Georganiseerd door:

EMC-dag voor installateurs & machinebouwers

13 oktober 2015

Electromagnetic Interference Mitigation

Frits J.K. Buesink, Senior Researcher EMC
frits.buesink@utwente.nl

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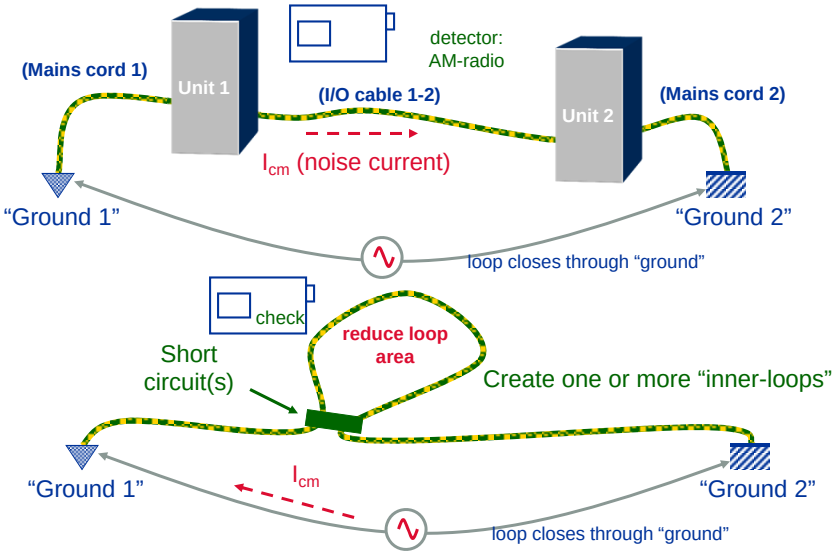
UNIVERSITY OF TWENTE.
TELECOMMUNICATION ENGINEERING.

in cooperation with THALES

The Current Boundary

a provision to split loops (and shut out noise sources)



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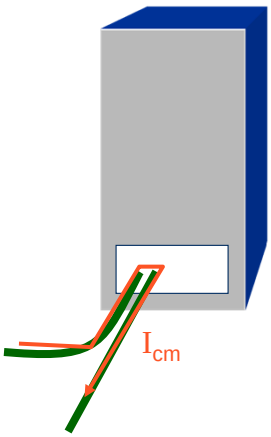
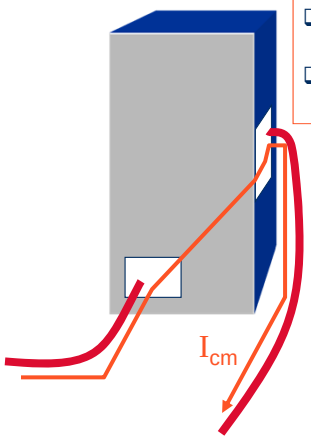
Install current boundaries at natural interfaces

edge of PCB, cabinet wall, basement of a building; one boundary per unit!

Right



Wrong



Drawbacks:

- ❑ Current follows long path over equipment
- ❑ Loop area cannot easily be minimized

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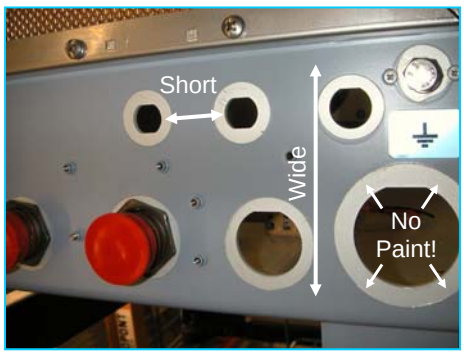
Examples of current boundaries on equipment

wide conductors and low-resistance transitions (be careful with paint) !



protect all units with a current boundary!
(and check any conductor that passes it)

check DC resistance with a milli-Ω meter: < 1 mΩ!

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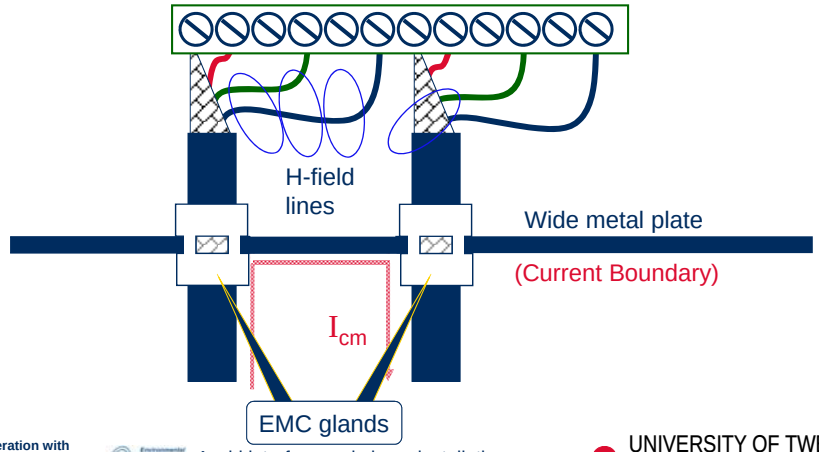
Use Current Boundary to protect existing “pig-tail”

pig-tails can be acceptable as long as CM currents are kept away from it



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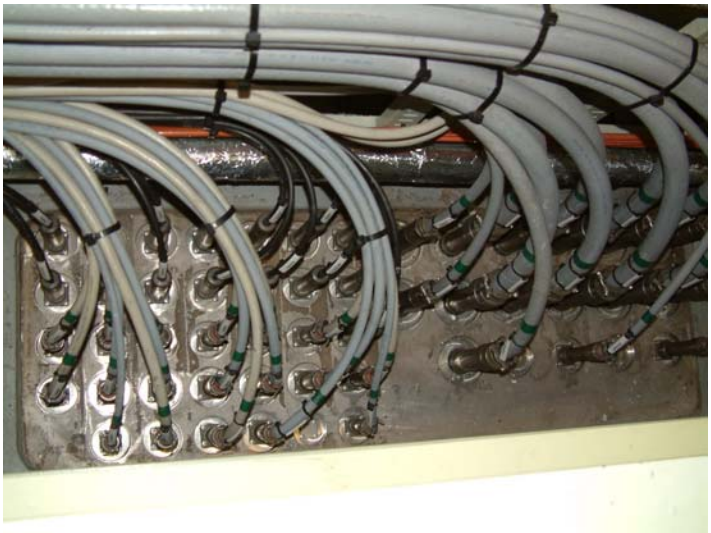
If many Cables are Guided through Shielding Wall..

