EMI ad hoc

- first steps generating an simulation model

Stefan Buntz, Daimler AG

motivation

(what do the chip designers need for simulations ?)

a) for emission
    a) Simulation model of emission tests + limits for design simulations
    b) measurement setups + limits for first chip design evaluations
b) for immunity
    a) Simulation model of immunity tests + limits for design simulations
    b) measurement setups + limits for first chip design evaluations

This (and all the following slides) is not a final result. This should be seen as an input for starting the discussion on EMI simulations !

Where to go for? (from May ‘12)

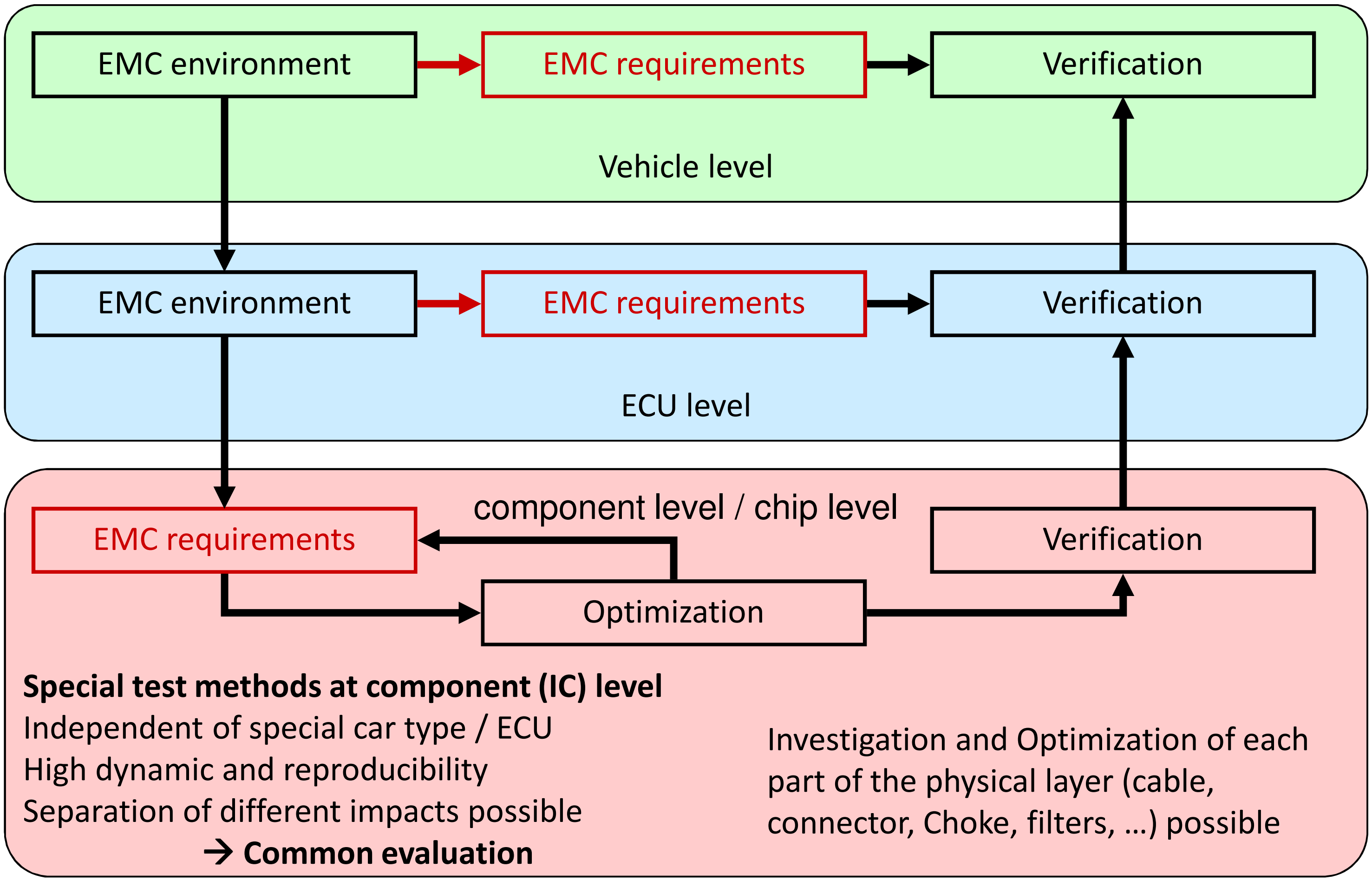
e.g. CISPR12/CISPR25/ ISO 11451

- radiated immunity
- radiated emission
- ESD

e.g. CISPR25/ISO11452

- radiated immunity
- radiated emission
- conducted immunity
- conducted emission
- Transients/ESD

