



EMC Introduction

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	Definition	Example	
Conducted Emission	Conducted emissions are EM energy created by a device and transmitted in the form of an electrical current through its power cord.	 Power source(AC/DC) Network port(CAT5, 6) 	
Radiated Emission	Radiated emissions are EM energy created by a device and released as electromagnetic fields that propagate through air, away from the device.	MotorSwitch	

https://sciencing.com/difference-between-conducted-radiated-emissions-14351.html



	Definition	Example	
Conducted Susceptibility	Energy coupled onto cables and wires, used to determine the ability of equipment or circuits to withstand or reject electrical noise.	ESDSurge	
Radiated Susceptibility	Energy coupled to the chassis, cables and wires by radiated means, used to judge the ability of equipment or circuits to withstand noise.	RF noise susceptibility	



What is EMC (examples)

- EMI
 - In 1982 the U.K. lost a destroyer (驅逐艦) in the battle of Falkland Island during the engagement with Argentinean forces. The destroyer's radio system for communication with the UK *would not operate properly* while the ship's antimissile detection was being operated.
 - A new version of an automobile has microprocessor-controlled emission and fuel monitoring system installed. When the customer drove down a certain street in the town, the car would stall. The *illegal FM radio* in this street cause that.
 - FM/AM radio is noisy when the Desktop PC is turned on.
 - It is forbidden to use the electronic devices, such as wireless phone, notebook, on the airplane.
- EMS
 - Walking across a nylon carpet with rubber-soled shoes can cause a build-up of static charge on the body. When an electronic device is touched, an <u>ESD</u> occurred. A protection system for ESD is required.
 - In the first <u>nuclear detonation</u> in the mid-1940s, it was discovered that semiconductor devices that was used to monitor the blast were destroyed. It is due to the intense EM wave (<u>EMP</u>) created by the charge separation and movement within the detonation.
 - <u>Lighting</u> carries upwards of 50,000A of current. The EM fields from this intense current can couple to electronic systems either by direct radiation or coupling.

What is EMC ?



- Electromagnetic Compatibility (EMC)
 - Low Electromagnetic Interference (EMI)
 - Conducted & Radiated
 - Low Electromagnetic Susceptibility (EMS)
 - ESD, Surge, Fast Transient
 - Good Signal Quality/Integrity (SI)

Why EMC

- Healthy reasons:
 - Microwave oven
 - GSM for brain tumor
 - Cancer caused by high power line
- Safety reasons
 - Aircraft navigation
 - Appliance in home
- Wireless comm. reasons
 - clear spectrum is necessary for WCOM.
 - For proper and secure data transmission.
 - Wide spectrum usage such as
 - AM radio in LF, MF and HF range
 - FM, TV, and mobile phone in VHF
 - GPS, Digital sound broadcasting in UHF
 - Satellite communication in Microwave range







Why EMC

• High-speed trend reason:

TABLE I TREND OF THE HIGH-PERFORMACE MICROPROCESSOR PREDICTED BY INTERNATIONAL TECHNOLOGY ROADMAP OF SEMICONDUCTOR

Year	Interconnect pitch (nm)	On-chip clock (GHz)	Power Supply (V)	Maximum power density (watts/mm2)	
2010	45	5.9	1.1	0.96	•
2012	36	6.8	1.0	1.11	
2014	28	7.9	1.0	1.17	
2016	22.5	9.2	0.9	1.07	
2018	17.9	10.7	0.9	1.19	
2020	14.2	12.4	0.8	1.24	
2022	11.3	14.3	0.8	1.73	
				L	:
	Hig	h speed	Low voltag	e	High power consumption

*Source: The International Technology Roadmap for Semiconductor (ITRS), 2008



(http://www.itrs.net)



Background - Motivation

Noise interference issues in 3-D IC:

In the high integration and high performance 3D IC, reducing the noise inference either in <u>intra(inter)-system</u> plays an important role in maintaining performance and stability.



