Why EMC is a headache and how to avoid it

The Magic of EMI/EMC in electronic design

Prof. **Arturo Mediano**
University of Zaragoza (SPAIN)
amediano@unizar.es

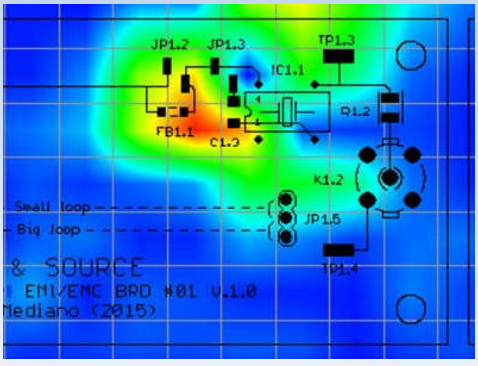
Organized by,

WÜRTH ELEKTRONIK

October 25th, 2021

2021

A High Frequency Lab for design, diagnostic, troubleshooting and training



Interferences (**EMI**)
Electromagnetic Compatibility (**EMC**)
Signal Integrity (**SI**)
Radiofrequency(**RF**)

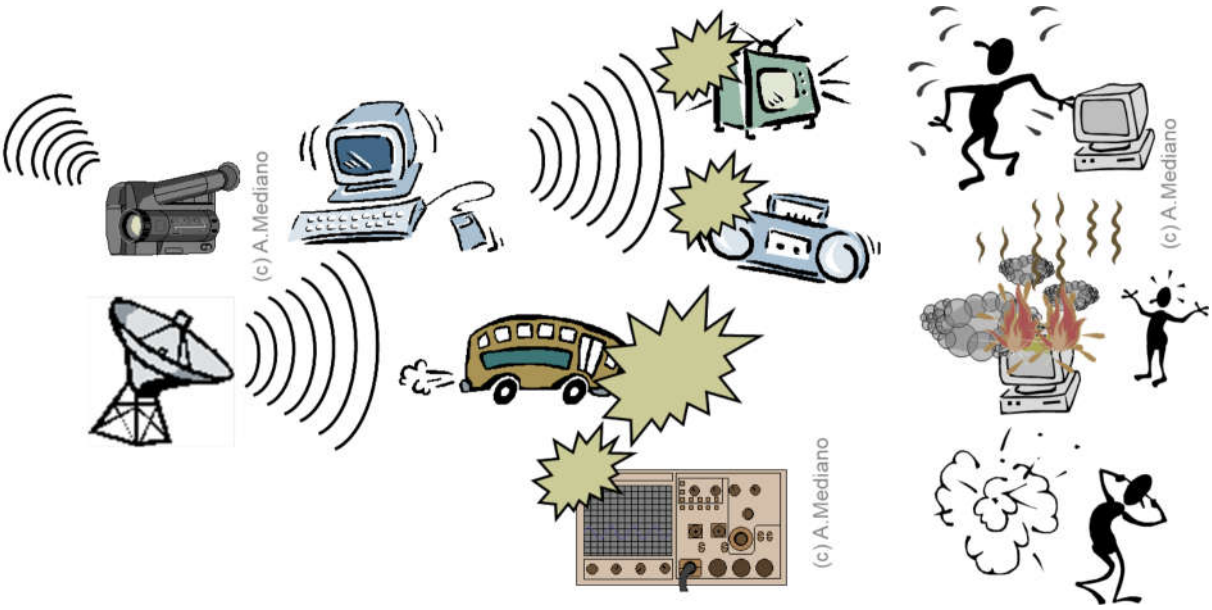
Contacto: Arturo Mediano
amediano@unizar.es
www.cartoontronics.com

WHAT IS EMI?
WHAT IS EMC?

