BMAS 2009

FULL SYSTEM VERIFICATION OF CAN NETWORK AT HIGH SPEED TRANSMISSION RATE USING VHDL-AMS

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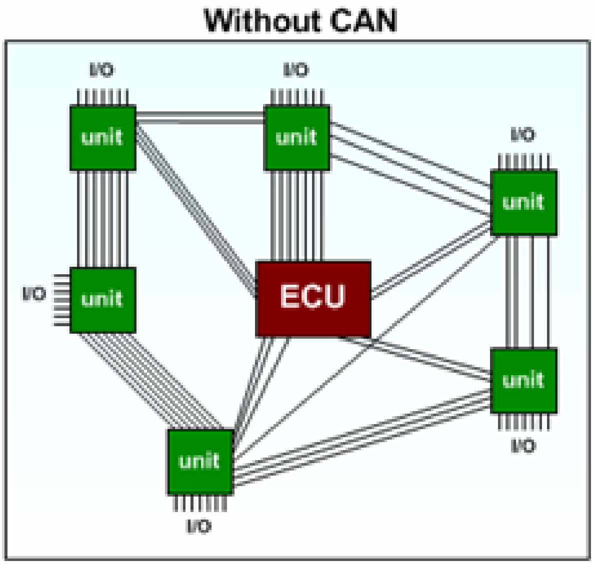
KAI

