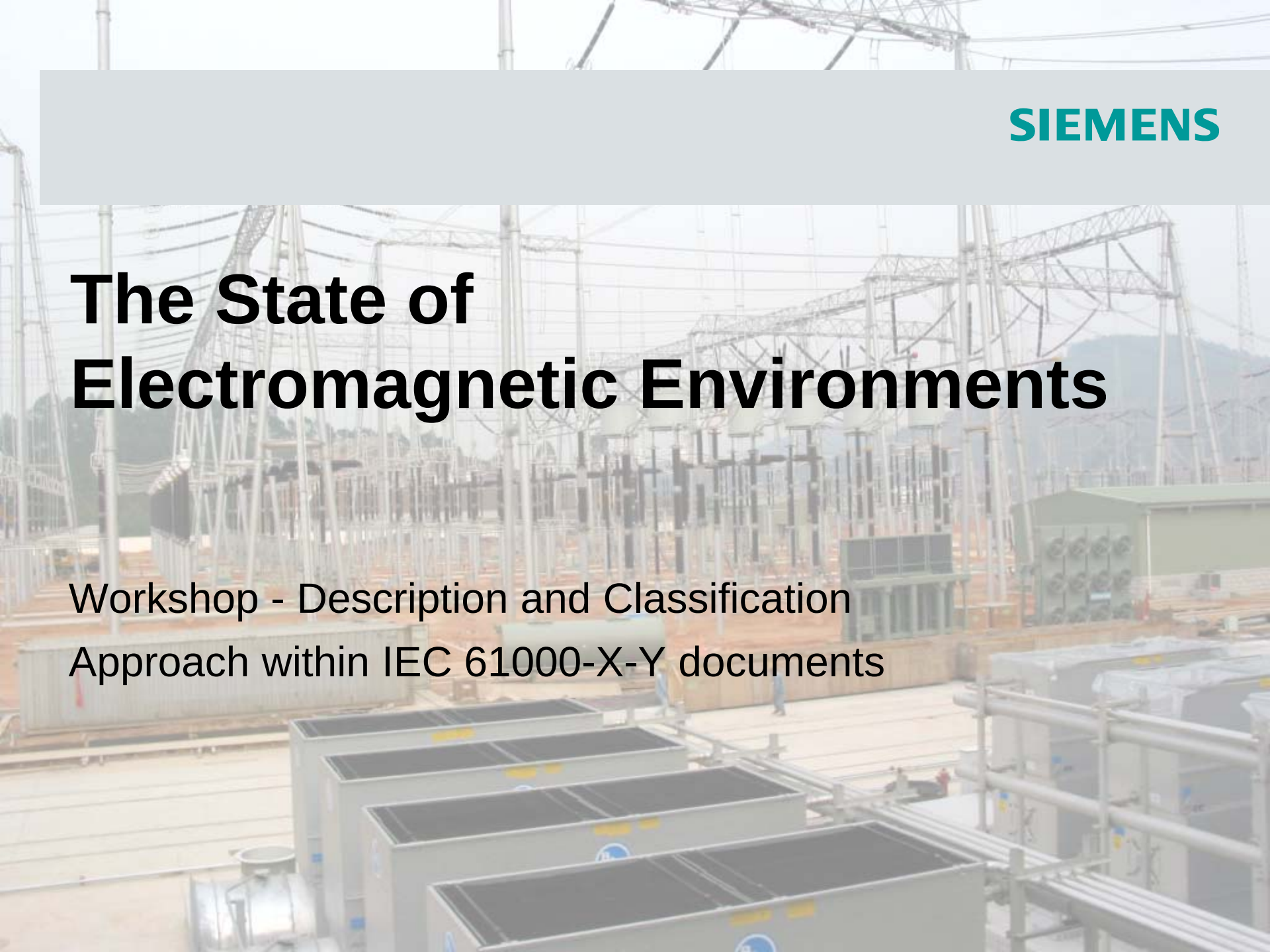
SIEMENS

Welcome

Dr. Bernd Jaekel
Siemens AG – Industry Sector – EMC-Center Erlangen, Germany
e-mail: bernd.jaekel@siemens.com

IEEE EMC 2008
International Symposium on Electromagnetic Compatibility
Detroit, Michigan, US, 18 – 22 August, 2008



SIEMENS

The State of Electromagnetic Environments

Workshop - Description and Classification

Approach within IEC 61000-X-Y documents

SIEMENS

IEEE EMC 2008 – Electromagnetic environments

- Introduction
- Electromagnetic phenomena
- Need for description
- Situation in international standardization
- Document IEC 61000-2-5
- Compatibility levels
- Classification of electromagnetic environments
- Developments in electromagnetic environments
- Summary and conclusion

Definition

(Electromagnetic) Environment:

