Automotive RF immunity test set-up analysis

Why test results can't compare …

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Presentation outline

- Introduction
- ISO 11452-4 (BCI)
- ISO 11452-2 (RI)
- Conclusions

Introduction

- ISO 11452-4 (BCI) and ISO 11452-2 (RI)
- Lack of reproducibility of test results when set-ups are recreated at different test labs

- Module compliance doesn't necessarily mean in-vehicle compliance after integration
- Compliance to over-testing over a large range has an inverse impact on economics

Introduction

- With shorter design cycles and higher reliability requirements, result matching between IC, module and vehicle is preferred
- Only possible when certain requirements are being met

ISO 11452-4 (BCI)

EMC COMPO DUBROVNIK 2011
EMC MCC BV

ISO 11452-4 (BCI)

- Cable harness at 50 mm above GRP: ~150 Ω
- Cable harness length
- BCI-clamp position
- BCI-design (turn ratio: 1:1, 1:2, 1:5)
- Open loop/ closed loop
- Load box (undefined)
- ISNs (defined up to 100 MHz, 25 Ω in CM)

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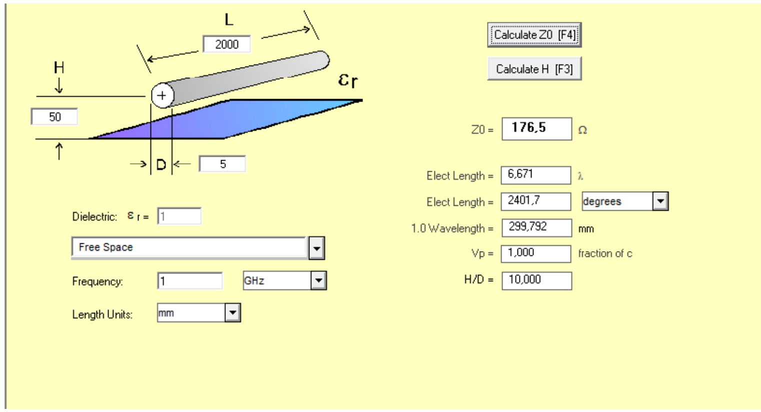
ISO 11452-4 (BCI)



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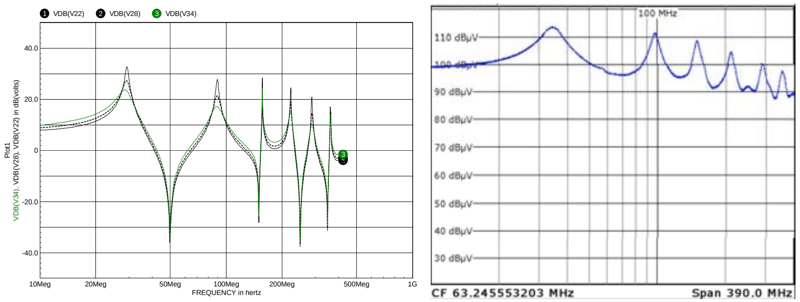
Simulated vs measured



RF scan 10 -400 MHz, RF voltage between EUT and reference ground plane with continuous forward power using BCI clamps prim./sec. winding ratios: **1:2**, load box impedance 1 Ω, EUT floating, open loop test.

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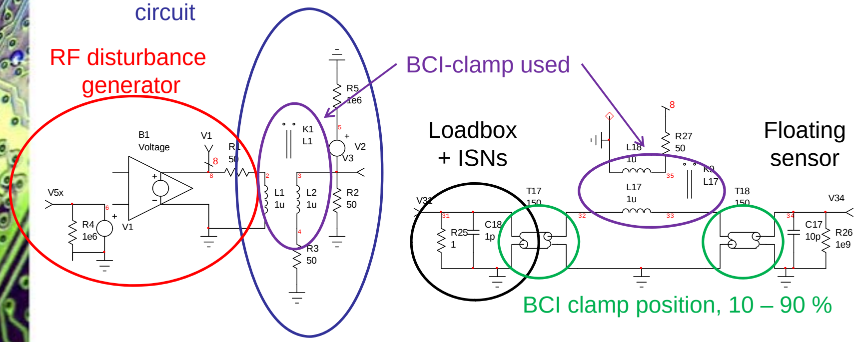
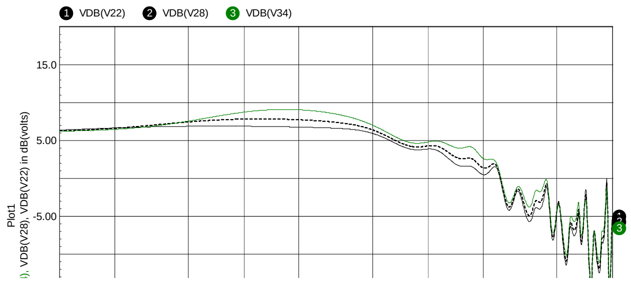
ISO 11452-4 (BCI)



Spice model for <u>open-loop</u> excitation with BCI-clamp corrections

ISO 11452-4 (BCI)



RF voltage between EUT and GRP with equal forward power using BCI clamps with different prim./sec. winding ratios:
VDB(V22): ratio **1:5**, VDB(V28), ratio: **1:2**, VDB(V34): ratio: **1:1**, load box CM impedance **150 Ω**, EUT floating, open loop test.

