



**UNIVERSIDAD
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Lesson 1: Electronics Standards and Regulations

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Introduction

- Professional activities are subject to compliance with standards and regulations.
- Electronics, in all its different fields, is no exception.
- Electronic design and manufacturing are governed by a wide range of regulations and standards of different kinds.
- Engineers must know which standards and regulations apply to their field of work and apply them correctly.
- Accredited organizations verify that electronic products (among others) comply with the applicable regulations and standards.
- Products and services received must also comply with the applicable standards and regulations, and such compliance should be required.

General Concepts

- Standardization: the process of establishing uniform requirements for products and processes.
- Tolerance: the permissible deviation from a nominal value.
- Reliability: the probability of failure.
 - ❖ Failure: the inability to meet the intended operating conditions.

Standardization

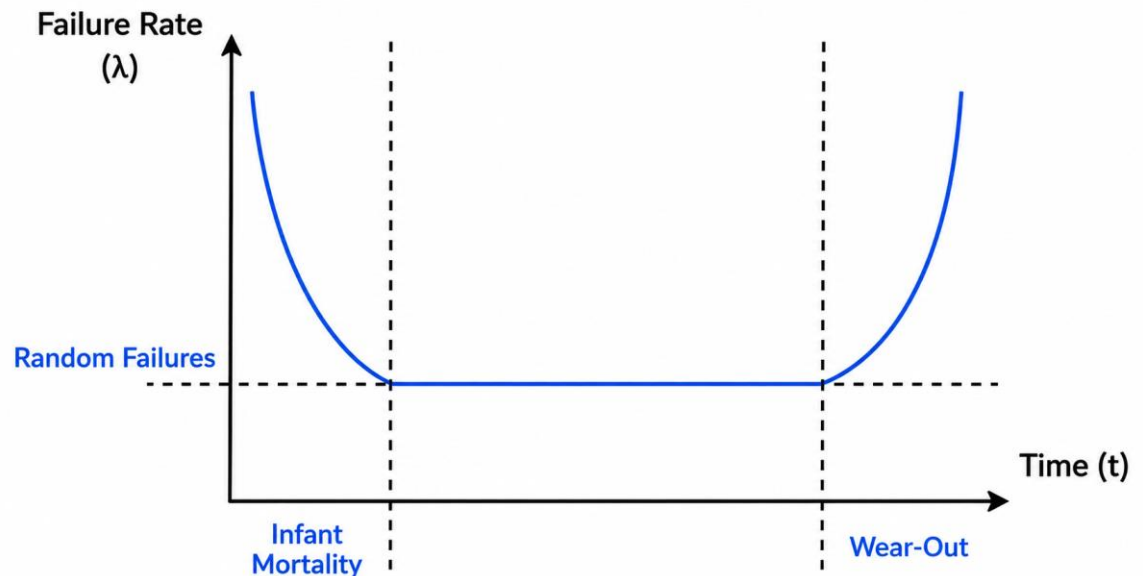
- Types of standards:
 - ❖ National: applicable within the country that issues them
 - ❖ International: applicable in multiple countries.
- Standardization organizations:
 - ❖ National: AENOR, ANSI.
 - ❖ International: ISO, IEC (International Electrotechnical Commission).
 - ❖ Private: IEEE (Institute of Electrical and Electronics Engineers), IPC (Institute for Printed Circuits), EIA–JEDEC (Electronic Industries Alliance).

Tolerance

- It can be expressed as:
 - ❖ Maximum and minimum values.
 - ❖ Percentage variation.
 - ❖ Absolute variation.
- It applies to:
 - ❖ Nominal values.
- It is affected by:
 - ❖ Environmental factors such as temperature, time, etc.

Reliability

- Mean Time Between Failures (MTBF): $MTBF = \frac{\sum_{i=1}^N t_{fallo_i}}{N}$
- Failure rate: the rate at which failures occur (bathtub curve).
- Types of failures:
 - ❖ Infant mortality.
 - ❖ Random failures.
 - ❖ Wear-out failures.
- Failure mechanisms:
 - ❖ Sudden.
 - ❖ Gradual lift.



