EMC challenges for electromobility

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What’s different with E-mobility?
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).
What is the challenge?
Electric vehicles and EMC

Challenge: to create a hybrid vehicle with high quality

- The car cannot have lower EMC performance just because it is electric
- The environment and use is the same
EMI risks in reality

- Immunity* to fields RI, RS
- Field emission RE
- Conducted Emission CE
- ESD
- CI, CS Immunity* to Conducted disturbances

*“Susceptibility” is sometimes used instead of “Immunity”
EMI risks in reality – land mobile
EMI risks in reality – marine
Complete ship – e-mobility basic picture
Complete ship – e-mobility zoning AC charge
Complete ship – e-mobility zoning DC charge
The shielding challenge

Proposals and discussion
3 ways of shielding

EMI noisy systems

Very EMI sensitive systems

OEM component acceptance

System shielding selected

Traditional filtered zones too complex or too expensive

High grade components

Trimmed shielded system design

Standard industrial design with low grade components

Robust and high cost

Robust and low cost

Low grade and low cost

High performance

High performance

Extra activity

Low performance
**Shielded system leakage**

**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?
Option: SE requirement on ESA + interfaces

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

No space for antenna in ESA
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!
Component testing, induced pulse frequency pulse shape

- Broadband (more advanced)
- Damped sinusoidal (MIL-std)
- Or some other pulse/method?
The challenge inside the shield

Ideas and proposals
Shielded system leakage

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!

Susceptible system within ESA1: needs to meet the Cl-int requirement
Measurement example on TVB

$I_{CM}$ internal TVB pos lead

$U_{CM}$ internal TVB pos - GND

$I_{CM}$ internal TVB pos lead
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 = ?

e.g. 6 dB margin

Sum of all ESA

Limit for one ESA
% of nominal

max Vpp
RF current emission limits = ?

- e.g. 6 dB margin
- Emission limit derived from SE value + external limit
Component testing, LF emission (ripple, f = 20 Hz – 1 MHz) - *Modified ISO 21498*
Component testing, conducted RF emission
\( f = 100 \text{ kHz} - 250 \text{ MHz} \) - \textit{Modified CISPR25 current method}
Component testing, induced audio frequency (ripple, f < 100 kHz) - *Modified ISO 11452-10 (= CS101!)*
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
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