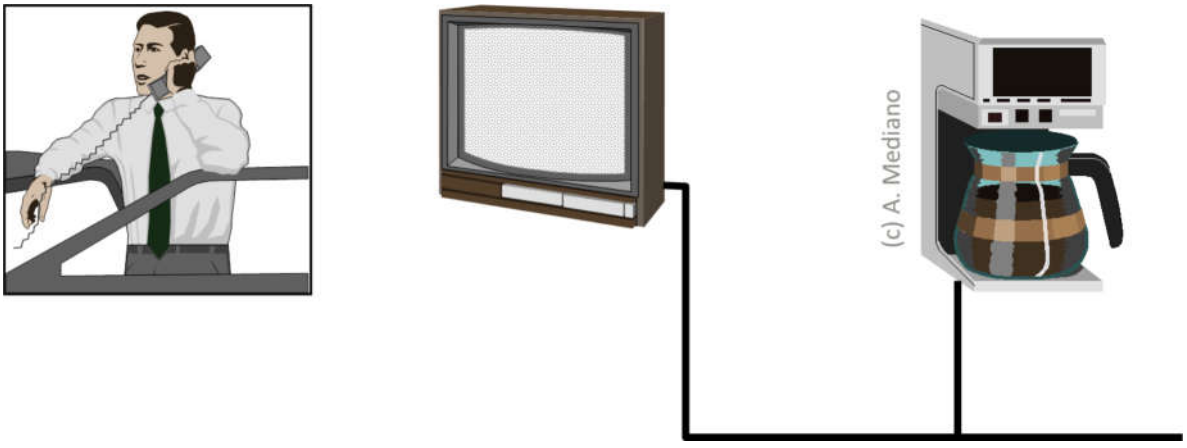
Introduction: electronics everywhere

© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

Introduction: problems appear

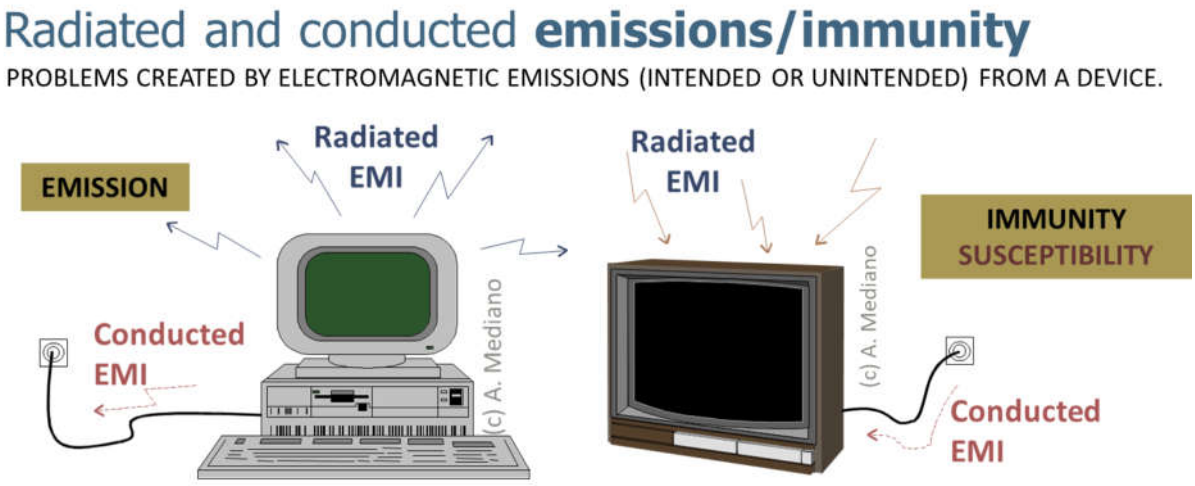


Introduction: EMI picture

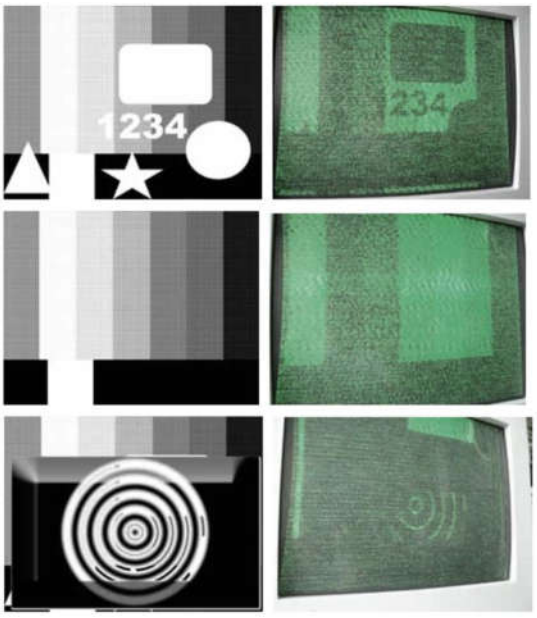


© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

Two cases: emissions-immunity



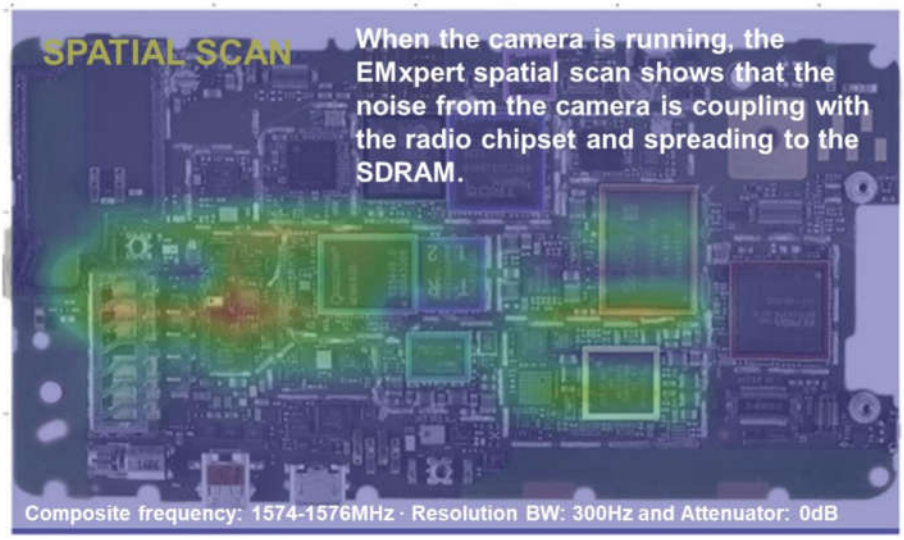
Problems with: confidential information



Problems with: desensing

Diagnose GPS self-interference problems

Emission of a cellphone around the GPS bands



EMI/EMC: a general perspective

Circuits with emissions ...

