



Electromagnetic Compatibility (*EMC*)

Introduction about EMC and Regulation





Agenda

- ❑ Term Definitions
- ❑ Source of Electromagnetic Interference
- ❑ Components of an EMC Situation
- ❑ Methods of Noise Coupling
- ❑ Time-Value of EMC Solutions
- ❑ EMC Solutions
- ❑ Standard Setting Institutions(機構)
- ❑ Emission Frequency Range of EMC Regulations
- ❑ Declaration Method
- ❑ National Regulations Summary





Term Definitions

- EMC (electromagnetic compatibility)
 - Ability to operate in, and not overly contribute to, an environment of electromagnetic interference.
 - Both radiated and conducted
- EMI (electromagnetic interference)
 - Electromagnetic energy emanating from one device which causes another device to have degraded performance
- EMS (electromagnetic susceptibility)
 - Tolerance in the presence of electromagnetic energy





Term Definitions

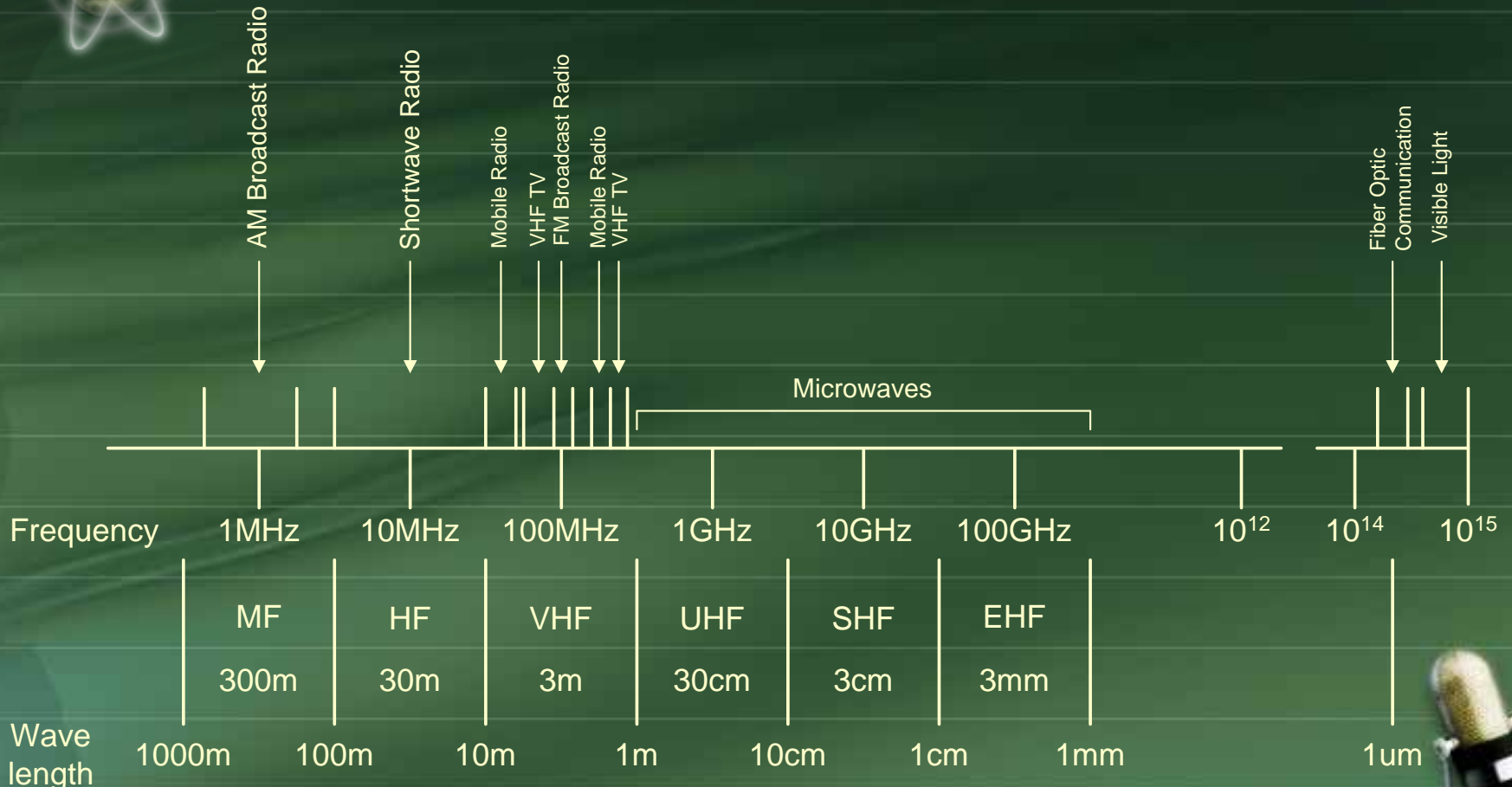
- EMC
- EMI
 - RE : Radiated Emission
 - CE : Conducted Emission
 - EMS
 - RS : Susceptibility / Immunity to Radiated emission
 - EN 61000-4-3
 - CS : Susceptibility / Immunity to Conducted emission
 - EN 61000-4-6

Electromagnetic interference(電磁干擾) is **not** the same as radio-frequency interference(射頻干擾).





Term Definitions



- MF : medium frequency
- HF : high frequency
- VHF : very high frequency

- UHF : ultra high frequency
- SHF : super high frequency
- EHF : extremely high frequency





Sources of Electromagnetic Interference

■ Natural

■ Cosmic(宇宙的) noise 、 Sun and Stars

- Above 10MHz

■ Phenomena like atmospherics(電離層), lightning(閃電), thunderstorms(雷雨), electrostatic discharge

