

# Welcome

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# The State of Electromagnetic Environments

Workshop - Description and Classification Approach within IEC 61000-X-Y documents

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## 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

Introduction Phenomena Description Standards IEC 61000-2-5 Compatibility Classification **Development** Conclusion

#### (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**

troduction	Electro
	Existi
enomena	man-
escription	<ul> <li>natur</li> </ul>
andards	Conditi
C 61000-2-5	instal
6 8 1000-2-5	type of
ompatibility	
	Method
assification	site s
evelopment	meas
	techn
onclusion	data

#### magnetic Phenomena

- ing at a location
- made phenomena
- ral phenomena

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- llation
- of power supply

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- surveys
- surements
- nical assessments
- base

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#### **Electromagnetic phenomena**

### Electrostatic discharge phenomena (ESD)

#### Conducted highfrequency phenomena

- induced CW voltages or currents
- broadband signals (PLC, power drive systems, etc/)
  - unidirectional transients
  - oscillatory transients

### Conducted low-frequency phenomena

- harmonics, interharmonics
- signalling voltages
- voltage fluctuations
- voltage dips and interruptions
- voltage unbalance
- power-frequency variations
- induced low-frequency voltages
- DC in AC networks
- broadband signals

### Radiated high-frequency phenomena

- magnetic fields
- electric fields
- electromagnetic fields
  - continuous waves
  - transients
  - modulation (FM, AM , FSK,
    - CDMA, CMA, TDMA etc.)

#### Radiated low-frequency phenomena

magnetic fields
electric fields

High-altitude electromagnetic pulse (HEMP) High power electromagnetic pulse (HPEM)

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#### **Need of description – EMC**

Introduction	Basic goal: achievement of electromagnetic compatibility
Phenomena	
Description	(1) Information about environment is needed in order to
Standards	specify immunity requirements
IEC 61000-2-5	(2) This is achooselly important when cofety related eveters
Compatibility	(2) This is especially important when safety-related systems are concerned
Classification	
Development	(3) EMC-Directive of EU requires taking into account electromagnetic environment
Conclusion	
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#### **Need of description – Documents**

Introduction	Information is needed for equipment design
Phenomena	
Description	(1) Not every manufacturer is able to do site surveys for each
Standards	location for which the equipment is intended
IEC 61000-2-5	
Compatibility	(2) A general description is needed
Classification	
Development	(3) A "standardized" way of describing the environment is needed
Conclusion	
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#### **Electromagnetic environment in IEC documents**

Phenomena         IEC 61000-2-X         Environment: description, classification; compatibility levels	
Description	
Standards IEC 61000-3-X Emission limits: e.g. harmonics, flicker	
IEC 61000-2-5 IEC 61000-4-X Testing and measurement techniques	
Compatibility IEC 61000-5-X Installation and mitigation guidelines Classification	
Development IEC 61000-6-X Generic standards	
Conclusion	



Introduction Phenomena	IEC 61000-2-1	Electromagnetic environment for low- frequency conducted disturbances and signalling in public power supply systems	1990
Description		This report is concerned with conducted disturbances in the frequency range up to 10 kHz with an extension for mains	
Standards		signalling systems. Separate sections give	
IEC 61000-2-5		numerical compatibility levels for different system voltage levels. The object is to give information on the various types of	
Compatibility		disturbances that can be expected on public power supply systems. It is a	
Classification		reference document for those associated parts that give values of compatibility level.	
Development			

#### Conclusion



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



Introduction	IEC 61000-2-3	Radiated and non-network-frequency- related phenomena	1992
Phenomena		This report is primarily concerned with the	
Description		characteristics and levels of electromagnetic fields and of non-network-	
Standards		frequency-related conducted emissions from unintentional sources of interference.	
IEC 61000-2-5			
Compatibility			
Classification			
Development			
Conclusion			
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Introduction	IEC 61000-2-4	Compatibility levels in industrial plants for low-frequency conducted disturbances	1994
Phenomena		This standard gives the requirements for	
Description		the compatibility levels for industrial and non-public networks. These levels are	
Standards		relevant to disturbances that may occur in the electrical power supply in normal	
IEC 61000-2-5		operating conditions. It applies to low- voltage and medium-voltage a.c. power	
Compatibility		supply at 50 Hz/60 Hz. The compatibility levels are given for different	
Classification		electromagnetic environment classes. This standard is in practice a classification of	
Development		the a.c. supplies associated with industrial and non-public networks.	
Conclusion			