other options exist



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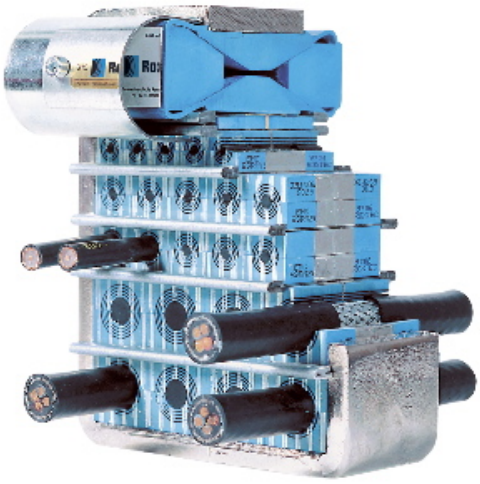
Roxtec / Brattberg Glands



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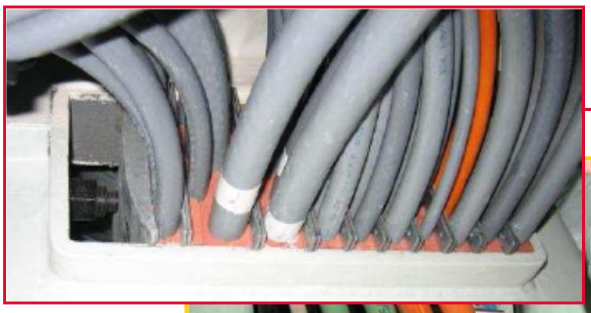
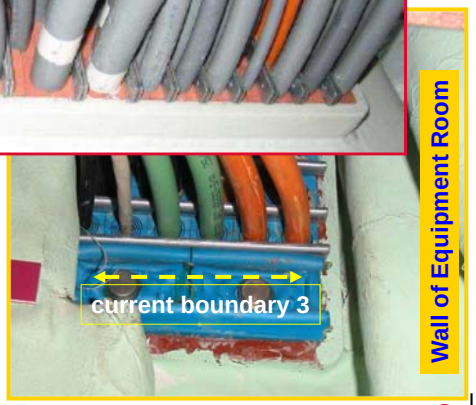
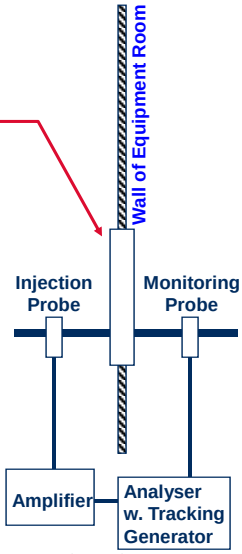
Special Gland System: Many Cables Through Wall

all make good electrical contact in wall (< 10 mΩ)







MIL-STD-1310G

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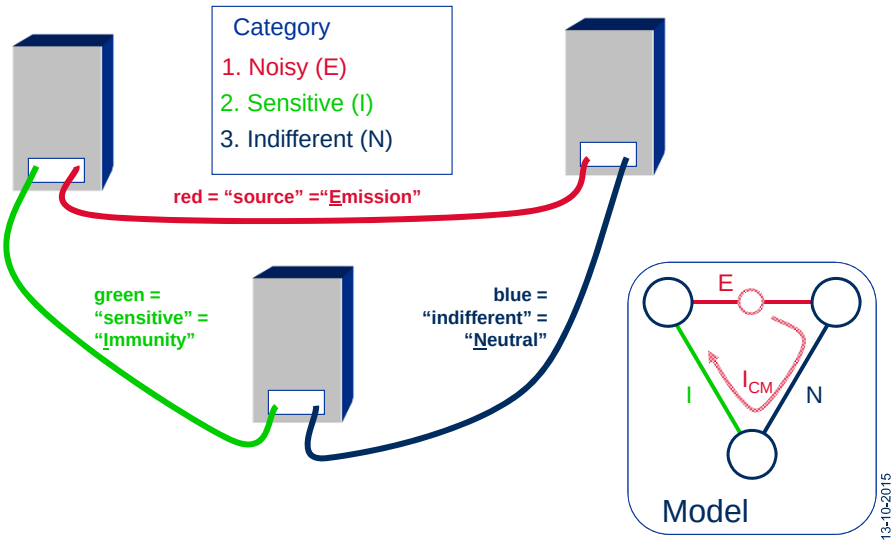
Next: Separate *Cables* with Current Boundaries

classify cables into categories



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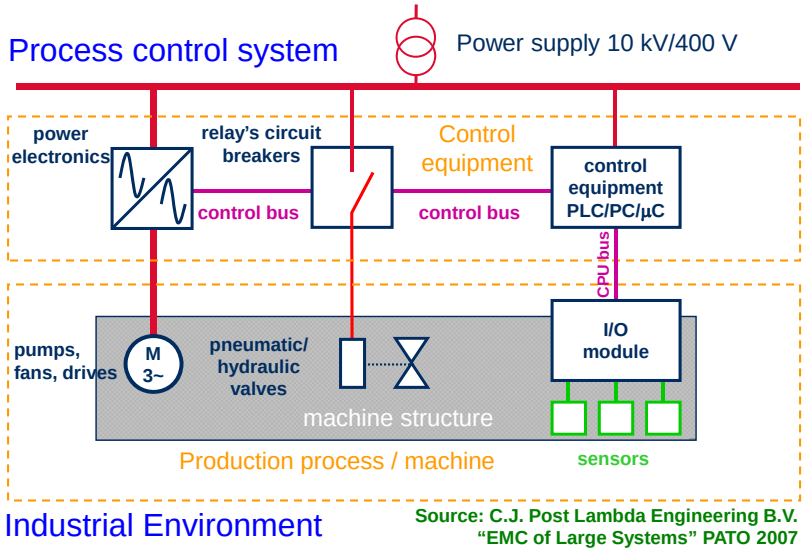
in cooperation with THALES Environmental Competence Centre Avoid interference in large installations