- Below 10MHz

■ Human made

■ Electrical, Electronic and Electromechanical apparatus

- Intentional(故意的) -- Commercial radio, TV stations, mobile phones

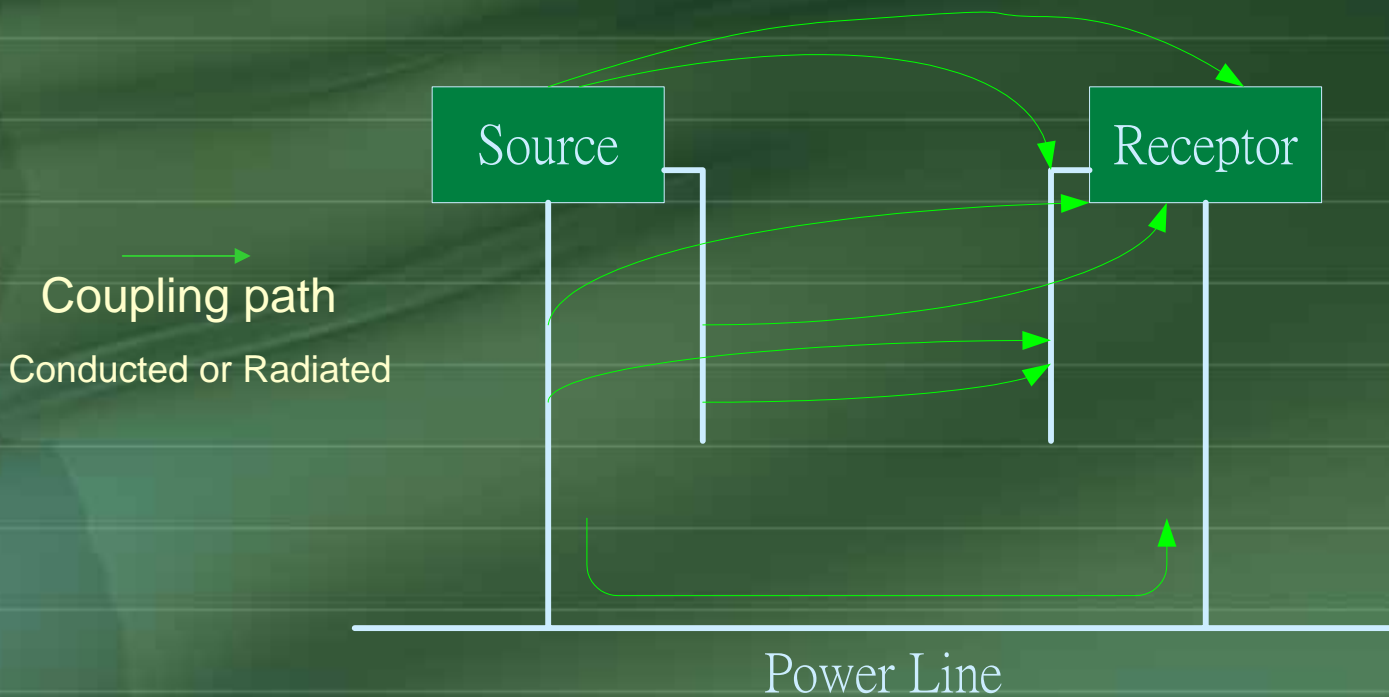
- Unintentional -- DC motor, ITEs (computer)





Components of an EMC Situation

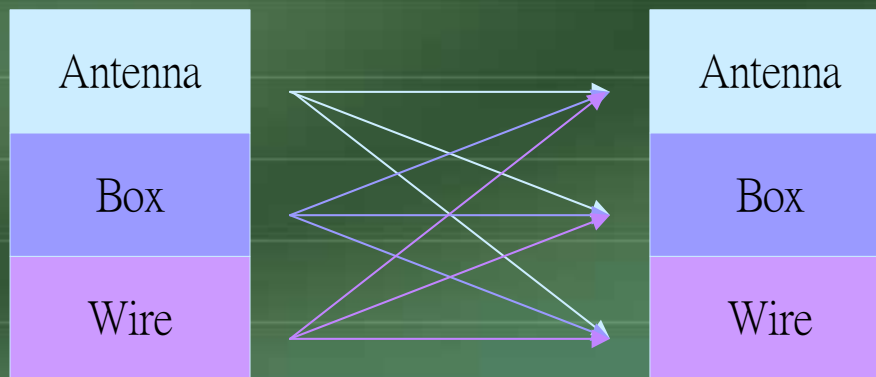
Source · Path · Receptor





Components of an EMC Situation

- The effect of the interference on the receptor depends on the strength of the source, transmission medium, distance from the source, coupling mechanisms, and degree of susceptibility of the receptor.
- Box-to-box coupling usually is not the most important path.





Methods of Noise Coupling

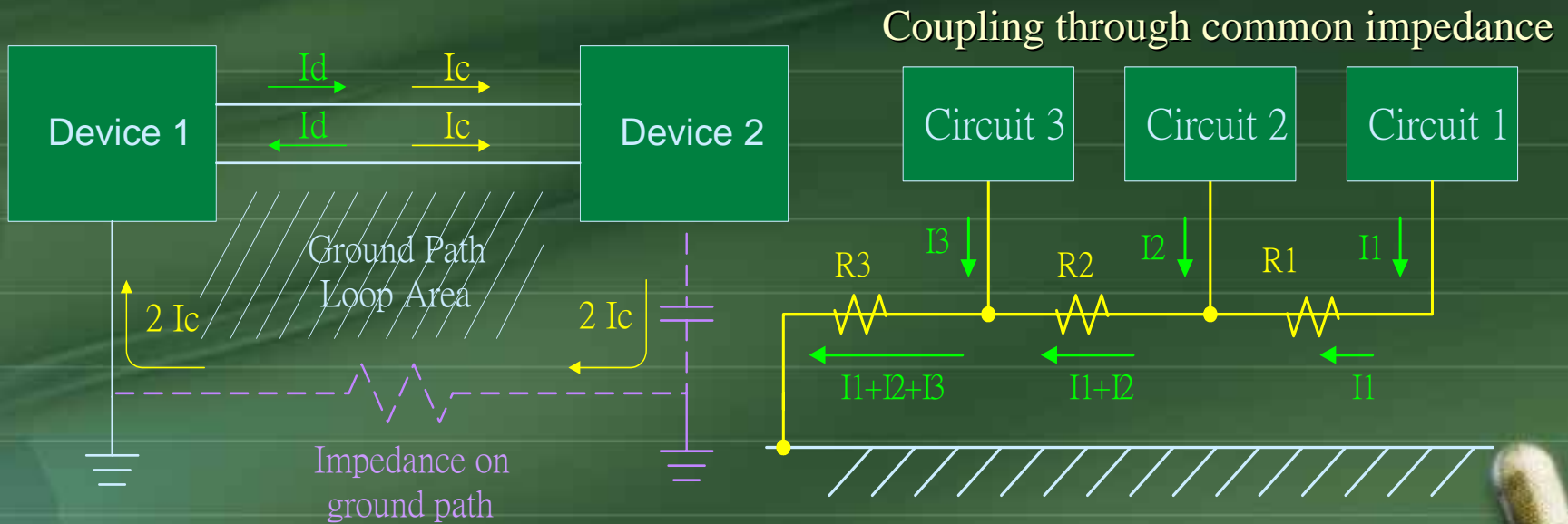
- Conductively coupled noise
 - A wire run through a noisy environment may pick up noise and then conduct it to another circuit.
 - The example is power supply leads.
- Coupling through common impedance
 - It occurs when currents from two different circuits flow through a common impedance.
 - The voltage drop across the impedance seen by each circuit is influenced.
- Electric and Magnetic Fields
 - When the receiver is close to the source (near field), electric and magnetic fields are considered separately.
 - When the receiver is far from the source (far field), the radiation is considered as combined electric and magnetic or electromagnetic radiation.





