Evaluation protocols for the safety of the IoT devices: non-ionizing exposure, electrical and chemical considerations

Tongning WU
CTTL-Terminals,CAICT
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Résumé

Tongning WU is a senior engineer in China Academy of Information and Communications Technology (CAICT), where he leads the laboratories of electromagnetic radiation, electrical safety and chemical safety. He worked for Orange Labs (Issy-Les-Moulineaux, France) between 2006 and 2008.

He obtained his Ph.D degree from Université Paris-Est Marne-la-Vallée , France, in 2009. His work focuses on electromagnetic fields dosimetry, numerical modeling and biomedical signal processing.

In the past three years, he led three national projects on biomedical imaging processing, one Franco-China project on dosimetry with infant models and several key projects from the mobile industry. He is the board member of the China Bioelectromagnetic Association and China Digital Medical Association. He also participated in the IEC/IEEE workgroups on EMF safety. He serves as the international consultant for WHO EMF project.

Course Objectives:

- **Definition of IoT, its prospective and its application**
- **Potential risks to the environment and human and the evaluation protocols**

-Electromagnetic Radiation

-Electrical safety

-Chemical safety

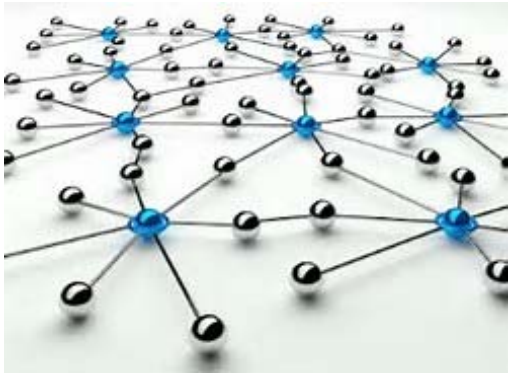
THE definition of IoT

- The **Internet of things** (**IoT**) is the inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to collect and exchange data.

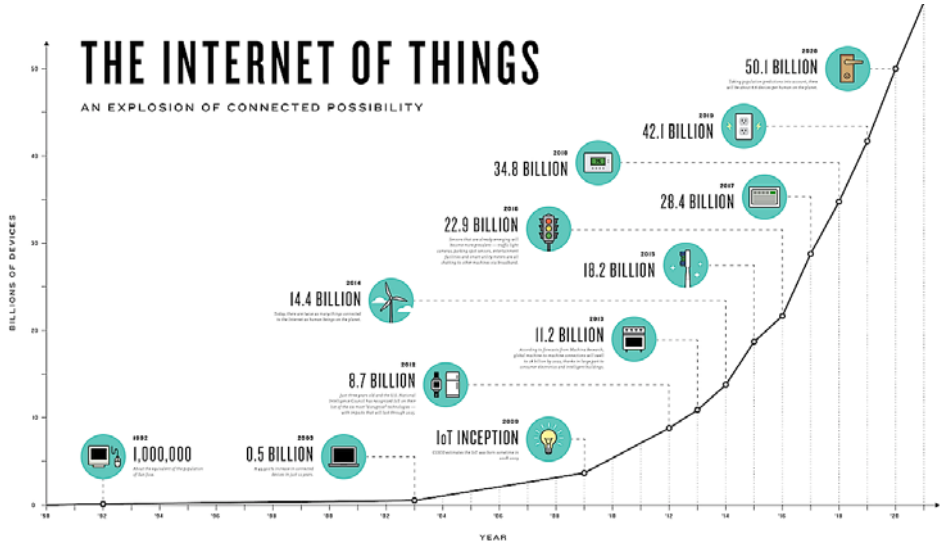
  - Internet of Things Global Standards Initiative. ITU. Retrieved 26 June 2015.

- IOT device is an device that has some form of imbedded connectivity that allows it to directly connect to the internet or an IP- addressable device. This connectivity can be wired or wireless. The device can include a range of sensors as well as some type of user interface, but neither sensors nor a user interface is required.