Model the Real System in CM loops

Both sensitive (analog, various busses) and (polluted) power lines



Source: C.J. Post Lambda Engineering B.V. "EMC of Large Systems" PATO 2007

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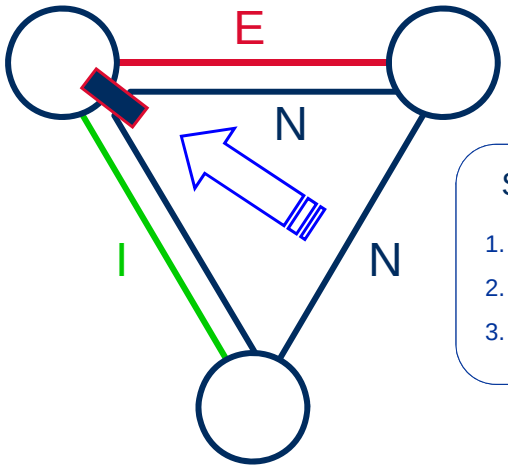
in cooperation with THALES Environmental Competence Centre Avoid interference in large installations

Separating Cables with Current Boundaries

use Neutral conductor to reduce loop area; then insert current boundary



Steps:

1. recognize loop
2. reduce looparea
3. add boundary

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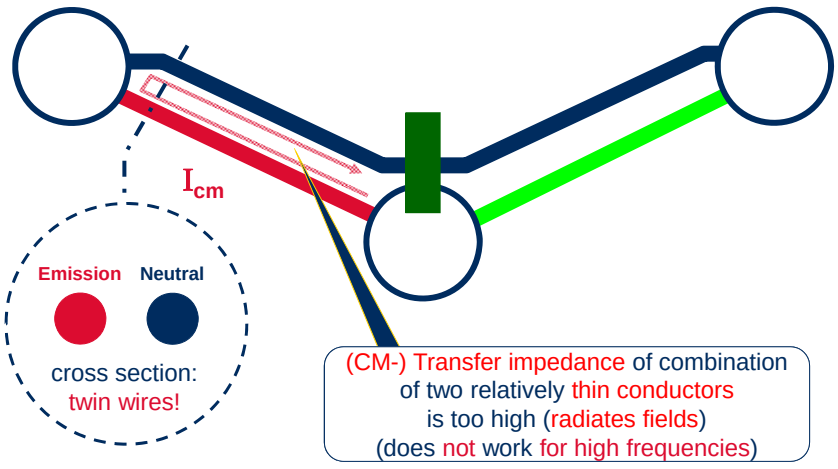
Separating Cables with Current Boundaries

neutral conductor in practical cases: never a "wire", always a structure part



(CM-) Transfer impedance of combination of two relatively thin conductors is too high (radiates fields) (does not work for high frequencies)

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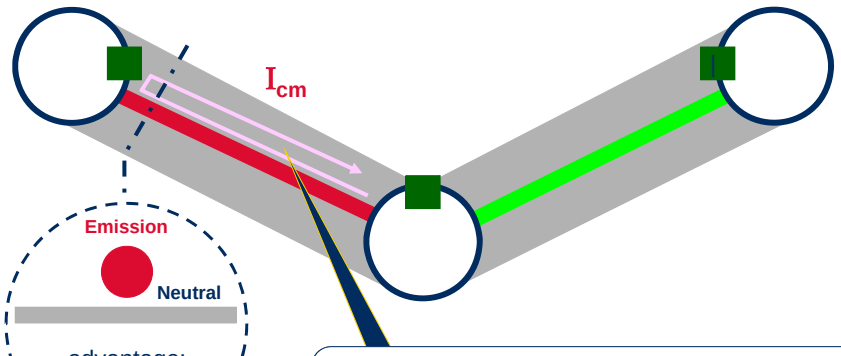
Separating Cables with Current Boundaries

wide metal reduces fields i.e. the transfer-impedance of the cm-current loop



advantage:
proximity & skin
effects

Wide sheet metal ("cable tray") is far superior to the previous situation. The common-mode transfer impedance is much lower. Skin effect helps.

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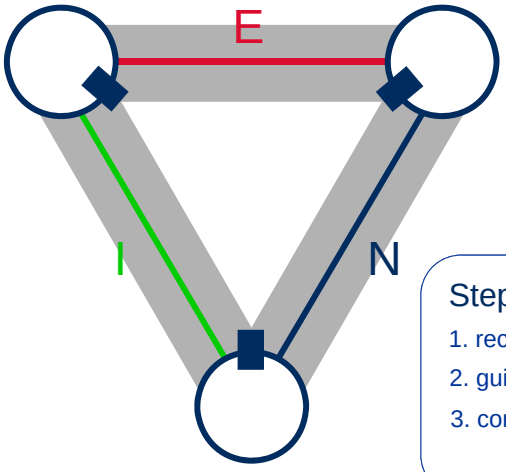
Separating Cables (Alternative)

use structure metal parts to "guide" cables and insert current boundaries



Steps:

1. recognize loop
2. guide cables with metal strips or trays
3. connect current boundaries to strips

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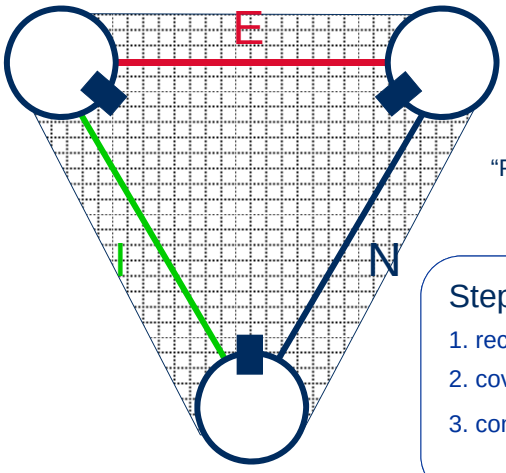
Separating Cables with Current Boundaries

use (Ground-) Plane to reduce loop area; then insert current boundaries



Note: we are actually reducing *CM-loop areas* here, using *wide* metal *"short-circuits"*

