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EMC basic aspects

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References

1. Williams T., *EMC for Product Designers*, Elsevier-Newnes, 5th ed., Oxford, 2015
2. Ott H. W., *Electromagnetic Compatibility Engineering*, Wiley, Hoboken, NJ, 2009

Ilustrations in this presentation are takem mostly from above

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EMC – Electro-Magnetic Compatibility

From Collins dictionary:

Compatible - adjective
If things, for example systems, ideas, and beliefs, are compatible, they work well together or can exist together successfully.
Synonyms of compatible: agreement, consistency, accordance, affinity

compatibility - uncountable noun
Synonyms: consistent, in keeping, consonant,

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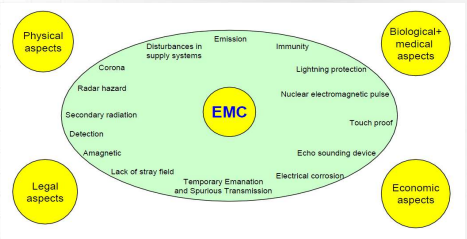
EMC – Electro-Magnetic Compatibility

- Apparatuses (systems) can coexist and cooperate without disturbances from electromagnetic phenomena
- and not introducing electromagnetic disturbances to the environment

EMC subjects



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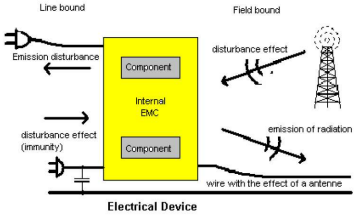
Electro-magnetic compatibility means the ability of an electrical device (component, system), to work properly in its electro-magnetic environment, without introducing intolerable electro-magnetic disturbances to anything in that environment.



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Noise vs. Interference

Noise – electric signal other than desired:

- intrinsic noise sources as thermal noise or shot noise, flicker noise
- natural *disturbances* as lightning or sunspots,
- man – made *noise* coupled from EM environment,
- but
- **not** distortion produced in a circuit due to nonlinearities unless coupled to other part of circuits

Interference – undesired effect of noise

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Noise vs. Interference

- interference can be eliminated – for example by eliminating nonlinearities
- noise cannot be eliminated – can be reduced in magnitude, until it no longer causes interference

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Electromagnetic phenomena which can be expected to interfere with control systems are:

- supply voltage interruptions, dips, surges and fluctuations;
- fast transient overvoltages (spikes and surges) on supply, signal and control lines;
- electrostatic discharge (ESD) from a charged object or person;
- radio frequency fields, both pulsed (radar) and continuous, coupled directly into the equipment or onto its connected cables;
- low frequency magnetic or electric fields

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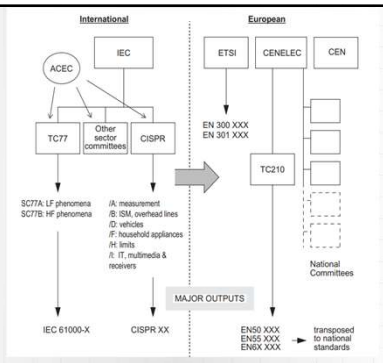
EMC standards structure



Abbreviations:

- IEC International Electrotechnical Commission
- CENELEC European Committee for Electrotechnical Standardization
- CISPR International Special Committee for Radio Interference
- CEN European Committee for Standardization
- ETSI European Telecommunications Standards Institute

TC210 = the committee charged with preparing the EMC standards
TC77 = "The United Nations for EMC"

Directive 2014/30/EU

of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to ElectroMagnetic Compatibility

Applicable from 20 April 2016.

Summary of references of harmonised standards published in the Official Journal – Directive 2014/30/EU

- This Directive applies to apparatus liable to cause electromagnetic disturbance or the performance of which is liable to be affected by such disturbance.
- It defines the protection requirements and inspection procedures relating thereto.
- Electromagnetic emissions of most electrical and electronic products are controlled and it is ensured that these products are not themselves unduly affected by electromagnetic interference

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Apparatus affected

- Domestic audio and video receivers
- industrial equipment
- mobile radio and commercial radiotelephone equipment
- medical and scientific apparatures and devices
- information technological appliances (e.g. computer)
- domestic appliances and household electronic equipment
- radio equipment ("walkie-talkie")
- electronic teaching devices
- telecommunication equipment and networks
- radio and television broadcast transmitters
- lights and fluorescent lamps