- Totality of electromagnetic phenomena existing at a given location
  - IEC 600500 – [161-01-01]
  - NOTE 1: In general, this totality is time-dependent and its description might need a statistical approach
  - NOTE 2: (electromagnetic) environment ≠ location

Description of electromagnetic environment

Electromagnetic Phenomena

- Existing at a location
- man-made phenomena
- natural phenomena

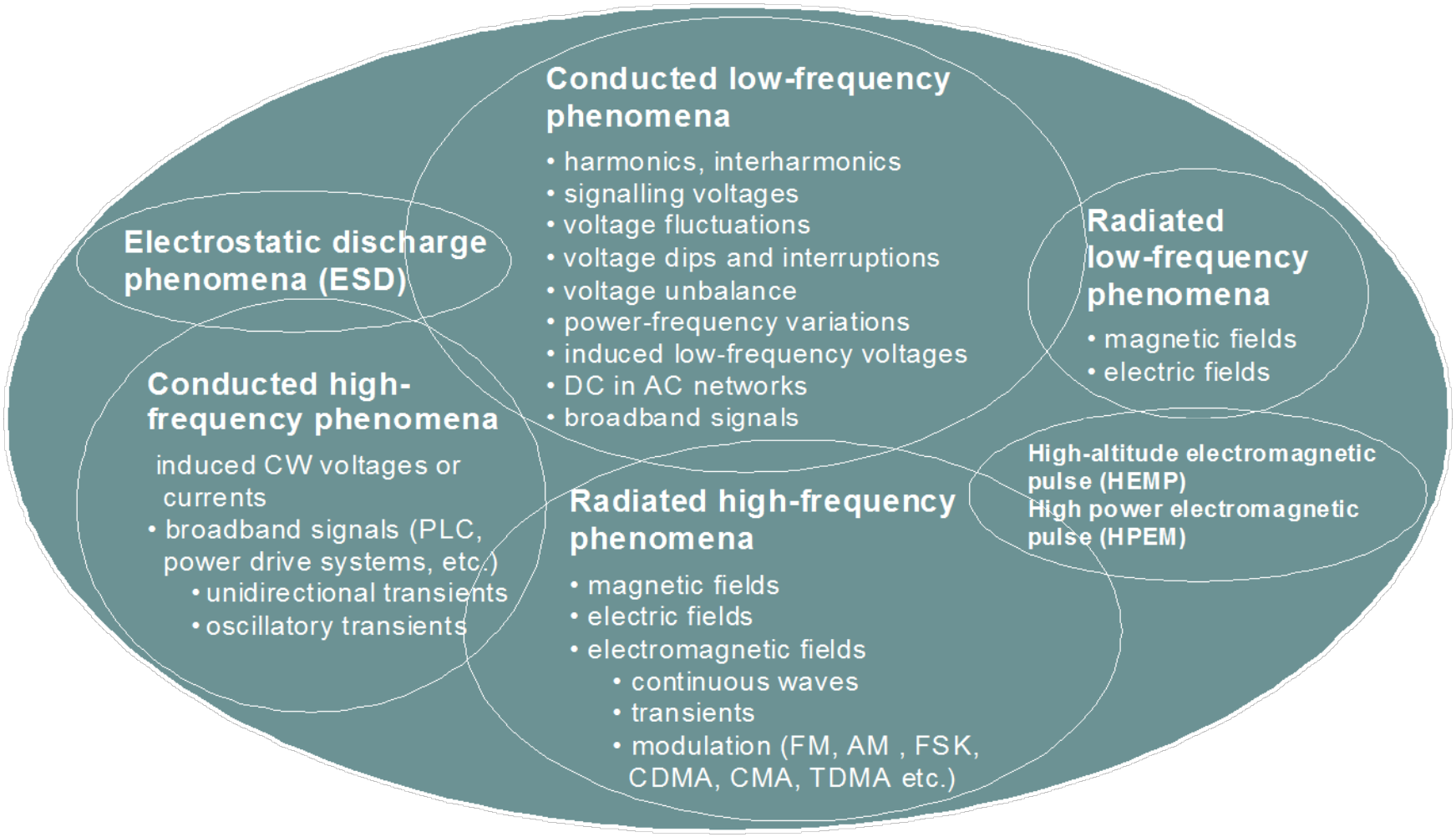
Conditions

- installation
- type of power supply

Methods

- site surveys
- measurements
- technical assessments
- data base

Electromagnetic phenomena



Need of description – EMC

Basic goal: achievement of electromagnetic compatibility

(1) Information about environment is needed in order to specify immunity requirements

(2) This is especially important when safety-related systems are concerned

(3) EMC-Directive of EU requires taking into account electromagnetic environment

Need of description – Documents

Information is needed for equipment design

(1) Not every manufacturer is able to do site surveys for each location for which the equipment is intended