"Plane" could be metal mesh

Steps:

1. recognize loop
2. cover loop with metal (ground-)plane
3. connect current boundaries to plane

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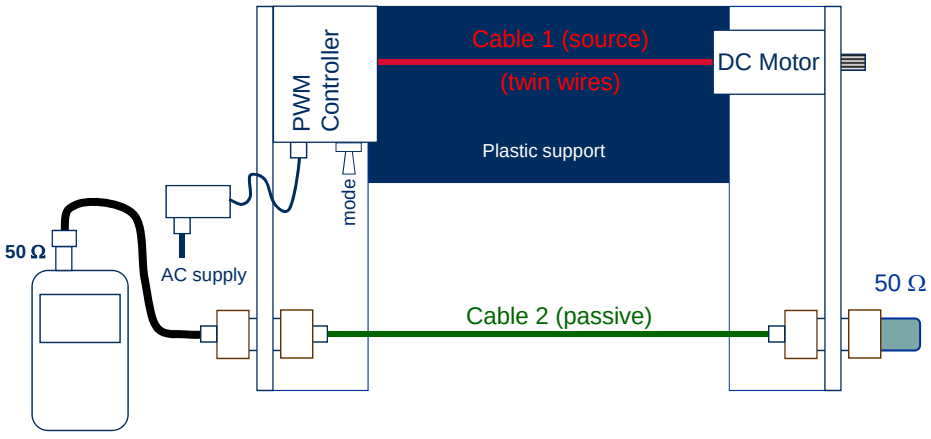
Experiment with Frequency Controlled Motor

crosstalk between cables due to transfer-impedance



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Experiment with Frequency Controlled Motor

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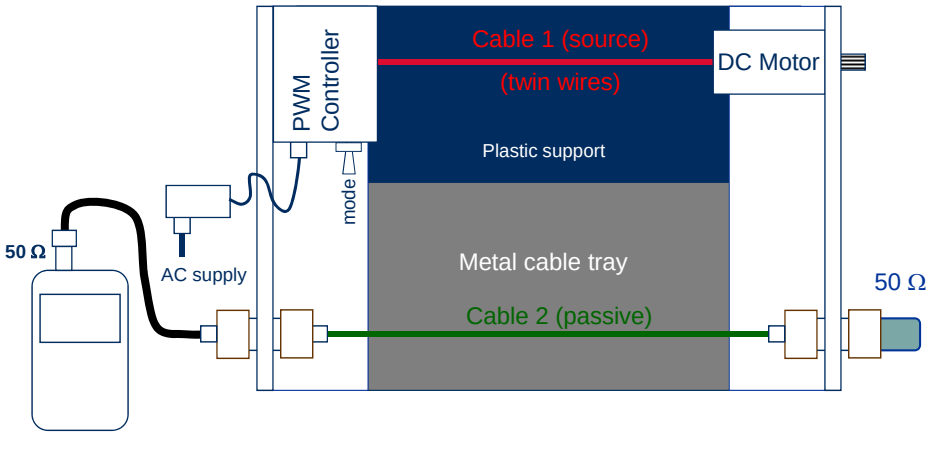

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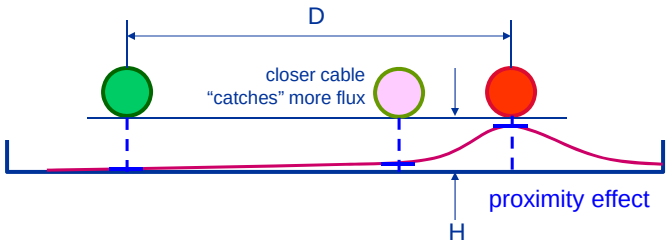
Cable distance is important

once a cable tray is used for protection



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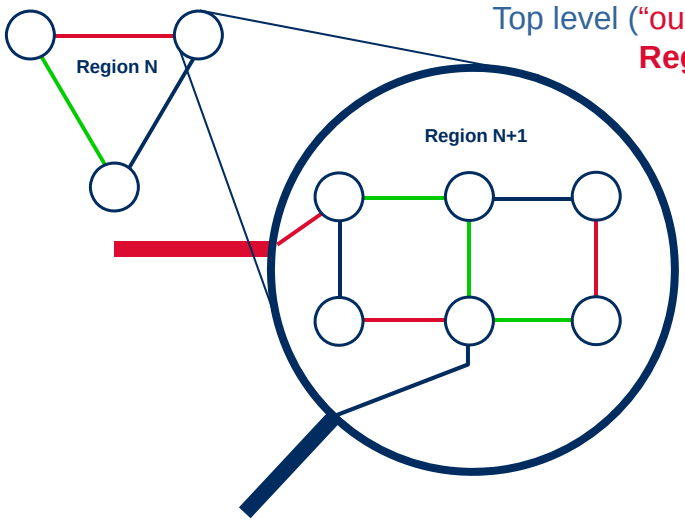
Separating Regions using Current Boundaries

enclosures with current boundaries form individual “environments”