Hierarchy of Standards

- **Basic standards:** define and describe phenomena, measurement and testing methods, as well as the required instruments and their accessories. *E.g., EN 61000.*
- **Generic standards:** apply to all types of products when no product-family or product-specific standards exist. *E.g., EN 50081 and EN 50082.*
- **Product-family standards:** apply to all equipment within the same product family when no product-specific standards exist. *E.g., EN 55011, EN 55014, EN 55015, EN 55022.*
- **Product standards:** apply to a specific and well-defined type of equipment. These standards take precedence over all others. *E.g., EN 60669.*

The standards listed as examples relate to Electromagnetic Compatibility (EMC).

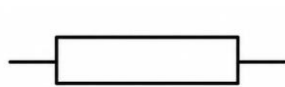
Electronics Standards and Regulations

- Electronic components.
 - ❖ Symbols.
 - ❖ Preferred values.
 - ❖ Marking.
 - ❖ Packages.
- Printed Circuit Board (PCB) design and manufacturing.
- Electromagnetic Compatibility (EMC).
- Environmental sustainability.
- CE and FCC marking.

Electronic Components – Symbols

IEC 60617 – UNE-EN 60617

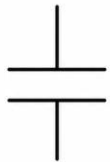
Passive components:
UNE – EN 60617 -4.



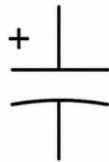
Fixed Resistor



Variable Resistor



Capacitor



Polarized Capacitor

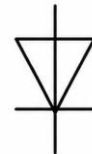


Inductor

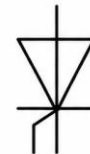


Inductor with
Magnetic Core

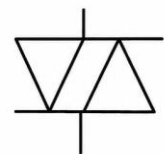
Active components:
UNE – EN 60617 -5.



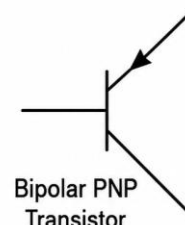
Diode



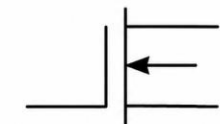
Thyristor



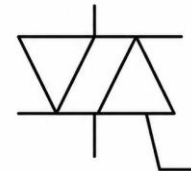
Diac



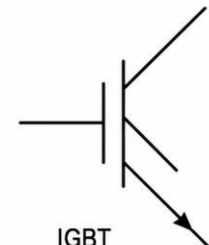
Bipolar PNP
Transistor



N-channel
Enhancement Mode JFET



Triac



IGBT
(Insulated Gate Bipolar Transistor)

Electronic Components – Preferred Values

IEC 60063 UNE 20531

Preferred values are defined primarily for resistors, capacitors, inductors and Zener diodes.

These are nominal values defined for each decade and grouped into series according to their tolerance (Tol).

Series	Tol	Values																									
E-12	10%	10		12		15		18		22		27		33		39		47		56		68		82			
E-24	5%	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91		

Other series:

E-6 (20%) E-48 (2%) E-96 (1%) E-192 (0.5%)

Electronic Components – Marking

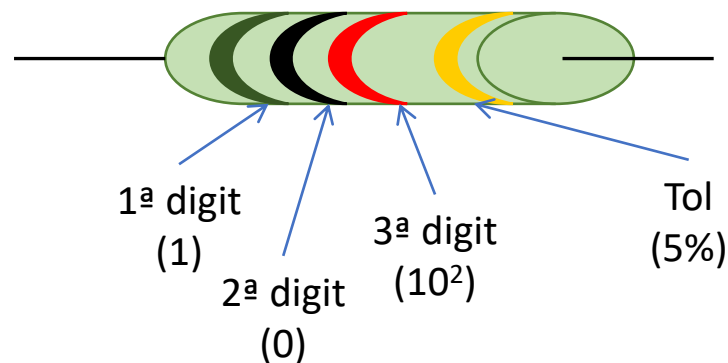
IEC 60062 UNE-EN 60062

Marking codes are defined for resistors and capacitors.

The following parameters are encoded: nominal value, tolerance, temperature coefficient, manufacturing date and dielectric material.