(2) A general description is needed

(3) A “standardized” way of describing the environment is needed

Electromagnetic environment in IEC documents

IEC 61000-1-X	General: general considerations (introduction, fundamental principles), definitions, terminology
IEC 61000-2-X	Environment: description, classification; compatibility levels
IEC 61000-3-X	Emission limits: e.g. harmonics, flicker
IEC 61000-4-X	Testing and measurement techniques
IEC 61000-5-X	Installation and mitigation guidelines
IEC 61000-6-X	Generic standards

Description of electromagnetic phenomena: IEC 61000-2-1

IEC 61000-2-1	Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems	1990
	This report is concerned with conducted disturbances in the frequency range up to 10 kHz with an extension for mains signalling systems. Separate sections give numerical compatibility levels for different system voltage levels. The object is to give information on the various types of disturbances that can be expected on public power supply systems. It is a reference document for those associated parts that give values of compatibility level.	

Description of electromagnetic phenomena: IEC 61000-2-2

IEC 61000-2-2	Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems	2002
	This standard is concerned with conducted disturbances in the frequency range from 0 kHz to 9 kHz, with an extension up to 148,5 kHz specifically for mains signalling systems. It gives compatibility levels for public low voltage a.c. distribution systems having a nominal voltage up to 420 V, single-phase or 690 V, three-phase and a nominal frequency of 50 Hz or 60 Hz. The compatibility levels specified in this standard apply at the point of common coupling. Compatibility levels are specified for disturbances which can be expected in public low voltage power supply systems.	

Description of electromagnetic phenomena: IEC 61000-2-3

IEC 61000-2-3	Radiated and non-network-frequency-related phenomena	1992
	This report is primarily concerned with the characteristics and levels of electromagnetic fields and of non-network-frequency-related conducted emissions from unintentional sources of interference.	

Description of electromagnetic phenomena: IEC 61000-2-4

IEC 61000-2-4	Compatibility levels in industrial plants for low-frequency conducted disturbances	1994
	This standard gives the requirements for the compatibility levels for industrial and non-public networks. These levels are relevant to disturbances that may occur in the electrical power supply in normal operating conditions. It applies to low-voltage and medium-voltage a.c. power supply at 50 Hz/60 Hz. The compatibility levels are given for different electromagnetic environment classes. This standard is in practice a classification of the a.c. supplies associated with industrial and non-public networks.	

Description of electromagnetic phenomena: IEC 61000-2-6

IEC 61000-2-6	**Assessment of the emission levels in the power supply of industrial plants as regards low-frequency conducted disturbances**	**1995**
	This report recommends the procedures to assess the disturbance levels produced by the emission of the devices, equipment and systems installed in non-public networks in industrial environment as far as low-frequency conducted disturbances in the power supply are concerned; it applies to low and medium a.c. non-public supply at 50/60 Hz. The disturbances considered are: harmonics and interharmonics, unbalances, voltage changes and voltage dips.	

Description of electromagnetic phenomena: IEC 61000-2-7

IEC 61000-2-7	**Low frequency magnetic fields in various environments**	**1998**
	Interest in magnetic fields has been stimulated in recent years by concern over the physiological effects they may have on humans and animals and the deleterious effects they have on the performance of some electrical equipment, particularly video display units. Investigations have yielded results which are presented in this report as reference values.	

Description of electromagnetic phenomena: IEC 61000-2-8

IEC 61000-2-8	**Voltage dips and short interruptions on public electric power supply systems with statistical measurement results**	**2002**
	This report describes the electromagnetic disturbance phenomena of voltage dips and short interruptions in terms of their sources, effects, remedial measures, methods of measurement, and measurement results.	

Description of electromagnetic phenomena

IEC 61000-2-9	Description of HEMP environment – Radiated disturbance	1996
IEC 61000-2-10	Description of HEMP environment – Conducted disturbance	1998
IEC 61000-2-11	Classification of HEMP environments	1999