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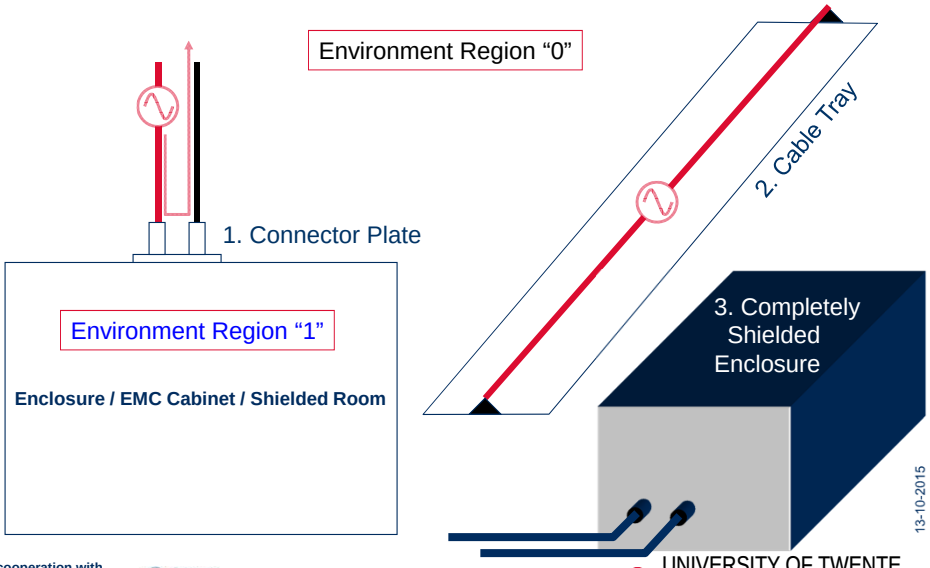
Three Types of Current Boundary

Short Circuit for Common-Mode “Sources”



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Regions/Environments can be Nested

prepare for current boundaries on every module interface

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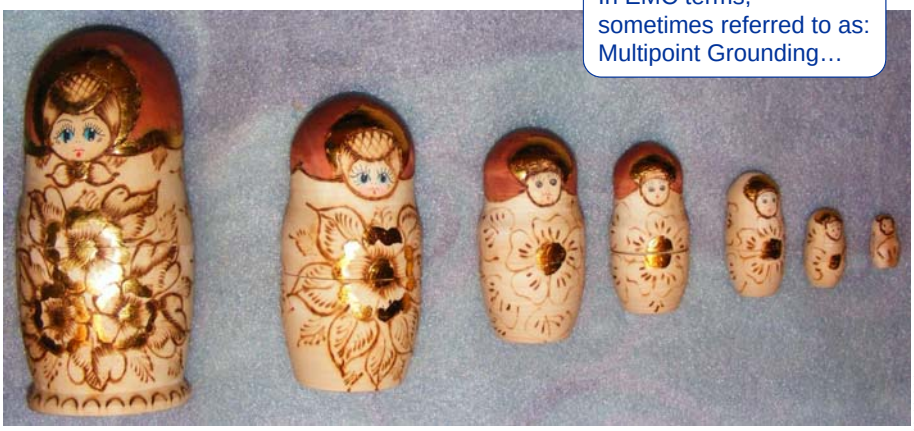
Only Limited Shielding can be achieved per Enclosure

20 -40 [dB]; but it can be applied recursively!

In EMC terms, sometimes referred to as: Multipoint Grounding…



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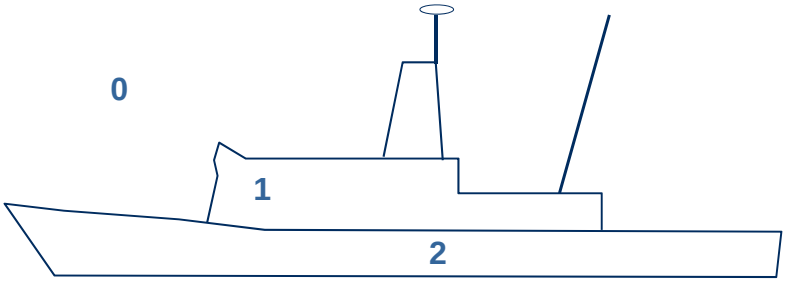
Regions are defined Electromagnetic Environments

(example) region 0: MIL-STD-464A, region 1: bridge, region 2: below deck



Aim: use commercial equipment in region 2 (susceptibility level 10 V/m)

Shielding between successive regions: 20 - 40 dB (factor 10 to 100)

- ❑ Define where EM zones will be
- ❑ Define the EM levels per region
- ❑ Use adequate current boundaries between regions

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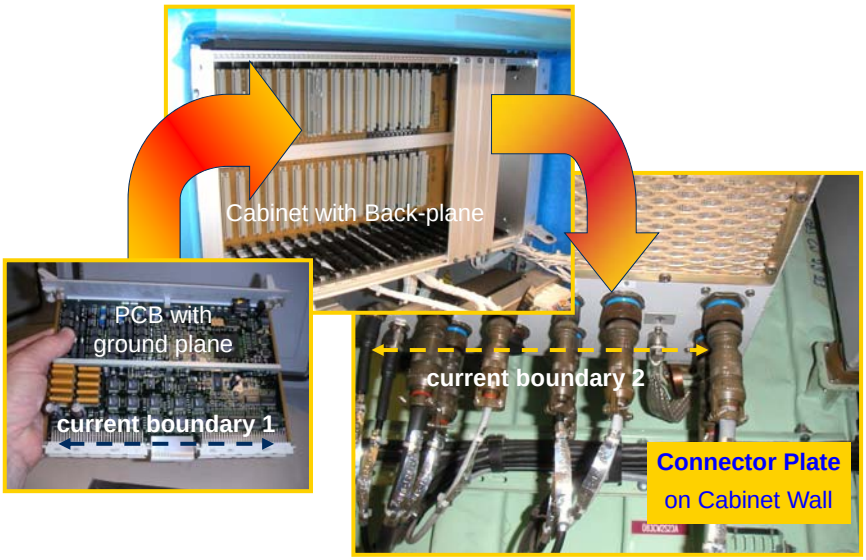
Multipoint Grounding

