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EMC challenges for electromobility

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KNOWLEDGE IN REALITY

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- What´s different with E-mobility?
- What are the challenges?
  - System level
  - Shielding
  - System internal
- Summary

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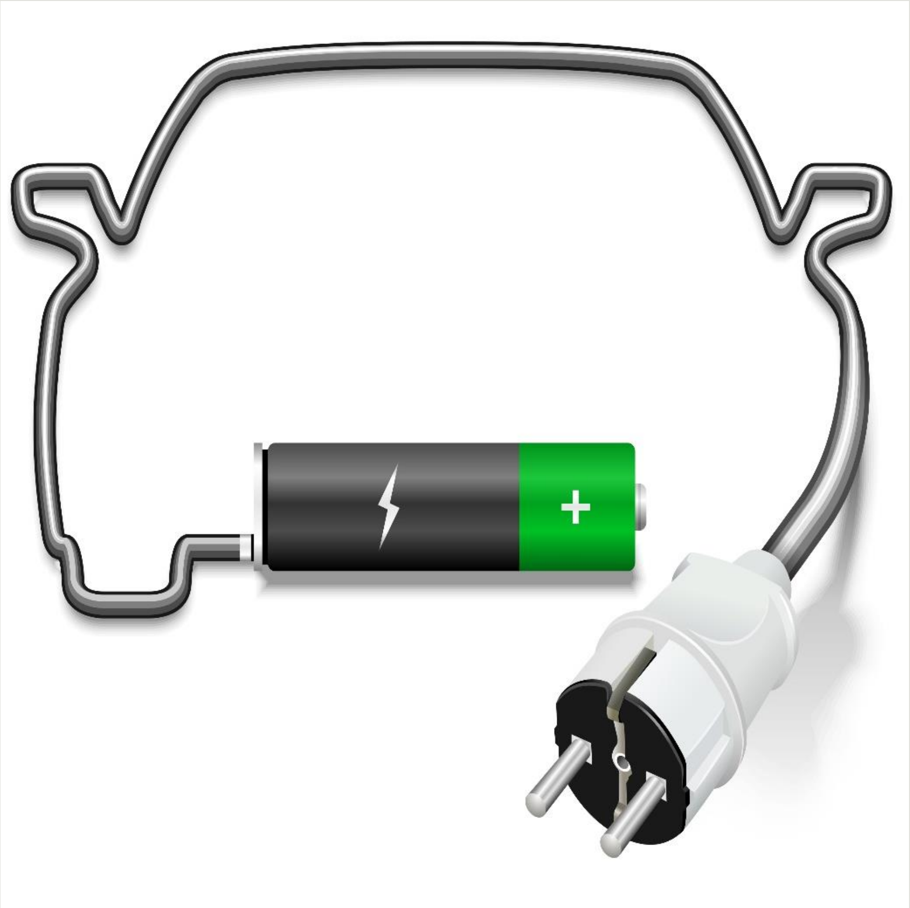
What´s different with E-mobility?



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EMC Requirements due to E-mobility

- Vehicle on road
  - UN ECE R10
- US: connected to power mains
  - FCC CFR 47 part 15B
- Marine
  - IEC 60533
  - IACS (ships classification)
- Vehicle off road
  - EN standards for machines

- Charging port has same requirement as every other domestic appliance
- To date, only China has unique EMC requirements for electric vehicles (GB/T-x).

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What is the challenge?

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Electric vehicles and EMC

Challenge: to create a hybrid vehicle with high quality

- The car can not have lower EMC performance just because it is electric
- The environment and use is the same

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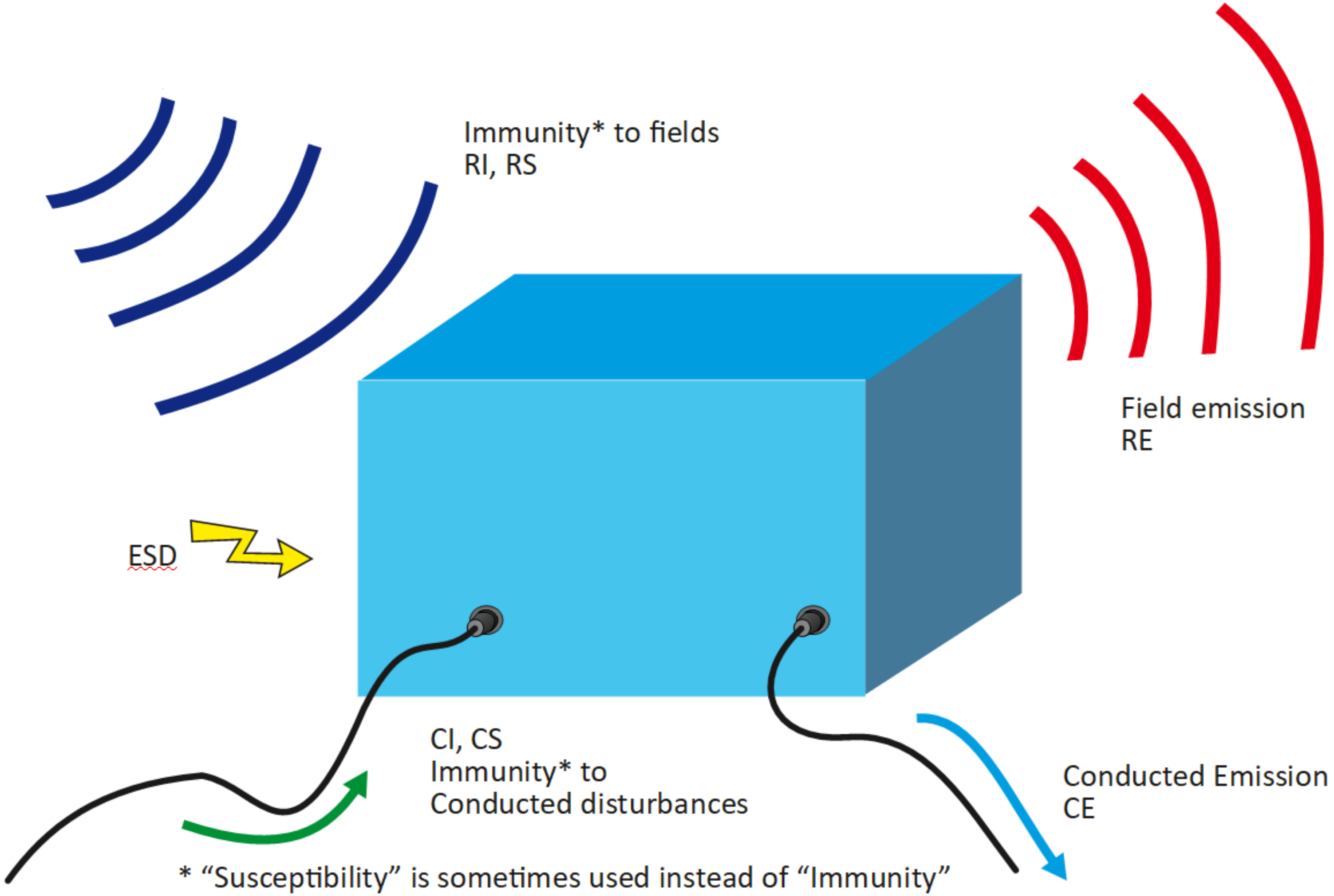
EMI risks in reality