Description of electromagnetic phenomena: IEC 61000-2-12

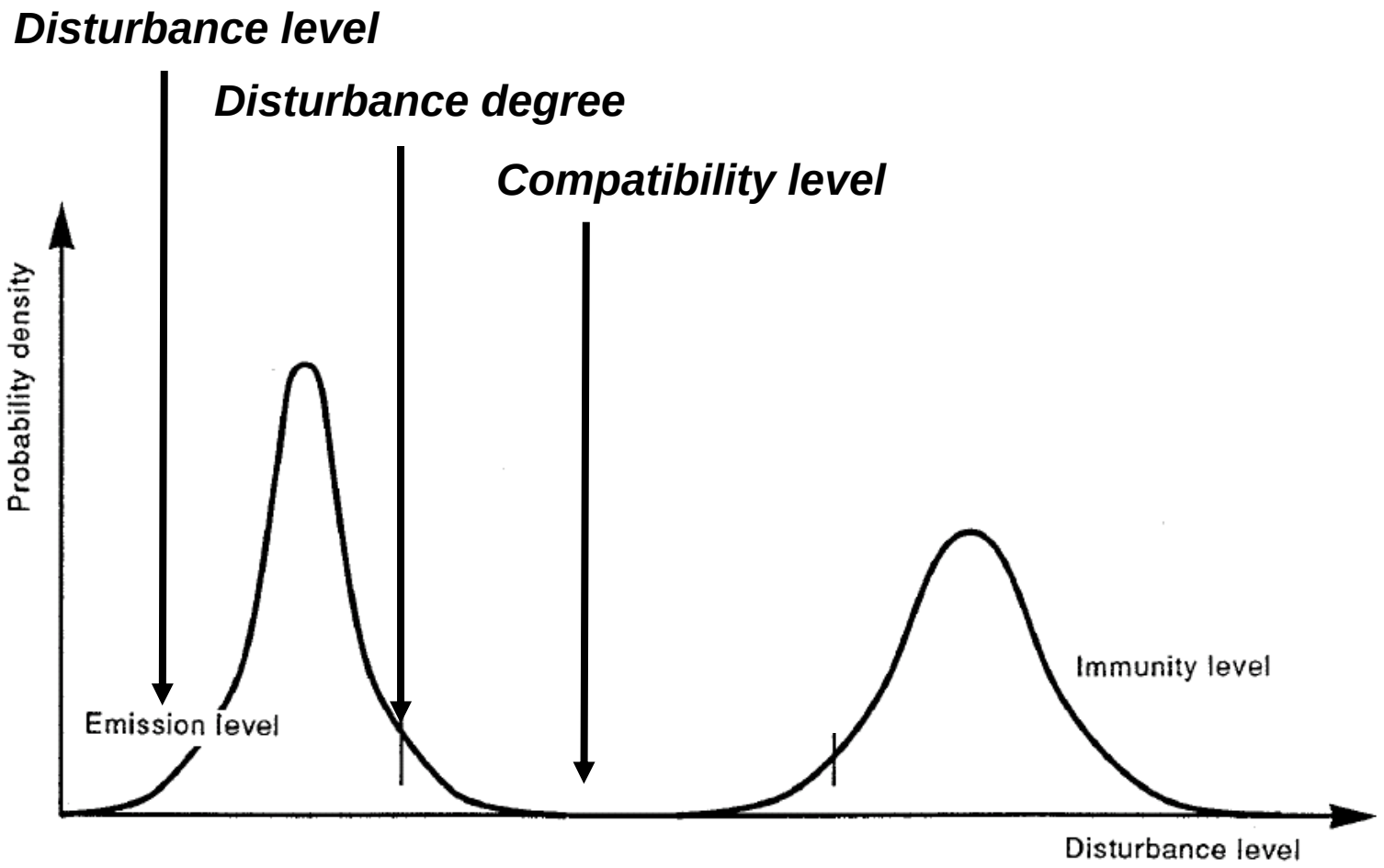
IEC 61000-2-12	Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems	2003
	This part is concerned with conducted disturbances in the frequency range from 0 kHz to 9 kHz, with an extension up to 148,5 kHz specifically for mains signalling systems. It gives compatibility levels for public medium voltage a.c. distribution systems with a nominal voltage between 1 kV and 35 kV. Compatibility levels are specified for disturbances of the types which can be expected in public medium voltage power supply systems.	

Description of electromagnetic phenomena: IEC 61000-2-5

IEC 61000-2-5	Classification of electromagnetic environments – Basic EMC Publication	1995

- User's guide for the report
- Low and high frequency, conducted and radiated phenomena
- Electrostatic discharge
- Classification of environments
- Principles of the selection of immunity levels
- Compatibility levels for typical location classes