Methods of Noise Coupling

Common Noise Example



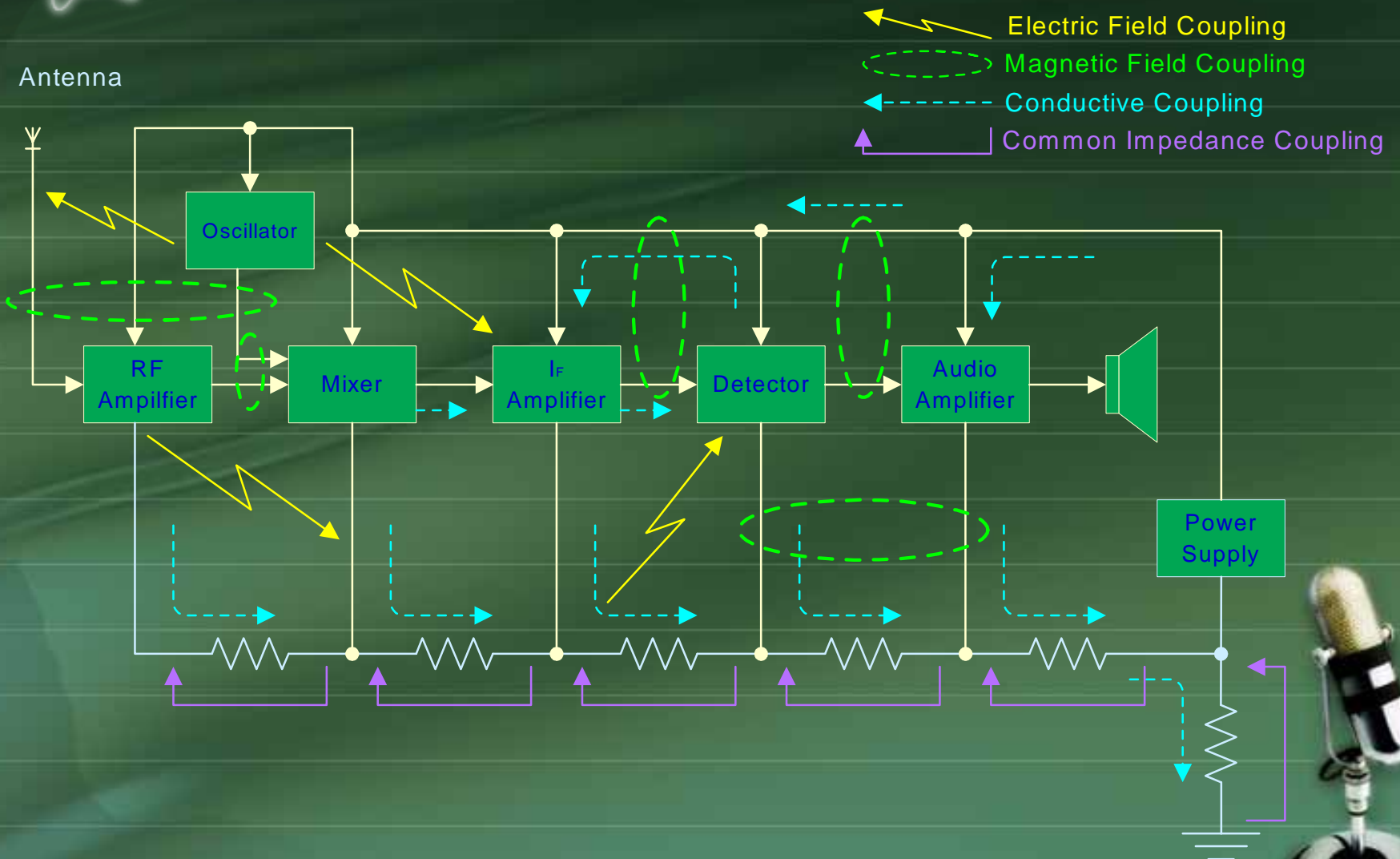
電流不會乖乖順著原本的差模訊號迴路return，反而由共模訊號方向透過另一個地迴路return的成因有二：電路設計因阻抗不匹配所造成的反射；輻射干擾同時作用在去與回的兩條線路上





