30\%$ for 0,1 s $\Delta U = 60\%$ for 0,1 s $\Delta U = 100\%$ for 0,05 s
<p>See Figure 3 and Figure 4 for information about interface types.</p> <p>For equipment with input current rating &gt; 16 A, the tests should be limited to the power port of electronic units/modules, etc.</p> <p>Applicable performance criteria are defined in Table 2.</p>					
<sup>a</sup>	The test level specified is the r.m.s. value of the unmodulated carrier.				
<sup>b</sup>	The test level specified is the r.m.s. value.				
<sup>c</sup>	Not applicable to low voltage d.c. output power ports.				

NOTE: Red boxes highlight differences in test requirements between power stations and substations.

# Future Plans

# Future Plans

- IEC 61000-6-5:20xx {Ed x.x}

Electromagnetic phenomenon	Basic standard	Test levels according to basic standard	Remarks
Radiated, radio frequency electromagnetic field	IEC 61000-4-3		Other modulation schemes are being considered and probably higher field strengths (e.g. 30 V/m) for close proximity situations.
Ring wave	IEC 61000-4-12	3	Should be considered for equipment which is likely exposed to oscillatory transients, induced in low-voltage cables due to the switching of electrical networks and reactive loads, faults and insulation breakdown of power supply circuits or lightning.
Differential mode conducted disturbances below 150 kHz	IEC 61000-4-19 <sup>a</sup>	3	Should be considered for equipment sensitive to AC power supply disturbances in the frequency range 2 kHz to 150 kHz, generated for example by PLC systems or power electronic equipment.

# Future Plans

- Additional areas of interest
  - Consider requirements to manage EM attacks due to terrorist activities or military actions.
    - Intentional EMI
    - (H)EMP
  - Consider requirements to manage catastrophic electromagnetic environmental events.
    - Solar effects
    - Geomagnetic storms
    - Regional lightning storms



# Recommendations and Resources

# Recommendations

- Determine the applicable EMC standards for your product and its intended operational electromagnetic environment.
- Purchase and read the standards.
- Derive the EMC applicable requirements, levels, conditions, and test method standards.
- Develop an initial EMC test plan.
- Determine the critical tests for the product.
- Develop an EMC control plan to guide the design for critical tests.
- Follow the EMC control plan.
- Complete the EMC test plan.

# Resources

- Links

- NIST (USA)

- Smart Grid: <http://www.nist.gov/smartgrid/>
    - Smart Grid Interoperability Panel (SGIP): <http://sgip.sitefpo.com/>
    - SGIP EMI Interoperability Working Group: <http://sgip.sitefpo.com/Electromagnetic>

- IEC (International)

- Smart Grid: <http://www.iec.ch/smartgrid>
    - Standards Mapping Tool: <http://smartgridstandardsmap.com/>

- IEEE

- EMC Society, Technical Committee 5: High-power Electromagnetics: <http://www.ewh.ieee.org/soc/emcs/committees/tc05/index.html>

# Questions?