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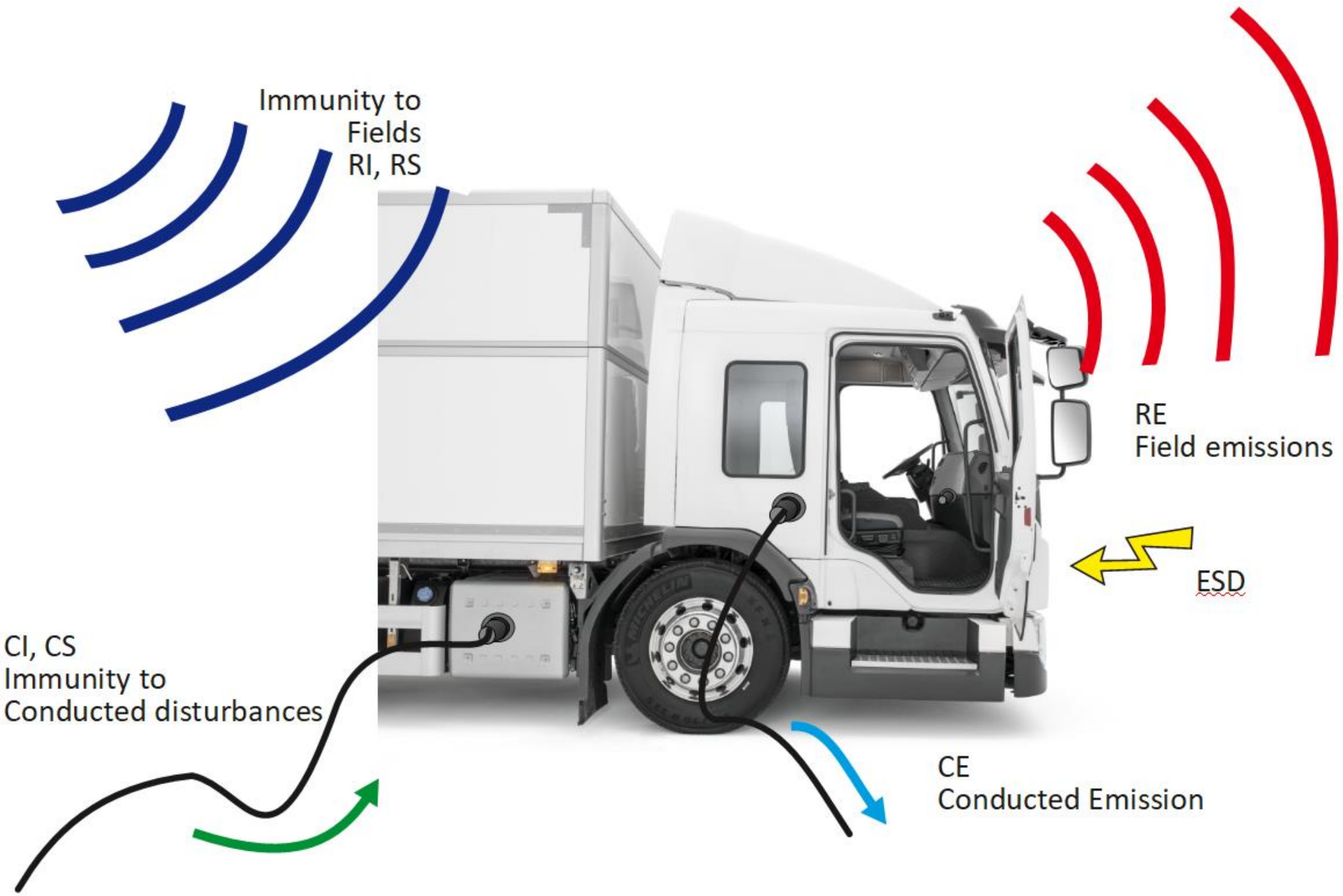
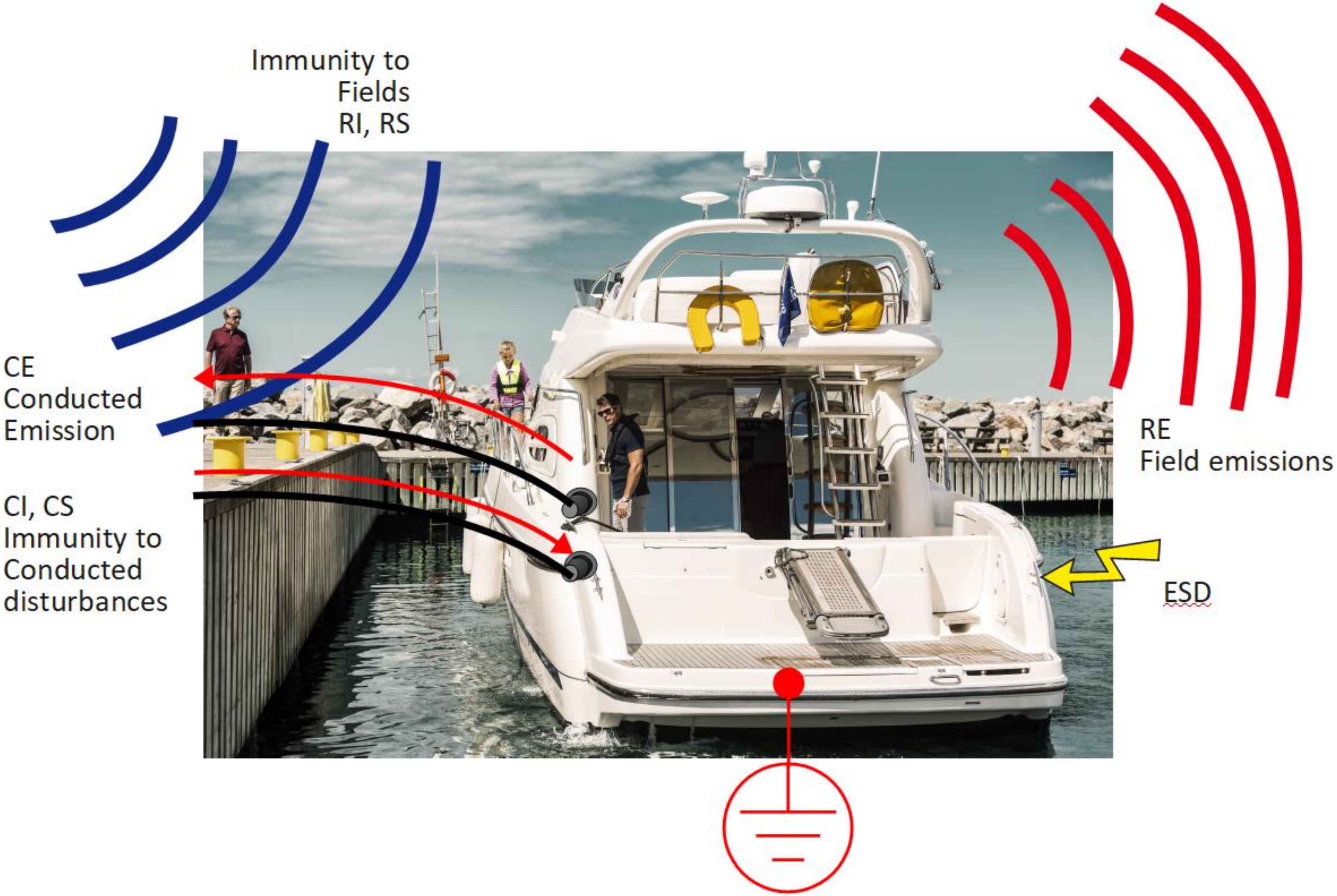
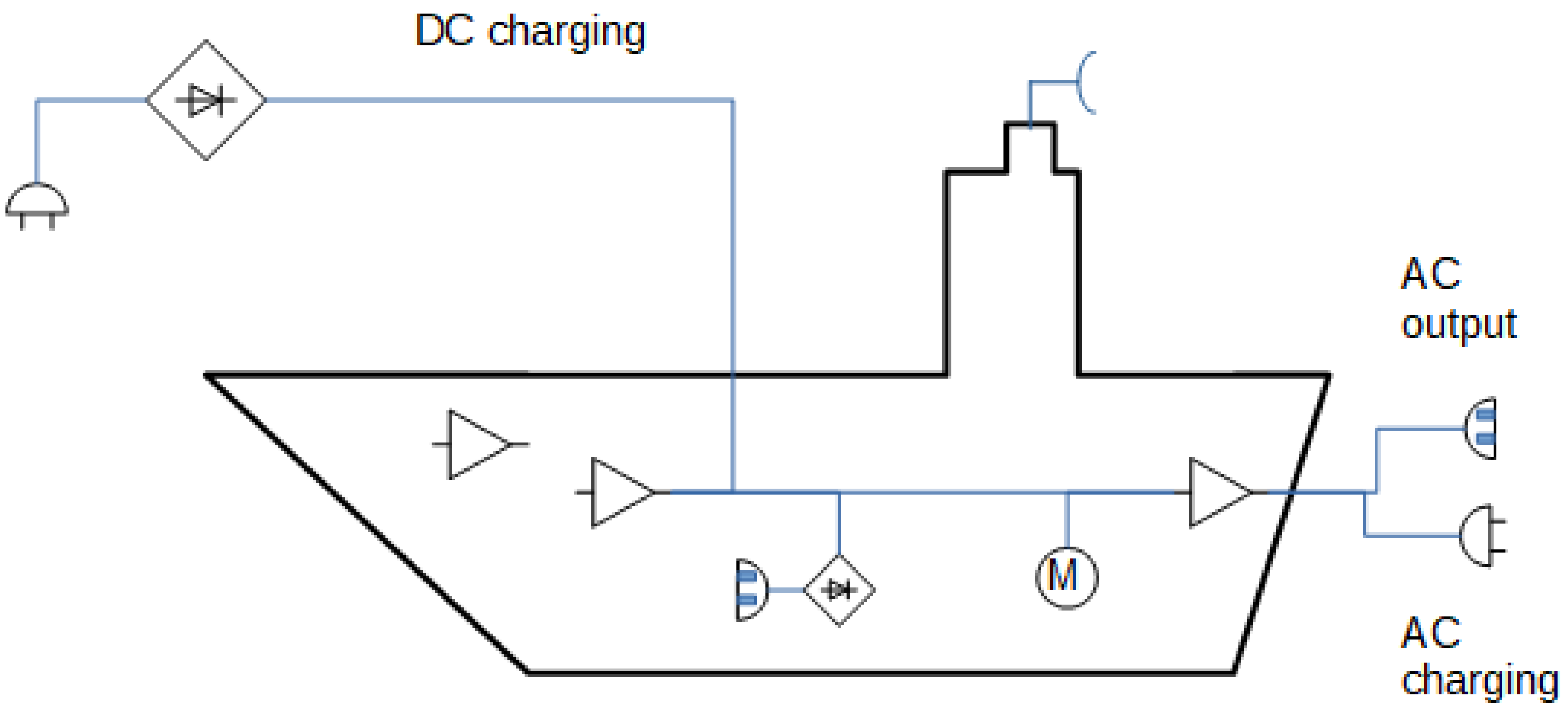
EMI risks in reality – land mobile