  - IHS: IOT connected devices: 2017

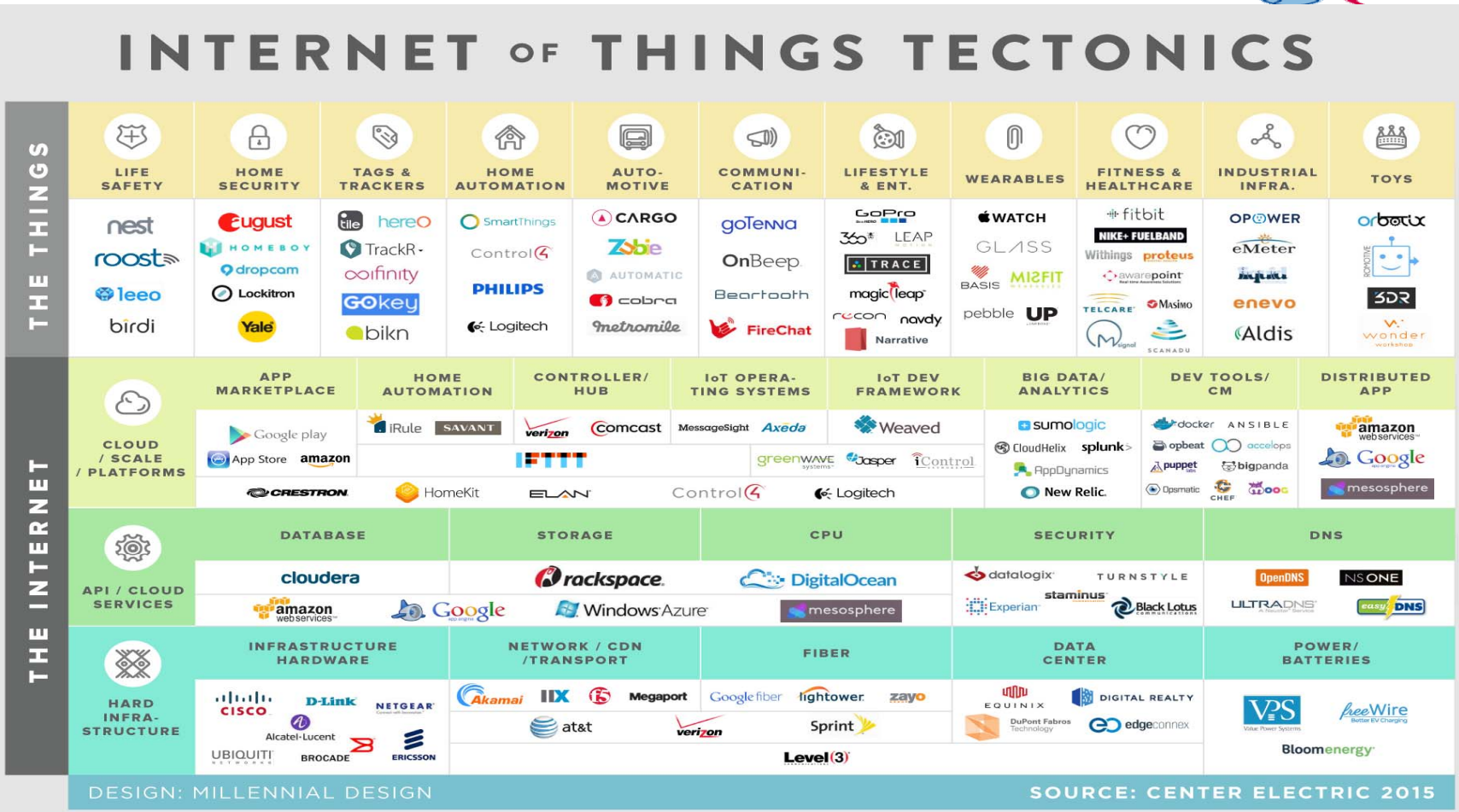


Prospective



IHS IOT-connected devices: 2017

Applications



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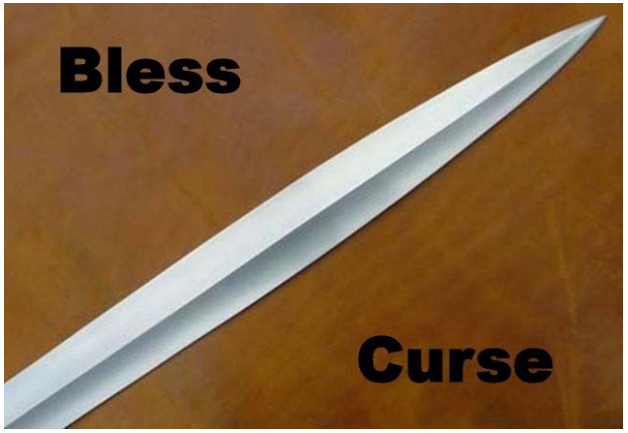
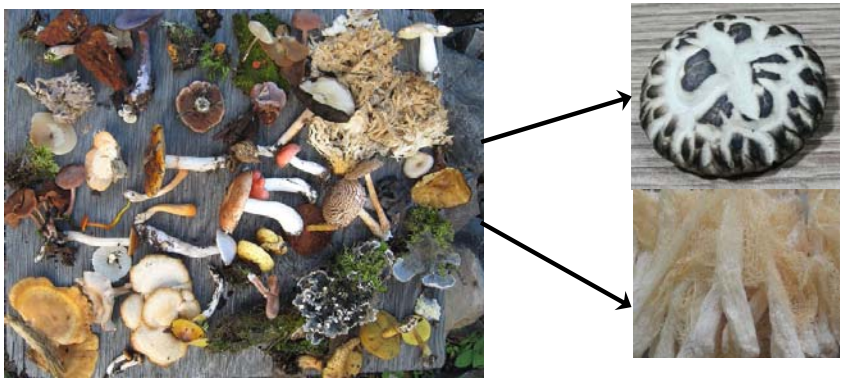
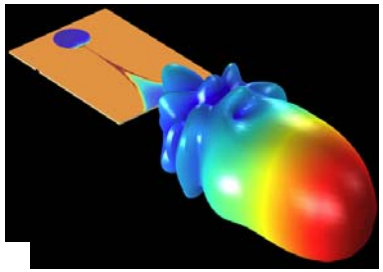
Every coin has two sides…



- Facilitate the communications
- Human concerns on the safety issues

Diversity → common elements?





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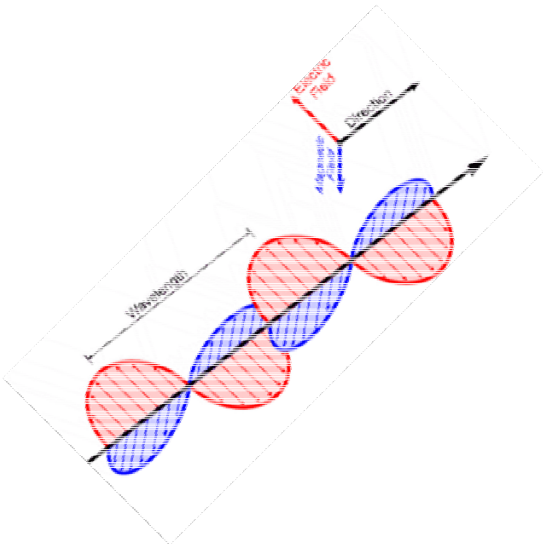
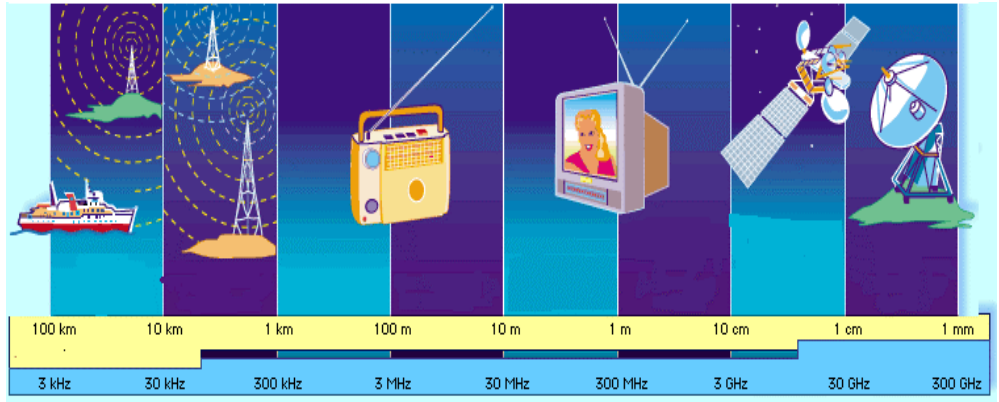
Electromagnetic fields

operation of the electronic devices – unintentional

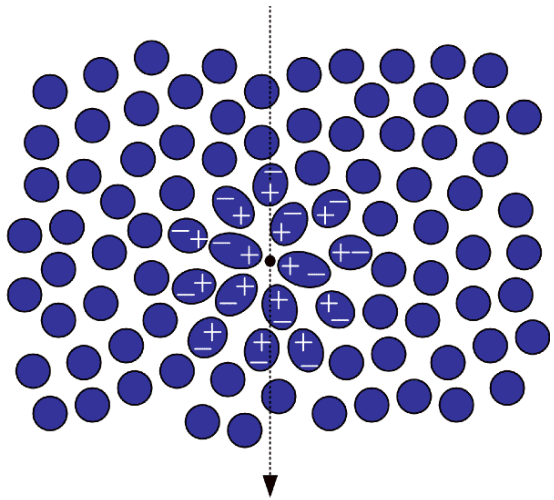
data transfer - intentional

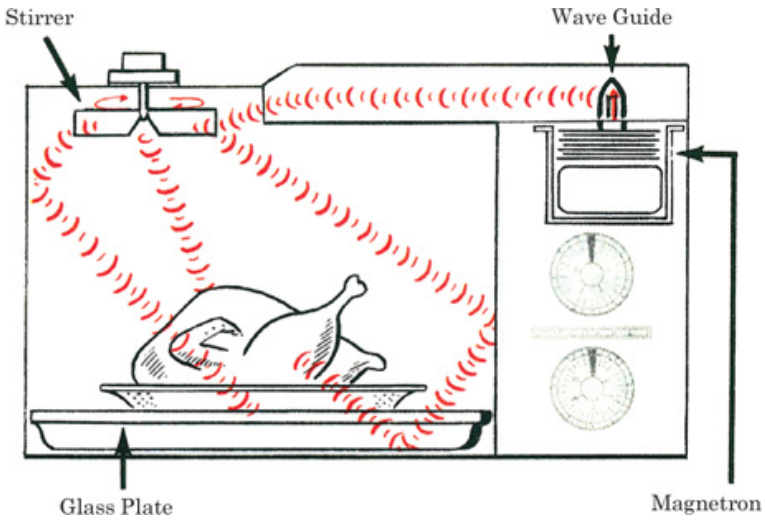




Effect of mechanisms: RF

Temperature elevation (core temperature rise >1 degree Celsius) : 10 MHz to 10 GHz





ICNIRP GUIDELINES

FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC AND ELECTROMAGNETIC FIELDS (UP TO 300 GHz)

PUBLISHED IN: **HEALTH PHYSICS 74 (4):494-522; 1998**

Effect of mechanisms: ELF

Stimulation of the nerve:
Time-varying magnetic field below 10 MHz

INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

ICNIRP GUIDELINES

FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC AND MAGNETIC FIELDS (1 Hz – 100 kHz)

PUBLISHED IN: **HEALTH PHYSICS 99(6):818-836; 2010**

Basic limits: intra-body metrics

	Frequency	Head and trunk Current density （mAm^{-2}） （rms）	Whole body SAR （Wkg^{-1}）	Localized SAR（Head and trunk） （Wkg^{-1}）	Localized SAR（limbs） （Wkg^{-1}）
Occupational	1 Hz	40	–	–	–
	1 – 4 Hz	40/f	–	–	–
	4 Hz–1 kHz	10	–	–	–
	1–100 kHz	f/100	–	–	–
	100 kHz–10 MHz	f/100	0.4	10	20
	10 MHz–10 GHz	–	0.4	10	20
Public	1 Hz	8	–	–	–
	1 – 4 Hz	8/f	–	–	–
	4 Hz–1 kHz	2	–	–	–
	1–100 kHz	f/500	–	–	–
	100 kHz–10 MHz	f/500	0.08	2	4
	10 MHz–10 GHz	–	0.08	2	4

Reference levels: environmental metrics

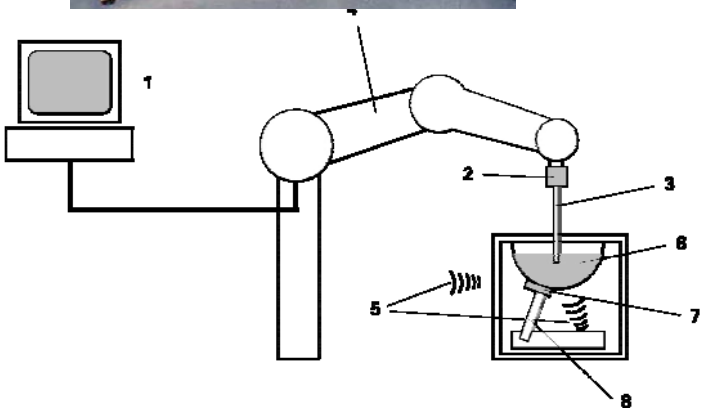
Frequency range	E（V/m）	H（A/m）	B（μT）	Seq（W/m2）
< 1 Hz	–	1.63×105	2×105	–
1–8 Hz	20 000	1.63×105	2×105/f	–
8–25 Hz	20 000	2×104/f	2.5×104/f	–
0.025–0.82 kHz	500/f	20/f	25/f	–
0.82–65 kHz	610	24.4	30.7	–
0.065–1 MHz	610	1.6/f	2.0/f	–
1–10 MHz	610/f	1.6/f	2.0/f	–
1–400 MHz	61	0.16	0.2	10
400–2000 MHz	3f1/2	0.008 f1/2	0.01f1/2	f/40
2–300 GHz	137	0.36	0.45	50