hierarchy of current boundaries



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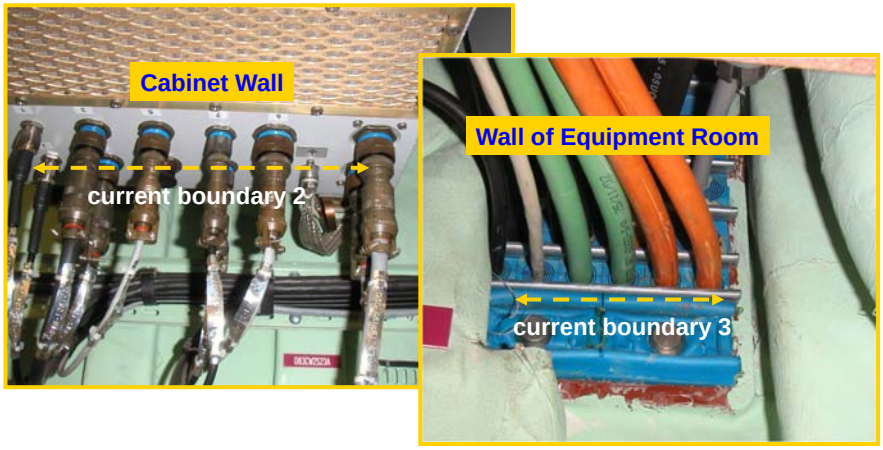
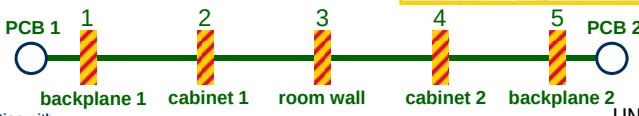
Multipoint Grounding

separating rooms in a ship is called Zoning (partitioning into EM-Regions)





20 dB per boundary: = 100 dB!

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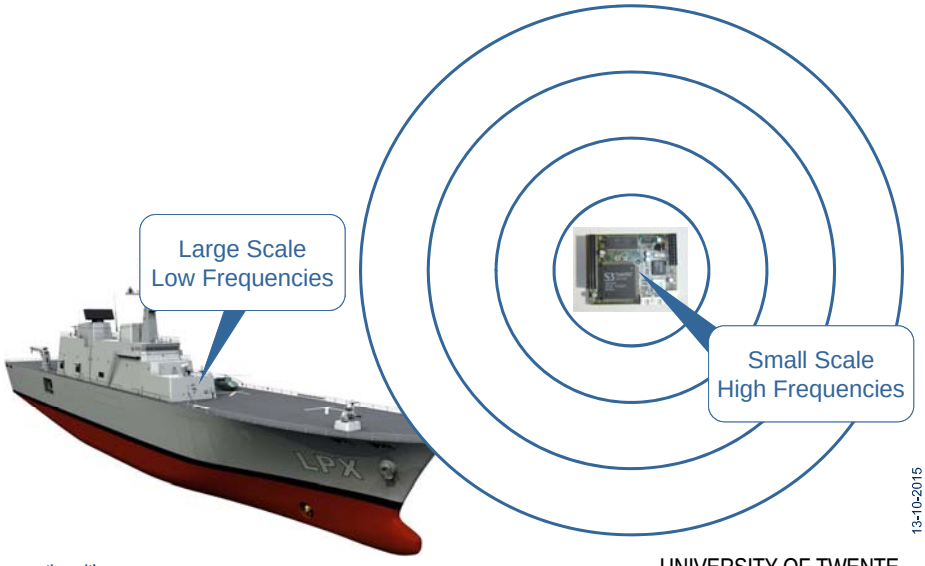
Try to stick to the “Low Frequency Approach”

use current boundaries to restrain sizes to way below half-wavelength



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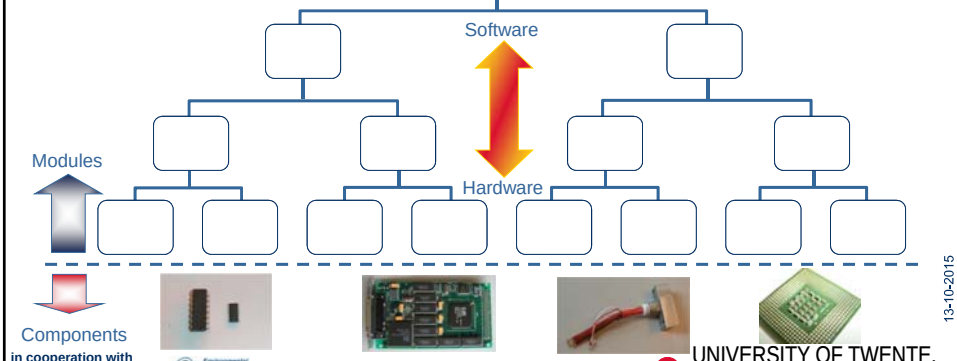
"Systems Designers Heaven"

independent building blocks with "abstract" behaviour

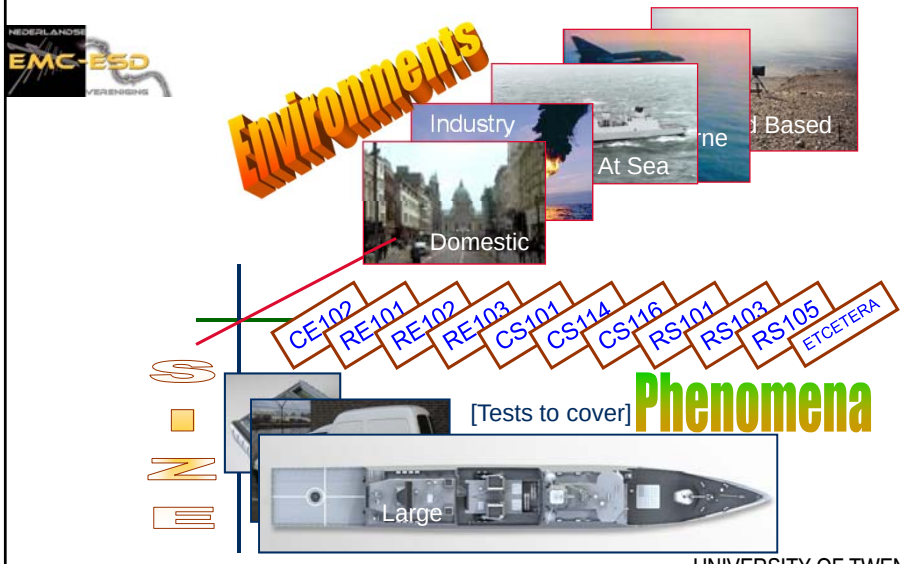
Object Oriented
- ❑ realise complex from simpler behaviour
- ❑ make assemblies independent
- ❑ solve "undesired" as low as possible