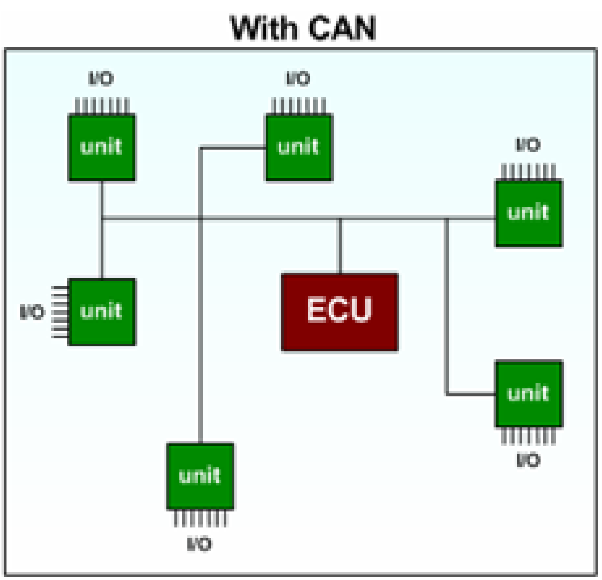
Infineon
Never stop thinking

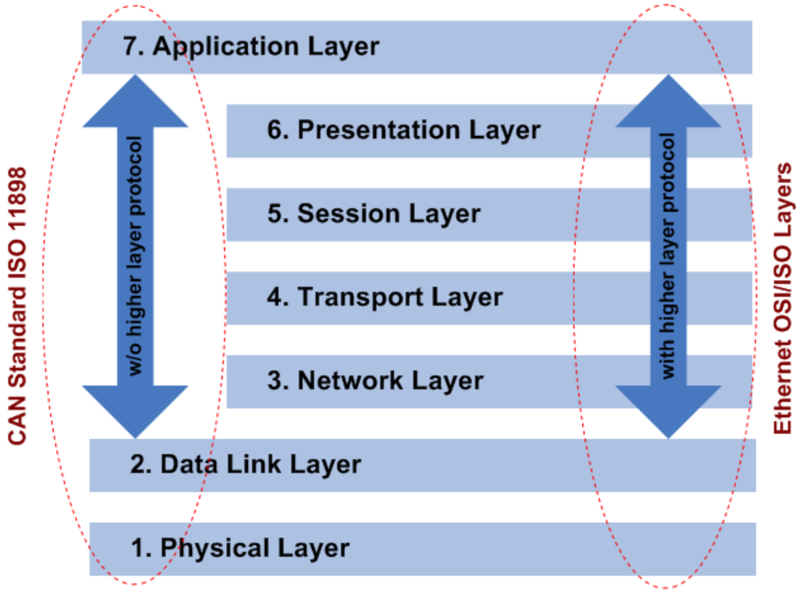
Agenda

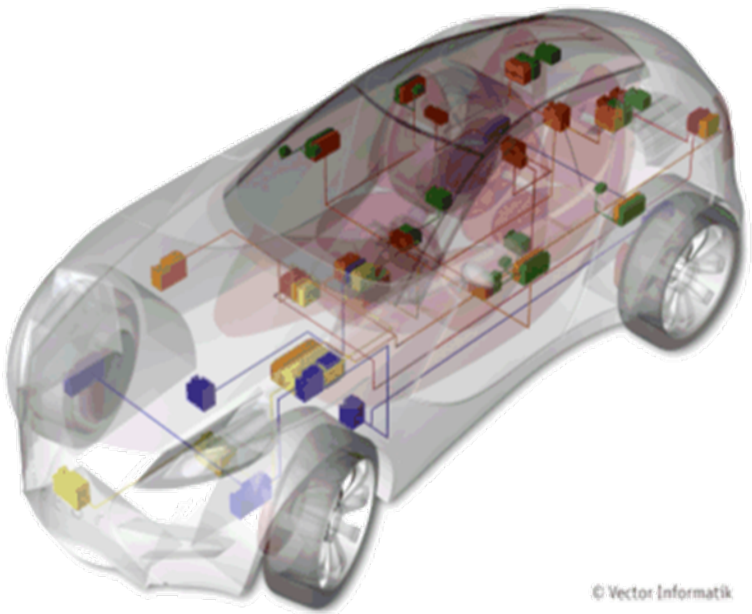
- Motivation
- The CAN measurement system setup
- Modeling of the CAN physical layer
- Modeling of the measurement environment
- Verification of star network at 500 kb/s and 1.0 Mb/s
- Simulation of the CAN Micro-controller interface
- Conclusion and Outlook

Background – The CAN Protocol









CAN Physical Layer Design Challenges

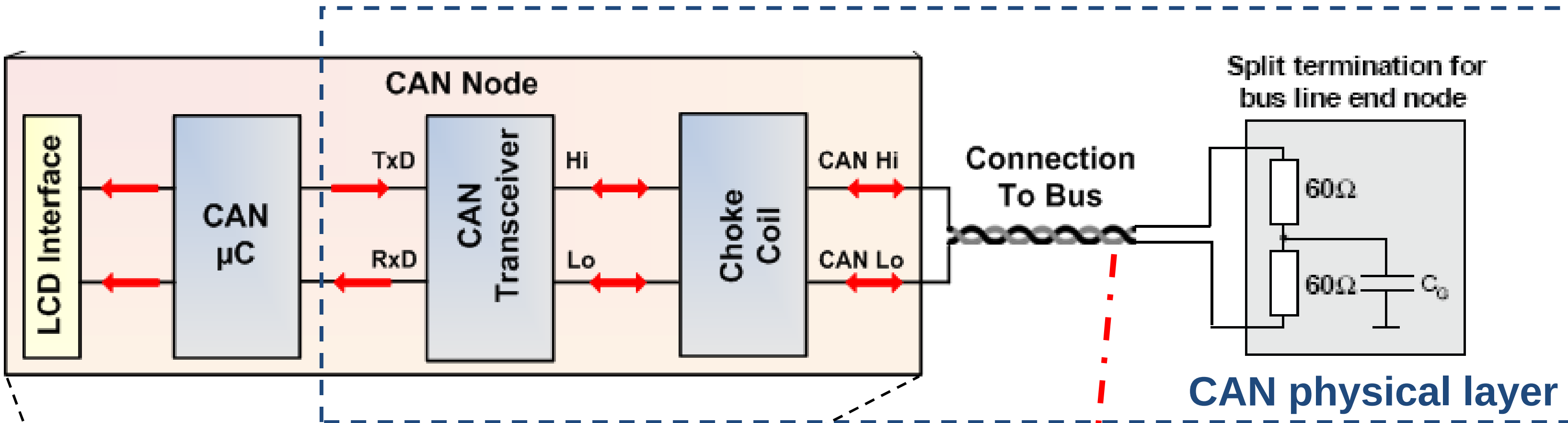
- **Implementation of networks:**
  - Hardware CAN components
  - Termination
  - Topologies
- **The main objective in analyzing the physical layer is to identify and evaluate signal integrity issues**
- **The transmit and receive waveforms need to be checked against the system specification :**
  - Safe transmission must be ensured
  - Problems at this layer can:
    - impact the entire communication system,
    - reduce the network performance
    - or cause errors in the control system behavior
  - Network reliability will be compromised