EMI risks in reality – marine



Complete ship – e-mobility basic picture



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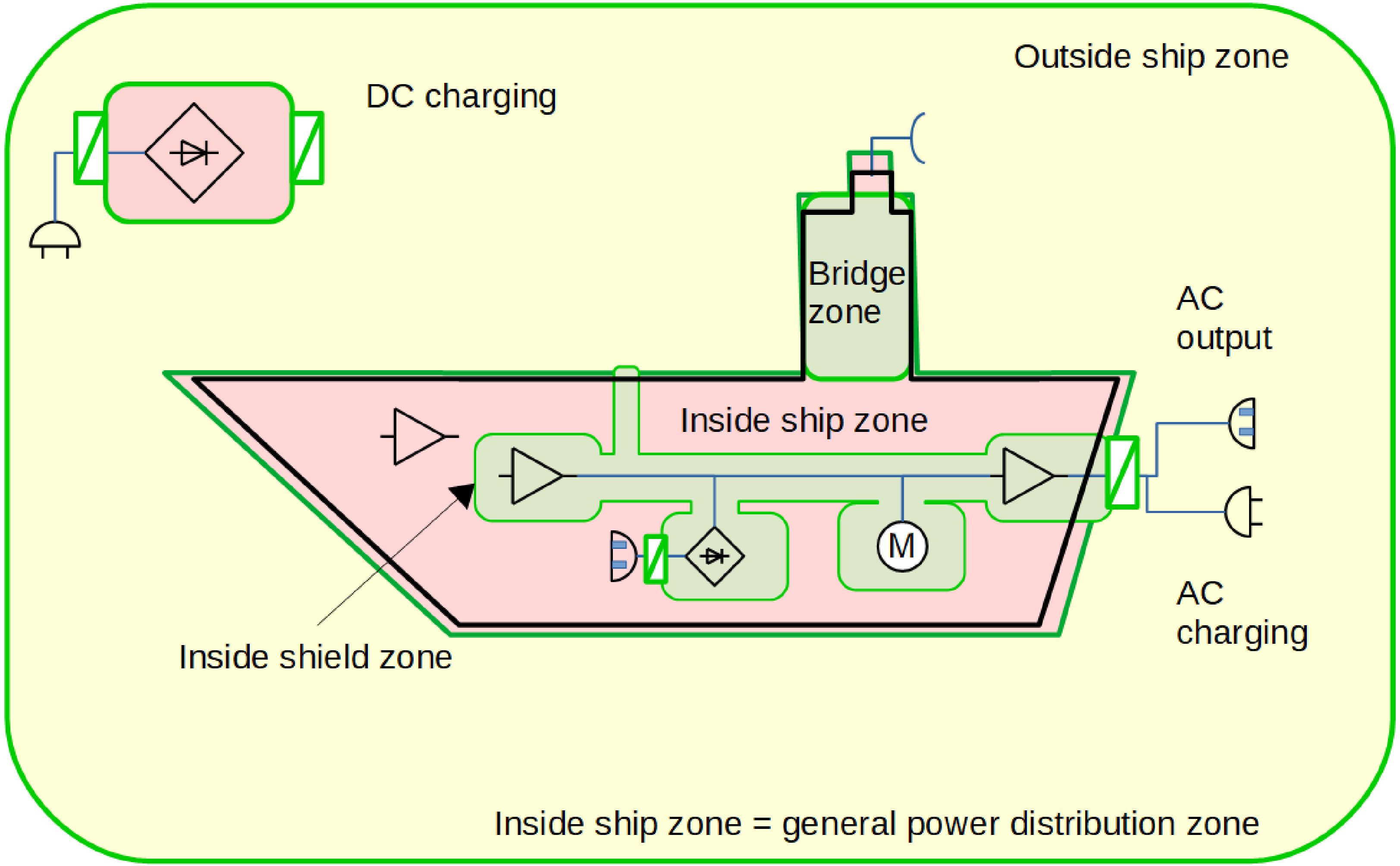
Complete ship – e-mobility zoning AC charge