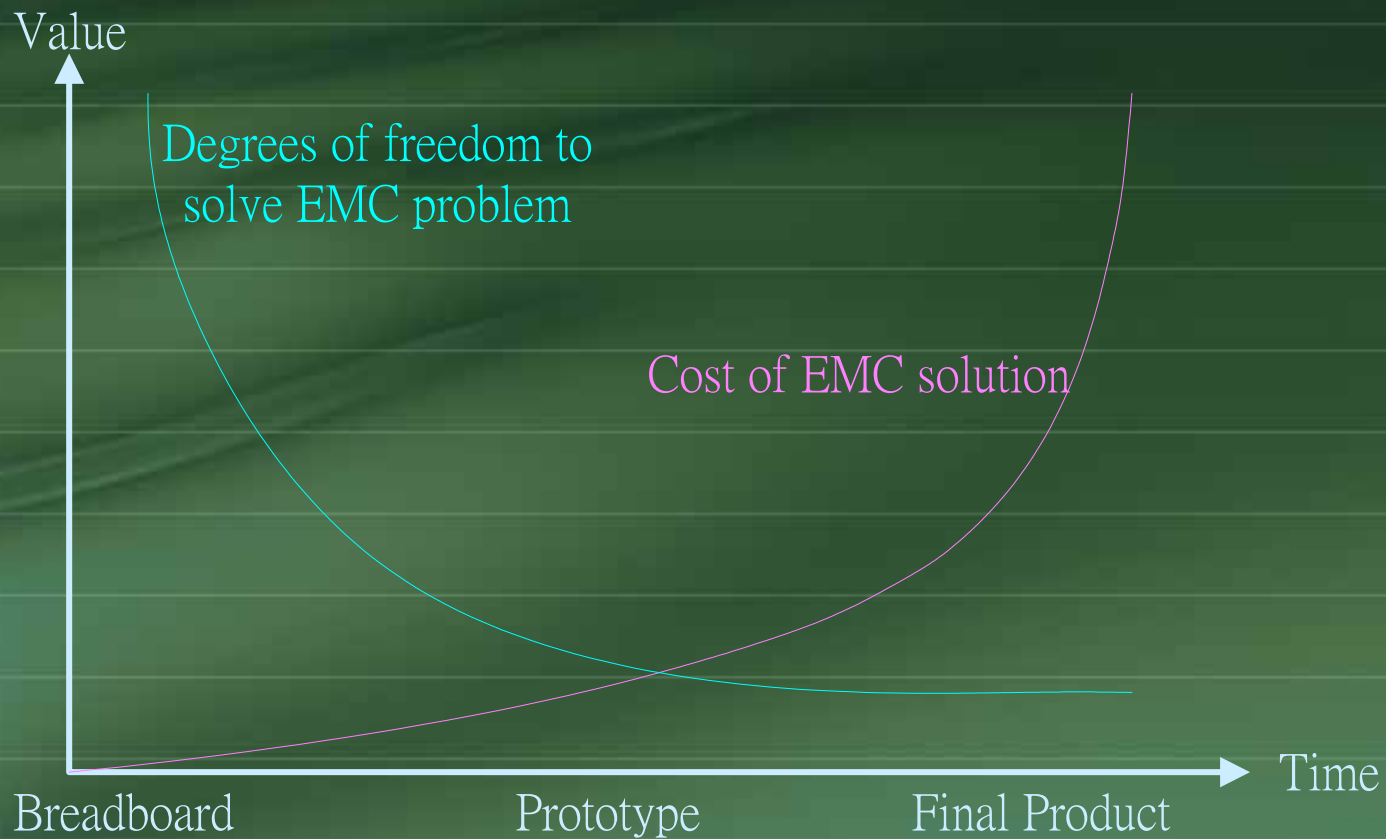
Methods of Noise Coupling

Noise Environment Example





Time-Value of EMC Solutions





EMC Solutions

- There are just basic concepts for EMC, and there is no absolute design rule for EMC
 - EMC strategies are *case by case*
 - A strategy *may be a trade-off* between different EMC concerns
 - Usually there are more than one strategy for a EMC problem, but just one solution best for your case
 - A EMC problem may need several strategies to cover it well
- In many practical situations, more than one approach is required to solve a single EMI problem.
 - Grounding
 - Shielding
 - Filtering
 - Others – Cables, Connectors, Gaskets(襯墊), Isolating transformers, Transient suppression components, Proper frequency engineering, Package, Layout ...





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- Term Definitions
- Source of Electromagnetic Interference
- Components of an EMC Situation
- Methods of Noise Coupling
- Time-Value of EMC Solutions
- EMC Solutions
- Standard Setting Institutions(機構)
 - FCC、IEC ...
- Emission Frequency Range of EMC Regulations
- Declaration Method
- National Regulations Summary





Standard Setting Institutions

- IEC 國際電器標準會議 (www.iec.ch)

- International Electrotechnical Commission



- CISPR 國際無線電波干擾委員會

- Comite International Special des Perturbations
Radioelectrique (下轄於IEC)

- FCC 美國聯邦通訊委員會 (www.fcc.gov)

- Federal Communication Commission



- ANSI 美國國家標準

- American National Standards Institution

- Be voluntary and apparent, not mandatory

- BSI 英國國家標準

- British Standards Institution





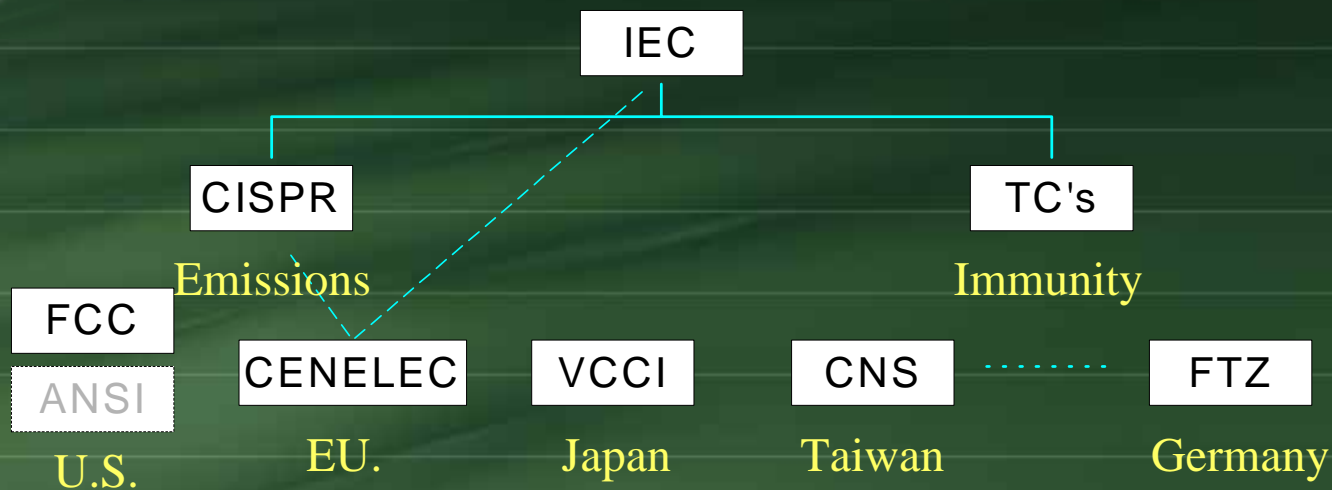
Standard Setting Institutions

- MIL-STD ([軍規](#))
 - Military Standards
 - More elaborate and stringent
- CENELEC 電器工業規格歐洲委員會
 - Comite European de Normalisation Electrotechniques
 - European Norms (EN's)
 - Emission limit and Immunity level
 - *CE* mark
- EIA/JEDEC (www.jedec.org)
 - JEDEC Solid State Technology Association is the semiconductor engineering standardization body of the Electronic Industries Alliance ([EIA](#)).