EMC Principal Laws
- ➢ No high frequencies
- ➢ Do not transport them
- ➢ Use adequate boundaries



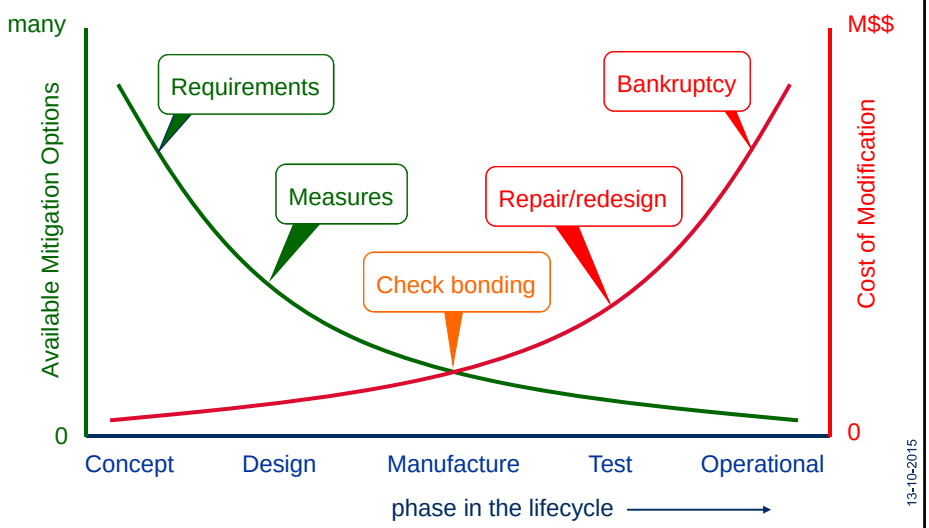
Product Development/Program Support

systems EMC requirements are set by the environment it is intended for



EMC is achieved during the design process

when problems appear during testing, we are too late!



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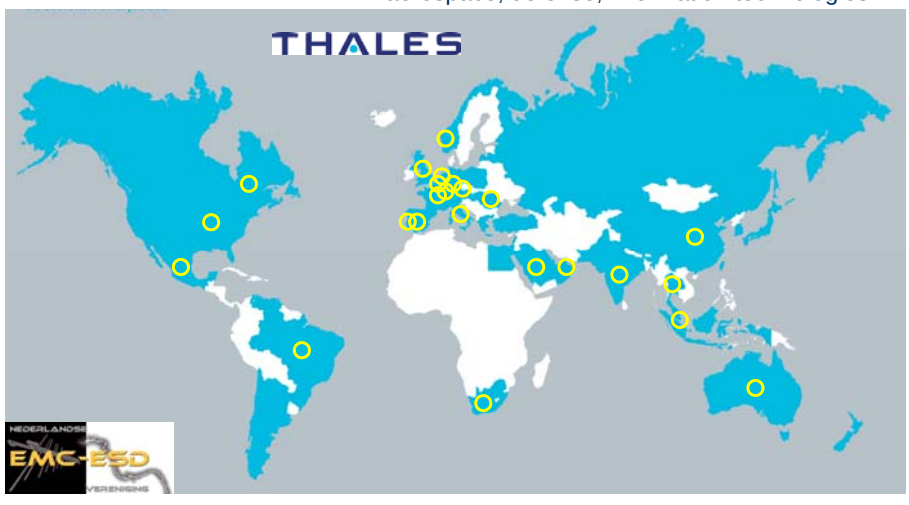
Example of a Large Organization: Thales

aerospace, defense, information technologies



In terms of EMC: How to keep the same quality standards all over the world?

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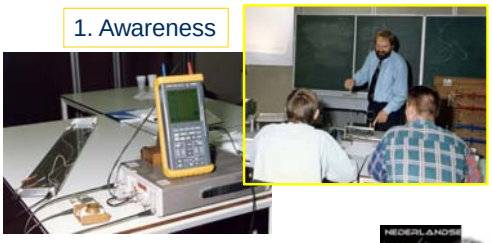
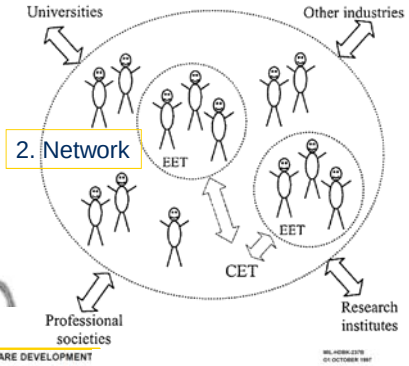
Four Key Elements

of EMC implementation in large organizations

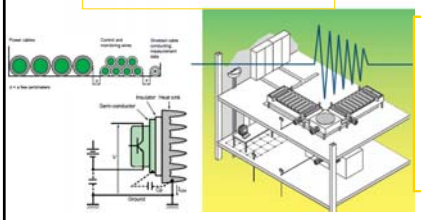
1. Awareness



2. Network



3. Rules & Guidelines



4. Program support

METHODOLOGY

DEPARTMENT OF DEFENSE HANDBOOK

EMC CONTROL PLAN

GUIDANCE FOR CONTROLLING ELECTROMAGNETIC ENVIRONMENTAL EFFECTS ON PLATFORMS, SYSTEMS, AND EQUIPMENT

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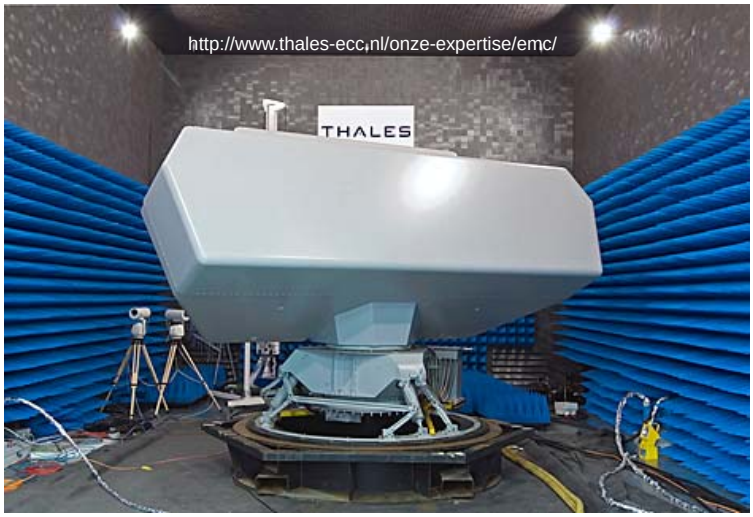
Product Development/Program Support