Frequency range	E（V/m）	H（A/m）	B（μT）	Seq（W/m2）
< 1 Hz	–	3.2×104	4×104	–
1–8 Hz	10 000	3.2×104/f2	4×104/f2	–
8–25 Hz	10 000	4 000/f	5 000/f	–
0.025–0.8 kHz	250/f	4/f	5/f	–
0.8–3 kHz	250/f	5	6.25	–
3-150kHz	87	5	6.25	–
0.15–1 MHz	87	0.73/f	0. 92/f	–
1–10 MHz	87/f1/2	0.73/f	0. 92/f	–
10–400 MHz	28	0.073	0.092	2
400–2000 MHz	1.375f1/2	0.0037f1/2	0.0046f1/2	f/200
2–300 GHz	61	0.16	0.20	10

Applicable standards

IEC 62479:2010	Assessment of the compliance of low-power electronic and electrical equipment with the basic restrictions related to human exposure to electromagnetic fields (10 MHz to 300 GHz)
IEC 62369-1:2008	Evaluation of human exposure to electromagnetic fields from short range devices (SRDs) in various applications over the frequency range 0 GHz to 300 GHz - Part 1: Fields produced by devices used for electronic article surveillance, radio frequency identification and similar systems
IEC 62209-1:2016	Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Part 1: Devices used next to the ear (Frequency range of 300 MHz to 6 GHz)
IEC 62209-2:2010	Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)
IEC 62311:2007	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)

Compliance measurement: near field



The evaluation protocol should be determined by:

- Frequency
- Emission power
- Position of usage

Low power? → IEC 62749 → Exemption?

↓

IEC 62209-1/2 → Termination

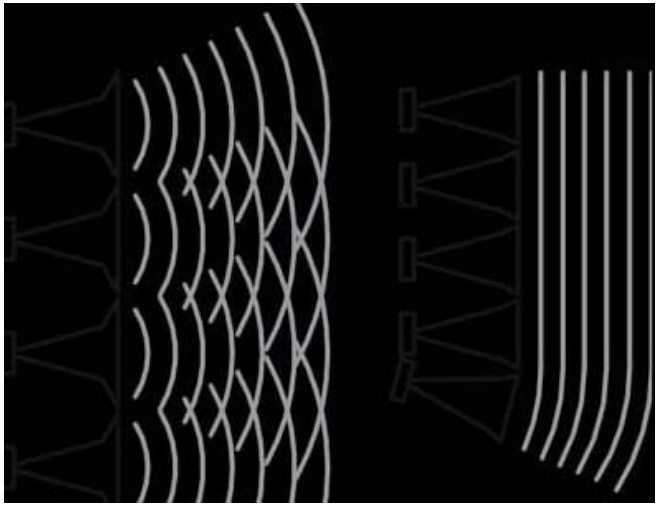
↓

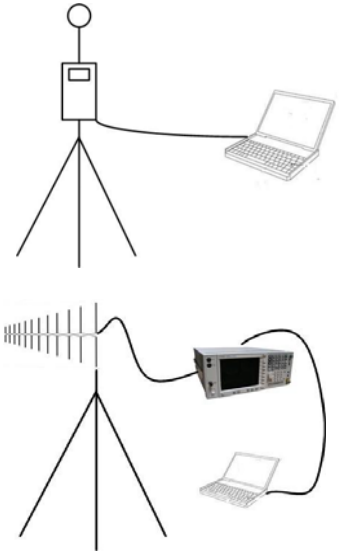
IEC 62311 → Termination

↓

Numerical simulation → Termination

Compliance measurement: far field





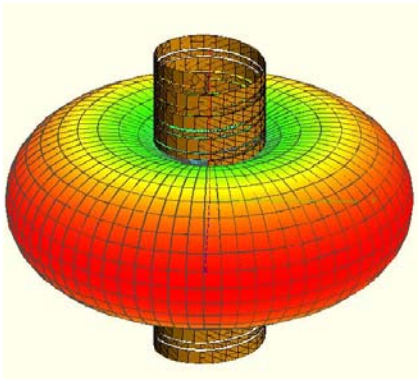
IEC 62232 Determination of RF field strength and SAR in the vicinity of radio communication base stations for the purpose of evaluating human exposure

IEC 62233 Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure

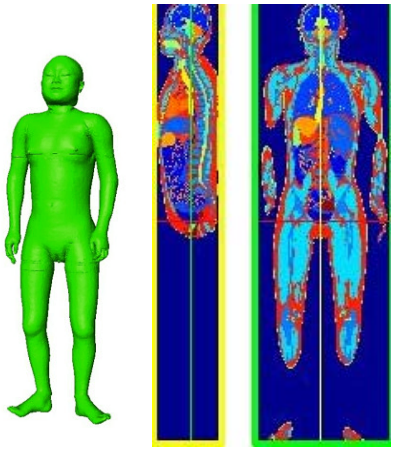
Numerical evaluation for EMF exposure

Three elements

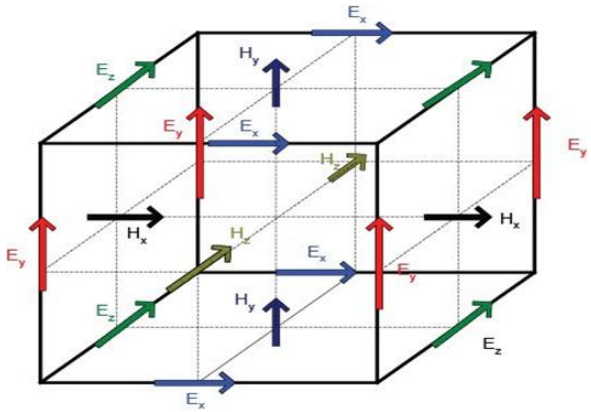
Emitter model



human model

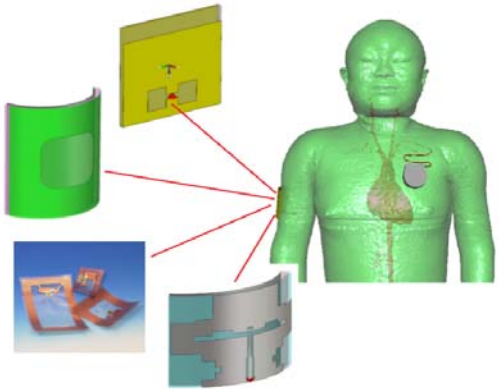


Numerical method

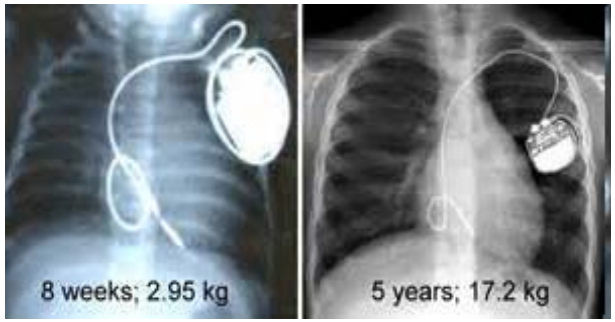


Example:

- **Public concerns on the emission of the wearable wireless devices are raised with the popular uses of this kind of products**