Introduction Phenomena	IEC 61000-2-6	Assessment of the emission levels in the power supply of industrial plants as regards low-frequency conducted disturbances	1995
Description		This report recommends the procedures to assess the disturbance levels produced by the emission of the devices, equipment and	
Standards		systems installed in non-public networks in industrial environment as far as low-	
IEC 61000-2-5		frequency conducted disturbances in the power supply are concerned; it applies to	
Compatibility		low and medium a.c. non-public supply at 50/60 Hz. The disturbances considered are:	
Classification		harmonics and interharmonics, unbalances, voltage changes and voltage dips.	
Development			

#### Conclusion



Introduction Phenomena	IEC 61000-2-7	Low frequency magnetic fields in various environments	1998
Description		Interest in magnetic fields has been stimulated in recent years by concern over the physiological effects they may have on	
Standards		humans and animals and the deleterious effects they have on the performance of	
IEC 61000-2-5		some electrical equipment, particularly video display units. Investigations have	
Compatibility		yielded results which are presented in this report as reference values.	
Classification			
Development			
Conclusion			



Introduction Phenomena	IEC 61000-2-8	Voltage dips and short interruptions on public electric power supply systems with statistical measurement results	2002
Thenomena			
Description		This report describes the electromagnetic disturbance phenomena of voltage dips and	
Standards		short interruptions in terms of their sources, effects, remedial measures, methods of measurement, and	
IEC 61000-2-5		measurement results.	
Compatibility			
Classification			
Development			
Conclusion			
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#### **Description of electromagnetic phenomena**

Introduction	IEC 61000-2-9	Description of HEMP environment – Radiated disturbance	1996
Phenomena Description	IEC 61000-2-10	Description of HEMP environment – Conducted disturbance	1998
	IEC 61000-2-11	<b>Classification of HEMP environments</b>	1999
Standards			
IEC 61000-2-5			
Competibility			
Compatibility			
Classification			
Development			
Conclusion			
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Introduction Phenomena	IEC 61000-2-12	Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems	2003
Description		This part is concerned with conducted	
Standards		disturbances in the frequency range from 0 kHz to 9 kHz, with an extension up to	
IEC 61000-2-5		148,5 kHz specifically for mains signalling systems. It gives compatibility levels for public medium voltage a.c. distribution	
Compatibility		systems with a nominal voltage between	
Classification		1 kV and 35 kV. Compatibility levels are specified for disturbances of the types which can be expected in public medium	
Development		voltage power supply systems.	

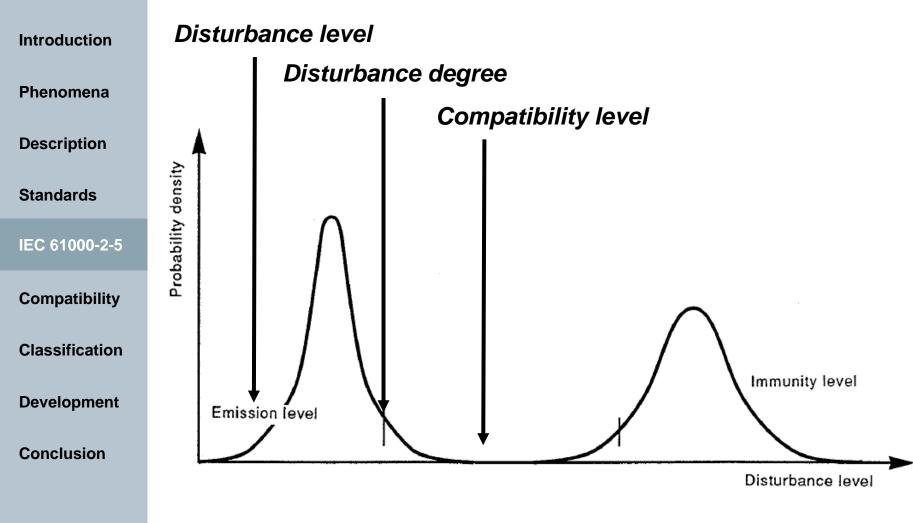
Conclusion



Description Standards IEC 61000-2-5 = Ele	w and high enomena	e for the report h frequency, conducted and radiated	
Description Standards IEC 61000-2-5 Ele	w and high enomena		
Standards Electronic	enomena	h frequency, conducted and radiated	
IEC 61000-2-5 = Ele			
Compatibility	ectrostatic	discharge	
	assificatior	n of environments	
Classification Pri	inciples of	the selection of immunity levels	
Development CO	ompatibility	y levels for typical location classes	
Conclusion			