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Exceptions:

1. Benign equipment
   a) it is incapable of generating or contributing to electromagnetic emissions which exceed a level allowing radio and telecommunication equipment and other equipment to operate as intended;
   b) it will operate without unacceptable degradation in the presence of electromagnetic disturbance normally consequent upon its intended use.
2. Other Directives
   a) 98/79/EC in vitro medical devices;
   b) 93/42/EEC medical devices;
   c) 72/245/EEC EMC of vehicles as amended by 95/54/EC, 2004/104/EC, and now UNECE Regulation 10, but see section 5.1.1.2 regarding non-safetycritical aftermarket equipment;
   d) 75/322/EEC EMC of agricultural or forestry tractors as amended by 2000/2/EC;
   e) 97/24/EC two- and three-wheel motor vehicles;
   f) 96/98/EC on marine equipment;
   g) 90/384/EEC non-automatic weighing instruments
3. Components
   a) Its sole purpose is to be incorporated into the device„

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EXCLUSIONS

- Certain installations (combinations of items put together at a given place to fulfil a specific function but not designed for supply as a single functional unit)
- Spare parts
- Second hand apparatus
- Apparatus for use in a sealed electromagnetic environment
- Some military equipment
- Certain radio equipment for radio amateurs which is not available commercially
- Apparatus which - irrespective of their design - can neither emit nor be affected by electromagnetic disturbance

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Apparatus/System ?

Component

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COMPONENTS and FINISHED PRODUCTS

- **Component** is any unit used in the assembly of an apparatus, which can perform a direct function, e.g. electronic circuit boards, electric motors, cards for computer systems (can be separately placed on the market).
  Single Commercial Unit with CE; if it is not ready to use: no CE, only assembly instructions).
  For Components without direct function (e.g. resistors, diodes, integrated circuits,...) EMC directive does not apply.
- **Finished product** means a device having always a direct function and enclosure of its own, e.g. a TV receiver (for the end-user)

SYSTEMS and INSTALLATIONS

- **System** means the combination of several types of apparatus to perform a specific task. The end user is assembling the so called system, e.g. a computer system with monitor, keyboard, printer etc. The manufacturers of each apparatus are complying with the EMC directive, they are CE marked and separate instructions exist.
- **Installation** means several combined apparatus or several systems assembled in a specific place in order to fulfil a specific purpose, which is not released on the market as a combined unit. All systems and apparatus included in the installation shall fulfil the requirements of the directive and be installed in accordance with the manufacturer's instructions to ensure that satisfactory EMC properties are achieved for the installation.

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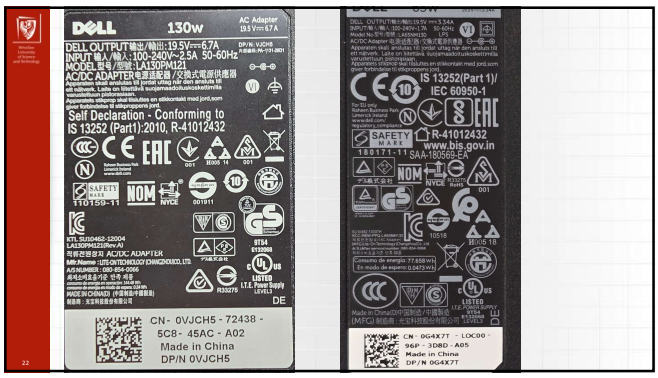
Components
Apparatus – finished product
System
Installation

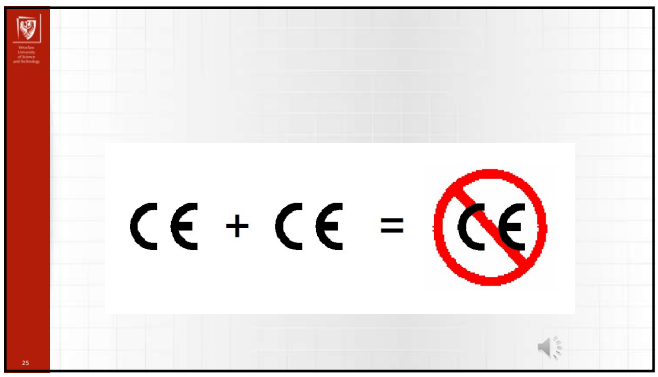
Regulations:
1.General -IEC 6xxxxxx
2. Apparatus specific -EN5xxxxx
3.Radio Equipment Directive…
4.International (e.g FCC……
5.Other standards (e.g. Aeronautic, Automotive, Manufacturer …..