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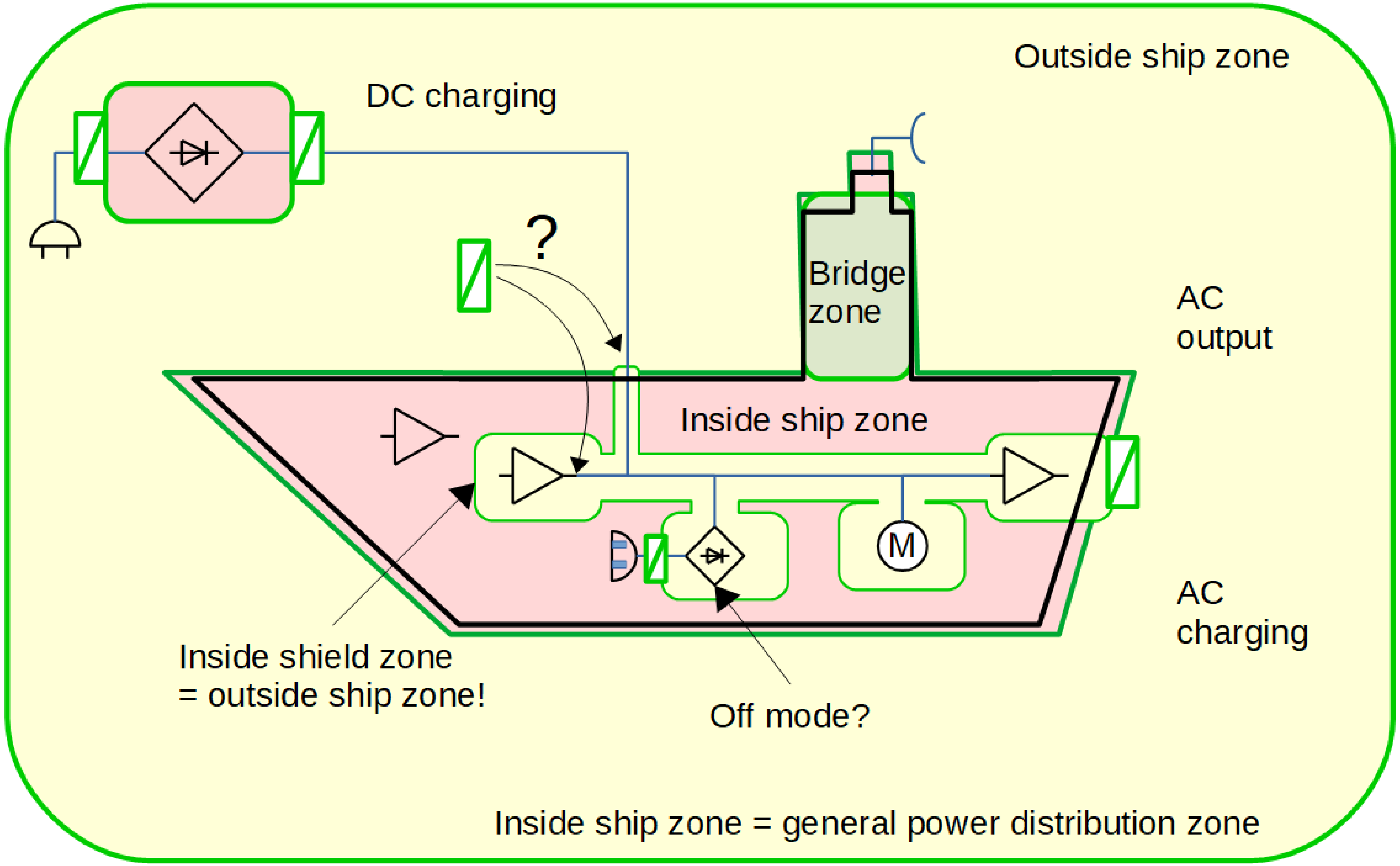
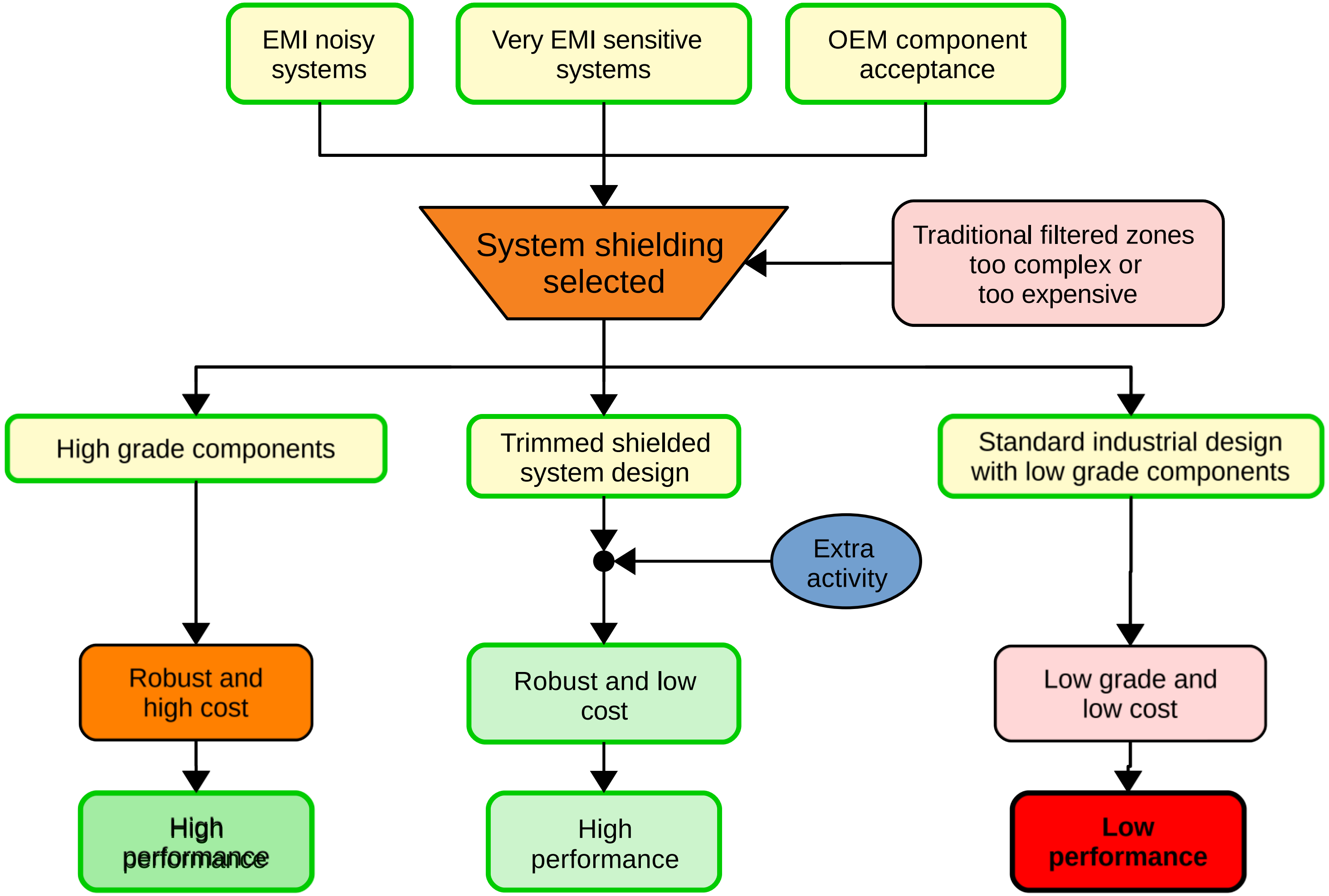
Complete ship – e-mobility zoning DC charge



The shielding challenge

Proposals and discussion

3 ways of shielding



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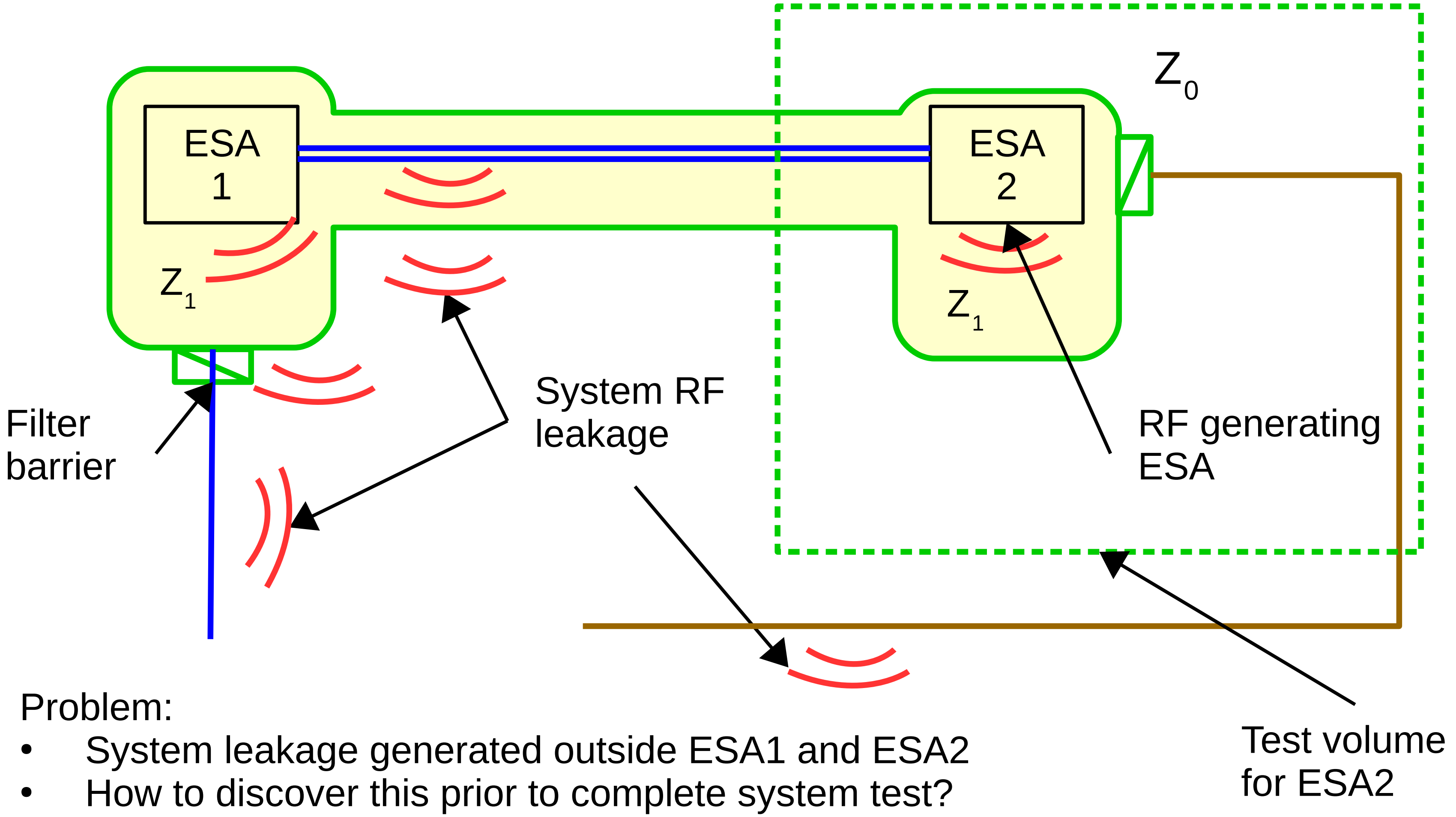
Risk: Leaking system including cables



Problem:

- System leakage generated outside ESA1 and ESA2
- How to discover this prior to complete system test?
- How to verify ESA1?
- What requirement?