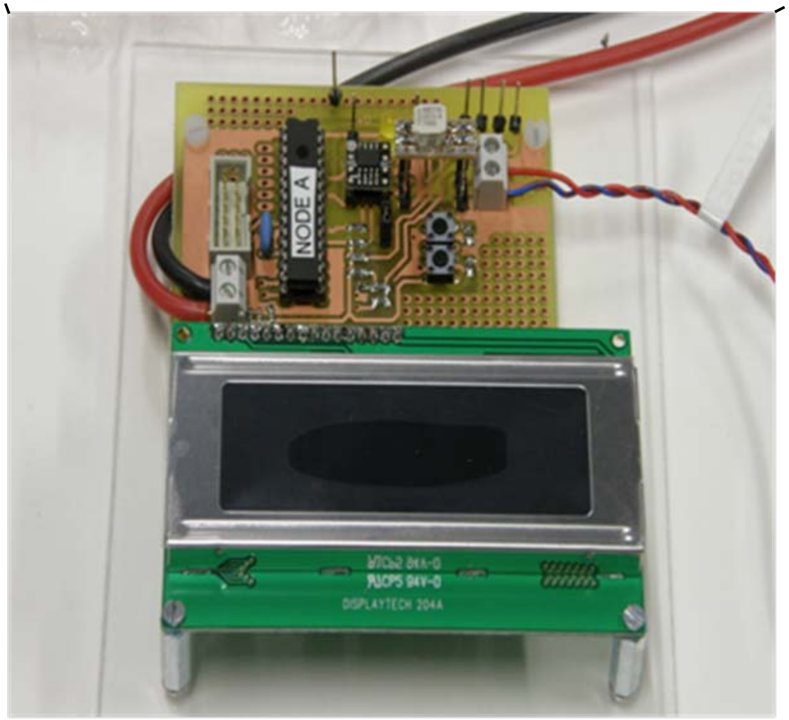
A comprehensive and reliable simulation solution is required

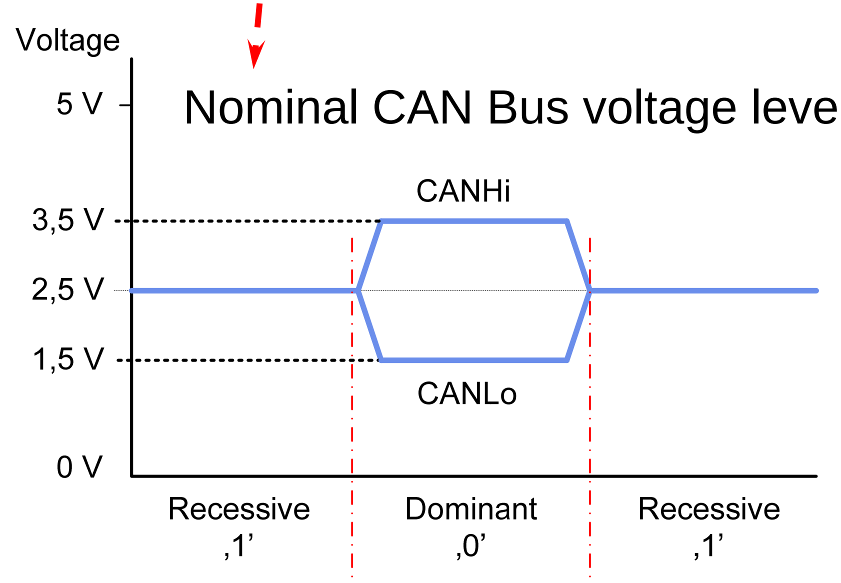
Motivation

- Verify the accuracy of CAN physical layer simulation models against real measurement at system level
- Star topology - neither covered by ISO11898 nor by SAE J2284 - used in automotive applications to overcome wiring constrains within a car.
- Prove the feasibility of a specific topology by simulations and measurements on a system setup