Terms from IEC 61000-2-5 (1995) – Ideal situation

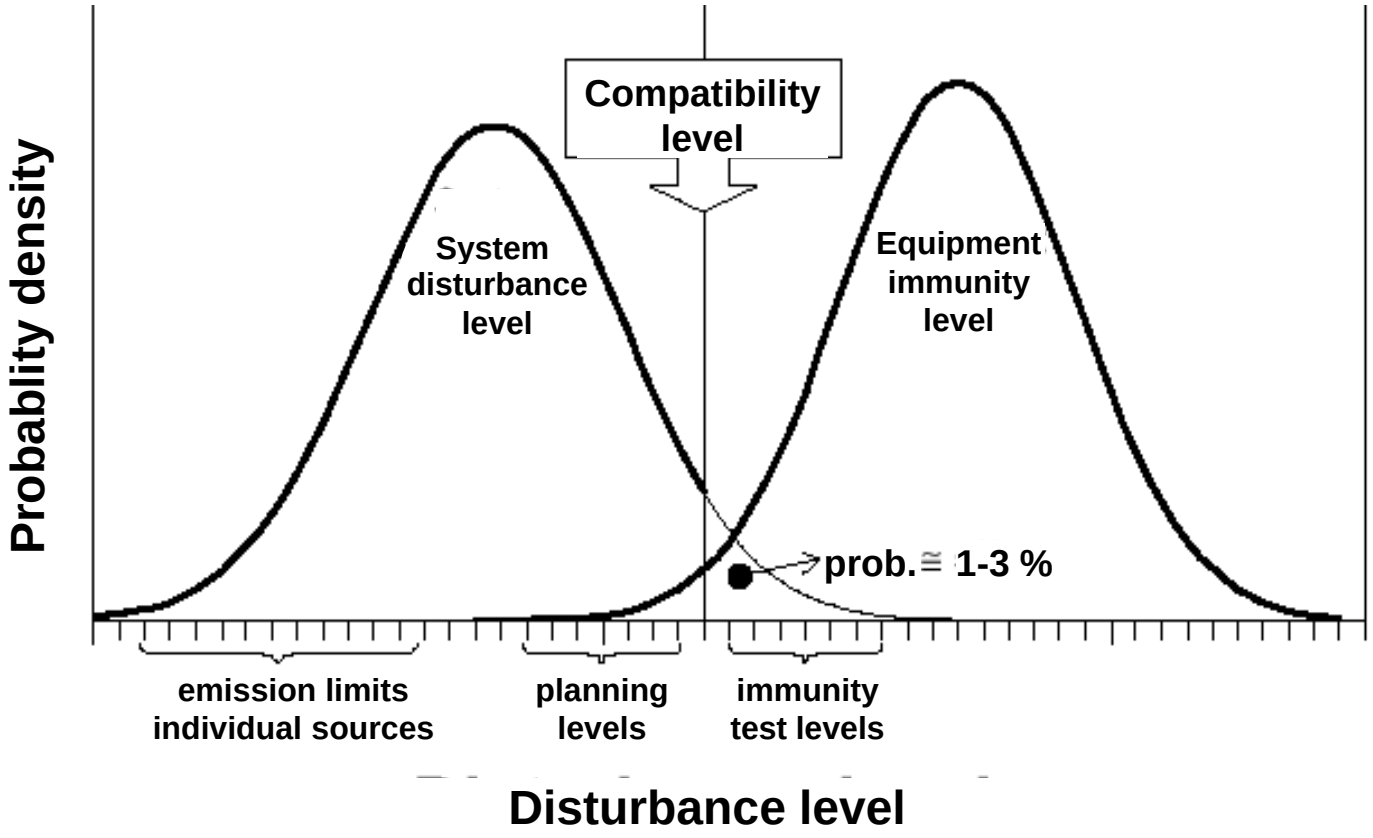


Terms from IEC 61000-2-5 (1995)

Compatibility level:

- specified maximum electromagnetic disturbance level expected to be impressed on a device, equipment or system operated in particular conditions
- but: In practice the compatibility level is not an absolute maximum but may be exceeded by a small probability
- compatibility level is used e.g. for planning or specifications and considers economical constraints

Terms from IEC 61000-2-5 (1995) – Real situation



IEC 61000-2-5 – Example for disturbance degrees (1)

Table 5 – Sources and range of disturbance degrees for low-frequency, common-mode induced voltages in signal and control cables (V)

Phenomena (sources) / Disturbance degrees	Power distribution and mains cables carrying network frequency and harmonics under normal operating conditions		Fault condition in power system 1)
	50 Hz to 1 kHz 2)	1 kHz to 20 kHz	50 Hz to 1 kHz
A (controlled)	Case-by-case according to the equipment requirements		
1	0,05-1	0,05	100
2	0,15-3	0,15	300
3	0,5-10	0,5	1 000
4	1-20	1	3 000 3)
X (harsh)	Case-by-case according to the situation		

1) Values may be limited by ITU-T or other mandated mitigation methods.
2) Level of disturbance decreases as frequency increases in range shown.
3) May be limited by sparkover of clearances. On insulated ground circuits, higher voltages might occur.

Appropriate immunity test would be: IEC 61000-4-16
Frequency range nowadays: 0 – 150 kHz

IEC 61000-2-5 – Example for disturbance degrees (2)

Table 6 – Sources and range of disturbance degrees for low-frequency magnetic fields (in A/m, d.c. or r.m.s.)