- immunity against direct injected power (DPI)
- Direct conducted emission (150 ohms method)
- ESD



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- **immunity against direct injected power (DPI)**
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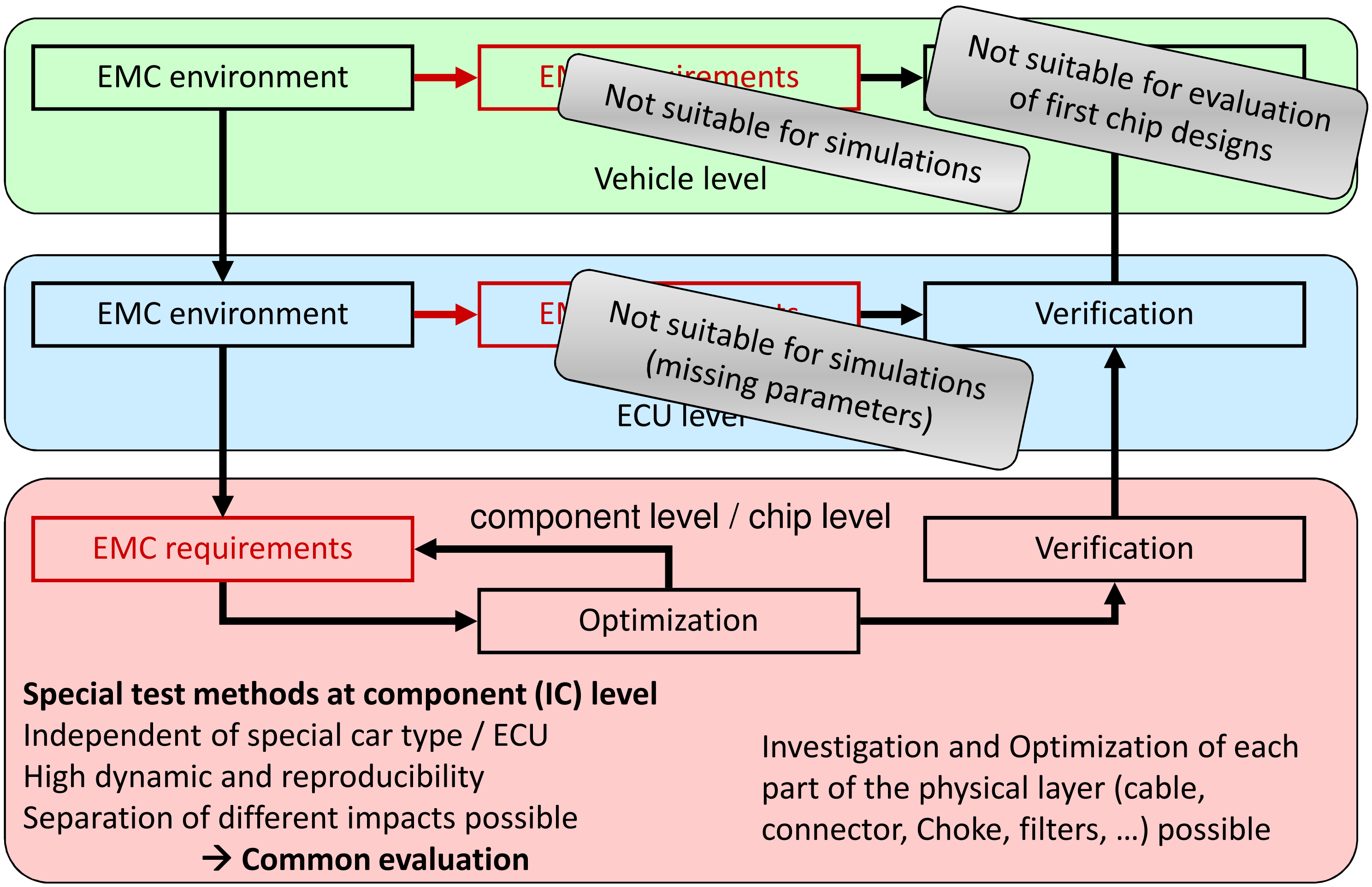


Where to go for?