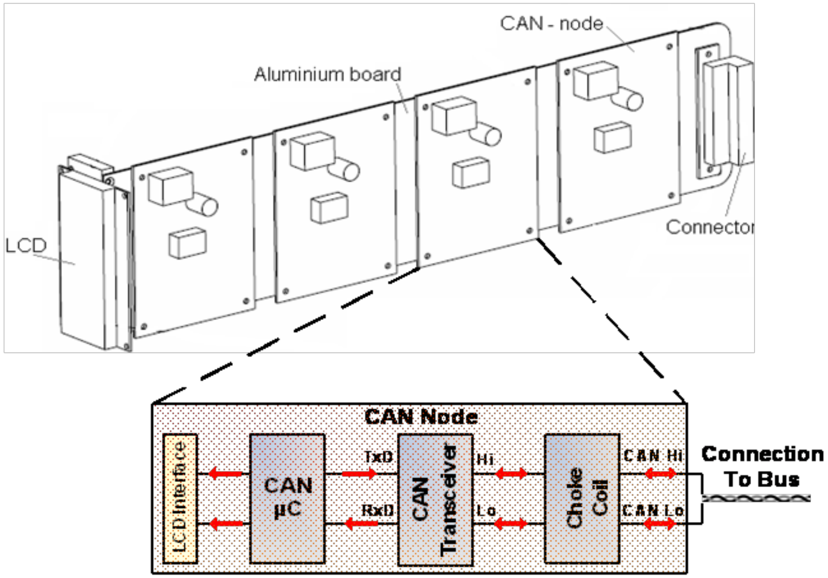
Components of CAN Physical Layer

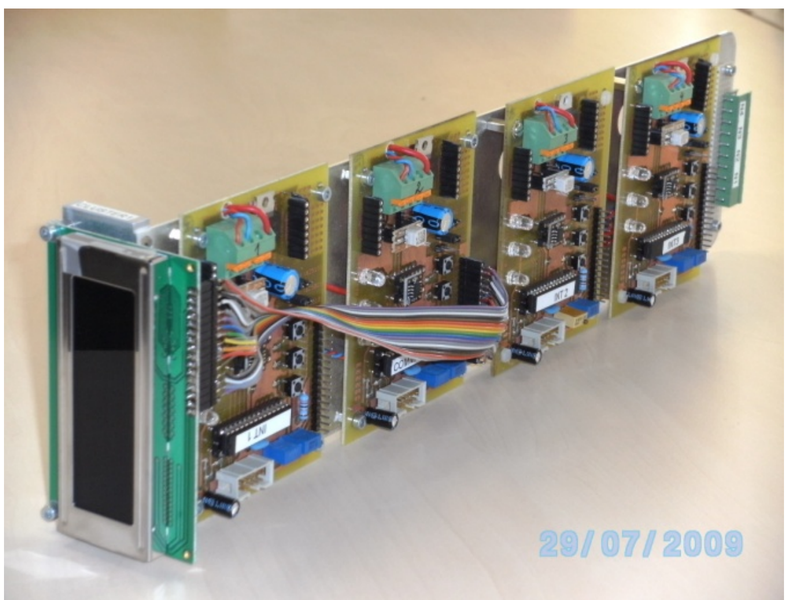


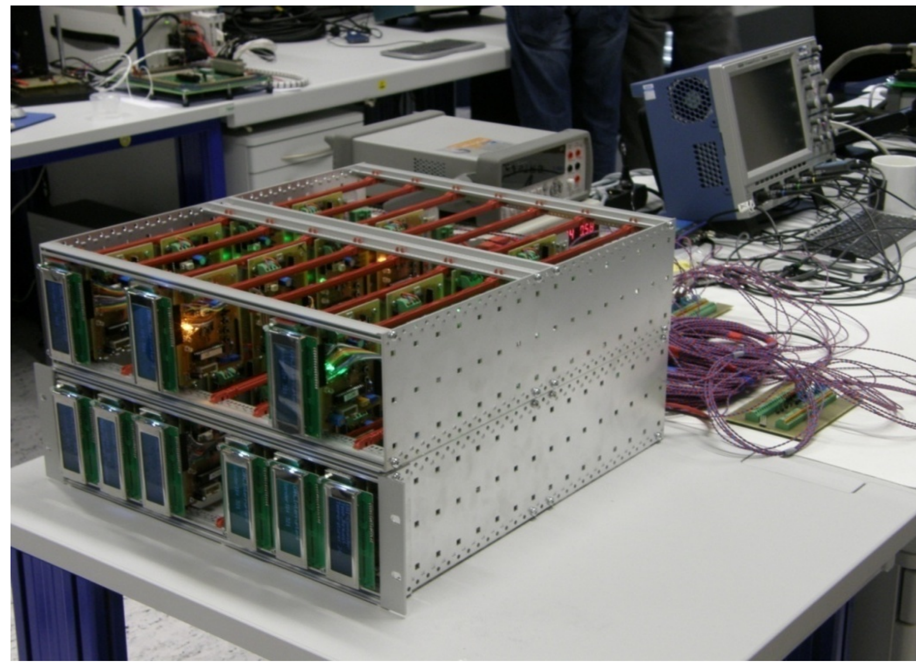




The CAN measurement system setup

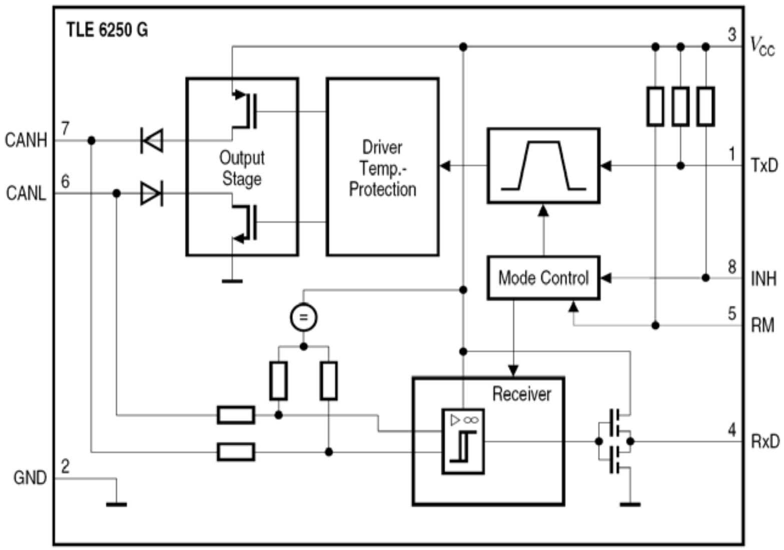






Modeling of the CAN Physical Layer

- The CAN Transceiver model:

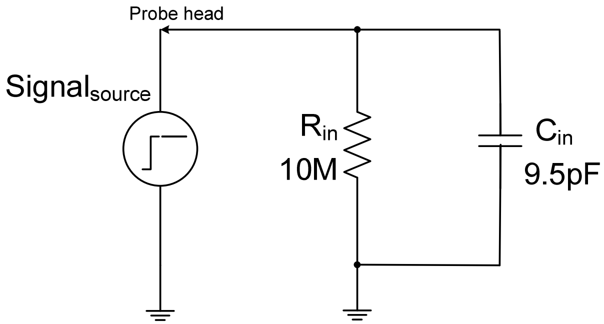


  - has a complex structure
  - covers temperature monitoring
  - covers bus failure detection