Why EMC



• Automobiles with electronics





Why EMC difficult to meet? (An example)



HGURE 2.18 A simple experiment to demonstrate the difficulty in meeting the radiated emission limits: (a) schematic and dimensions of device tested; (b) cross-sectional dimensions of the printed circuit board (PCB).



Three elements are necessary to produce an interference problem

- 1. Noise source: natural, manmade
- 2. Coupling path: radiation (far field, near field), conduction
- 3. Receptor: biological (human, animal), manmade





How EMC



- Suppress the emission at its source
- Make the coupling path as inefficient as possible
- Make the receptor less susceptible to the emission





Design Process 1 (not good)



- EMC incompliance forces product redesign
- Product redesign is very costly
- Time-to-market delayed
- Potential profit reduced



Design Process 2 (improved)





EMC technique includes 3 levels



EQUIPMENT DEVELOPMENT TIME SCALE

H. Ott, Engineering Electromagnetic Compatibility, Ch 1, John Wiley and Sons, 2009.

Example: PC

Suppress the emission:

- 1. Proper layout with EMC concept
- 2. Use components with low edge rate as possible

Less susceptible receptor:

- 1. Use differential signaling
- 2. Error-correcting code

Reduce coupling path:

1. Additional shielding



Example: Mobile phone

Potential EMI sources:

- (1) Timing clock in CPU: Current high performance IC's are clocked at frequencies well into the GHz.
- (2) Digital circuit noise: Noise from digital circuit would reduce the receiver sensitivity.

Potential EMI coupling path:

(3) Interconnect discontinuity: The interface between any two different circuits not only degrades the signal quality, but also serves as a potential radiator that causes RF interference.



Ref: https://product.tdk.com/en/products/emc/guidebook/eemc_practice_05.pdf

Example: Mobile phone



Example: Automobile

Modern automotive has many different sensors installed. Considering the safety of drivers and passengers, it requires a high-class standard of EMC regularity. Radio systems inside a modern (or future) vehicle (**EMI victims**) include:

- 1. Parking radars
- 2. FM/AM radio
- 3. Bluetooth
- 4. Satellite navigation
- 5. Vehicle tracking
- 6. Collision notification
- 7. Vehicle-to-vehicle (V2V)
- 8. Vehicle-to-everything (V2X)





Electronic motor control: Surface currents at 50 kHz on a motor control PCB, showing the conducted emissions.



Cable harness EMC: Radiated emissions from a cable inside a vehicle.

Ref:https://www.cst.com/-/media/cst/solutions/articles/flyer/cst-automotive-flyer/cst_automotive_flyer_web.ashx

Giant testing chamber!



Ref: http://www.autocarpro.in/news-national/natrip-icat-centre-ii-inaugurated-india-leaps-ahead-automotive-testing-29702





FCC ID : E5XKB5137 Model No: 5137 VOLTS:5V AMPS:50mA Made in CHINA (B)



CE





3001525664 WY

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. The Windows logo is a registered trademark of Microsoft Corporation.







https://liveandletsfly.boardingarea.com/2017/02/19/united-inflight-calls/

Some EMC Books

- C. R. Paul, Introduction to Electromagnetic Compatibility, 2nd ed., John Wiley & Sons, 2006.
- H. Ott, *Engineering Electromagnetic Compatibility*, John Wiley and Sons, 2009.
- V. P. Kodali, Engineering Electromagnetic Compatibility: Principles, Measurements, Technologies, and Computer Models, IEEE Press, 2001.
- M. Mardiguian, *Controlling Radiated Emissions by Design*, 3rd ed., Switzerland: Springer, 2014.
- Using NTU's IP, you can access all these books online.



Clayton Paul 1942-2012



Henry Ott

https://www.emcs.org/acstrial/newsletters/winter06/clayton.html http://www.hottconsultants.com/public.html