Standard Setting Institutions



- International Committees
IEC, CISPR, ...
- European Regional Committees
CENELEC
- National Committees
FCC, VCCI, CNS (www.bsmi.gov.tw)...





Standard Setting Institutions

FCC

■ Part 15

- Radio-frequency (10KHz ~ 3GHz) devices
 - Radiation, conduction or some other means

■ Part 18

- Industrial, scientific and medical equipment (ISM equipment)

■ Part 68

- Equipment connected to the telephone network
 - Provide the protection of the telephone network from harm caused by the connection of terminal equipments





Standard Setting Institutions

FCC Part 15, Subpart J

■ FCC Part 15, Subpart J (1979)

■ Digital electronics, called **computing devices** by FCC

■ Define the product uses digital circuitry with clock **10KHz**

■ Radiated emission 30~1000MHz

■ Conducted emission 450K~30MHz

■ Computing devices are divided into two classes

■ **Class A** : Industrial(工業用), commercial(商業用)

■ **Class B** : Residential(家用 and **ITE** like computer & peripherals)

■ Since Class B devices are more likely to be located in closer proximity to radio and television receivers, the emission limits are about 10dB more restrictive than Class A devices

家用產品的**EMI**限制比工業用的嚴格





Emission Frequency Range of EMC Regulations

- EMC development history ([2] Ch 1-2)
- Radiated emission range will be above 30MHz ([immunity](#))
 - Above 30MHz, the conducted noise will be translated into radiated emission while it transmits on 2~3m cable line.

$$v = f \lambda, 3 \times 10^8 \text{m} = 30 \text{MHz} \times \lambda \Rightarrow \lambda/4 \approx 2.5 \text{m}$$

	Conducted	Radiated
MIL-STD	30Hz ~ 40GHz	30Hz ~ 40GHz
VCCI	150kHz ~ <u>30MHz</u>	30MHz ~ 1GHz
CISPR	9k/150kHz ~ <u>30MHz</u>	9k/30MHz ~ 1GHz
FCC	450kHz ~ <u>30MHz</u>	30MHz ~ 1GHz





Emission Frequency Range of EMC Regulations

Conducted Emission Requirements



AC/DC power ports of ancillary and integral antenna equipment for fixed / vehicular use

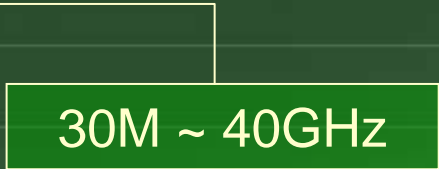


Antenna port of non-integral antenna equipment

Radiated Emission Requirements



Enclosure port of ancillary equipment



Enclosure port of non-integral antenna equipment and antenna port of ancillary equipment





Test Requirements

- Achieving valid, **repeatable results**
- The EUT is normally exercised in a way that represents its typical usage.
 - For intentional radiators, FCC requires to test to the **10th** harmonic or 40GHz

Highest Internal Freq.(MHz)	Upper Freq. of Measurement(MHz)
Below 1.705	30 (only conducted measurement)
1.705 ~ 108	1000
108 ~ 500	2000
500 ~ 1000	5000
Above 1000	5th harmonic of highest freq. or 40GHz





Declaration Method

FCC Part 15 on Radio Freq. Device

■ Classification of Computing Device

■ Class B devices, like computers and their peripherals

■ Require certification (需要送審, 耗時≈35天, \$845)

■ Class A and Class B – other than PCs and their peripherals

■ Self-certification, manufacturer verifies

(不須送審, 但測試報告要備查)

[Refer](#)

■ Self-Declaration of Conformity (DoC) (自我認證)

■ Manufacture/importer of CPU board, power supply

■ System integrators who assemble PC from self-certified parts





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- *National Regulations Summary*





National Regulations Summary

- One of the main reasons to do EMC test is because government agencies require it.
- Just EMI is concerned at the first, until January 1st, 1996, Europe requires product to accept European Norms (including EMS / immunity).





National Regulations Summary

Catalogs of EMC standard

- Generic Standard
 - Used for all product not defined in particular standard. (環境分類)
- Basic Standard
 - Define and describe the method and setup of the measurement. No limits and criteria specified.
- Product or Product Family Standard
 - Provide the test limits for specific category of devices.





National Regulations Summary

EMI -- Generic Emission Standards

FCC	EN's	Description
Part 15	EN50065-1	Signaling on low-voltage electrical installations in the frequency 3~148.5kHz
	EN50081-1	Generic emissions standards – Residential
	EN50081-2	Generic emissions standards -- Industrial
FCC	EN's	Limits & Methods of Measurement
Part 15	EN 55022	Information technology equipment (ITE)