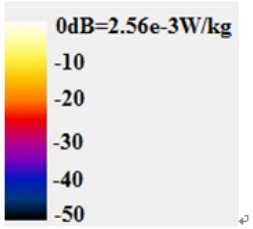
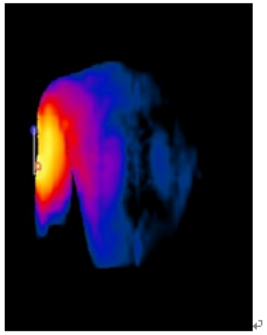
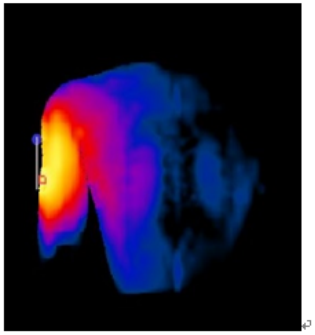
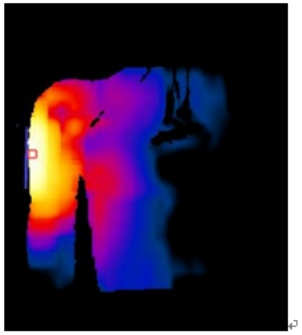
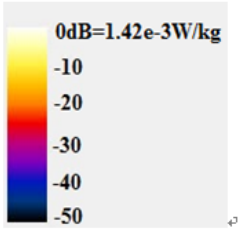
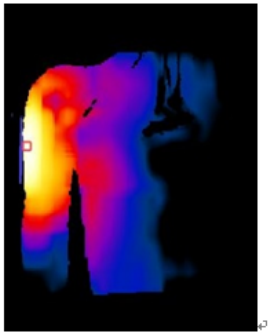
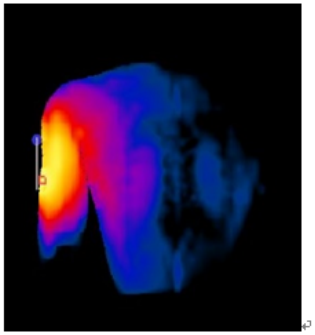
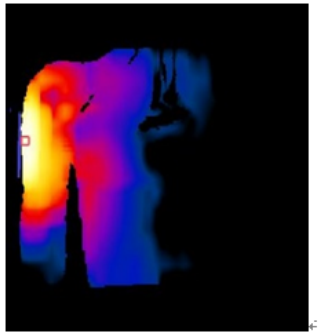
- **Infants are accessible to this kind of emitters and the cardiac pacemakers**



- **Special consideration should be made on the magnetic field (MF) exposure safety and the electromagnetic interference to the implanted medical devices**

Example:

Results

	Chinese Infant	Thelonious	Chinese adult male
pSAR1g 			
pSAR10g 			

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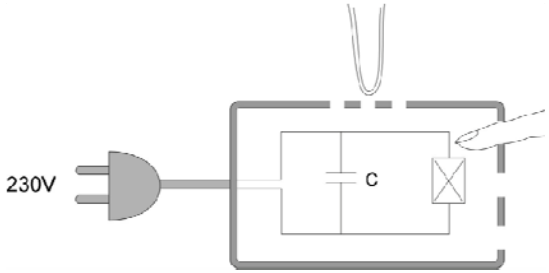
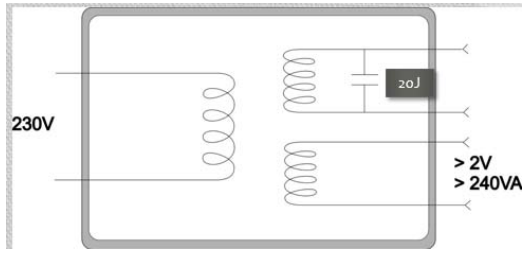
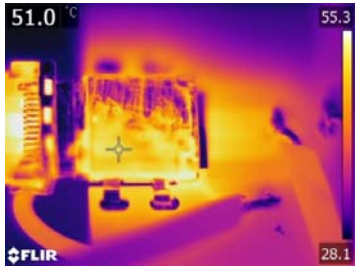
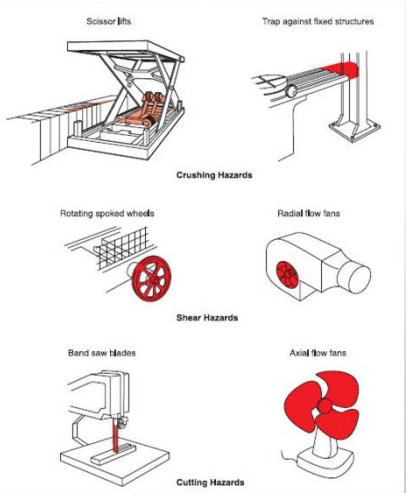
Electrical safety

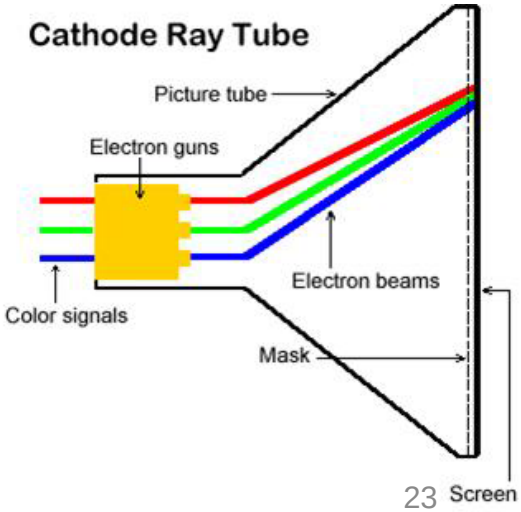
Hazards： electric shock, energy related hazards, fire, heat related hazards, mechanical hazards, radiation, chemical hazards



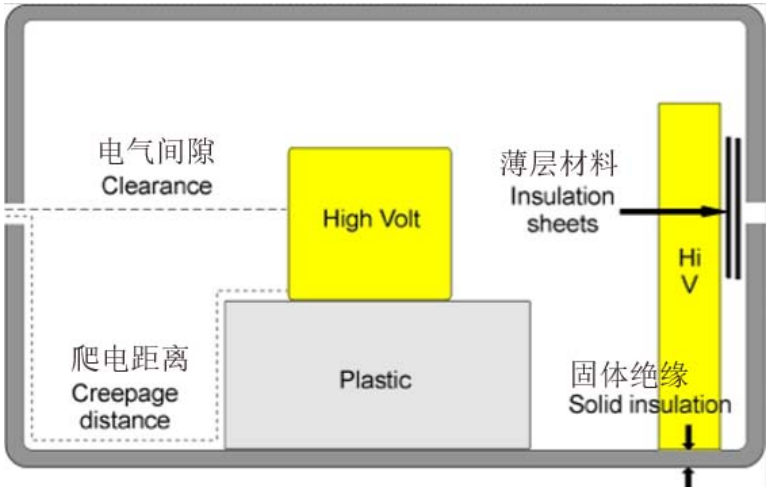


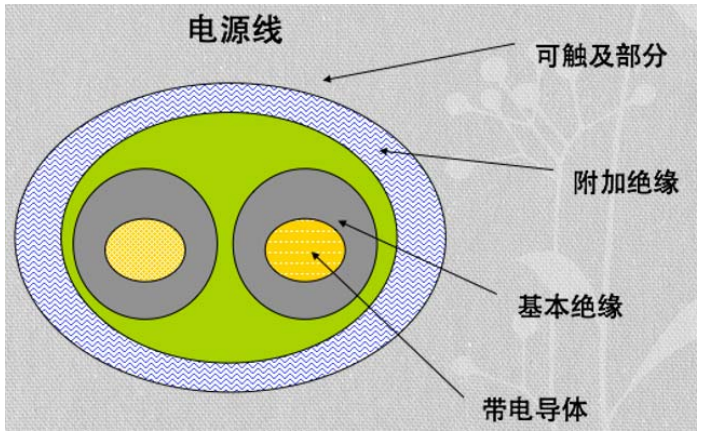


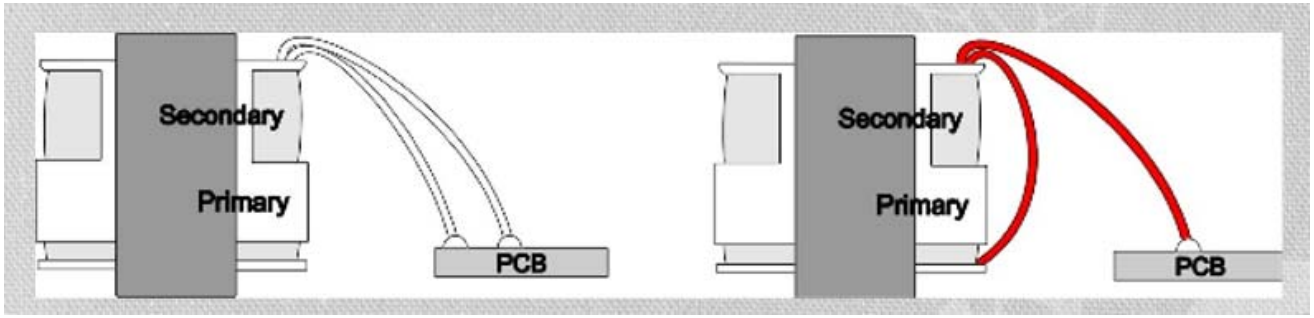




Terminology







Test items

- Input current
- Access to energized parts
- Energy related hazards
- Discharge of capacitors in equipment
- Measurement of SELV circuits
- Measurement of TNV circuits
- Measurement of Limited current circuits
- Limited power sources
- Provisions for earthing and bonding
- Impact test, Drop test
- Direct plug-in equipment
- Batteries (Including protection circuit)
- Radiation(Ionizing radiation, Lasers, LED, Ultraviolet radiation)
- Temperature tests
- Openings
- Resistance to fire
- Touch current

International standardization/certification

- **CB**

is IECEE (International Electrotechnical Commission) established a global system of mutual recognition, there are 34 countries and 45 institutions take part in the mutual recognition of certification systems, namely IEC approved NCB Member States between the laboratories recognized each other's inspection reports.