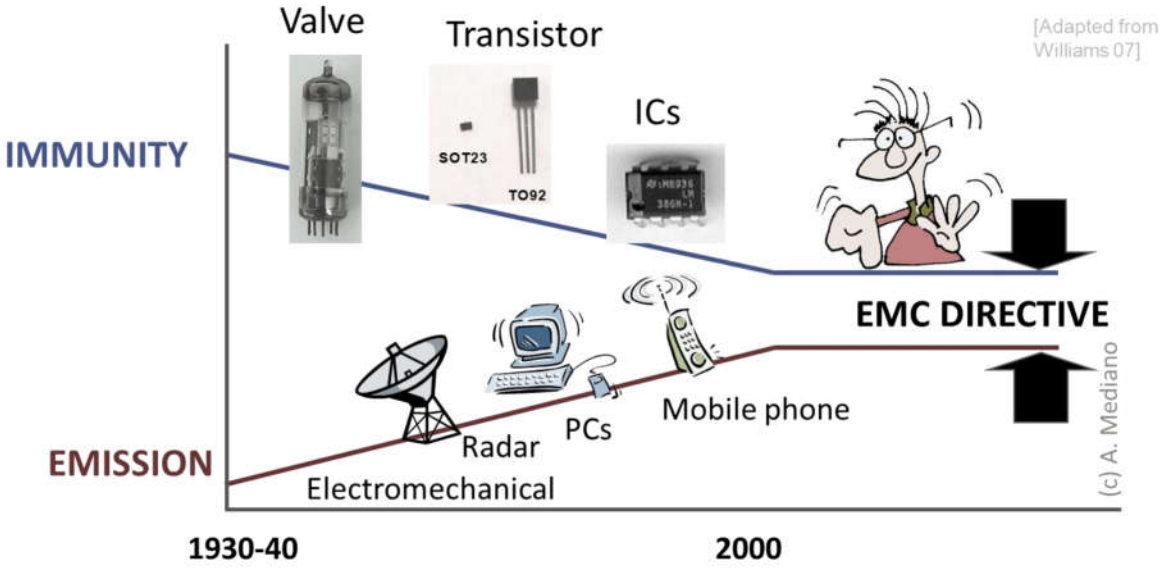
INTENTIONALLY

UNINTENTIONALLY

... and some collateral effects:

1) **Interferences** for other systems.
2) **Mandatory regulations**.
3) **Exposition** of humans to electromagnetic fields.
4) Compromise for **confidential info**

EMC: the safety "gap" for interferences



Introduction: EMI/EMC definition

Electromagnetic Interference

*"Noise is any electrical signal present in a circuit other than the desired signal. **Interference is the undesirable effect of noise**. If a noise voltage causes improper operation of a circuit, it is interference". (H. W. Ott).*

Electromagnetic Compatibility

*The **aptitude** of an electrical or electronic equipment to work satisfactorily in its electromagnetic environment, without introducing intolerable disturbances and supporting the produced ones for other equipments.*

© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

WHO IS AFFECTED BY EMI/EMC

© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

Problems with: any electronic system …

© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

EMC and... power electronics...

Applications ...

- **Solar/wind** and smart/green energy systems
- **Lighting** and illumination systems
- **Motor drivers and VFD**
- **Electrical car** (i.e. on board electric battery chargers)
- **Battery chargers** (other products)
- **Energy storage** systems
- Travel **adapters**
- **Wireless chargers**
- **Power supplies**
- **Home** appliances
- More

On January 9, 2018, Lithia Toyota was ordered by the FCC to turn the lights off. Induction lighting devices were causing harmful interference to LTE radio communications. Noncompliance would result in fines of $16,000 per day. (Citation and Order DA 18-18).

telecompaper:::

HOME | WIRELESS | BROADBAND | VIDEO | GENERAL | IT | INDUSTRY RESO

WIRELESS

German regulator investigates 4,700 cases of radio interference in 2018

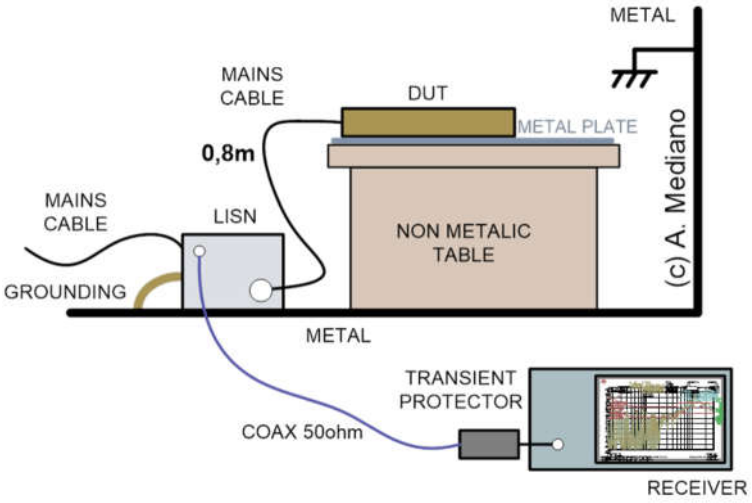
Wednesday 2 January 2019 | 16:10 CET | News

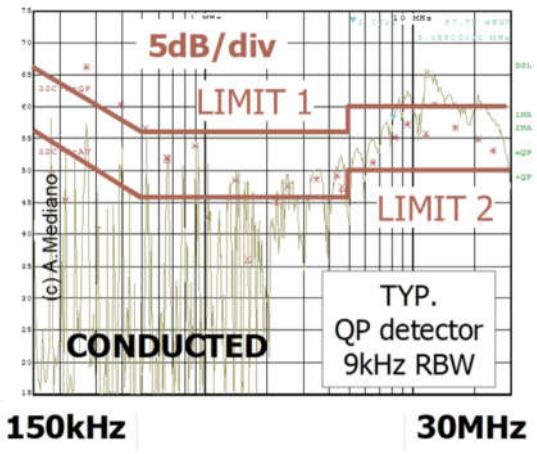
The German Federal Network Agency's test and measurement service intervened in 2018 in about 4,700 cases to identify and eliminate radio and electromagnetic interference. More than 1,200 cases were safety-related, involving air traffic, radio communications for emergency services and police, railway and public mobile networks, the regulator said. The agency has investigated the use of frequencies without authorisation, and more than 1,600 devices and WLAN networks were taken out of service.

© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

HOW EMC IS CONFIRMED ?