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





#### Terms from IEC 61000-2-5 (1995)

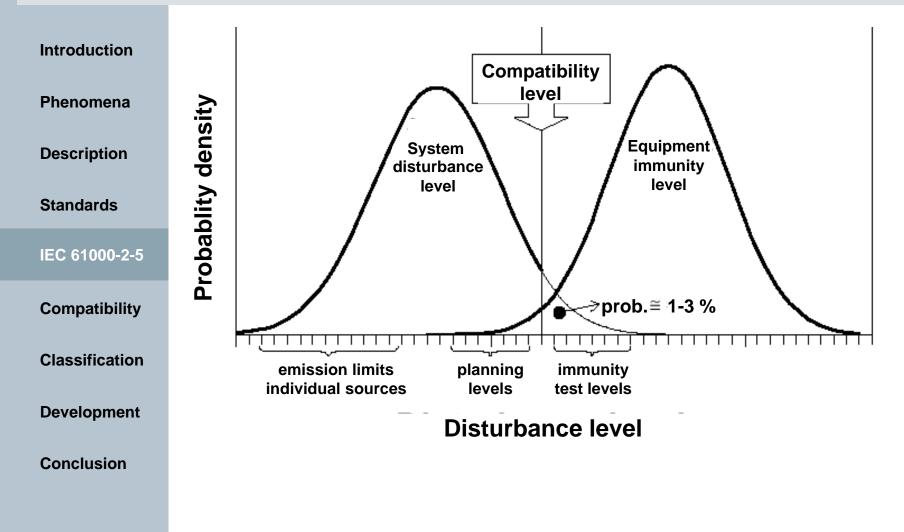
Introduction	Compati
Phenomena	<ul> <li>specifie to be in particul</li> </ul>
Description	·
Standards	but: In
IEC 61000-2-5	maxim
Compatibility	compa
Classification	and co
Development	
Conclusion	

#### 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, Introduction common-mode induced voltages in signal and control cables (V) Phenomena Fault condition in power Power distribution and mains cables carrying network Phenomena (sources) system 1) frequency and harmonics under normal operating conditions 50 Hz to 1 kHz <sup>2)</sup> Disturbance 1 kHz to 20 kHz 50 Hz to 1 kHz degrees Description A (controlled) Case-by-case according to the equipment requirements 1 0.05-1 0.05 100 **Standards** 2 0.15 - 30.15 300 3 0.5-10 0.5 1 000 IEC 61000-2-5 3 000 3) 4 1-20 1 X (harsh) Case-by-case according to the situation Compatibility Values may be limited by ITU-T or other mandated mitigation methods. 1) Level of disturbance decreases as frequency increases in range shown. 2) Classification May be limited by sparkover of clearances. On insulated ground circuits, higher voltages might occur. 3) **Development** Appropriate immunity test would be: IEC 61000-4-16 Frequency range nowadays: 0 – 150 kHz Conclusion IEEE EMC 2008 – Electromagnetic environments Industry Sector Slide 23/27 2008-08



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

Phenomena	Phenomena (sources) Disturbance	DC <sup>1)</sup>	Railway frequency 16-2/3 <sup>2)</sup>	Power system frequency 50/60 Hz <sup>3)</sup>	Harmonics of power system 0,1-3 kHz <sup>4)</sup>	Not related to power systems <sup>5)</sup>
Description	degrees A (controlled)		Case-by-case a	according to the equi	ipment requirements	s
Standards	1	3	1	3	3/n	0,015
EC 61000-2-5	2	10	3	10	10/n	0,05
	3	30	10	30	30/n	0,15
Compatibility	4	100	30	100	100/n	0,5
Classification	X (harsh)		Case-b	I y-case according to	the situation	
Development						
Conclusion	Appropriate in Frequency ran					