- **UL**

UL(Underwriter Laboratories Inc.）UL is one of several companies approved to perform safety testing by the US federal agency Occupational Safety and Health Administration (OSHA).

What about CE?

- "CE" ***Conformité Européenne***, （**European Conformity**）is a symbol of free marketability in the European Economic Area (Internal Market).
- The CE marking is the manufacturer's declaration that the product meets the requirements of the applicable <u>EC directives</u>

Major Standard evolution

Traditional Prescriptive Standards

For Audio, Video and Similar Electronic Apparatus:

- IEC 60065
- CSA/UL 60065
- EN 60065

For Information Technology Equipment:

- IEC 60950-1
- CSA/UL 60950-1
- EN 60950-1

Focus:

- Following a set of rules written in the standards

Today	2013/2014	2018 & beyond
60065 60950 62368-1 Ed 1.0	60065 60950 62368-1 Ed 1.0 62368-1 Ed 2.0	62368-1 Ed 2.0

Hazard-based Standards

For Audio/Video, Information and Communication Technology Equipment:

- IEC 62368-1
- CSA/UL 62368-1
- EN 62368-1

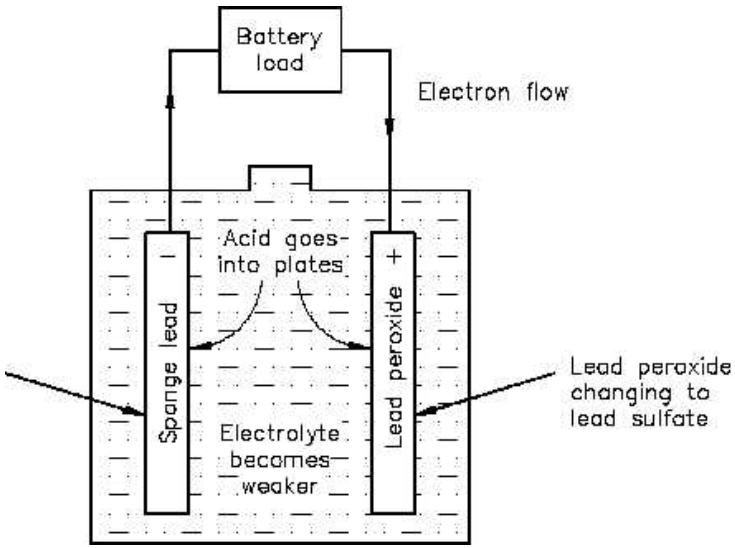
Focus:

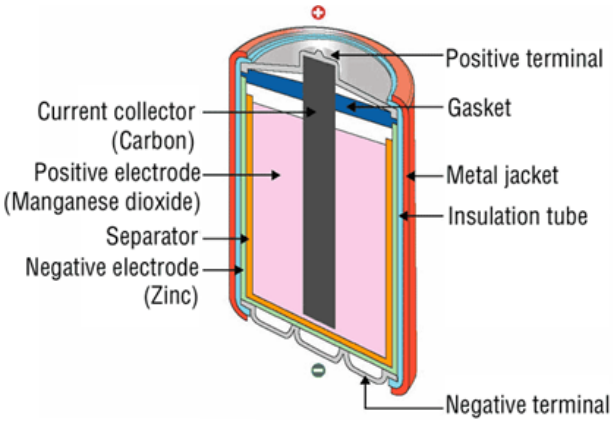
- Identifying safety hazards in the early product development phase and designing the product to eliminate them
- Providing more performance options to demonstrate compliance

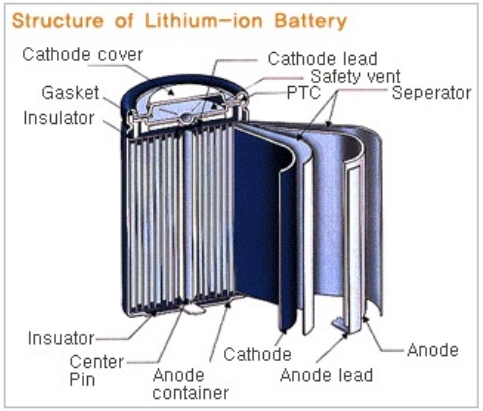
Scope of 62368-1

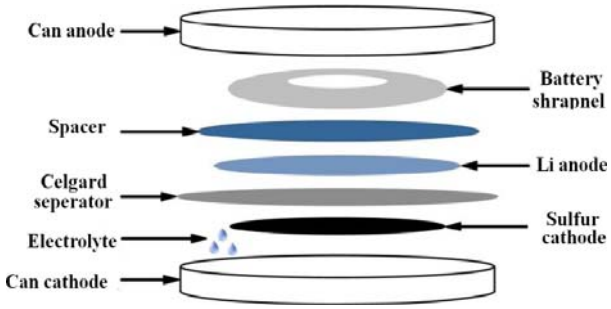
- The new standards cover a wide range of high-tech products, including:
  - Computing & networking products: servers, PCs, routers, notebook/laptop computers and their power supplies
  - Consumer electronics: amplifiers, home theater systems, digital cameras and personal music players
  - Displays and display units: monitors, TVs and digital projectors
  - Telecommunication products: network infrastructure equipment, cordless and mobile phones, and similar communication devices, including battery powered devices
  - Office appliances: copiers and document shredders
  - Musical instruments
  - Similar varieties of audio/video, information & communication technology equipment: devices used in homes, schools, data processing centers, commercial, and professional environments