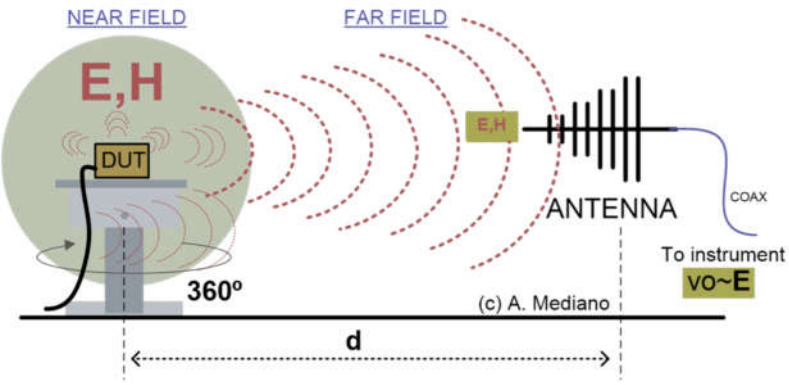
Introduction: examples for EMC tests (1)

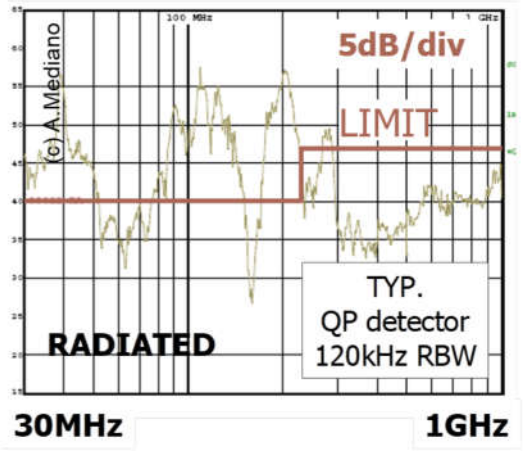




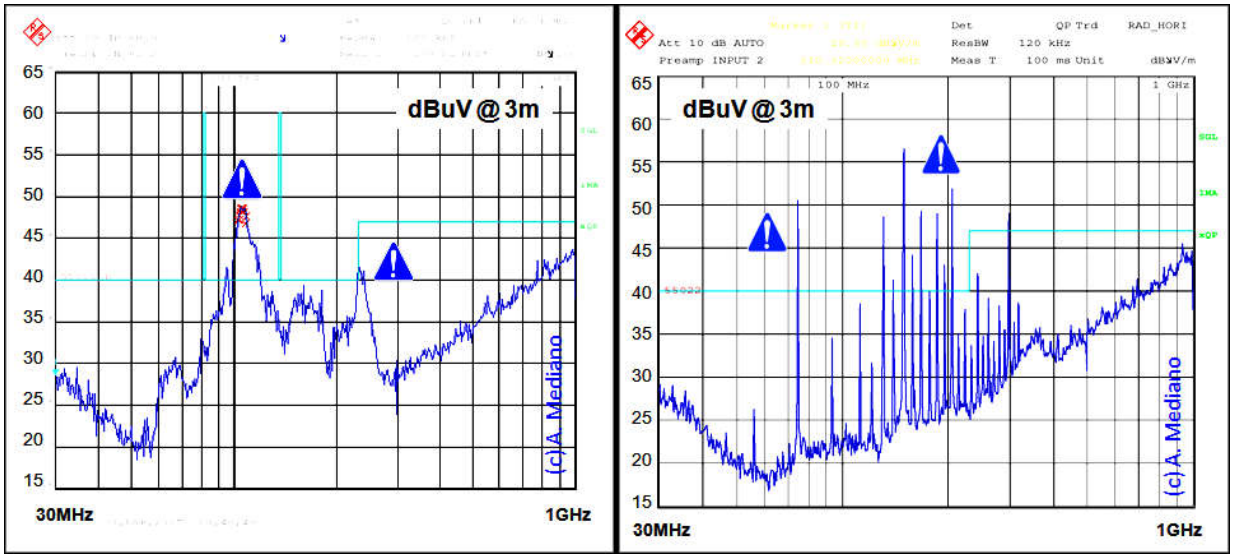
© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

Introduction: examples for EMC tests (2)





Introduction: example failures



SO, WHY EMC IS A HEADACHE ?

EMI/EMC: why it is a headache?.....

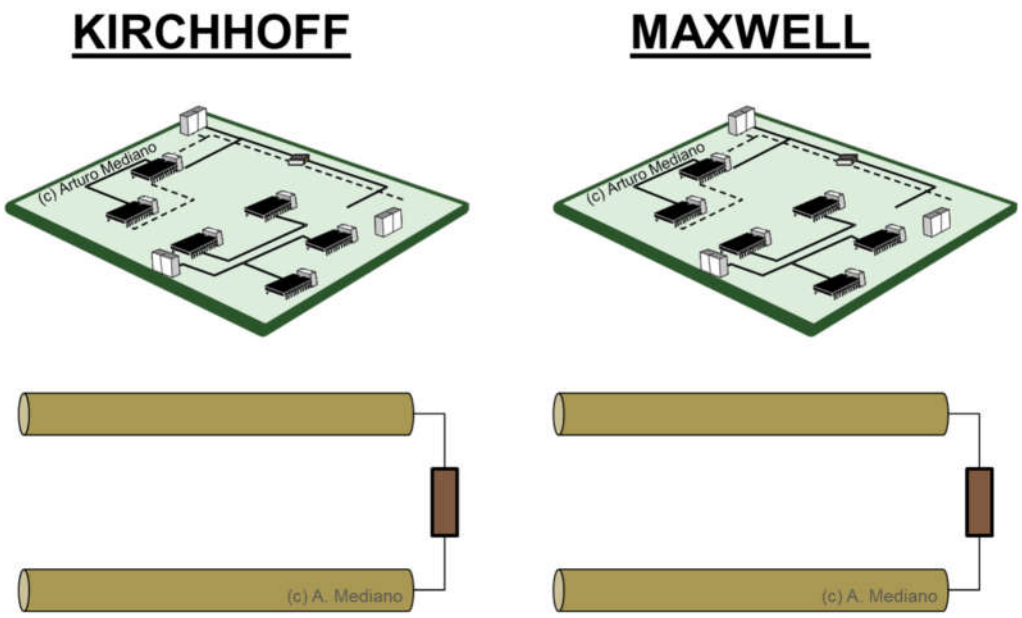
- **Delays**
- Unexpected **costs**
- **Need for tests** (external and internal) = time + cost
- **Image degradation** for customer/market
- **Size**
- **Weight**
- **Difficult subject**
  - Parasitic and “magical” effects + high frequency knowledge + special measurement techniques
- **Stress**

© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

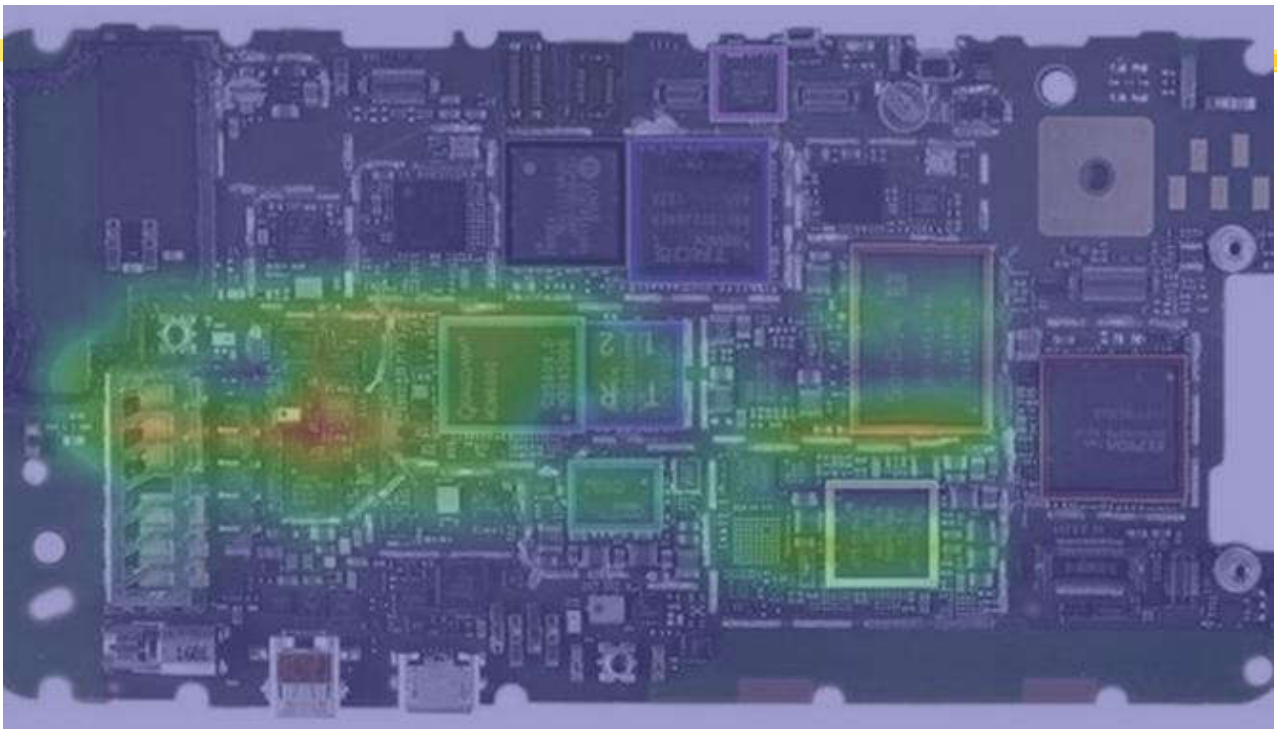
WHY EMI/EMC IS DIFFICULT ?

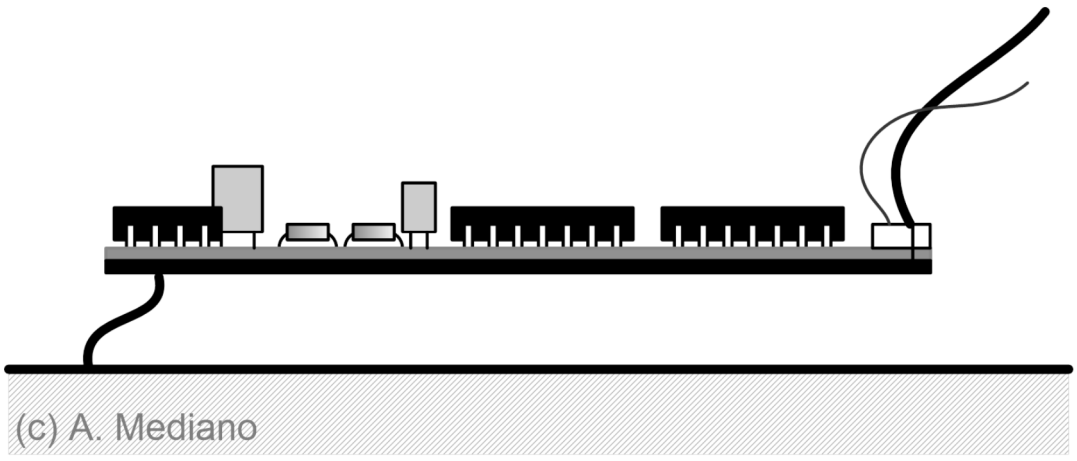
(technically)

EMC: controlling signals



© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es





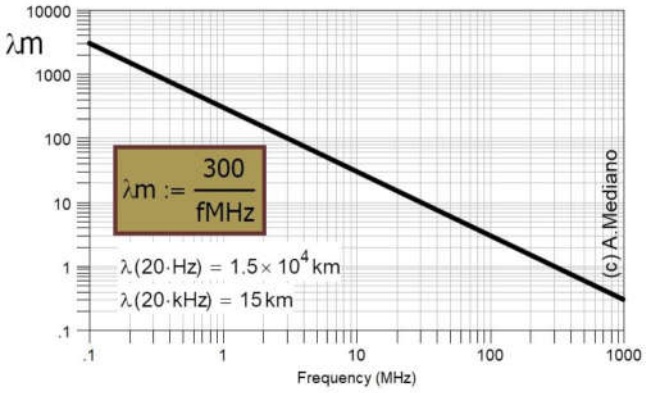
© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

Point of view: .. Frequency vs Wavelength

Two related parameters ...