Color	Digit	Multiplier	Tol	T. Coefficient
Black	0	1	-	$\pm 250 (10^{-6}/K)$
Brown	1	10	1%	$\pm 100 (10^{-6}/K)$
Red	2	10^2	2%	$\pm 50 (10^{-6}/K)$
Orange	3	10^3	0.05%	$\pm 15 (10^{-6}/K)$
Yellow	4	10^4	-	$\pm 25 (10^{-6}/K)$
Green	5	10^5	0.5%	$\pm 20 (10^{-6}/K)$
Blue	6	10^6	0.25%	$\pm 10 (10^{-6}/K)$
Purple	7	10^7	0.1%	$\pm 5 (10^{-6}/K)$
Grey	8	10^8	-	$\pm 1 (10^{-6}/K)$
White	9	10^9	-	-
Silver	-	10^{-2}	10%	-
Gold	-	10^{-1}	5%	-

Resistor Color Code



$$R = 10 \times 10^2 = 1.000\Omega = 1k\Omega$$



A third significant digit may be present



Although not specified in the standard, manufacturers also use this code for capacitors

Electronic Components – Marking

IEC 60062 UNE-EN 60062

Letter code for resistors and capacitors: the unit symbol (or its multiples and submultiples) is used to replace the decimal point.

R10 = 0.10Ω 10R = 10Ω 4k7 = 4.7kΩ 10M = 10MΩ p10 = 0.10pF 5n9 = 5.9nF 10μ = 10μF

A three-character code can also be used as an alternative to the colour code.

R10 = 0.10Ω 100 = 10Ω 472 = 4.7kΩ 106 = 10MΩ

This system is also applicable to capacitors.

472 = 4.7nF

Tolerance and temperature coefficient may also be encoded using letters.

F = 1% G = 2% J = 5% K = 10% M = 20%

G = 0.1 (10⁻⁶/K) J = 0.5 (10⁻⁶/K) K = 1 (10⁻⁶/K)

Manufacturing date and dielectric material may also be encoded for capacitors.

Electronic Components – Marking

PROELECTRON Semiconductor Designation

Consists of two letters followed by a serial number, which may include a third letter.

1st Letter: Material (Band Gap Energy)		2nd Letter: Function	
A	0.6 -1.0 eV (Germanium)	A	Signal diode
B	1.0 – 1.3 eV (Silicon)	C	Small-signal audio transistor
C	> 1.3 eV	D	Audio power transistor
D	Ceramic	F	High-frequency signal transistor
R	Compound materials	N	Optocoupler
		Z	Zener diode

JEDEC defines a marking system consisting of one digit, one letter and a serial number.
Example: 1N4007.

Electronic Components – Marking Integrated Circuits

PROELECTRON defines a code consisting of three letters followed by a serial number.

1st Letter: Device Type		2nd Letter: Function	
F	Device belonging to a logic family		Specific logic family
S	Stand-alone digital circuit		Part of the serial number
T	Analog integrated circuit		
U	Mixed-signal (analog/digital)		
M	Microprocessor		Processor type or related device
N	Others		

Major manufacturers such as Texas Instruments use their own marking systems:
Manufacturer + temperature range + subfamily + serial number + suffixes

N74LS04: Texas Instruments + commercial temperature range + LS subfamily + six NOT gates

Electronic Components – Packages

JEDEC - JESD30-B

Defines the designation system for packages of discrete semiconductors and integrated circuits.

Se especifican distintos tipos de encapsulados. No se definen encapsulados concretos.

Code					
Characteristics	Material	Mounting Position	Package Type	Lead Configuration	Number of Leads

Only the "Package Type" field is mandatory; all other fields are optional.



CP
(clamped package)



FM (flange mount)



LF
(long form)



IP (in parallel)



CY (cylinder)



CC (chip carrier)



DB (disk button)



PM (post mount)

Printed Circuit Board Design. IPC 2221

Provides recommendations covering many aspects of PCB design:
Materials, dimensions, clearances, routing, etc.

$$\text{Example: } I = k\Delta T^{0.44} A^{0.725}$$

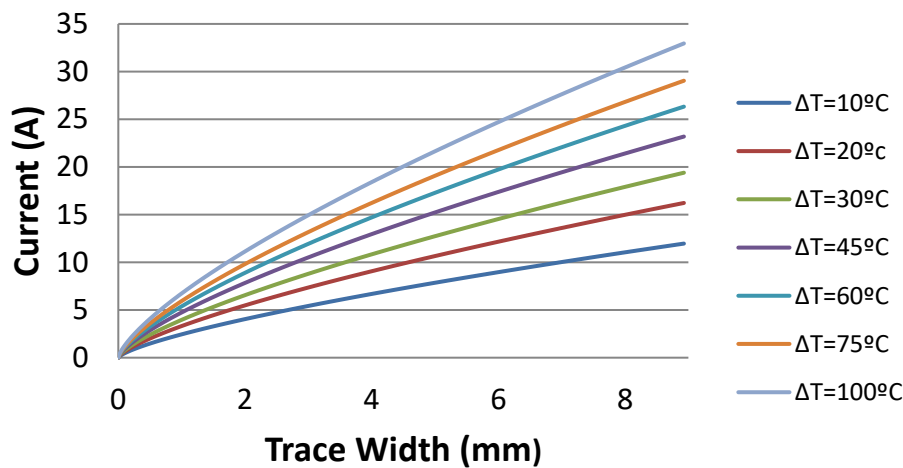
I: current (A)