Phenomena (sources) / Disturbance degrees	DC [1]	Railway frequency 16-2/3 [2]	Power system frequency 50/60 Hz [3]	Harmonics of power system 0,1-3 kHz [4]	Not related to power systems [5]
A (controlled)	Case-by-case according to the equipment requirements				
1	3	1	3	3/n	0,015
2	10	3	10	10/n	0,05
3	30	10	30	30/n	0,15
4	100	30	100	100/n	0,5
X (harsh)	Case-by-case according to the situation				

Appropriate immunity test would be: IEC 61000-4-8
Frequency range nowadays: power frequency

IEC 61000-2-5 – Example for disturbance degrees (3)

Table 8 – Disturbance degrees of induced CW voltages with respect to reference ground

Disturbance degree	10-150 kHz *		0,15-27 MHz		27-150 MHz	
	V	mA	V	mA	V	mA
A (controlled)	Case-by-case according to the equipment requirements					
1	0,1	0,7	0,3	2	0,3	2
2	1	7	1	7	1	7
3	3	21	3	21	3	21
4	10	70	10	70	10	70
5	30	210	30	210	30	210
X (harsh)	Case-by-case according to the situation					

* Some VLF transmitters can induce considerably higher voltages in the 10-150 kHz range.

Appropriate immunity test would be: IEC 61000-4-6
Frequency range nowadays: 150 kHz – 80 MHz

IEC 61000-2-5 – Example for disturbance degrees (4)

Table 10 – Sources and range of disturbance degrees for conducted oscillatory transients in low-voltage a.c. power systems

Phenomena attributes and disturbance degrees	Ringing transients frequency range		
	High frequency 0,5-5 MHz	Medium frequency 5-500 kHz	Low frequency 0,2-5 kHz
Typical source	Local system response to impulsive disturbance [1]	Building response to impulsive disturbance [1]	Capacitor switching [2]
Rise time [3] Duration [4] Rate of occurrence Source impedance	50 ns 5 µs Frequent 50-300 Ω	0,5 µs 20 µs Occasional 10-50 Ω	1,5 µs 3 ms Infrequent 10-50 Ω
A (controlled)	Case-by-case according to the equipment requirements		
1	0,5 kV	1,0 kV	0,5 U_{peak}
2	1,0 kV	2,0 kV	1,0 U_{peak}
3	2,0 kV	4,0 kV	2,0 U_{peak}
4	4,0 kV	6,0 kV	3,0 U_{peak}
X (harsh)	Case-by-case according to the situation		

Appropriate immunity test would be: IEC 61000-4-12 and IEC 61000-4-18

Example of the description of a location class by means of compatibility levels, taken from IEC 61000-2-5 (1995)

Phenomenon		For details, see table	Disturbance degrees for five ports				
			Enclosure	AC power	DC power	Control and signalling	Earth
LF-conducted	Total harmonics distortion	2	–	1	–	–	–
	Signalling 0,1-3 kHz	3	–	1	–	–	–
	3-95 kHz			1	–	–	–
	95-500 kHz			1	–	–	–
	Voltage fluctuations	4	–	2	–	–	–
	Voltage dips		–	2	–	–	–
	Short interruptions		–	2	–	–	–
	Voltage unbalance		–	2	–	–	–
	Frequency variations		–	1	–	–	–
	Induced LF	5	–	–	–	3	–
	DC in a.c. networks	*	–	*	*	*	–
LF magnetic field	DC	6	1	–	–	–	–
	Railway		1	–	–	–	–
	Power system		2	–	–	–	–
	Power system harmonics		1	–	–	–	–
	not power system related		1	–	–	–	–
LF electric field	DC lines	7	1	–	–	–	–
	Railway (16 2/3 Hz)		2	–	–	–	–
	Power system (50-60 Hz)		2	–	–	–	–
HF-conducted induced CW	10-150 kHz	8	–	3	–	3	*
	0,1-30 MHz		–	4	–	4	*
	30-150 MHz		–	3	–	3	*
HF-conducted signalling	3-95 kHz	3	–	1	–		–
	95-500 kHz		–	2	–		–
HF-conducted unidirectional transients	Nanoseconds	9	–	3	–	2	–
	Microseconds, close		–	3	–	2	*
	Microseconds, distant		–	2	–	2	*
	Milliseconds		–	1	–	–	*

Light industrial location

Example of the description of a location class by means of compatibility levels, taken from IEC 61000-2-5 (1995)