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

roduction	with respect to reference ground						
enomena	Disturbance degree	10-150 kHz *		0,15-2	27 MHz	27-150 MHz	
		V	mA	V	mA	V	mA
cription	A (controlled)		Case-by-o	ase according to	o the equipment r	equirements	
	1	0,1	0,7	0,3	2	0,3	2
ndards	2	1	7	1	7	1	7
_	3	3	21	3	21	3	21
61000-2-5	4	10	70	10	70	10	70
	5	30	210	30	210	30	210
npatibility	X (harsh)		C	ase-by-case acc	ording to the situa	ation	
	* Some VLF transmitters can induce considerably higher voltages in the 10-150 kHz range.						
ssification							
velopment							
	Appropriate	immu	nity test	would be	e: IFC 61	000-4-6	

Table 8 – Disturbance degrees of induced CW voltages

#### Conclusion

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

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

		Ring	ging transients frequency ran	ge
Phenomena	Phenomena attributes and	High frequency	Medium frequency	Low frequency
	disturbance degrees	0,5-5 MHz	5-500 kHz	0,2-5 kHz
Description	Typical source	Local system response to impulsive disturbance <sup>1)</sup>	Building response to impulsive disturbance <sup>1)</sup>	Capacitor switching <sup>2</sup>
Standards	Rise time <sup>3)</sup>	50 ns	0,5 μ <b>s</b>	1,5 μ <b>s</b>
	Duration <sup>4)</sup>	5 μs	20 µs	3 ms
IEC 61000-2-5	Rate of occurrence	Frequent	Occasional	Infrequent
	Source impedance	50-300 Ω	10-50 Ω	10-50 Ω
Compatibility	A (controlled)	Case-by-case	according to the equipment	requirements
Compatibility	1	0,5 kV	1,0 k∨	0,5 U <sub>peak</sub>
	2	1,0 k∨	2,0 k∨	1,0 U <sub>peak</sub>
Classification	3	2,0 kV	4,0 k∨	2,0 U <sub>peak</sub>
	4	4,0 k∨	6,0 k∨	3,0 U <sub>peak</sub>
Development	X (harsh)	Case-	by-case according to the situ	

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

			For					
Introduction		nenomenon	details, see table	Enclosure	AC power	DC power	Control and signalling	Earth
Phenomena	LF-conducted	Total harmonics distortion	2	-	1	-	-	_
		Signalling 0,1-3 kHz 3-95 kHz	3	_	1 1			_
Description		95-500 kHz Voltage fluctuations	4	_	1 2	-	_	-
		Voltage dips Short interruptions			2 2	_	_	-
Standards		Voltage unbalance Frequency variations			2	-	-	-
		Induced LF	5	_	-	-	3	-
IEC 61000-2-5		DC in a.c. networks	*	-	*	*	*	-
	LF magnetic field	DC Railway	6	1	-	-	_	-
		Power system		2	_	_	_	_
Compatibility		Power system harmonics not power system related		1	-	-	_	-
Classification	LF electric field	DC lines Railway (16 <sup>2/</sup> 3 Hz) Power system (50-60 Hz)	7	1 2 2	- - -		- - -	
	HF-conducted induced CW	10-150 kHz 0,1-30 MHz	8		3 4	- -	3 4	*
Development		30-150 MHz		-	3	-	3	*
	HF-conducted signalling	3-95 kHz 95-500 kHz	3	_	1 2			-
Conclusion	HF-conducted unidirectional transients	Nanoseconds Microseconds, close Microseconds, distant	9		3 3 2		2 2 2	*
	. difference	Milliseconds		_	1	_	_	*
	ŀ	1	ł	Li	ght industri	ial location		<u> </u>