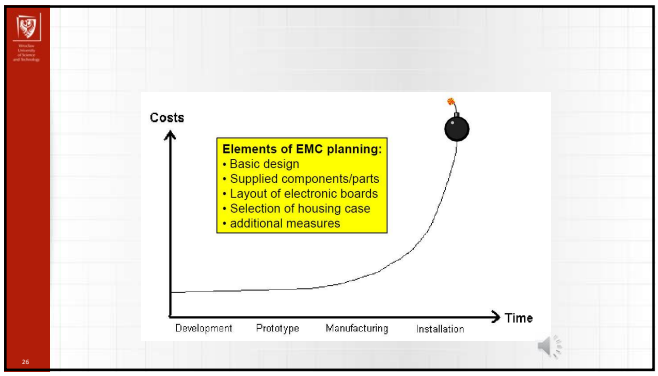
International and other regulations :
Europe Declaration of Conformity CE
Radio Equipment Directive (old)
United Kingdom (since 1 Jan. 2021; CE ext. To 31 Dec. 2024) UKCA
Federal Communications Commission(USA) FC
China
Australi and New Zeland
Rassia and EAEU EAC
Japan
Taiwan
South korea



Other standards and legislation

- Automotive
  - Europe-Automotive EMC Directive 2004/104/EC
  - International - ISO, CISPR and SAE
  - Manufacturer tests
  - Specialist requirements (ambulances, police…..)
- Militari
  - USA - MIL-STD-461/462 (now MIL-STD-461G)
  - UK - DEF STAN 59-411
- Aerospace
  - Europe - EUROCAE/ED-14
  - USA - RTCA/DO-160
- Rail (e.g. EN 50121/EN 50155 or London Undeground….)
- Safety standards – e.g. ex (explosive hazard)

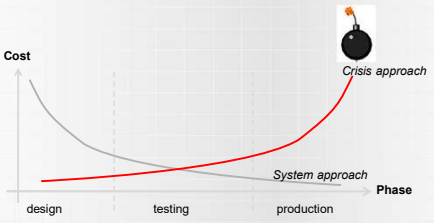




Two approaches to EMC engineering:

- ***Crisis approach*** – designer proceed with a total disregard of EMC – EMC problems are solved by „add on" („Band Aid")
  - *very expensive and nervous*
- ***System approach*** – designer proceed with EMC rules at the beginning
  - *90 % of problems are eliminated during designing process*

Available techniques and costs to solve noise problems



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the steps to take for a new product to achieve compliance and bear the CE

A. Case of **Self certification**

1. From the marketing specification, determine what type of product it will be and what environment it will be sold for use within
2. Specify the standards that the product must meet
    1. General -IEC 6xxxxxx…
    2. Apparatus specific -EN5xxxxx
    3. International (e.g FCC……
    4. RED (Radio Equipment Directive)….
    5. Other standards (e.g. Aeronautic…..
3. Draw up a test plan, !!!!!!!!
    1. Describe in detail the versions of product and configuration
    2. Decide the pass/fail criteria
4. If your product is in the phase of prototype or pre-production stages you can make pre-compliance tests to check the performance of the product and also the validity of the test plan – modify, if nesesery, both design and test plan.
5. Conduct full in-house testing or have a specialized company do it on one or more production samples,
6. Mark the product with the CE mark and your empowered signatory can sign the Declaration of Conformity (valid for ten years) (If other New Approach Directives apply, a parallel process needs to be followed for each).
7. The product can be placed on the market.
8. Take steps to ensure that any changes in production or technology do not change the properties of the product, otherwise tests must be conducted again.

B. The case of hiring a **Notified Body** (this approach is in addition to the steps outlined above).

1. In step 3 above, select a Notified Body capable of evaluating the product type in question. Provide them with documentation and expect a statement confirming compliance, as well as an *invoice*.
2. In practice, NB can be selected in step 1 above. NB will help you decide what standards must be met, create a test plan and execute it, and *invoice*.