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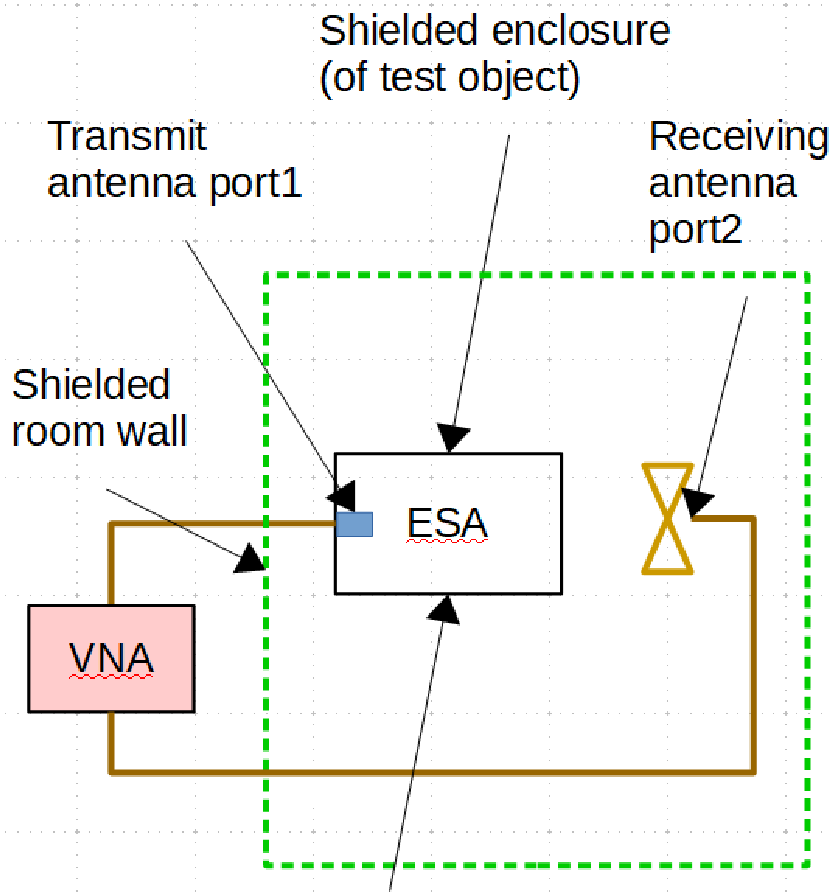
Option: SE requirement on ESA + interfaces



No space for antenna in ESA

Approach:
Measure the attenuation through the enclosure

Alternatives:

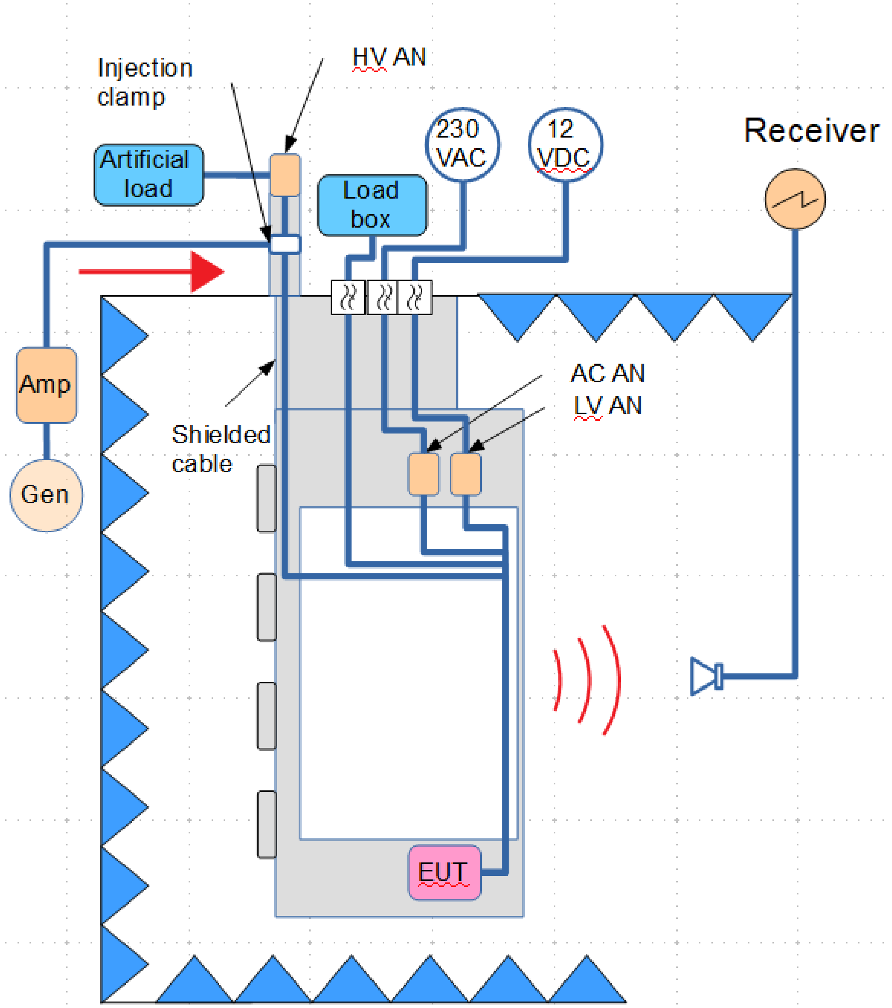
- Figure: Standard IEEE 299 for radiated cabinet measurement
- CISPR25 method for conducted measurements (transfer methods)
- many IEC standards for cables and connectors

Cons for IEEE 299:

- 30-300 MHz not covered for enclosures
- Interfaces of connectors and cables may be missed in IEEE method
- What shielding level shall be specified
- Electronic HW influence may be missed

Methods for cables + connectors OK

Option: Injection on ESA during emission measurement



Approach:
Simulate the actual worst case disturbance generator

- Needs to be tailored for each project

Pros:

- All interfaces, connectors and cables are included – must be specified!
- Test is integrated into regular test setup
- No tailored test items (EUT)
- Active system: Electronic HW influence included

Cons:

- How to specify the injection
- The major source must be known
- **Pulse generator is complicated**
- The laboratory must be prepared!

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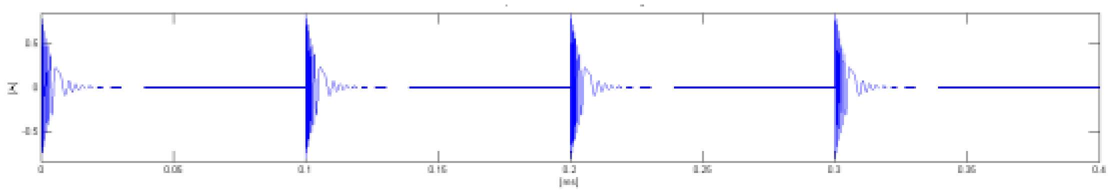
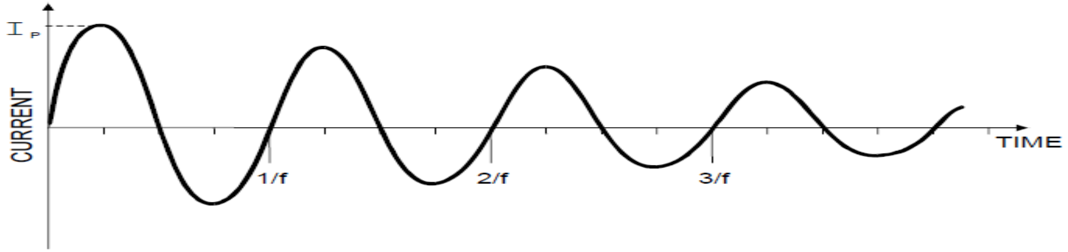
Component testing,
induced pulse frequency pulse shape



Broadband (more advanced)



Damped sinusoidal (MIL-std)

X

Or some other pulse/method?