National Regulations Summary

FCC -- Radiated Emission



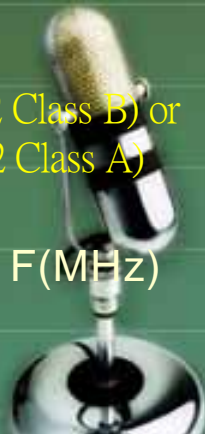
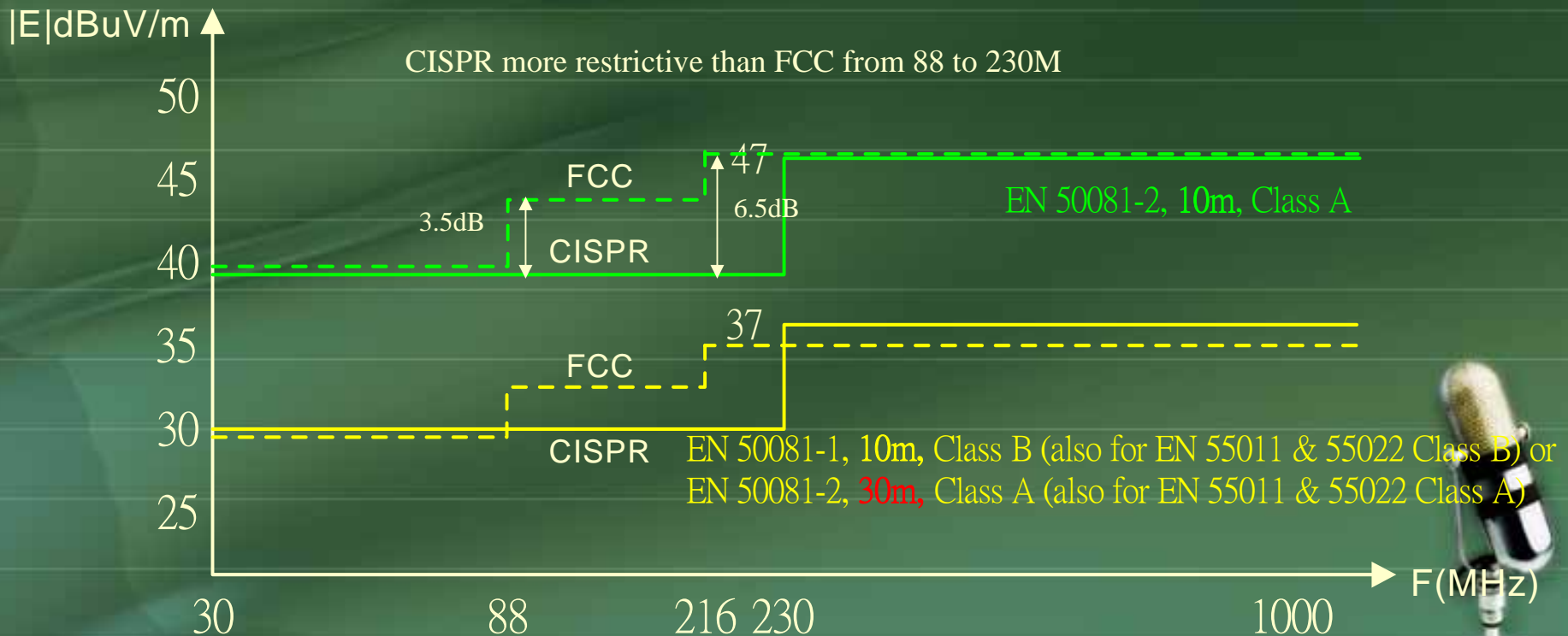


National Regulations Summary

EN 50081 (1991) -- Radiated Emission

- EN50081-2 : Class A for Industrial (工業用)
- EN50081-1 : Class B for Residential (家用)

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National Regulations Summary

EMI – Basic Radiated Emission Standards

CISPR	FCC	EN's	Limits & Methods of Measurement
11	Part 18	EN 55011	Industrial, Scientific and Medical (ISM)
12		EN 55012	Vehicles(載運工具), Automotives (汽車用)
13	Part 15	EN 55013	Broadcast Receivers
14		EN 55014	Household Appliances / Tools
15		EN 55015	Fluorescent lamps / Luminaries
16			Measurement apparatus / Methods

■ Part 15 classifies products in three general categories

- Intentional radiators
- Incidental(伴隨發生的) radiators
- Unintentional radiators

Class A / B

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National Regulations Summary

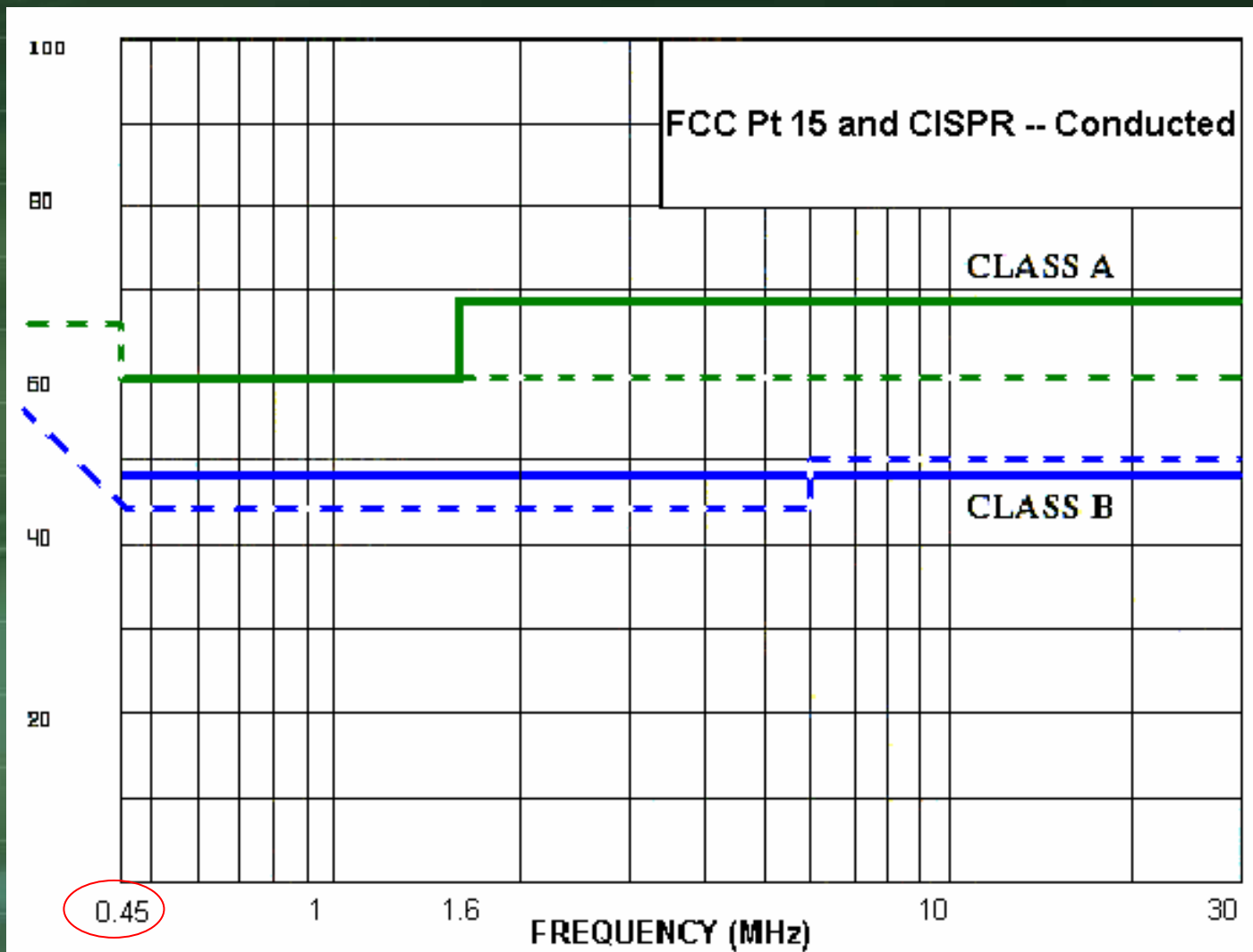
EMI – Basic Conducted Emission Standards