FREQUENCY (Hz)

WAVELEGTH – SIZE (m)

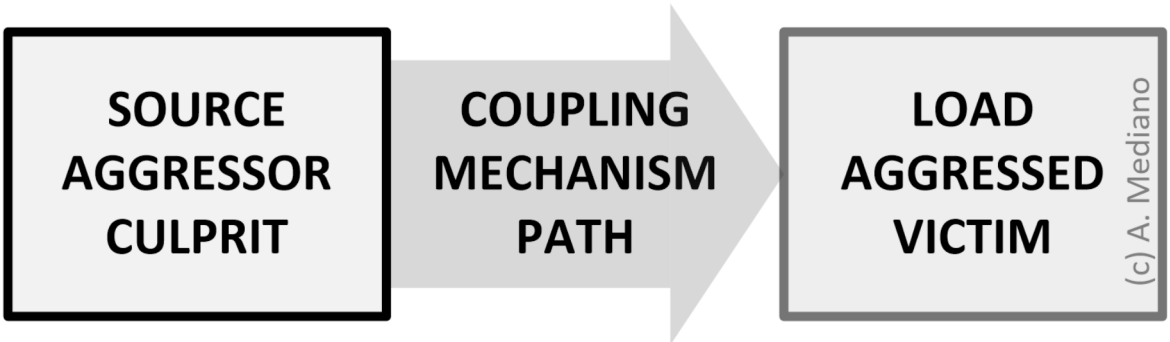


EXAMPLE FROM WIRELESS COMMUNICATIONS:

Optimum dimensions for antenna efficiency at λ/2 and λ/4.

Antenna on PCB for ESP8266 Transmitter and Receiver RF Module

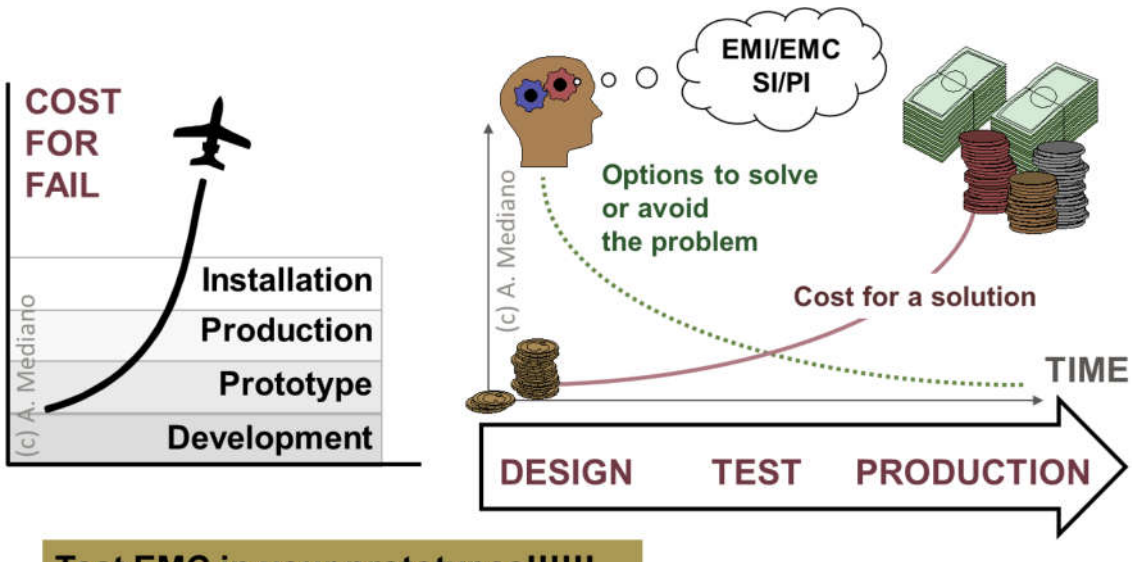
Introduction: EMI general picture



© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

Some suggestions for success ...

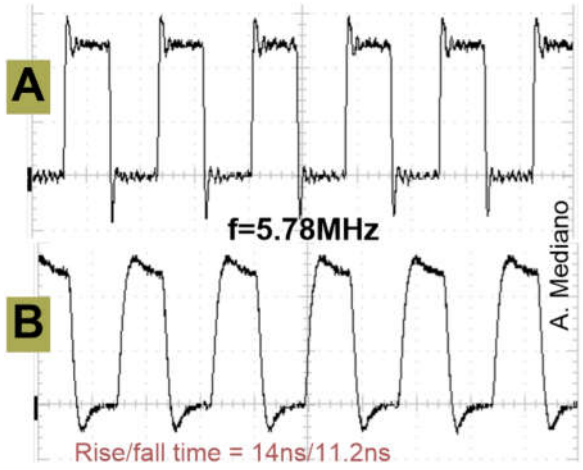
Suggestion 1: consider EMI/EMC at the very beginning of the project

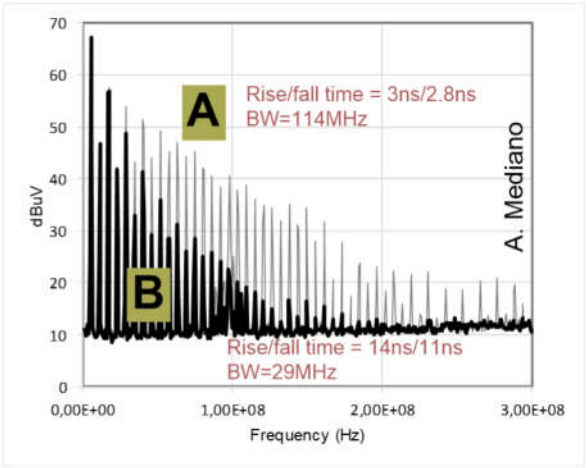


Test EMC in your prototypes!!!!!!

© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

Suggestion 2: work as slow as possible





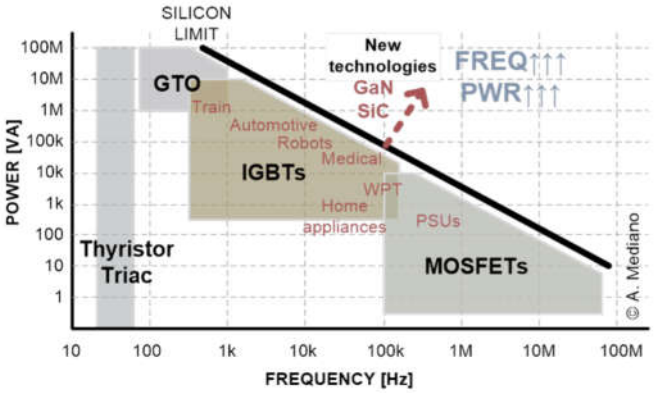
Suggestion 2: work as slow as possible

IGBT introduction → **EMI potential increased 40dB**

Why?

- **Voltage handling capabilities x 5**
- **Turn off time / 20**

→ **dV/dt is main cause of CM EMI: 5 x 20 = 100 = 40dB**



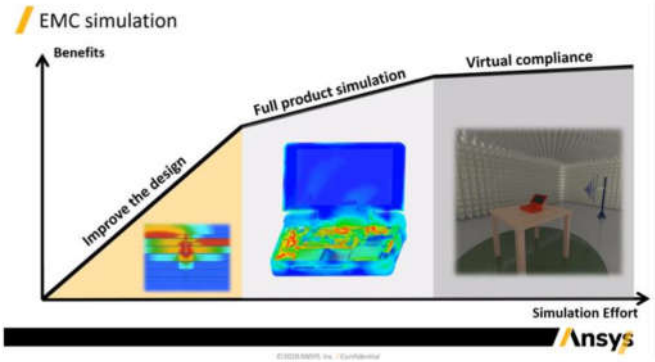
Near future:
Faster electronics with gallium nitride components GaN
Add 20-30dB increase in emissions!

© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

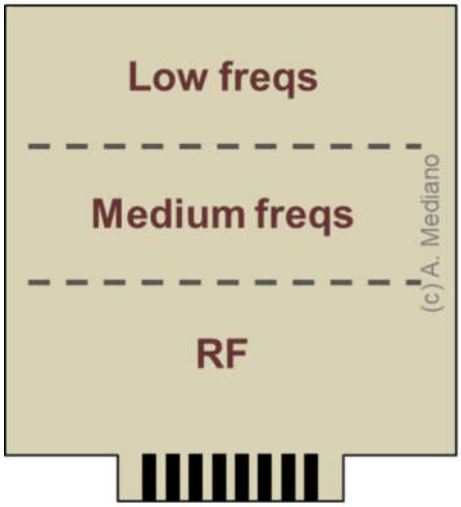
Suggestion 3: measurement & simulation

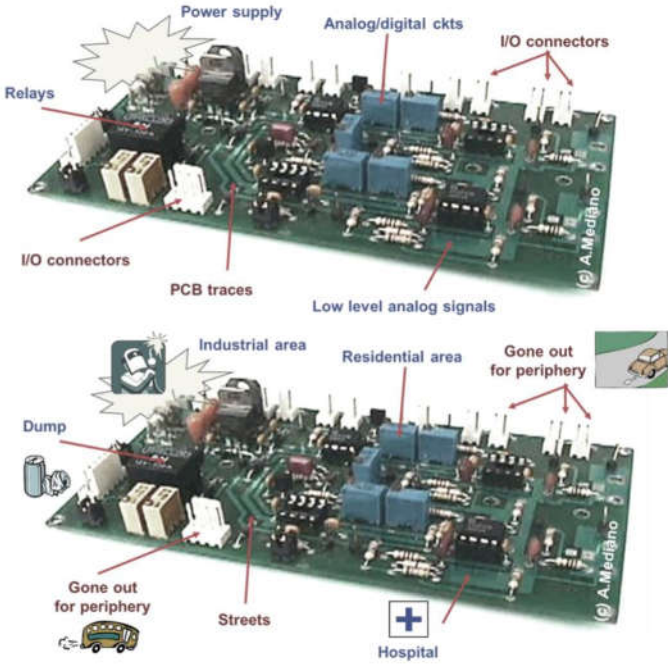
- **Test continuously.**
Buy instrumentation and probes

- **Simulation** if possible



Suggestion 4: partitioning/placement



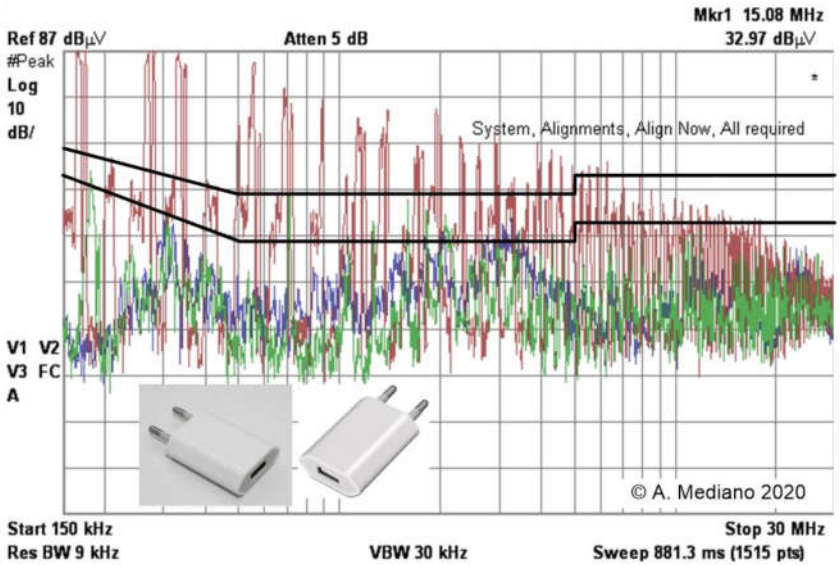


Suggestion 5: design ideas ....