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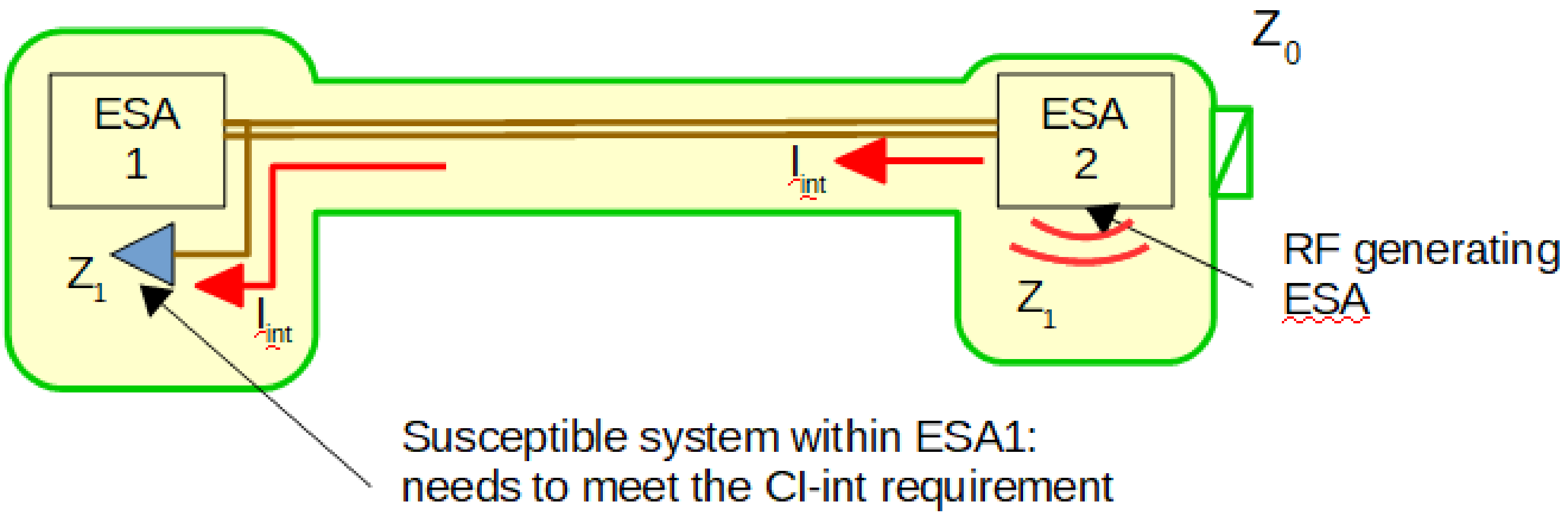
The challenge inside the shield

Ideas and proposals

Risk: Internal immunity – and emission



Problem:

- Noisy internal system creates interference in adjacent internal system
- Tailored specification
  - Matching requirements Conducted Susceptibility vs Emission
  - With margin
- Main coupling path = current path between components
- Requirement related to main RF generator
- Result: *the EM environment within the shielded system is specified and known!*

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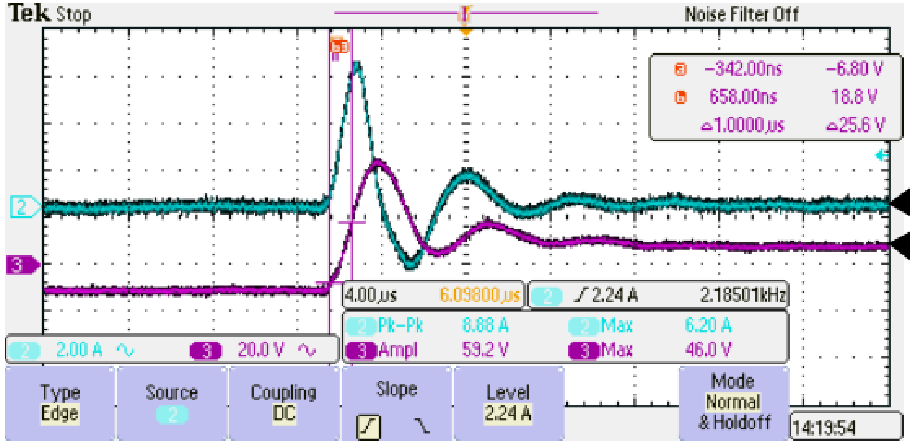
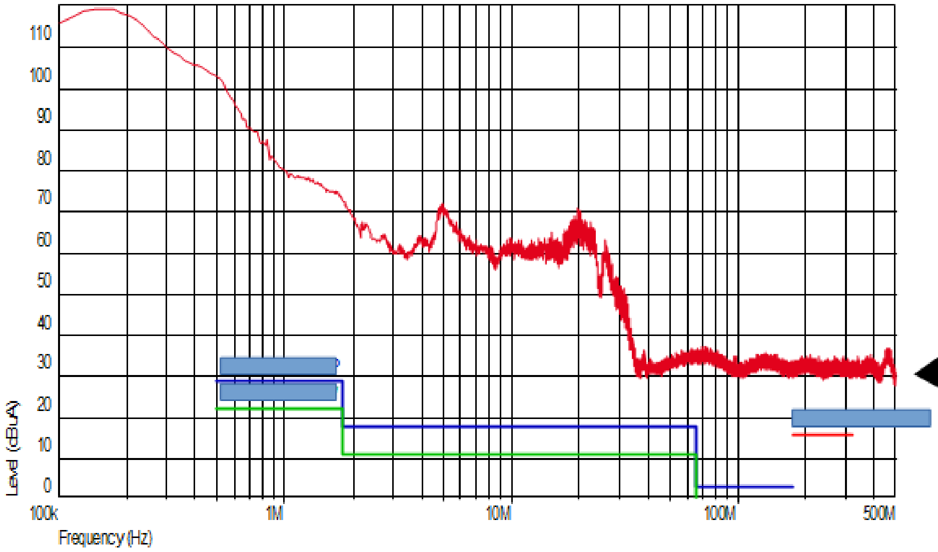
Measurement example on TVB