Battery safety

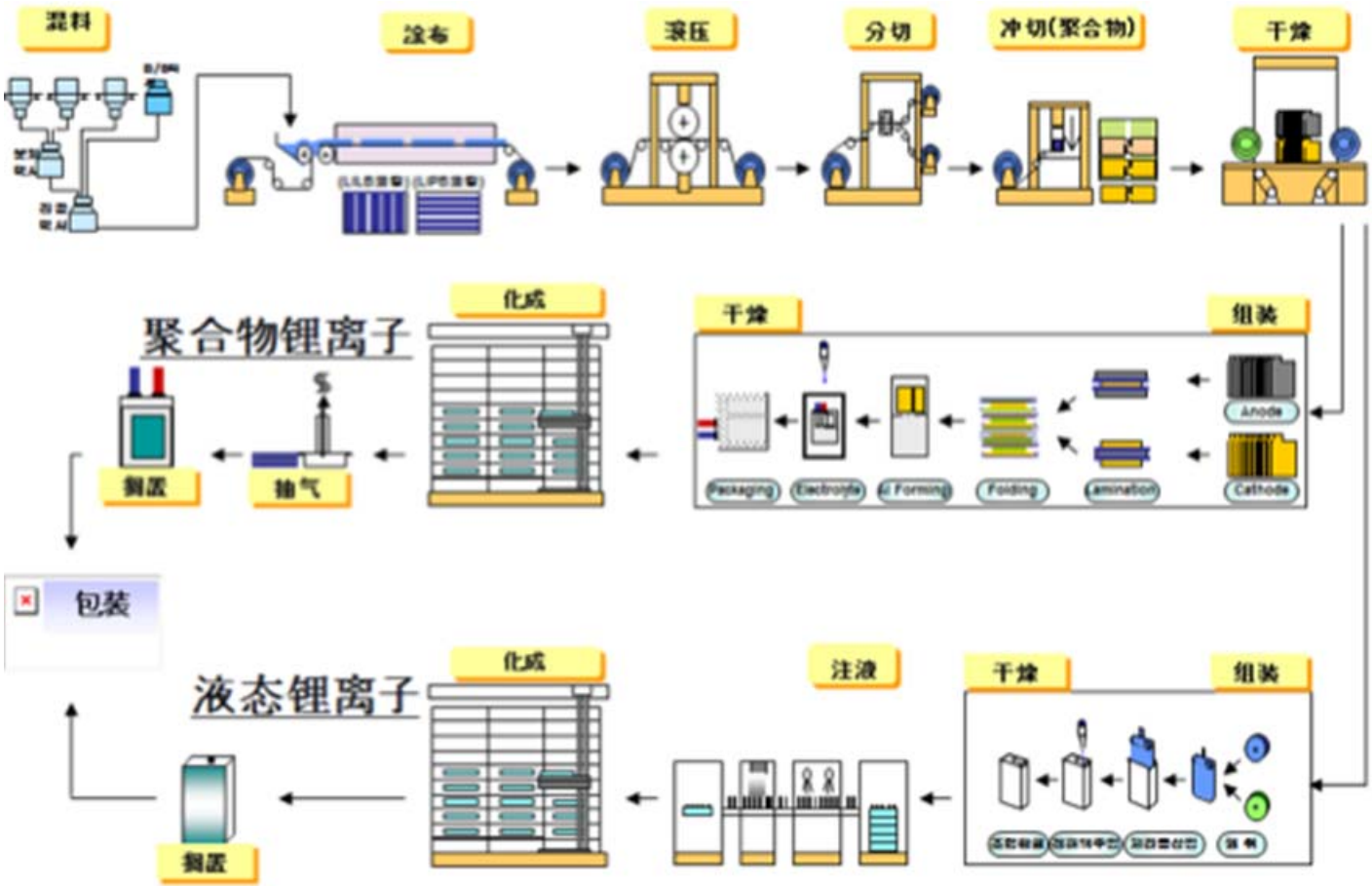








Fabrication of the batteries



Typical test item

Electrical performance	Charge/Discharge at high/low current, Overcharge , Forced discharge , External short circuit（Normal temp, High temp）, Discharge at low temperature, Internal resistance, ESD and so on.
Mechanical performance	Free fall, impact, Vibration, Shock, Crush, Acupuncture test and so on.
Environmental adaptability	Altitude simulation, Temperature cycle，Steady damp, Thermal abuse, Charge (capacity) retention and recovery , Washing performance and so on.
Other case	Projectile test, Cell vent Mechanism and so on.

International battery standards

●UN 38.3, Part Ⅲ 38.3<Transport of dangerous goods>Manu of Tests and Criteria Rev.5

- Reports according this criteria must be provided through air transport

●IEC 62133:2012<Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications >

●IEC 61960:2011< Secondary cells and batteries containing alkaline or other non-acid electrolytes – Secondary lithium cells and batteries for portable applications >

●UL 1642-2007 < Lithium Batteries >

●UL 2054-2006< Household and Commercial Batteries>

-Standard used for UL certification

●IEEE 1725-2011 < IEEE Standard for Rechargeable Batteries for Cellular Telephones >

-Standard used by North American Operators (CTIA certification)

Test equipment (I)

Withstanding Voltage Tester

Projectile Test Equipment

Battery Impact Test Equipment

Battery Washing Test-bed

Battery pinhole note pressure test bench

Test equipment (II)

Drop Tester

Dust Chamber

Salt Chamber

Thermal camera

Course Objectives:

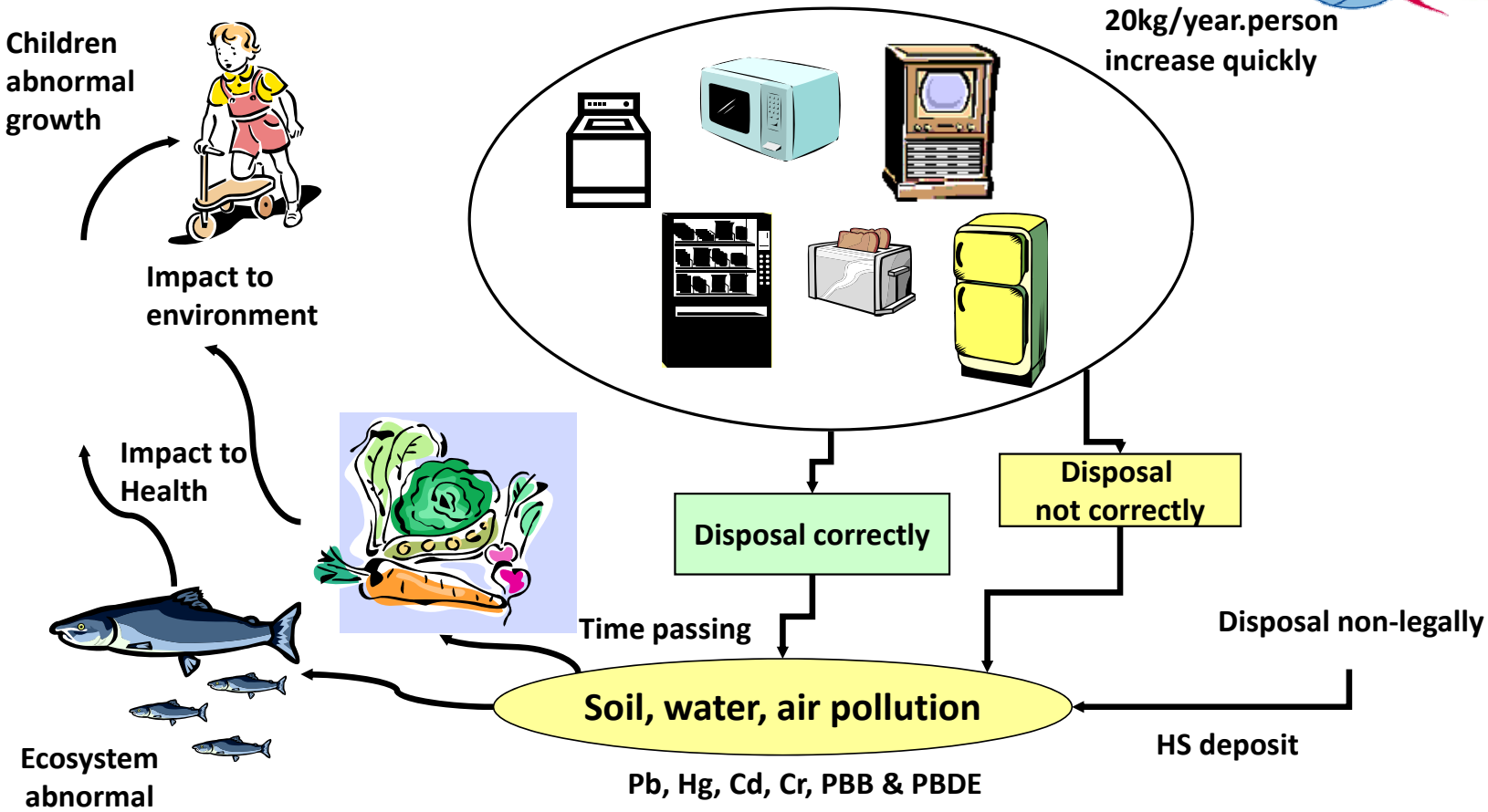
- Definition of IoT, its prospective and its application
- Potential risks to the environment and human and the evaluation protocols

-EMF Radiation

-Electrical safety

-Chemical safety

Footprint of the electronic devices



Worldwide Expansion of Product Policy

US

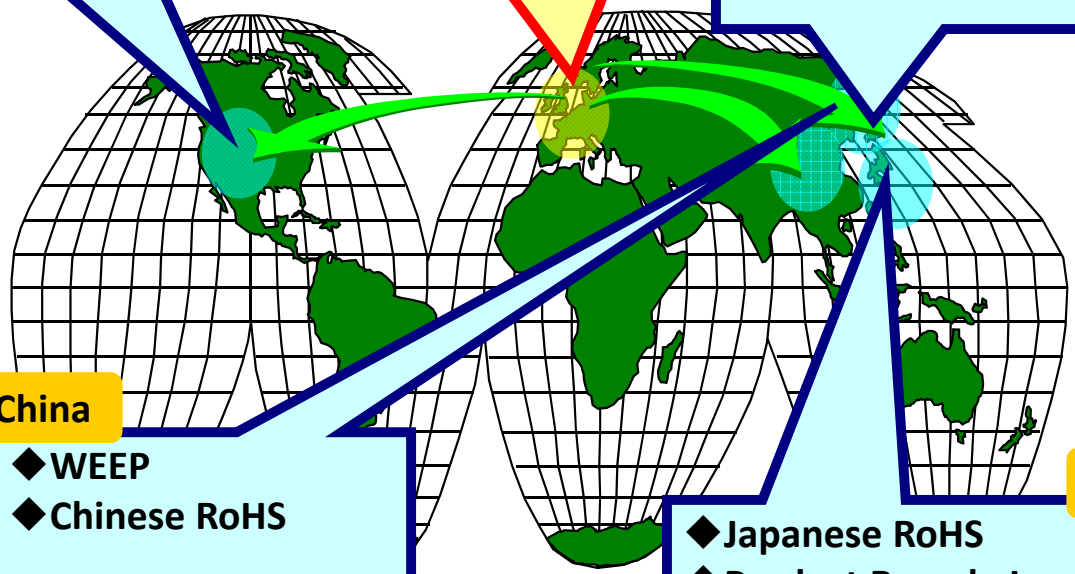
- ◆Proposition 65
- ◆E-Waste (SB20)