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

			For		Disturbance	e degrees for	five ports	
Introduction		Phenomenon	details, see table	Enclosure	AC power	DC power	Control and signalling	Earth
Phenomena	HF-conducted induced CW	10-150 kHz 0,1-30 MHz	8		3 3 3	3 3 3	4 5 3	* *
Description	HF-conducted signalling	30-150 MHz 3-95 kHz 95-500 kHz	3	 	1 2	1		-
Standards	HF-conducted unidirectional transients	Nanoseconds Microseconds, close Microseconds, distant	9		3 3 2	3 2 2	2 3 3	
Stanuarus	HF-conducted oscillatory	Milliseconds High frequency Medium frequency	10	- - -	2 3 2	2	2 2	* * *
IEC 61000-2-5	transients HF-radiated	Low frequency 9 kHz-27 MHz	11	5	3	-	-	*
Compatibility	oscillatory	any source 27 MHz band CB Amateur radio all bands		2 3	-	-	-	-
Classification		27-1 000 MHz portable except CB 27-1 000 MHz mobile		4	-	-	-	-
Development		except CB 27-1 000 MHz all others 1-40 GHz all sources	10	2 3			- - -	_ _ _
Conclusion	HF-radiated pulsed	Lightning, distant Gas-insulated substation Air insulated substation**	12	2 4 4 4	- - -	- - -	- - -	- - -
Conclusion	ESD	power-system related Slow Fast	13 and 14	2 2	- - -	- - -	- - -	- - -

Heavy industrial location



#### **Principles of the selection of immunity levels**

Introduction	Approach: Immunity levels selected according to electromagnetic environment
Phenomena	
Description	Uncertainties: In the test situation, in the application situation, selection of appropriate margins
Standards	situation, selection of appropriate margins
IEC 61000-2-5	Dealing with high density sources: Superposition, estimating peak emissions
Compatibility	estimating peak emissions
Classification	Criticality (performance) criteria: Catastrophic, critical, major, minor, inconsequential interference
Development	major, minor, moonsequentiar interference
Conclusion	
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#### IEC 61000-2-5 – Types of location classes

Introduction		Location class type	Description see
Phenomena	1	Residential-rural location	A.1
Description	2	Residential-urban location	A.2
Standards IEC 61000-2-5	3	Commercial location (may include densely populated public areas)	A.3
Compatibility	4	Light industrial location	A.4
Classification	5	Heavy industrial location	A.5
_	6	Traffic area	A.6
Development	7	Telecommunication centre	A.7
Conclusion	8	Hospital	A.8



#### **Description of location classes – IEC 61000-2-5**

Introduction	Ed. 1: 8 types of location classes which descriptions by means of compatibility levels can hardly be maintained
Phenomena	
Description	Ed. 2: Introduction of three generic types (archetypes) of
Standards	location classes: residential, commercial, industrial
IEC 61000-2-5	Electromagnetic environment might be described by the
Compatibility	conditions within an archetype of location class or by an overlap of two or even three of them
Classification	
Development	Description of each archetype: by means of characteristics, interference sources, boundaries, interfaces, attributes
Conclusion	
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#### **Proposal for a new concept**

#### Introduction

Phenomena

Description

**Standards** 

IEC 61000-2-5

Compatibility

Classification

**Development** 

Conclusion

#### Residential

characteristics, attributes interference sources boundaries interfaces

#### Commercial

characteristics, attributes interference sources boundaries interfaces

#### Industrial

characteristics, attributes interference sources boundaries interfaces

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#### **Developments in electromagnetic environments**

Introduction	Current edition of IEC 61000-2-5 dates from 1995
Phenomena	
Description	Long-term trend: Introduction of new technologies, increasing spread of interference sources
Standards	
IEC 61000-2-5	Necessity to update description
Compatibility	
	At present: Maintenance by TC 77 WG 13
Classification	
Development	Focus: Radiated environment above 1 GHz
Conclusion	
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#### IEC 61000-2-5 Ed. 1

Introduction	High frequency radiated phenomena						
Phenomena							
Description	Current edition of IEC 61000-2-5						
Standards	Sources of high	<b>AM Broadcasting</b> 150 kHz -30 MHz	Walkie-talkie 27-1000 MHz	CB 27 MHz	<b>TV – VHF</b> 48-223 MHz		
IEC 61000-2-5	frequency electro-	P = 500  kW	P = 5 W	P = 12 W			
Compatibility	magnetic fields						
Classification							
Development							
Conclusion							
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#### IEC 61000-2-5 Ed. 2 (future)

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

Introduction	Need of description of electromagnetic environments	5
Phenomena		
Description	Description by means of disturbance degrees and compatibility levels	
Standards		
IEC 61000-2-5	New scheme of classification is under discussion	
Composibility		
Compatibility	Severe changes in the electromagnetic environment	
Classification		
Development	Needed input: Updated data and assessment	
Conclusion		
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