EN's	Description (input current $\leq 16\text{A}$ per phase)
EN61000-3-2	Harmonic current emission
EN61000-3-3	Voltage fluctuations and flicker in low voltage supply systems



National Regulations Summary

FCC Pt. 15 / CISPR Pub. 22-- Conducted Emission



FCC

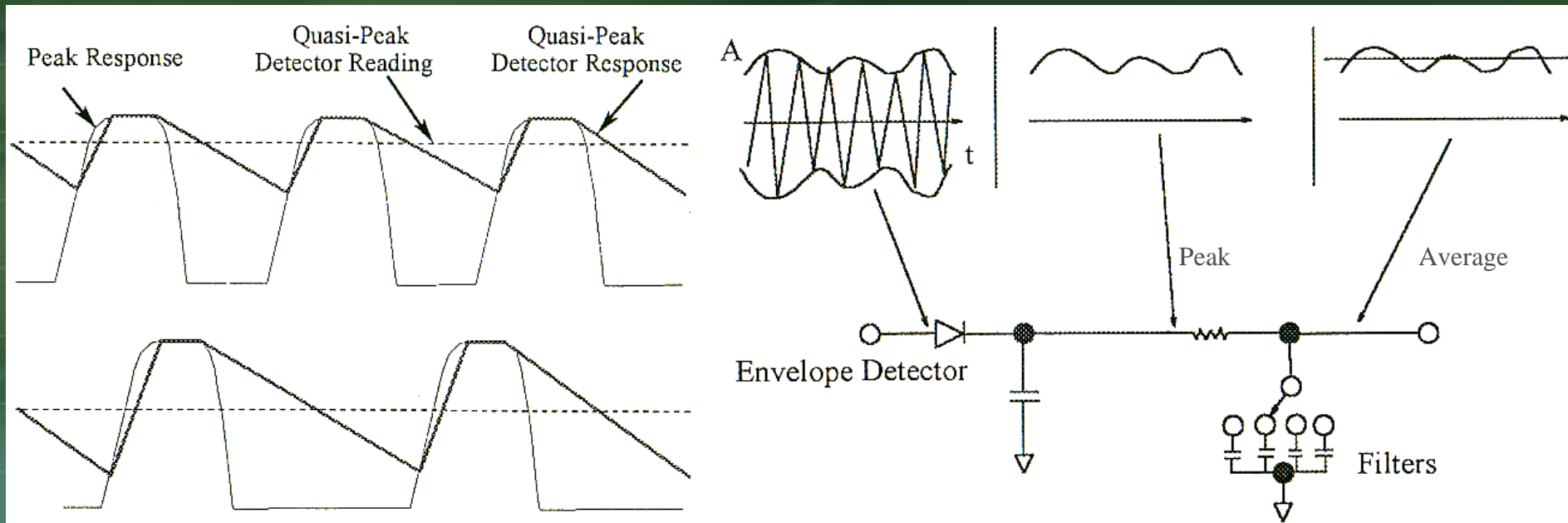
CISPR





National Regulations Summary

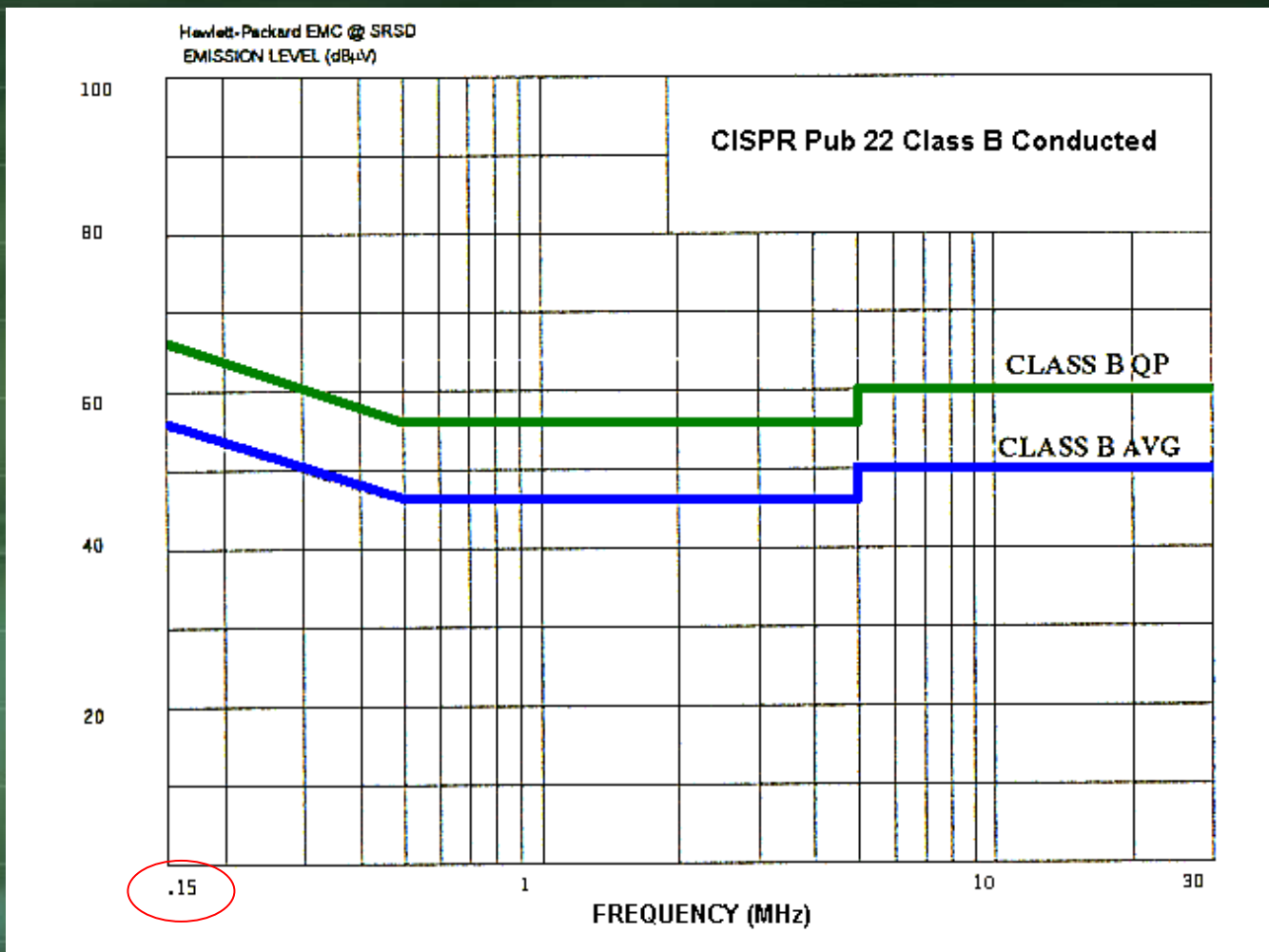
Peak / Quasi-Peak / Average





National Regulations Summary

CISPR Pub. 22 Class B -- Conducted Emission



Quasi-peak limit
Average limit





National Regulations Summary

EMS -- Generic Immunity Standards

EN's	Description (input current $\leq 16A$ per phase)
EN50082-1	Residential, commercial and light industry environment
EN50082-2	(Heavy) industrial environment
EN's	Limits & Methods of Measurement
EN55024	Information technology equipment (ITE)

- No FCC standards for EMS (Immunity)





National Regulations Summary

EMS -- Basic Immunity Standards

EN 50082(1997) or EN55024(1998) for ITE

IEC / EN's	Description
61000-4-1	Overview of EMC immunity test
61000-4-2	Electrostatic Discharge (ESD) immunity test
61000-4-3	Radiated, radio-frequency electromagnetic field immunity test
61000-4-4	Electrical Fast Transient (EFT) / Burst immunity test
61000-4-5	Surge immunity test
61000-4-6	Immunity to <u>conducted</u> disturbances <u>induced by radio-frequency</u> fields above 9kHz

IEC 1000-4-x → IEC 61000-4-x == EN 61000-4-x





National Regulations Summary

EMS -- Basic Immunity Standards

EN 50082(1997) or EN55024(1998) for ITE

IEC / EN's	Description
61000-4-7	Guide on harmonics & inter-harmonics measurements & instrumentations for power supply systems
61000-4-8	Power frequency magnetic fields immunity test
61000-4-9	Pulse magnetic fields immunity test
61000-4-10	Damped Oscillatory magnetic fields immunity test
61000-4-11	Voltage dips, short interrupts and voltage variations immunity test





National Regulations Summary

Standards Summary

Environment	Generic Emissions (EMI)	Generic Immunity (EMS)
Residential, commercial, and light industrial	EN 50081-1	EN 50082-1
Industrial	EN 50081-2	EN 50082-2
Information Technology Equipment (ITE)	EN55022	EN55024