ISO 11452-2 (RI)

- Cable harness at 50 mm above GRP: ~150 Ω
- Cable harness length; 1,5 – 2 m
- Antennae used; bi-conical log-per, horn
  E/H field ratio determined by antenna gain
- Closed-loop E-field @ 0,15 m above GRP, 0,1 m from GRP edge, 1 m from antenna front
- Load box CM impedance (undefined)
- ISNs (defined up to 100 MHz, 25 Ω in CM)

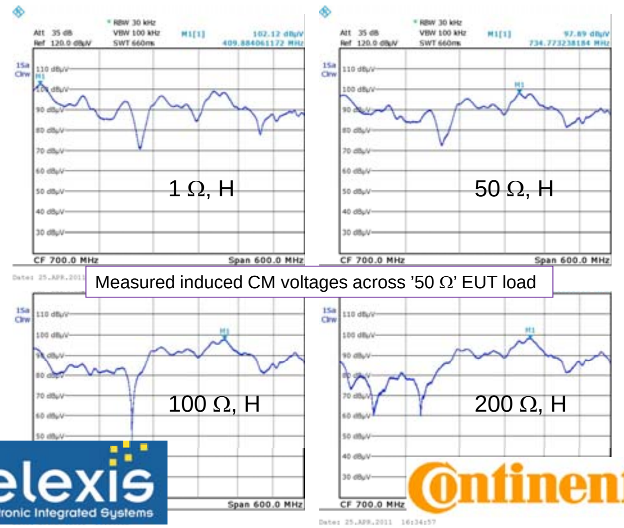
ISO 11452-2 (RI)

E/H field ratio in front of antenna differ by antenna used
(only E-field is used with feedback)
Photos are examples only: http://www.emc-kashima.co.jp/english/services/automotive_test.html

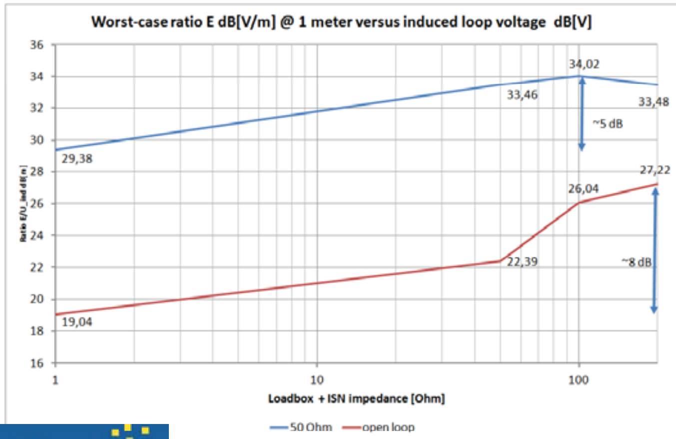
ISO 11452-2 (RI)

- RI test done in 400 – 1000 MHz range
- H/V polarized antenna
- Cable harness: 2 m @ 50 mm above GRP
- Loadbox CM impedance at 1, 50, 100, 200 Ω and 5kΩ (open circuit)
- Worst case value from transfer taken

ISO 11452-2 (RI)



ISO 11452-2 (RI)



ISO 11452-2 (RI)

- Induced CM voltage across 'open' EUT load substantially higher then when loaded with 50 Ω
- Induced CM voltage has little relation with E-field as function of frequency due to resonances
- Induced CM voltages hardly calculable due to 'odd' E-field sensing technique used

Possible (cor)relation with DPI or other EMC IC test methods

- DPI: 10 V over 50 Ω equals 200mA (max.)
  DPI applies to pins, BCI to harnesses
  DPI doesn't simulate resonances like BCI
  Without resonances DPI more severe than BCI
- TEM cell, 5 W over 50 Ω equals 15,8 V
  15,8 V over 45 mm equals 351 V/m
  10 V over 45 mm equals 222 V/m
  TEM cell exposes device not complete sensor
  TEM cell more severe than RI

Conclusions

- Present ISO standards not unambiguous:
  - ISN vs CM impedance
  - Loadbox impedances and reference undefined
  - Harness impedance (50 mm → 176 Ω in CM)
  - BCI clamps used (different turn ratio)
  - Open-/closed-loop determined by EUT application
  - Antennae used (at too close distance: E/H ratio)
  - E-field sensor's position (motor hood measurements?)
  - E-fields not calculable, H-field ignored (odd calibration)

Recommendations

- Integrate loadbox with ISN to defined CM impedance; 150 Ω, 100 kHz - 400 MHz
  - BCI clamp turn ratio becomes irrelevant
  - Set-up resonances diminish
  - Open-/closed loop determined by EUT grounding
  - E-field calibration acc. IEC 61000-4-3, then apply test set-up to field
  - Fix harness length e.g. 2 m for all measurements, wide meander (s > h) shall be allowed

Application recommendations

- Don't RF short-circuit inputs nor outputs directly to ground (by using caps to gnd)
- Apply RF series impedance or better CM impedances towards harness to enforce characteristic termination
- Characteristic harness impedance less than 150 Ω near to metal structures, 50 Ω more appropriate