Phenomenon		For details, see table	Disturbance degrees for five ports				
			Enclosure	AC power	DC power	Control and signalling	Earth
HF-conducted induced CW	10-150 kHz	8	–	3	3	4	*
	0,1-30 MHz		–	3	3	5	*
	30-150 MHz		–	3	3	3	*
HF-conducted signalling	3-95 kHz	3	–	1	1	–	–
	95-500 kHz		–	2	1	–	–
HF-conducted unidirectional transients	Nanoseconds	9	–	3	3	2	–
	Microseconds, close		–	3	2	3	*
	Microseconds, distant		–	2	2	3	*
	Milliseconds		–	2	2	–	*
HF-conducted oscillatory transients	High frequency	10	–	3	–	2	*
	Medium frequency		–	2	–	2	*
	Low frequency		–	3	–	–	*
HF-radiated oscillatory	9 kHz-27 MHz any source	11	5	–	–	–	–
	27 MHz band CB		2	–	–	–	–
	Amateur radio all bands		3	–	–	–	–
	27-1 000 MHz portable except CB		4	–	–	–	–
	27-1 000 MHz mobile except CB		2	–	–	–	–
	27-1 000 MHz all others		2	–	–	–	–
	1-40 GHz all sources		3	–	–	–	–
HF-radiated pulsed	Lightning, distant	12	2	–	–	–	–
	Gas-insulated substation		4	–	–	–	–
	Air insulated substation**		4	–	–	–	–
	power-system related		4	–	–	–	–
ESD	Slow	13 and 14	2	–	–	–	–
	Fast		2	–	–	–	–

Heavy industrial location

Principles of the selection of immunity levels

Approach: Immunity levels selected according to electromagnetic environment

Uncertainties: In the test situation, in the application situation, selection of appropriate margins

Dealing with high density sources: Superposition, estimating peak emissions

Criticality (performance) criteria: Catastrophic, critical, major, minor, inconsequential interference

IEC 61000-2-5 – Types of location classes

	Location class type	Description see
1	Residential-rural location	A.1
2	Residential-urban location	A.2
3	Commercial location (may include densely populated public areas)	A.3
4	Light industrial location	A.4
5	Heavy industrial location	A.5
6	Traffic area	A.6
7	Telecommunication centre	A.7
8	Hospital	A.8

Description of location classes – IEC 61000-2-5

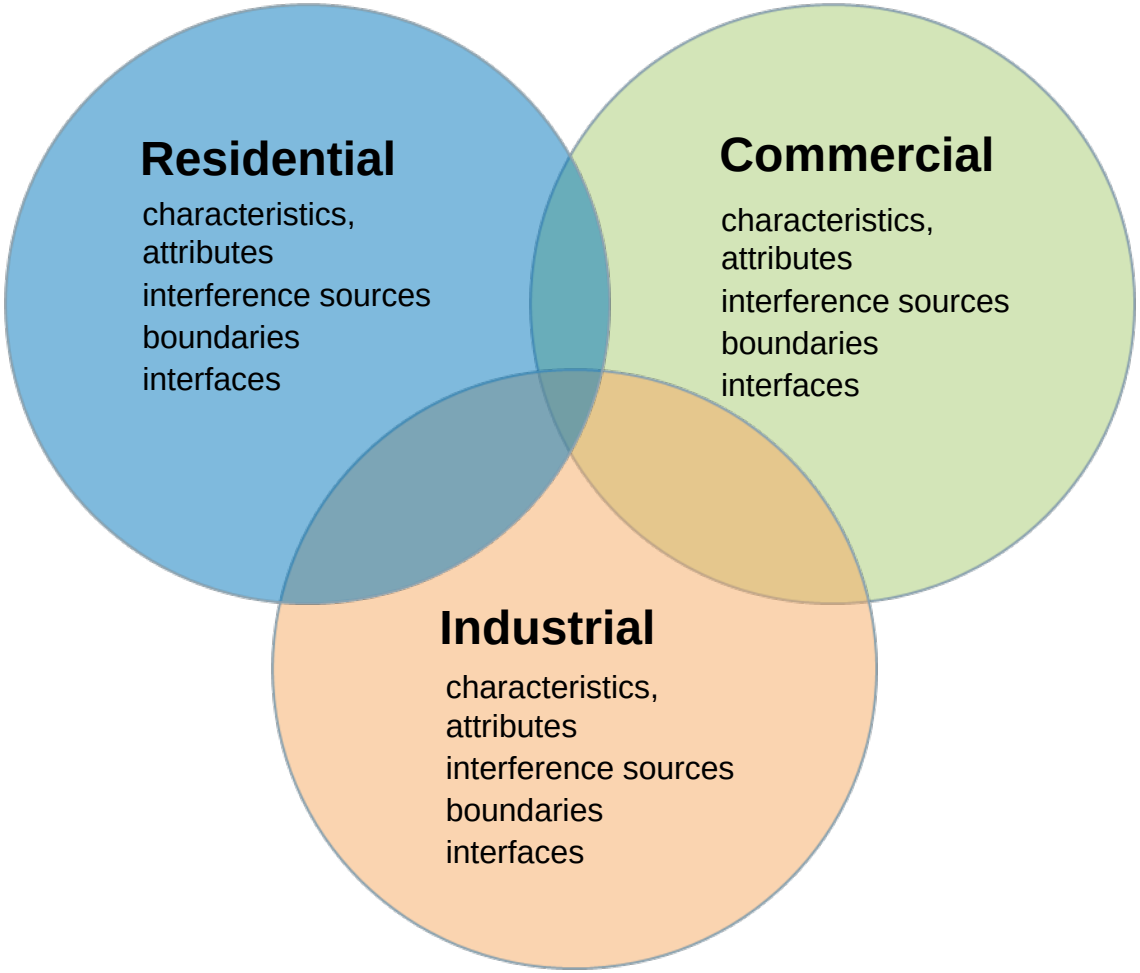
Ed. 1: 8 types of location classes which descriptions by means of compatibility levels can hardly be maintained