I_{CM} internal TVB pos lead

U_{CM} internal TVB pos - GND



I_{CM} internal TVB pos lead

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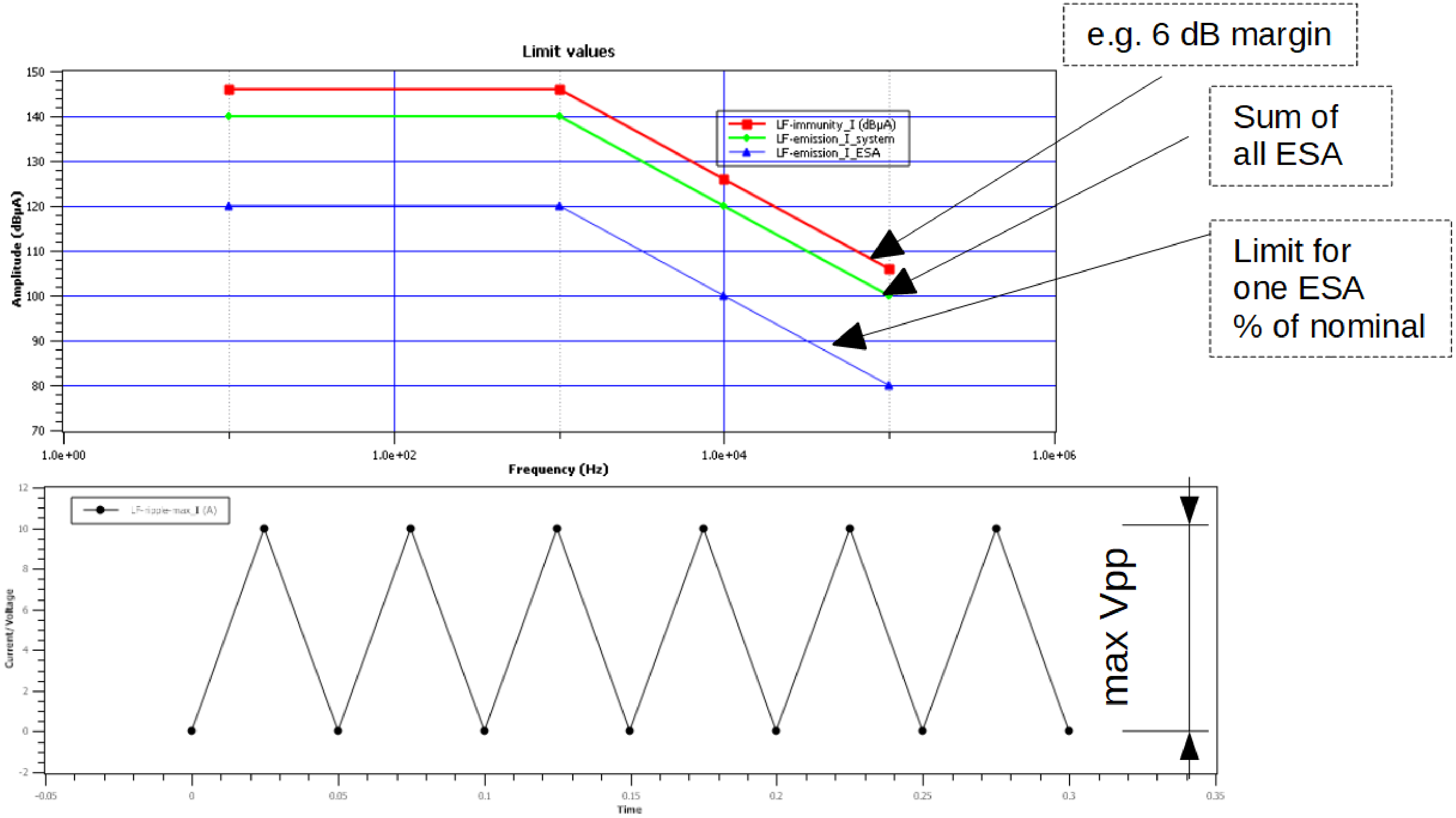
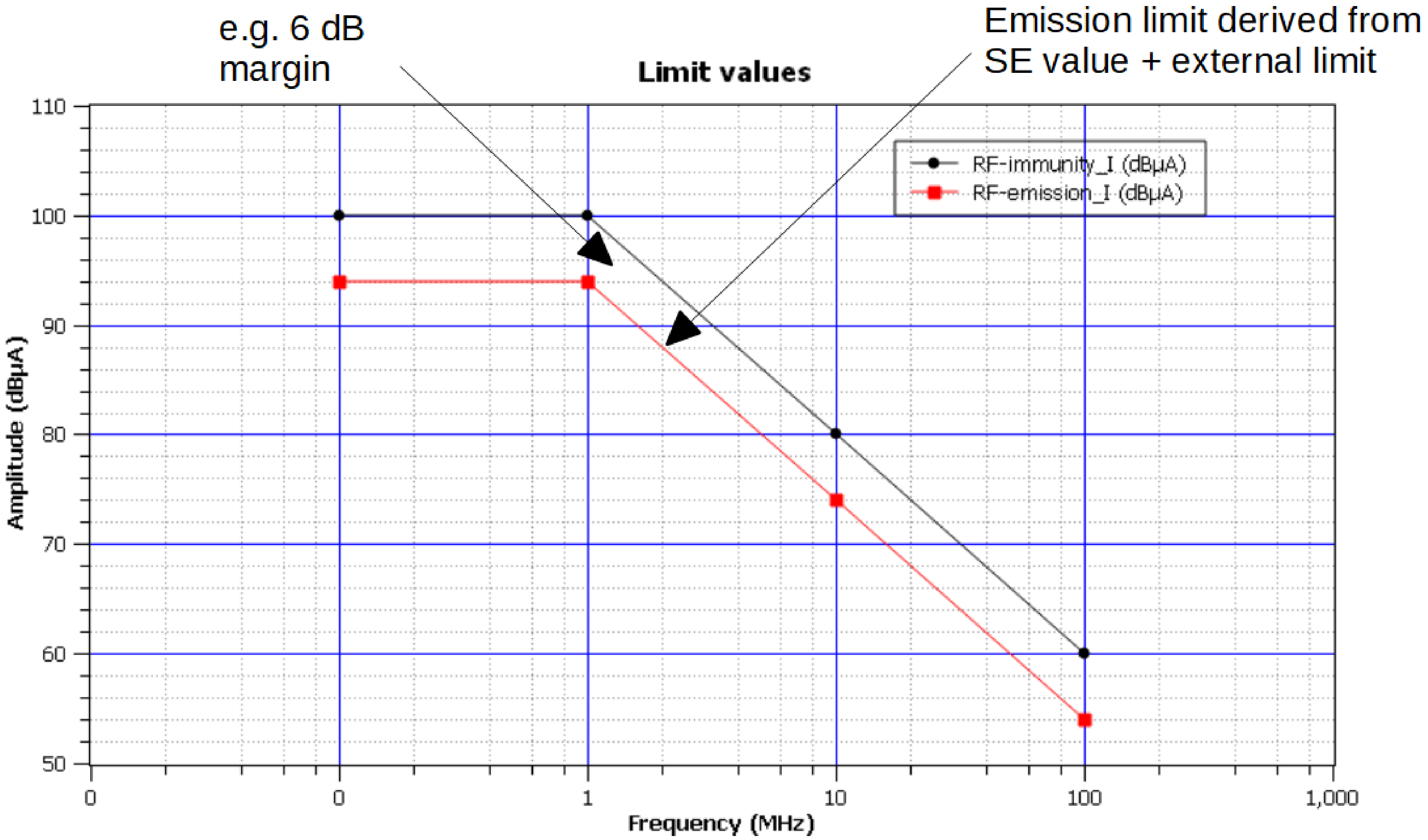
Technical rationale

- The ripple test (emission and immunity) at **low** frequencies is intended to simulate the effect of high ripple current into the test object
  - Overheating
  - Possible interference to sensors
  - Dominant differential mode
- RF emission test aims at limiting the source energy inside the shield
  - Protecting radio communication on the outside
- RF pulse immunity aims at testing electronics inside the shield
  - Dominant common mode

LF ripple limits = ?



RF current emission limits = ?



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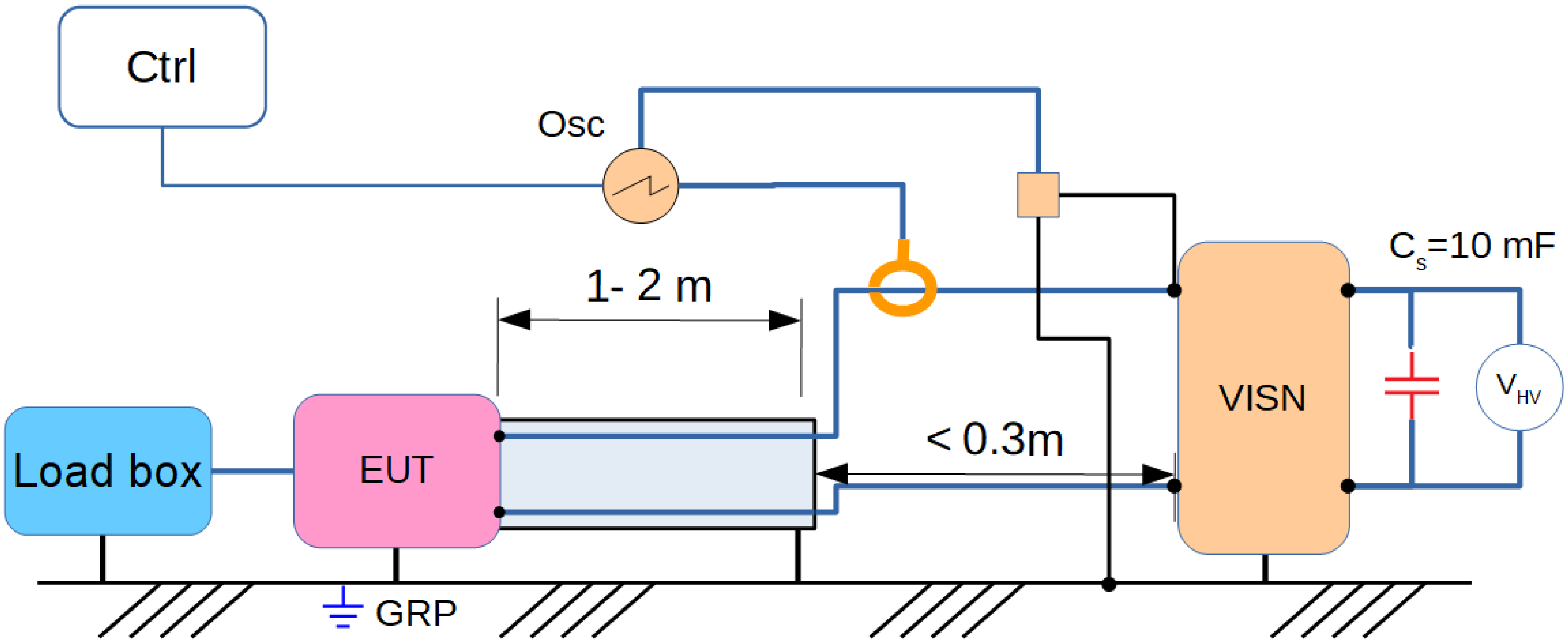
Component testing, LF emission (ripple, f = 20 Hz – 1 MHz) - *Modified ISO 21498*