National Regulations Summary

Immunity Standards Summary

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Description of Immunity Test	IEC (old)	IEC (new)	CENELEC Num.	Test limits or application
Overview of Immunity Tests	N.A.	IEC 1000-4-1	EN61000-4-1	N.A.
Generic Immunity	N.A.	N.A.	EN50082-1 EN50082-2	Residential Environment Industrial Environment
Electrostatic Discharge	IEC 801-2	IEC 1000-4-2	EN61000-4-2	2~8 kV contact discharge 2~15 kV air discharge
RFI (Radiated)	IEC 801-3	IEC 1000-4-3	EN61000-4-3	80M~1GHz, 80% AM mod. @1, 3, 10, 30V/m
EFT / Burst	IEC 801-4	IEC 1000-4-4	EN61000-4-4	0.250KV~2kV I/O lines 0.5KV~4kV AC/DC mains
Surge	IEC 801-5	IEC 1000-4-5	EN61000-4-5 EN61000-4-5(ring wave)	Depends on product installation class
Induced RF Fields (Conducted)	IEC 801-6	IEC 1000-4-6	EN61000-4-6	9k/150kHz~80MHz, 80% AM mod. @1V(7mA), 3V(21mA), 10V(70mA) 30V(210mA)
Power Frequency Magnetic-field	N.A.	IEC 1000-4-8	EN61000-4-8	1~100 A/m continuous on AC
Pulsed Magnetic-field	N.A.	IEC 1000-4-9	EN61000-4-9	100~1000 A/m
Damped Oscillatory Magnetic-field	N.A.	IEC 1000-4-10	EN61000-4-10	10~100 A/m
Voltage Dips, Interrupts, Variation	N.A.	IEC 1000-4-11	EN61000-4-11 (AC) EN61000-4-29 (DC)	Product and test type dependent 70% /40% /0% dip, 0.5cycle~1s





National Regulations Summary

Radiated Immunity Standards

- IEC 801-3
 - 27 - 500 MHz, no modulation
 - Withdrawn
- IEC 1000-4-3 → IEC 61000-4-3
 - 80 - 1000 MHz, 80% AM mod
 - Accepted
- ENV 50140 → EN 61000-4-3
 - 80 - 1000 MHz, 80% AM mod pulse mod
 - Accepted





National Regulations Summary

Conducted Immunity Standards

- IEC 801-6
 - 150K - 230 MHz, no modulation
 - Withdrawn
- IEC 1000-4-6 → IEC 61000-4-6
 - 150K - 80 MHz, 80% AM mod
 - Accepted
- ENV 50141 → EN 61000-4-6
 - 150K - 80 MHz, 80% AM mod pulse mod
 - Accepted





Summary

- EMC will be more and more important.
- The kinds of regulations are complex.
- No one approach or design rule can result in a solution to all EMC problems.
- Strategies in different point of views usually are used for an EMC condition
 - Internal circuit level or system level concerns.
 - In many practical situations, more than one approach is required to solve an EMC problem.