EU

- ◆RoHS,WEEE
- ◆EuP
- ◆REACH

Korea

- ◆ Extended Producer Responsibility
- ◆ Eco-Assurance System



China

- ◆WEEP
- ◆Chinese RoHS

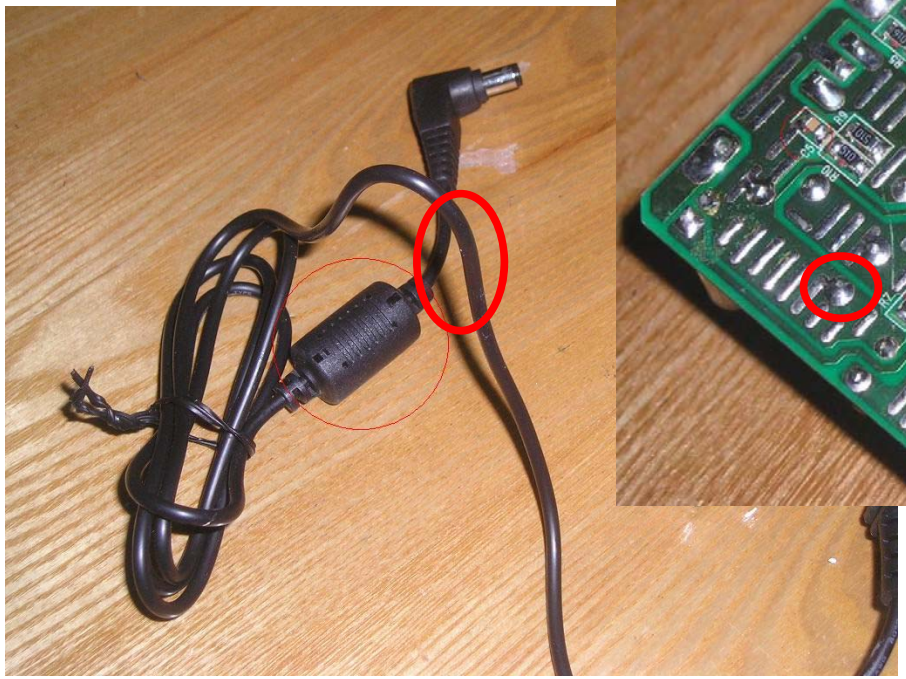
Japan

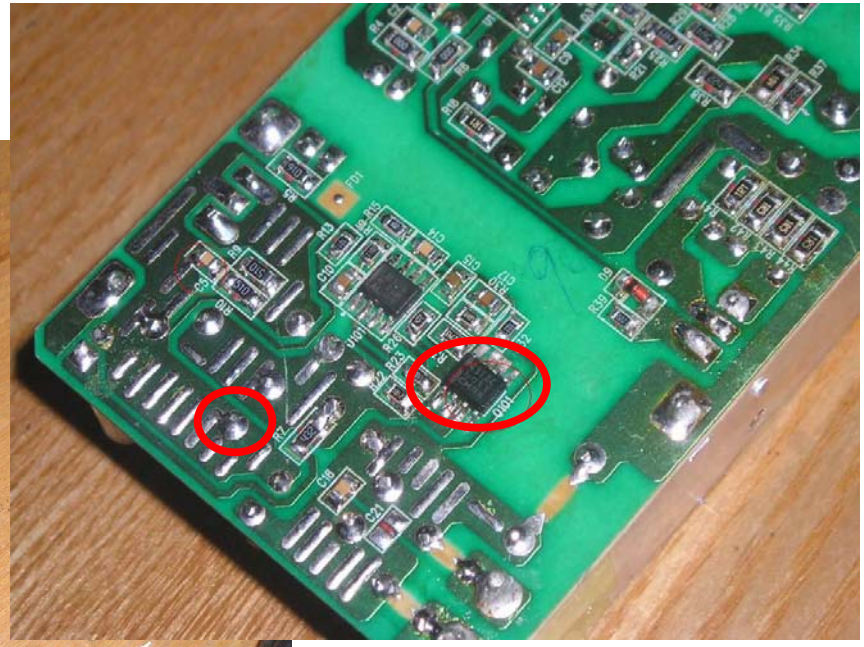
- ◆Japanese RoHS
- ◆Product Recycle Law
- ◆Eco-design (voluntary)

Fair Competition in the Domestic Market

Pb

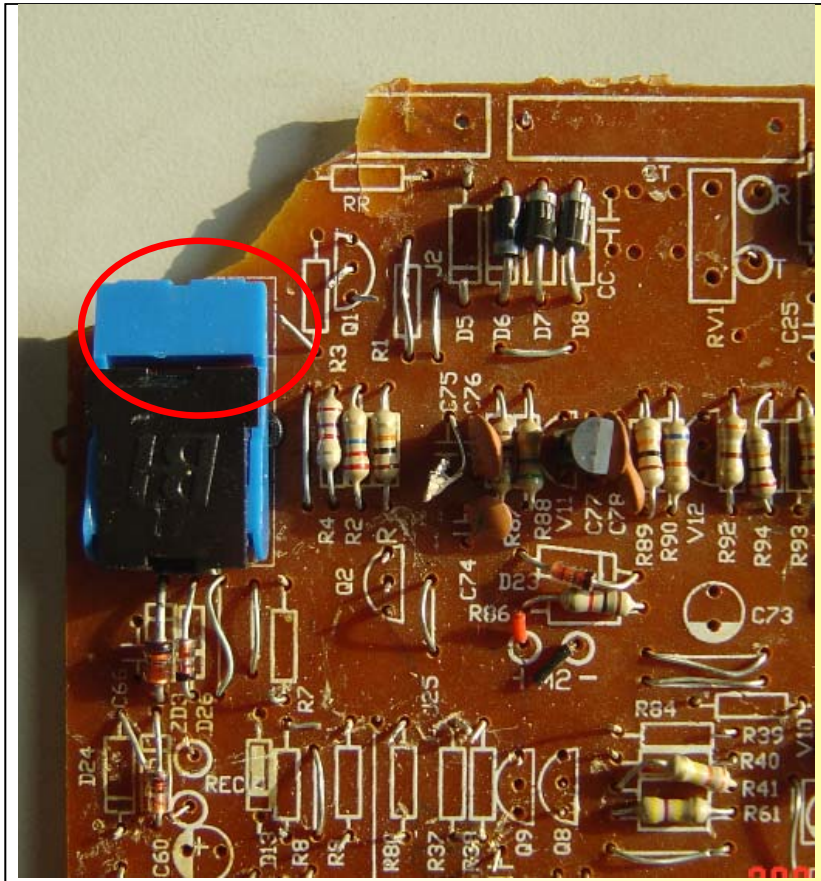
Cable, wire, PVC





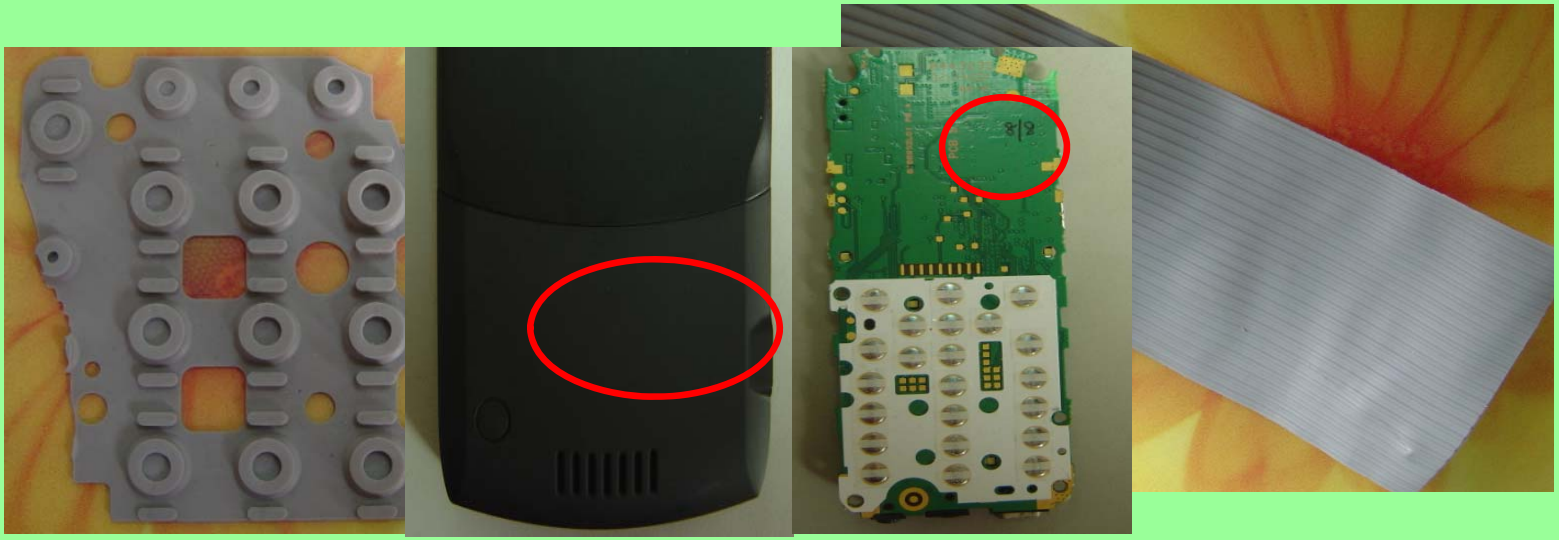
Solder, component, polishing

Cd：switch, power relay and LCD



hexavalent chromium Cr(VI) ：surface treatment, plastics, solder

Hg：cable and wire, contactor



PBB and PBDE：rubber, fire-resisting PCB

RoHS

European Union's **DIRECTIVE 2002/95/EC**

Restriction on Hazardous Substances

RoHS: European Union Member States shall ensure that, from 1 July 2006, new electrical and electronic equipment put on the market does not contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE).