Ed. 2: Introduction of three generic types (archetypes) of location classes: residential, commercial, industrial

Electromagnetic environment might be described by the conditions within an archetype of location class or by an overlap of two or even three of them

Description of each archetype: by means of characteristics, interference sources, boundaries, interfaces, attributes

Proposal for a new concept



Developments in electromagnetic environments

Current edition of IEC 61000-2-5 dates from 1995

Long-term trend: Introduction of new technologies, increasing spread of interference sources

Necessity to update description

At present: Maintenance by TC 77 WG 13

Focus: Radiated environment above 1 GHz

IEC 61000-2-5 Ed. 1

High frequency radiated phenomena

Current edition of IEC 61000-2-5				
Sources of high frequency electro-magnetic fields	**AM Broadcasting** 150 kHz -30 MHz P = 500 kW	**Walkie-talkie** 27-1000 MHz P = 5 W	**CB** 27 MHz P = 12 W	**TV – VHF** 48-223 MHz P = 200 kW

IEC 61000-2-5 Ed. 2 (future)

Current status for future edition of IEC 61000-2-5				
Sources of high frequency electromagnetic fields	**AM Broadcasting** **150 kHz-30 MHz** ***P* = 500 kW**	**Walkie-talkie** **27-1 000 MHz** ***P* = 5 W**	**CB** **27 MHz** ***P* = 12 W**	**TV – VHF** **48-223 MHz** ***P* = 200 kW**
Mobile Phones (mobile and portable components, part 1)	**GSM** **890-915 MHz** **P=20 W**	**DCS 1800** **1,71-1,784 GHz** ***P* = 4 W**	**DECT** **1.88-1.96 GHz** ***P* = 0.25 W**	**CT-2** **864-868 MHz** ***P* = 0.01 W**
Mobile Phones (mobile and portable components, part 2)	**PDC** **940-955MHz** **1,429-1,453 GHz** **P=2 W**	**PHS** **1,895-1,918 GHz** ***P* = 0.01 W**	**NADC** **825-845 MHz** ***P* = 6 W**	**IMT-2000** **1,900-1,920 GHz** **1,920-1,980 GHz** ***P* = 0.25 W**
Mobile Phones (base stations, part 1)	**GSM** **935-960 MHz** **P=320 W**	**DCS 1800** **1,805-1,880 GHz** ***P* = 200 W**	**DECT** **1.88-1.96 GHz** ***P* = 0.25 W**	**CT-2** **864-868 MHz** ***P* = 0.25 W**
Mobile Phones (base stations, part 2)	**PDC** **810-826MHz** **1,477-1,501 GHz** **P=96 W**	**PHS** **1,895-1,918 GHz** ***P* = 0.5 W**	**NADC** **870-890 MHz** ***P* = 500 W**	**IMT-2000** **1,900-1,920 GHz** **2,110-2,170 GHz** ***P* = 20 W**
Other HF-Components (part 1)	**RFID** **2,446-2,454 GHz** ***P* = 4 W**	**RTTT** **5,795- 5,815 GHz** ***P* = 8 W**	**Wideband data transmission systems and HIPERLANs** **2,400-2,4835 GHz** ***P* = 0.1 W**	**-**
Other HF-Components (part 2)	**Wideband data transmission systems and HIPERLANs** **5,150-5,350 GHz** ***P* = 0.2 W**	**Wideband data transmission systems and HIPERLANs** **5,470-5,725 GHz** ***P* = 1 W**	**Non specific short range devices** **2,400–2,4835 GHz** **5,725-5,875 GHz** ***P* = 0.025 W**	**-**

Summary – Conclusion

Need of description of electromagnetic environments

Description by means of disturbance degrees and compatibility levels

New scheme of classification is under discussion

Severe changes in the electromagnetic environment

Needed input: Updated data and assessment

SIEMENS

Thank you

Name:	Dr. Bernd Jaekel
Department:	Industry Sector
Address:	EMC-Center
	Erlangen/Germany
Phone:	+49 (9131) 7-33037
Mail:	bernd.jaekel@siemens.com