Using simple simulations models for a first step

- Available inputs from hardware tests (FTZ)
- Simple and easy (and identical) simulations for everyone
- Correlation between simulations and measurements has some uncertainties (only done for available bus systems and the bandwidth used there, which is typically below 100MHz)

Following slides show input to this way

Generating models for MDI/cable/in-line/etc.

- …to enable simulations on ECU level.
- Definition of all components necessary.
- Different requirements by different carmakers possible
- Influence of all parts of the channel can be shown clearly (and therefore requirements to all parts of the channel can be derived).

Both ways will provide input to our work and both parts are necessary for realizing automotive Gigabit Ethernet

What could we (car makers) provide

(from my personal point of view)

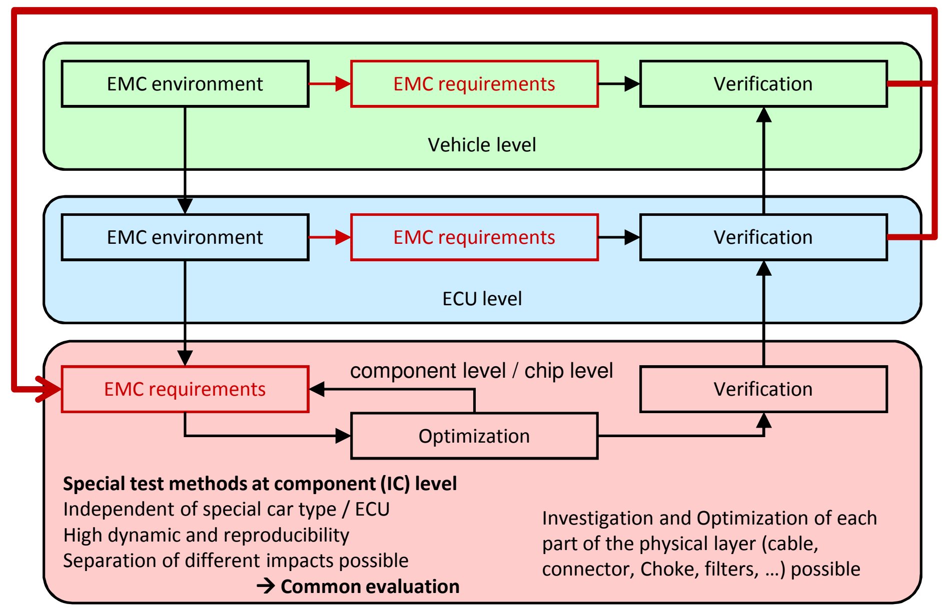
a) for emission
   a) Simulation model of emission tests + limits for design simulations
      → **exact schematic and test levels of 150ohm method**
   b) measurement setups + limits for first chip design evaluations
      → **first tests of chip designs with 150ohm method**
      → test setups and requirements for ECU level tests
        (e.g. radiated emission, CISPR25)
b) for immunity
   a) Simulation model of immunity tests + limits for design simulations
      → **exact schematic and test levels of DPI test**
   b) measurement setups + limits for first chip design evaluations
      → **first tests of chip designs with DPI test**
      → test setups and requirements for ECU level tests (e.g. BCI test, ISO11452)

Focus for IEEE (chip design and standard) should be 150ohm methode and DPI test

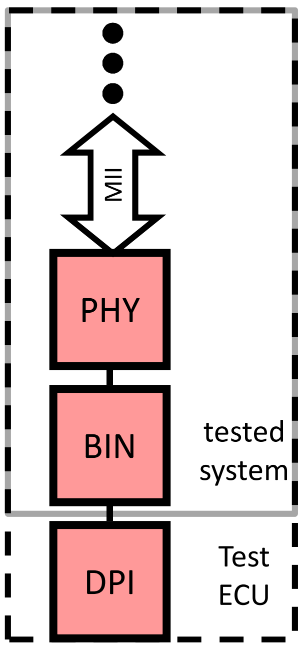
As ECU level tests are different (mostly similar setups, different requirements) this has to provided by each car manufacturer, which is interested…

Remark #1 (limitation of limit lines)

- Typically chip level limit lines are derived and/or refined from measurement experience on ECU and especially on vehicle level.
- As we have no chips/no system we cannot derive limits for chip level tests from measurement experience!
- We can only relay on previous experience (e.g. from 100MBit/s systems measurements).