A: conductor cross-sectional area (square mils)

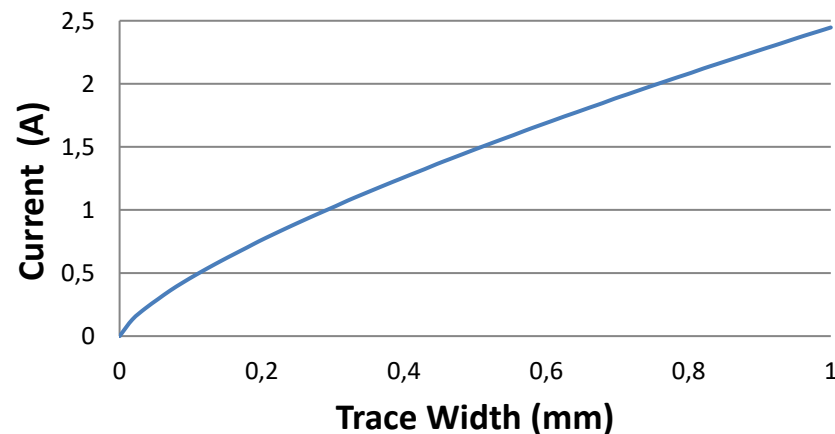
ΔT : temperature rise ($^{\circ}\text{C}$)

K= 0.048 for external layers, 0.024 for internal layers

Copper Thickness = 35 μm



$\Delta T = 10^{\circ}\text{C}$ Copper Thickness = 35 μm



Printed Circuit Board Manufacturing. IPC 4101

Rigid printed circuit boards are made of a base material and a bonding resin. The standard defines the different material combinations and their properties.

Base materials are designated according to the NEMA (National Electrical Manufacturers Association) standard. A complete description can be found on page 25 of the standard.

	Epoxy Resin	Phenolic Resin
Glass Fiber	G10, CEM-3, FR4, FR5	
Paper	FR3	XPC, FR1, FR2
Glass Fiber + paper	CEM-1	

Equivalent European standards: IEC 249 – UNE 20620-1.

Electromagnetic Compatibility (EMC)(I)

EMC is a broad discipline affected by every stage of the design and manufacturing process.

A large number of standards apply, as discussed in the hierarchy of standards.

IEC 61000 – UNE EN 21000 can be used as the starting point.

- **Electromagnetic disturbance:** *"Any electromagnetic phenomenon capable of degrading the performance of a device, equipment or system, or adversely affecting living or inert matter."*
- **Electromagnetic interference (EMI):** *"Degradation in the performance of a device, equipment or system caused by an electromagnetic disturbance."*
- **Electromagnetic compatibility (EMC):** *"The ability of equipment or a system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment."*
- **Immunity:** *"The ability of a device, equipment or system to operate without degradation in the presence of an electromagnetic disturbance."*
- **Susceptibility:** *"The inability of a device, equipment or system to operate without degradation in the presence of an electromagnetic disturbance."*

Electromagnetic Compatibility (EMC)(II)

- **Emitter:** *"A device, equipment or system that generates potentially disturbing voltages, currents or electromagnetic fields."*
- **Susceptible device:** *"A device, equipment or system whose performance may be degraded by such emissions."*
- **Emission level:** *"The level of electromagnetic disturbance of a given type emitted by a device, equipment or system and measured in a specified manner."*
- **Immunity level:** *"The maximum level of electromagnetic disturbance of a given type that can be applied to a device, equipment or system in a specified manner without degrading its performance."* The minimum required immunity level is known as the immunity limit.

Environmental Sustainability – RoHS

The RoHS Directive was published in the Official Journal of the European Union as Directive 2002/95/EC on 27 January 2003, concerning the restriction of the use of certain hazardous substances in electrical and electronic equipment. It was transposed into Spanish legislation through Royal Decree 208/2005.