WEEE

European Union's DIRECTIVE 2002/96/EC
Waste Electrical and Electronic Equipment (WEEE)

Producers or third parties acting on their behalf, in accordance with Community legislation, set up systems to provide for the treatment of WEEE using best available treatment, recovery and recycling techniques.

- **Effective since August 13, 2005**
- **Extends producer responsibility towards end-of-life**
- **Sets minimum collection target for WEEE**
- **Sets minimum recovery / recycling targets for collected WEEE**
- **Encourages measures for design for reuse / recycling**

  EuP Directive Later
- **Wants to reduce disposal, hazardous impacts and resource losses**

EuP

European Union's DIRECTIVE 2005/32/EC
A framework for the setting of EcoDesign requirements for Energy-using Products

Source: European Commission

- **first appeared on July 06, 2005, and have to be transposed to a law by August 11, 2007**
- **based on article 95 framework for integration of various environmental aspects: energy efficiency, hazardous substances control, water consumption, noise emission, etc, into the design of energy using product**

EuP is the result of the merger of the former draft "EEE" and "EER" proposals and is stated to be the first IPP (Integrated product policy) model directive.

(Aug 11, 2007)

EuP Directive

Eco-design Requirements

(July 1, 2006)

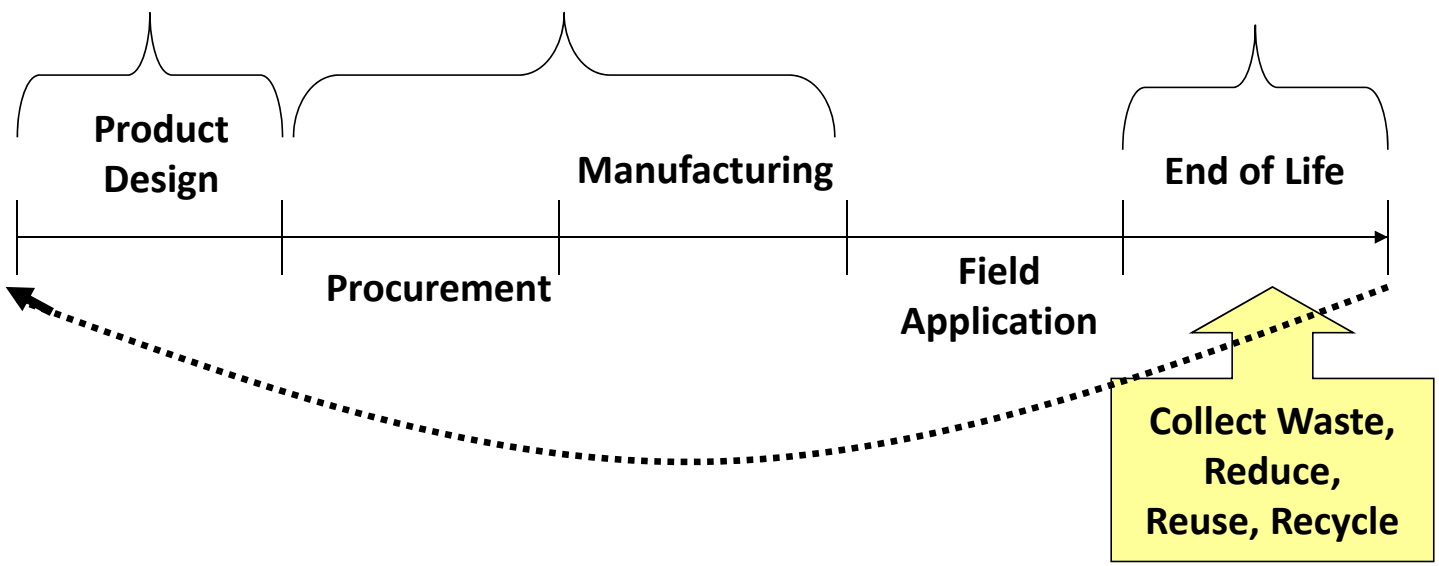
RoHS Directive

Upper limits on 6 Hazardous substances

(Aug 13, 2005)

WEEE Directive

Collection, recovery and Recycling of waste EEE



EU RoHS – Objective

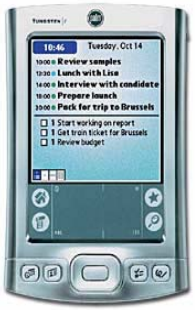
To assist recycling efforts set forth by WEEE documents

– Restricting hazardous substances which may have adverse effects on human health

– Restricting hazardous substances which may have adverse effects on the environment

EU RoHS – Scope

- Large Household Appliances
- Small Household Appliances
- IT & Telecommunication Equipmer
- Consumer Equipment



EU RoHS – Scope

- Lighting Equipment (including electric light bulbs and household luminaires)
- Electrical and Electronic Tools(with the exception of large-scale stationary industrial tools)
- Toys, Leisure & Sports Equipment
- Automatic Dispensers

Difference between EU & China RoHS

	Different point	Identical point
China RoHS	1. Implement directly; 2. Scope is electronic information products; 3. Management model, key catalogue; 4. Promulgated on Feb. 28, 2006; Effective on Mar.1, 2007; 5. Standard and Key Catalogue; 6. CCC certification; 7. Two steps approach.	1.Both are legislation； 2.Same objective 3.trade involved in； 4.Same restricted hazardous substance
EU RoHS	1. Need to transform to each country law; 2. Scope is EEE; 3. Exemption to technical and economic impossible products 4. Promulgated on Feb. 13, 2003; Effective on Jul. 1, 2006; 5. only need standard; 6. self-declaration; 7. One step approach	

disassemble, screening and further chemical testing

disassemble

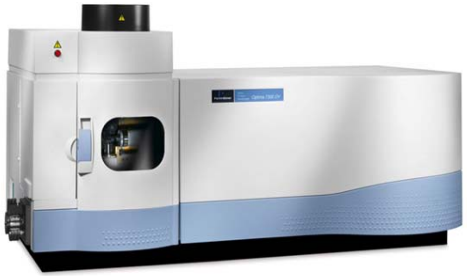
XRF Screening

When result obtained by XRF screening is uncertain, further chemical testing is recommended to be performed.

RoHS testing equipments

X Ray Fluorescence

inductively coupled plasma optical emission spectroscopy

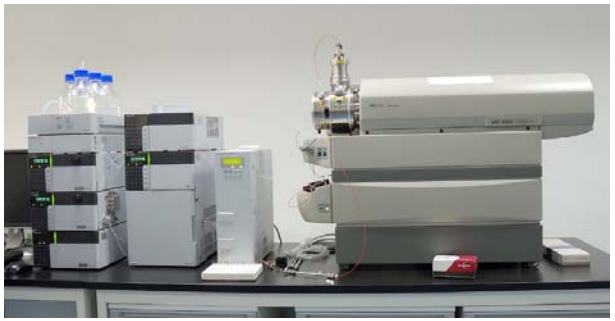


gas chromatography mass spectrometer

ultraviolet–visible spectroscopy

Organic and inorganic analytical equipment

high performance liquid chromatography



high performance liquid chromatography-mass spectrometry

ion chromatography

infrared spectroscopy

atomic fluorescence spectrometry

atomic absorption spectrometry

Material analysis

field-emission scanning electron microscope

transmission electron microscope

Confusion to avoid…

Trunk SAR or Head SAR?

Far field or near field scenario?

Wireless router w/wo RJ 11 interface
120 V vs. 60 V internal voltage
Class III equipment： no requirement for protection against electric shock

- THANKs.

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