Remark #2 (Influence of BIN Bus Interface network)



- For the DPI test, the tested network/tested system is the PHY with it's bus interface network (BIN).
- The BIN belongs to the PHY and can consist of different parts:
  - common mode termination (e.g. 2x500Ω to GND)
  - capacitive coupling and Common mode choke
  - transformer
  - additional filters

  (however remember to keep it as simple (and cheap) as possible)
- The BIN can be different for different possible solutions.
- The BIN and it's possible asymmetries must be included in simulations, however as the BIN is not defined yet, there needs to be detailed investigation of this point (e.g. measurements of CMCs)

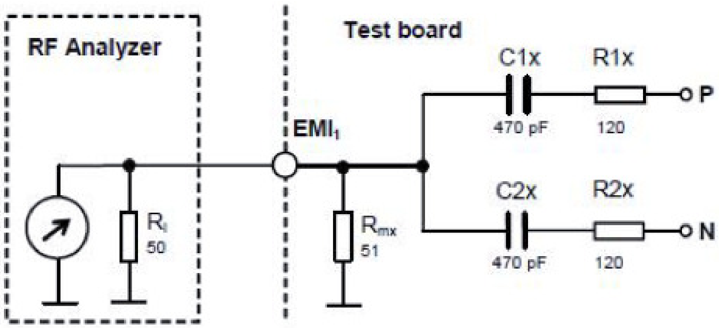
BIN definition to be discussed and defined in the ad hoc group!

What we can provide now

- From Michael‘s presentation in Geneva (jones_01_0912.pdf)
  http://grouper.ieee.org/groups/802/3/RTPGE/public/sept12/jones_01_0912.pdf

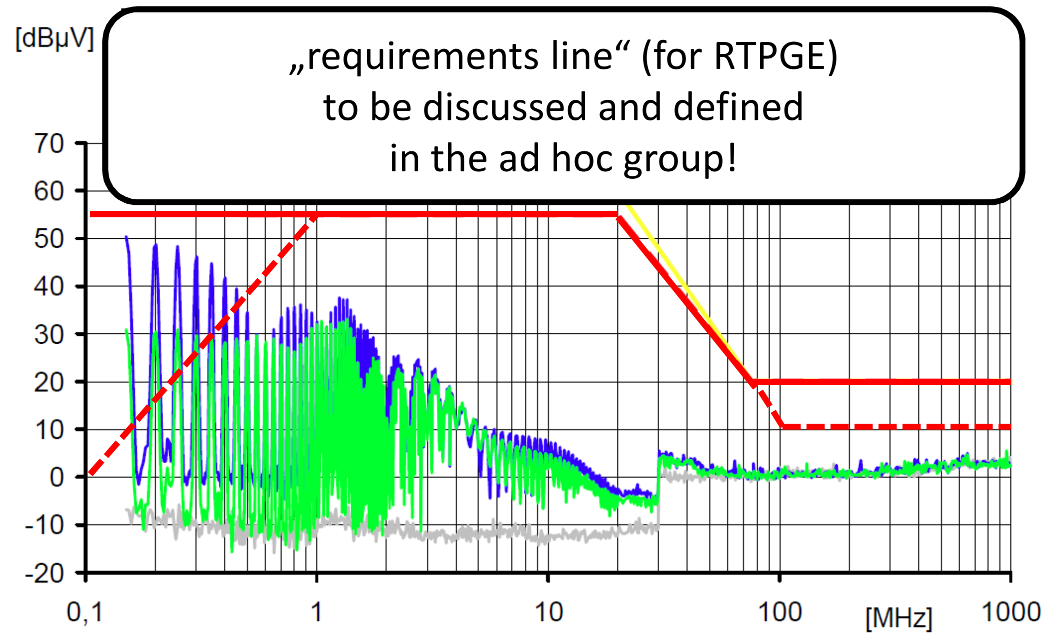
Emission 150ohm method (for simulation)