The Directive aims to harmonize national legislation regarding the use and disposal of materials potentially hazardous to the environment and human health in electrical and electronic equipment.

Royal Decree 208/2005 transposes both Directives 2002/95/EC and 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE), as well as Directive 2003/108/EC, which updates the latter. In particular, it prohibits the use of several hazardous substances in the manufacture of electronic equipment.

- Lead
- Mercury
- Cadmium
- Hexavalent Chromium
- Polybrominated Biphenyls
- Polybrominated Diphenyl Ethers

Several exemptions are defined for specific applications where technically viable substitute materials are not yet available, subject to quantity limitations.

Environmental Sustainability – WEEE

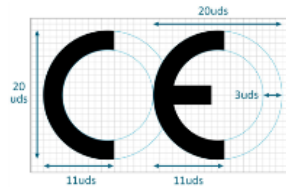
The WEEE Directive was published in the Official Journal of the European Union as Directive 2012/19/EU on 4 July 2012 concerning Waste Electrical and Electronic Equipment (WEEE). In Spain it was implemented through Royal Decree 110/2015, later updated by Royal Decree 27/2021.

Its objective is to protect the environment by regulating waste electrical and electronic equipment.

The Directive requires collection rates above 45% from 2016 and above 65% from 2019. It defines the stakeholders involved in the process, the methodology for measuring collection rates, and restrictions on the export of WEEE.

“Los RAEE que se exporten fuera de la Unión computarán para la consecución de las obligaciones y los objetivos contemplados en el artículo 11 de la presente Directiva únicamente si, cumpliendo con los Reglamentos (CE) n o 1013/2006 y (CE) n o 1418/2007, el exportador puede demostrar que el tratamiento se realiza en condiciones equivalentes a los requisitos impuestos por la presente Directiva.”

Product Marking (I)



CE marking is based on Directive 93/68/EEC of July 1993. It became mandatory in 1995, with a transition period until 1997.

CE stands for "Conformité Européenne" (European Conformity)

It requires manufacturers and importers of many products (including electronic equipment) to comply with the applicable European Directives.

Independent notified bodies verify compliance whenever required by the relevant Directive.

How can the applicable regulations for a product be identified?

<http://www.marcado-ce.com/guia-interactiva-evaluar-directivas-marcado-ce-aplicables-producto.php>

Example: Radio-frequency remote control equipment

- Low Voltage Directive (LVD, 2006/95/EC)
- Electromagnetic Compatibility (EMC, 2004/108/EC)
- Radio and Telecommunications Terminal Equipment (R&TTE, 1999/5/EC)
- Restriction of Hazardous Substances (RoHS, 2011/65/EU)

Product Marking (II)



CE marking is a manufacturer self-declaration. Therefore, CE marking is not merely a document but a complete compliance process. The manufacturer is responsible for ensuring compliance with all applicable legislation. CE marking is not retroactive.

Another key aspect of certification is electrical safety.

Outside the European Union, other certification schemes are used. In the United States, the **Federal Communications Commission (FCC)** regulates areas such as electromagnetic compatibility.

In contrast, products marketed in the United States must be approved by the FCC, which determines whether they comply with the applicable standards (for example, EMC requirements). If approved, the FCC label may be displayed on the product.

Example: Bluetooth module →



References

- PROELECTRON System:
http://www.eeca.eu/images/downloads/PRO%20ELECTRON_D15%20final%20version%202007_12%20ESIA%20updated%2016%2007%2010.pdf
- Overview of EMC Regulations: <https://eur-lex.europa.eu/ES/legal-content/summary/electromagnetic-compatibility-of-electrical-and-electronic-apparatus.html>
- PCB Materials Overview:
[https://www.pcbgogo.com/Article/What is PCB Substrate Material.html](https://www.pcbgogo.com/Article/What_is_PCB_Substrate_Material.html)
- Use of Standards in Electronics: <https://www.aldeitatec.com/blog-diseno-con-normas-y-certificaciones/normas-pcb-y-electronica/>
- Application of the WEEE Directive: <https://erp-recycling.org/es-es/que-hacemos/flujos-de-residuos/raee/>
- CE vs FCC Marking in Electronics:
<https://www.youtube.com/watch?v=CTPb7etzOmA>