- **PCB**:
  - do not try to save money with 1-2 layers in your PCB
  - partitioning at PCB level too!
  - (real) ground planes are critical!
- **FILTERS**
  - be careful with parasitics
  - layout and location is critical
- **CABLES:**
  - your enemy for 30MHz-400MHz radiated emissions
  - optimum number of cables = 0
  - minimum length
- **SHIELDING**
  - Mechanical design is critical
  - Avoid slots/apertures
  - Filter I/O cables

Suggestion 6: “low cost” equivalents

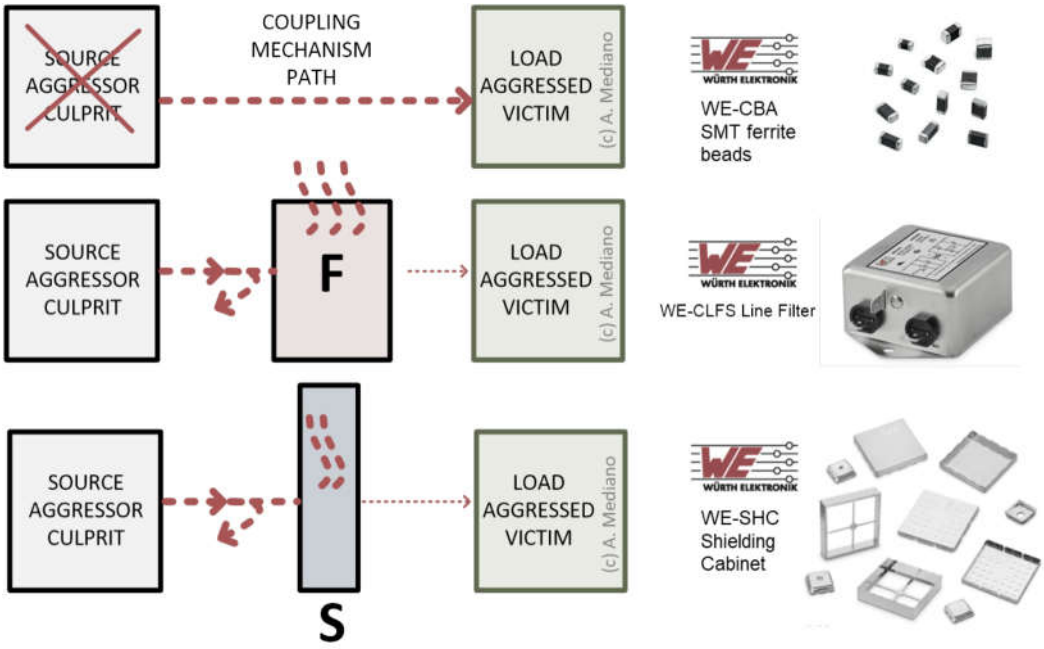
Be careful!



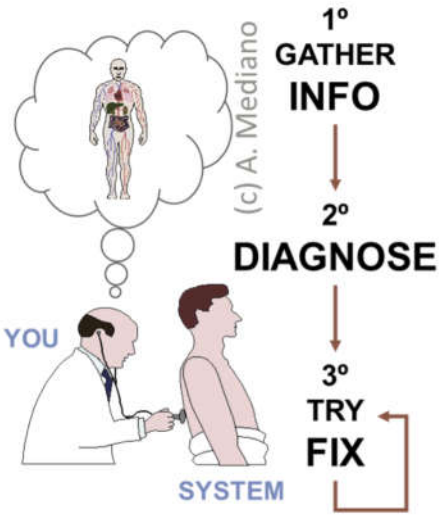
© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

Suggestion 7: if problems appear ...

Avoid trial and error!



Suggestion 7: if problems appear ...



STEP 1
UNDERSTANDING NEEDS

STEP 2
ASK QUESTIONS

It is harder to ask the rigth questions than to find answers for the wrong questions

STEP 3
DIAGNOSIS

STEP 4
APPLY SOLUTIONS ...

... that can go to production!

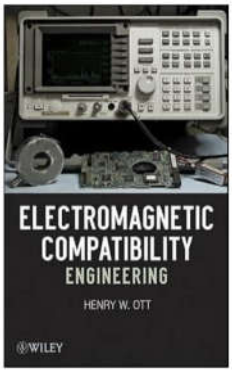
STEP 5
EXPLAIN HOW YOU SOLVED THE PROBLEM

People want to learn.

© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

Suggestion 8: design ideas ....

- **Training is mandatory**:
  - books, courses, conferences, ...



2021 JOINT IEEE INTERNATIONAL SYMPOSIUM
ON ELECTROMAGNETIC COMPATIBILITY,
SIGNAL & POWER INTEGRITY, AND EMC EUROPE

www.emc2021.emcss.org

Suggestion 9: EMC support ....

- **Have your "expert" in EMC** or ...

.... ask for external support!

© A. Mediano University of Zaragoza (SPAIN) · amediano@unizar.es

THANK YOU!

Prof. **Arturo Mediano**
University of Zaragoza (SPAIN)
amediano@unizar.es