Line Emissions coupling network



	R_{1x} [Ω] (Bus +)	R_{2x} [Ω] (Bus -)
Symmetry	120	120
+ 2,5 % unbalance	121	118
- 2,5 % unbalance	118	121
+ 5 % unbalance	121	115
- 5 % unbalance	115	121

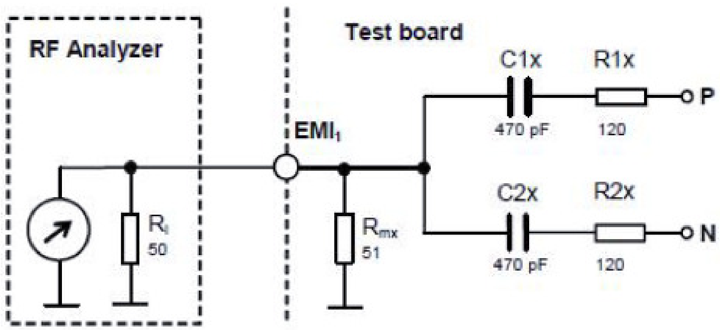
- Limit is originally for 100MBit/s system!
- Asymmetry variation of resistors R1x/R2x is ±2,5% (limits to be fulfilled).
- Typically/often additional measurements with ±5% are done for information purposes.



All pictures from http://grouper.ieee.org/groups/802/3/RTPGE/public/sept12/jones_01_0912.pdf

Emission 150ohm method (measurement)

Line Emissions coupling network



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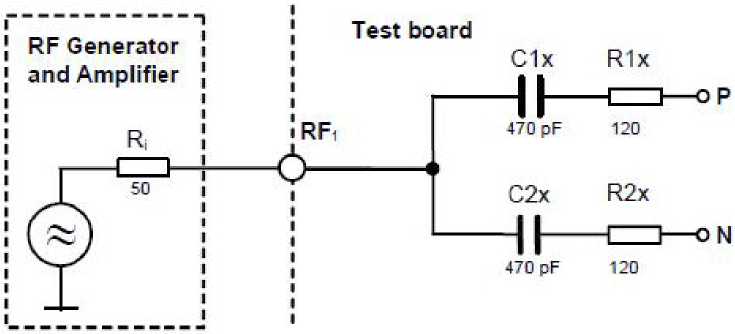
Measuring equipment	Spectrum analyzer	Measuring receiver
Detector	Peak	
Frequency range	0.15 to 2750 MHz	
Resolution bandwidth (RBW) 150 kHz to 30 MHz: 30 MHz to 2750 MHz:	 10 kHz 100 kHz	 9 kHz 120 kHz
Video bandwidth (VBW)	equal to RBW	-
Numbers of passes	10 (max hold)	1
Measurement time per step	-	≥ 1 ms
Frequency sweep time	≥ 20 s	-
Frequency step width 150 kHz to 30 MHz: 30 MHz to 2750 MHz:	-	 ≤ 9 kHz ≤ 120 kHz

Table: Settings of the measurement device

All pictures from http://grouper.ieee.org/groups/802/3/RTPGE/public/sept12/jones_01_0912.pdf