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Test planning
- The need for a test plan
- The requirements of accreditation
- The requirements of standards
- The requirements of the customer

Contents of the test plan
- Description of the equipment under test (EUT)
- Statement of test objectives
- The tests to be performed
- EUT exercising software and ancillary equipment or simulators
- Requirements of the test facility
- Details of the test set-up
- How to evaluate test results

Immunity performance criteria
- The generic criteria
- Interpreting the generic criteria

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Test questions example:

1. Describe briefly two approaches to EMC engineering.
2. What kind of regulations should be considered for compliance certification?
3. Noise vs. Interference.
4. How to understand graphics:

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Design checklist to assess your design against EMC:

- Design for EMC from the beginning: know what performance you require; During the design/prototyping process, perform "precompliance" testing
- Partition your design into EMC zones:
  - determine which circuits will be noisy or susceptible and which will not
  - lay them out in separate areas as far as possible
  - select internal and external interface locations to allow optimum common mode current control
- Select components and circuits with EMC in mind:
  - use slow and/or high-immunity 'logic', apply slew rate limiting to data transmission interfaces
  - use series R buffering on all high-speed clock and data lines
  - use good power decoupling techniques: small, low-inductance capacitors adjacent to the ICs they are decoupling
  - use series ferrite chips in the supplies to create power segments
  - reduce fan-out on clock circuits by liberal use of buffers
  - minimize analogue signal bandwidths
  - maximize dynamic range of analogue signal paths
  - check stability in wideband amplifiers
  - don't leave unused IC input pins floating: tie them to 0V or VCC
  - include resistive, ferrite or capacitive filtering at all sensitive analogue inputs
  - incorporate a watchdog circuit on any critical processor
  - avoid edge triggered digital inputs if possible, protect them if unavoidable
- PCB layout:
  - refer to separate checklist in section about PCB design
- Cables:
  - segregate, and avoid parallel runs of, signal and power cables
  - choose RF-screened cables if the wanted signal cannot be properly filtered
  - avoid screened cable with the screen connected only at one end; if unavoidable, treat the cable as unscreened at RF
  - use twisted pair both within and outside an enclosure, for balanced or high dV/dt lines
  - use properly designed looms, ribbon or flats for internal wiring – avoid loose wires or bundles
  - run cables away from apertures in the shielding, tied close to conductive grounded structures
  - apply ferrite suppressors to damp resonances and control common mode currents
  - ensure that cable screens are properly terminated to the connector backshell; avoid pigtails
  - terminate lines carrying high frequency signals with the correct transmission line impedance
- Grounding:
  - design and enforce the ground system at the product definition stage
  - consider the ground system as a return current path, not just as 0V reference
  - provide for parallel earth conductors at the system level
  - ensure metal-to-metal bonding of screens, connectors, filters, and enclosure panels • ensure that bonding methods will not deteriorate in adverse environments
  - mask paint from, and apply a conductive finish to, any intended contact surfaces • keep earth straps short and define their geometry
  - avoid common ground impedances for different circuits • provide an interface ground area for decoupling and filtering
- Filters:
  - assume that a supply filter is needed: design the filter for the application
  - filter all I/O lines, using either or both of three-terminal capacitors to interface ground, and common mode chokes
  - apply rf filters at the DC power input to each board, in multi-board designs
  - ensure a defined ground return for each filter
  - apply filtering to interference sources, such as switches or motors, directly at their terminals
  - locate all filter components and associated wiring or tracks adjacent to the interface being filtered
- Shielding:
  - design all metallic structures as if they were electrical components: account for their stray capacitance and inductance
  - consider segregated enclosures: enclose particularly sensitive or noisy areas with extra internal shielding
  - avoid large or resonant apertures in a shield, or take measures to mitigate them
  - avoid dipole-like structures in a metallic enclosure
  - ensure that separate panels are well bonded along their seams using conductive gaskets: apply good bonding practice as in "grounding" above
  - design plastic enclosures to allow internal conductive coating if necessary
  - decide on and implement 'DC or RF' tie points between circuit/0V and the shield
  - use multiple internal tie-points to minimize box resonances
- During the design/prototyping process, perform "precompliance" testing

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