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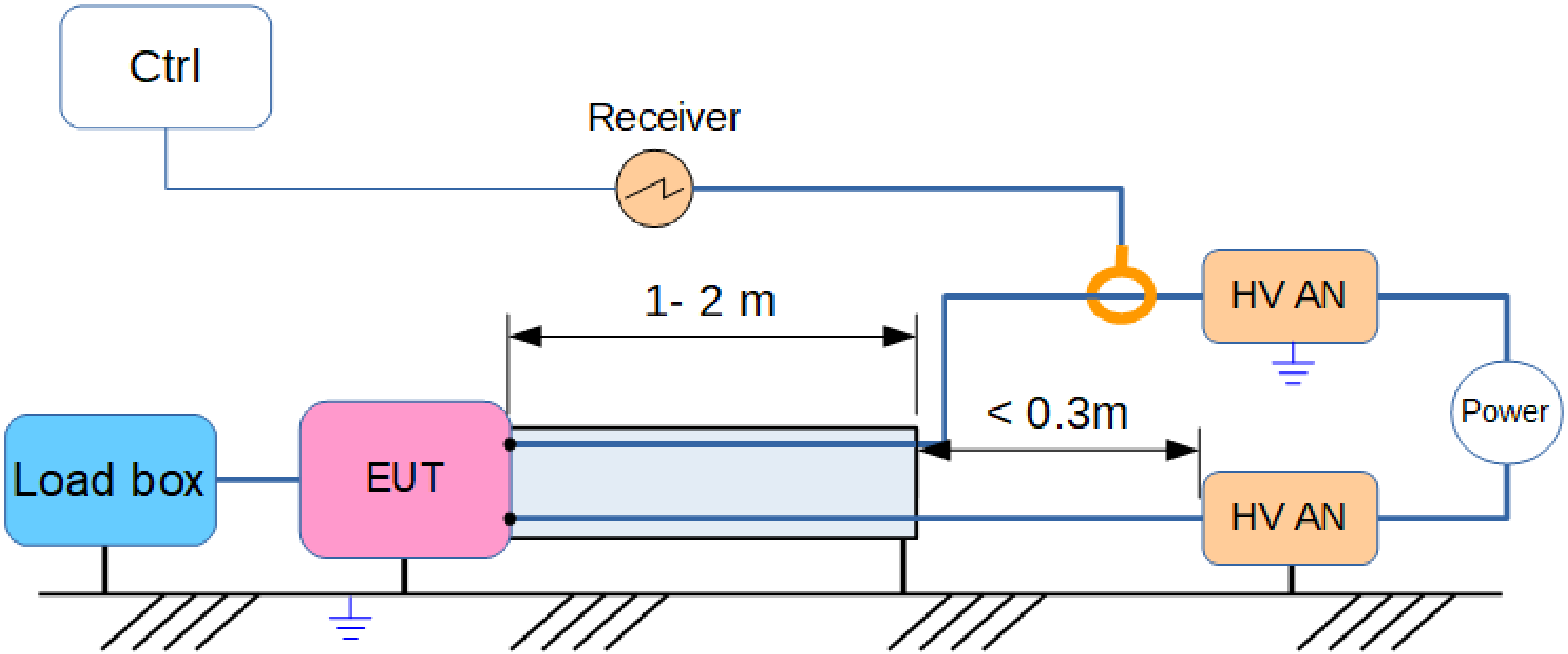
Component testing, conducted RF emission
f = 100 kHz – 250 MHz - *Modified CISPR25 current method*



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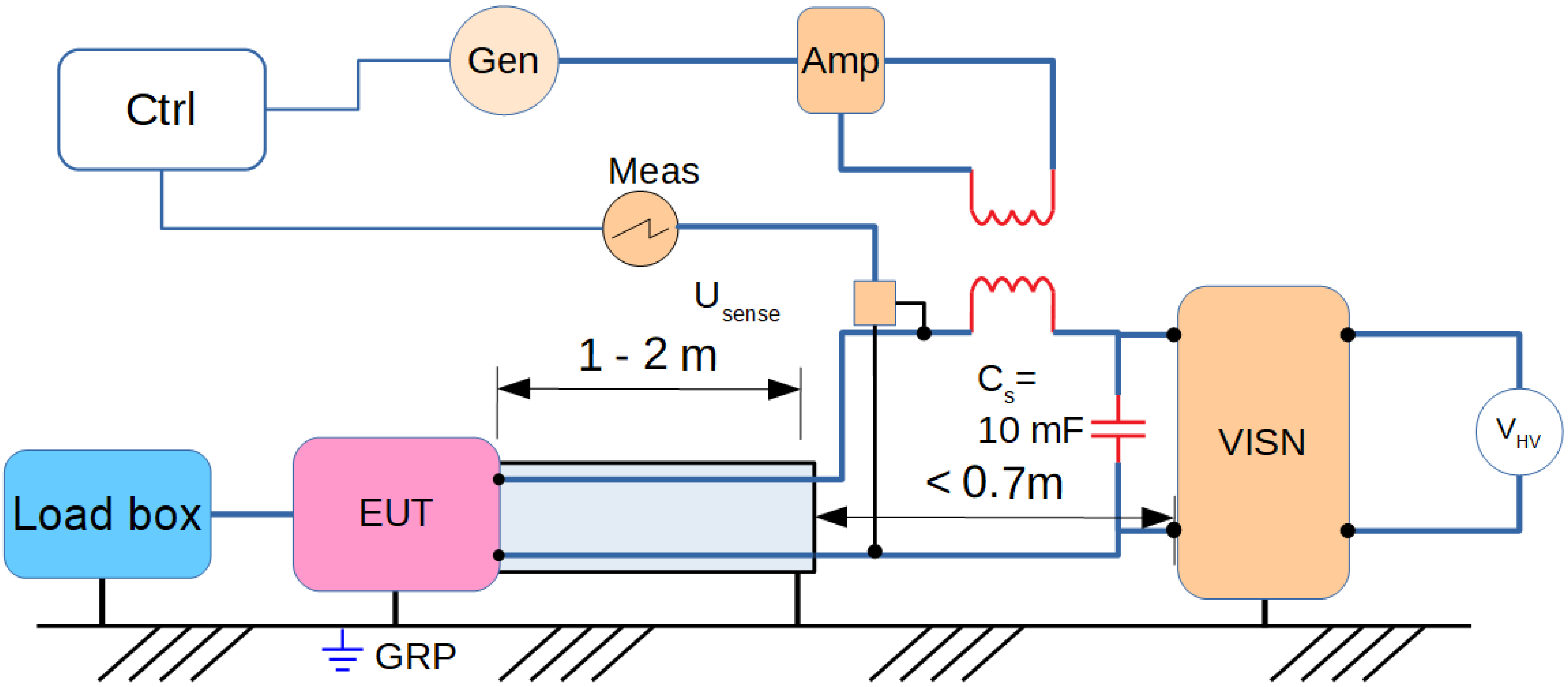
Component testing, induced audio frequency (ripple, f < 100 kHz) - *Modified ISO 11452-10 (= CS101!)*



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RF noise during DC charging

- Solution: turn everything off during charging
  - Including DC/DC converter for 24VDC batteries
  - *EMC Software requirement on system level*
  - Will also handle RF disturbance from external radio transmitters

Summary

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Summary

- The risk for system leakage calls for better control
  - E-mobility needs system EMC design
  - Low Cost -> No more cutting the corners
- Component level requirement for shielded system
  - Needs tailoring
- New test methods in development
  - LF internal ripple emission and immunity
  - RF internal emission and immunity
  - RF shielding requirements – including passive components