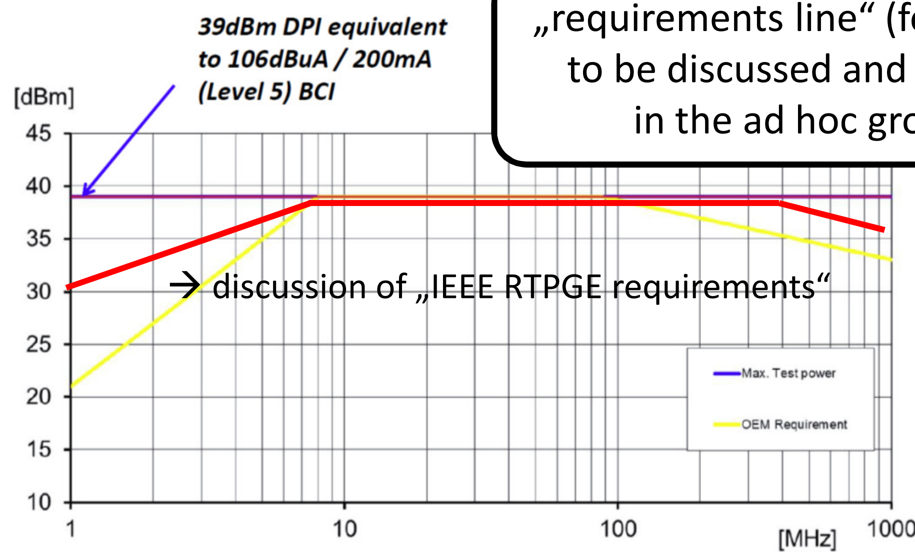
Immunity DPI method (for simulation)

Line Immunity coupling network



	R_{1x} [Ω] (Bus +)	R_{2x} [Ω] (Bus -)
Symmetry	120	120
+ 2,5 % unbalance	121	118
- 2,5 % unbalance	118	121
+ 5 % unbalance	121	115
- 5 % unbalance	115	121

- Limit is originally for 100MBit/s system!
- Input power is 39dBm for setup with BIN (1MHz-1GHz) CW and AM 80% 1kHz with peak conservation ($P_{max,AM} = P_{max,CW}$)
- Asymmetry variation of resistors R1x/R2x is ±2,5% (limits to be fulfilled). Typically additional measurements with ±5% are done for information purposes.

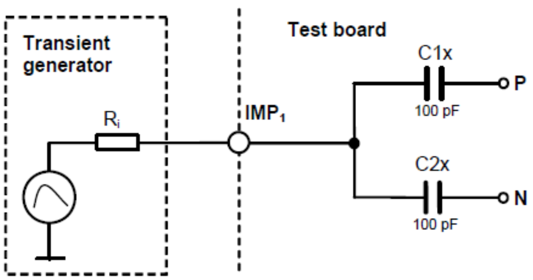


„requirements line“ (for RTPGE) to be discussed and defined in the ad hoc group!

All pictures from http://grouper.ieee.org/groups/802/3/RTPGE/public/sept12/jones_01_0912.pdf

Immunity to transients (simulation + meas.)

- According to ISO7637-3
- Test pulses from ISO7637-2
- Direct capacitive coupling method (DCC) using 2 x 100pF (2 x 470pF) to the bus lines.
- Pulse generator typically with R_i (which can slightly vary to match the pulse parameters).



Test pulse	V_{peak} (V)	Pulse repetition (Hz)	R_i (Ω)
1	-100	2	10
2a	75	2	2
3a	-150	10k	50
3b	100	10k	50

„requirements“ (for RTPGE) to be discussed and defined in the ad hoc group!

- The measurement of immunity against transient pulses shall be tested using the capacitive coupling clamp according to ISO 7637-3: 2007-07 (CCC method) and using the current probe (BCI) according to ISO 7637-3: 2007-07 (ICC method).

Test pulse	V_{peak} (V)	Pulse repetition (Hz)	R_i (Ω)
Fast a (CCC)	-75	10k	50
Fast b (CCC)	60	10k	50
Slow + (ICC)	6	2	2
Slow – (ICC)	-6	2	2

Conclusion

- using available test setups for 100MBit/s as starting point for generation of the EMI simulation model
  - How to handle BIN components (especially asymmetry of CMC)?
  - No model of MDI for first simulations necessary, as MDI could be included in asymmetries of coupling network (MDI requirements however have to be derived from asymmetry tested in simulations).
  - Defining appropriate requirements for this simulation.
    (we should discuss and find our own limit lines, which trade in the uncertainty of the not known correlation to vehicle measurements and the higher bandwidth probably used)
  - (+additional simulations for information purposes during our work in IEEE, e.g. ±5% or more asymmetries to rate different approaches to there EMI margin)

What we have to keep in mind: Uncertainty about margins in higher frequency range, as correlation of simulation asymmetries to vehicle experience is valid for (available) bus systems using frequencies below 100MHz (LIN, CAN, FlexRay, 100MBit/s ETH)