perform engineering & qualification tests



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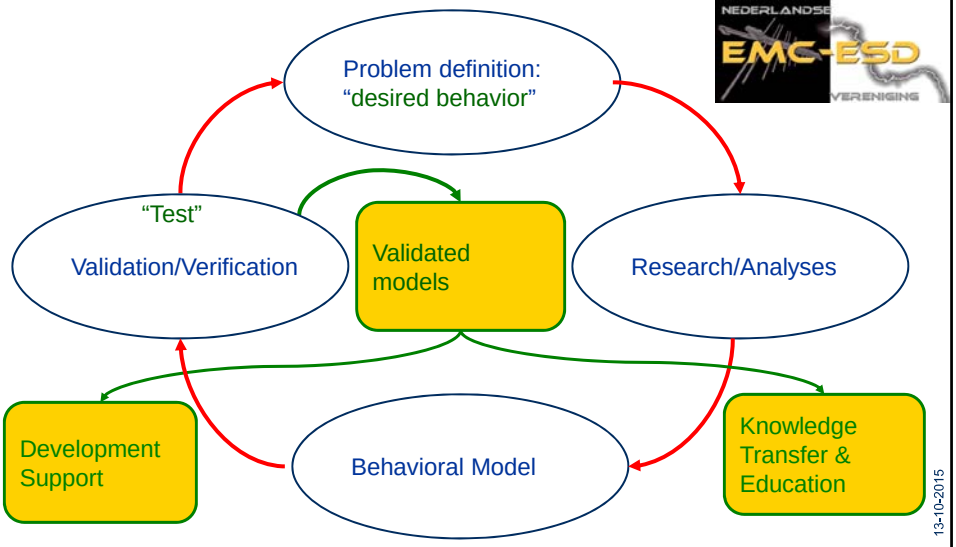
EMC approach through the Knowledge Cycle

insert electro magnetic behavior up front



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EMC Rules and Guidelines

a lot of information on EMC engineering can be found on the internet

A. Roc'h en F. Leferink, „An audit tool for the implementation of emc in large companies", *International Symposium on EMC, EMC Europe, Rome, Italy*, sep 2012.

F. Leferink, S. Lerose, M. Sauvageot en W. van Etten, „The four key elements of emc implementation in large organizations", *International Symposium on EMC, Sorrento, Italy*, 2002.

Mil-hdbk-237b guidance for controlling electromagnetic environmental effects on platforms, systems and equipment, US Department of Defense Handbook, okt 1997.

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Iec 61000-5-2 electromagnetic compatibility, part 5: installation and mitigation guidelines, section 2: earthing and cabling, International Electrotechnical Commission, 1997.

(Aug 2015). Schneider cahiers techniques. English, addres: `http://www.schneider-electric.com/sites/corporate/en/products-services/technical-publications/technical-publications.page`.

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K. Armstrong. (jan 2000). Design techniques for emc part 1. English, Cherry Clough Consultants, addres: `http://www.humerboard.at/ftkl/Design_Techniques_For_%20EMC.pdf`.

Allen-Bradley. (jul 2001). System design for control of electrical noise, Rockwell Automation, addres: `http://literature.rockwellautomation.com/idc/groups/literature/documents/rm/gmc-rm001_-en-p.pdf`.

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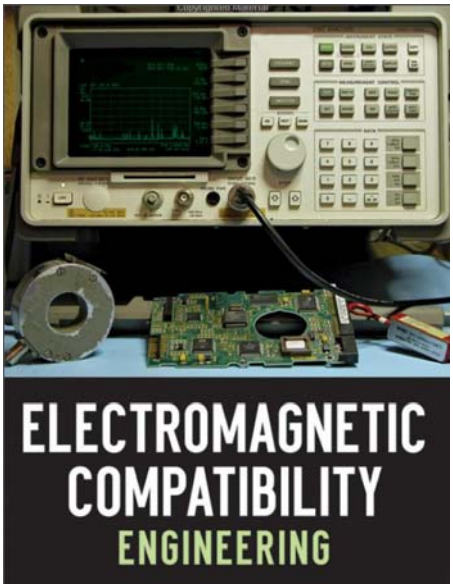
EMC Rules and Guidelines



or: buy a book!

ISBN 978-0-470-18930-6

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End of Part II

QUESTIONS?

13-10-2015

Relation of MIL-STD-461E tests to Phenomena

survey of test identifiers

CE102	Conducted Emissions, Power Leads, 10 kHz to 10 MHz
RE101	Radiated Emissions, Magnetic Field, 30 Hz to 100 kHz
RE102	Radiated Emissions, Electric Field, 10 kHz to 18 GHz
RE103	Radiated Emissions, Antenna Spurious and Harmonic Outputs, 10 kHz – 40 GHz
CS101	Conducted Susceptibility, Power Leads, 30 Hz to 150 kHz
CS114	Conducted Susceptibility, Bulk Cable Injection, 10 kHz to 200 MHz
CS116	Conducted Susceptibility, Damped Sinusoidal Transients, 10 kHz to 100 MHz
RS101	Radiated Susceptibility, Magnetic Field 30 Hz to 100 kHz
RS103	Radiated Susceptibility, Electric Field, 2 MHz to 40 GHz
RS105	Radiated Susceptibility, Transient Electromagnetic Field (NEMP)

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