- The choke coil model → based on its SPICE model
- The transmission line model
  - Characteristic impedance, propagation delays, length
  - → Cable tree (the star network topology)

Modeling of the CAN Measurement Environment

- **Measurement probe model**

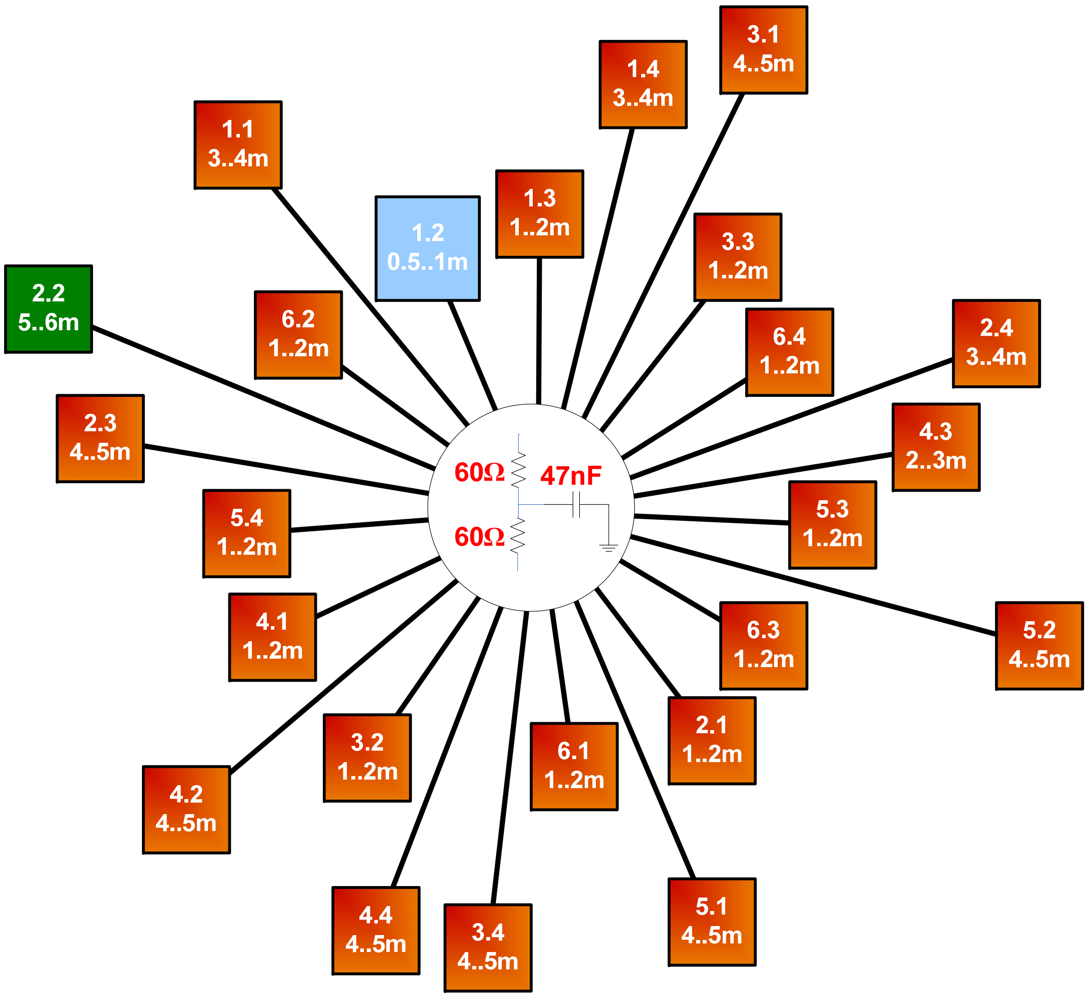


  - passive probe model (R_{in}=10M;C_{in}=9.5pF)
  - active probe model (R_{in}=1.0M;C_{in}=0.95pF)

- **The CAN triggering module model**

- **The CAN frame generator model**
  - CAN transmission speed
  - Rising/Falling time of TxD signal

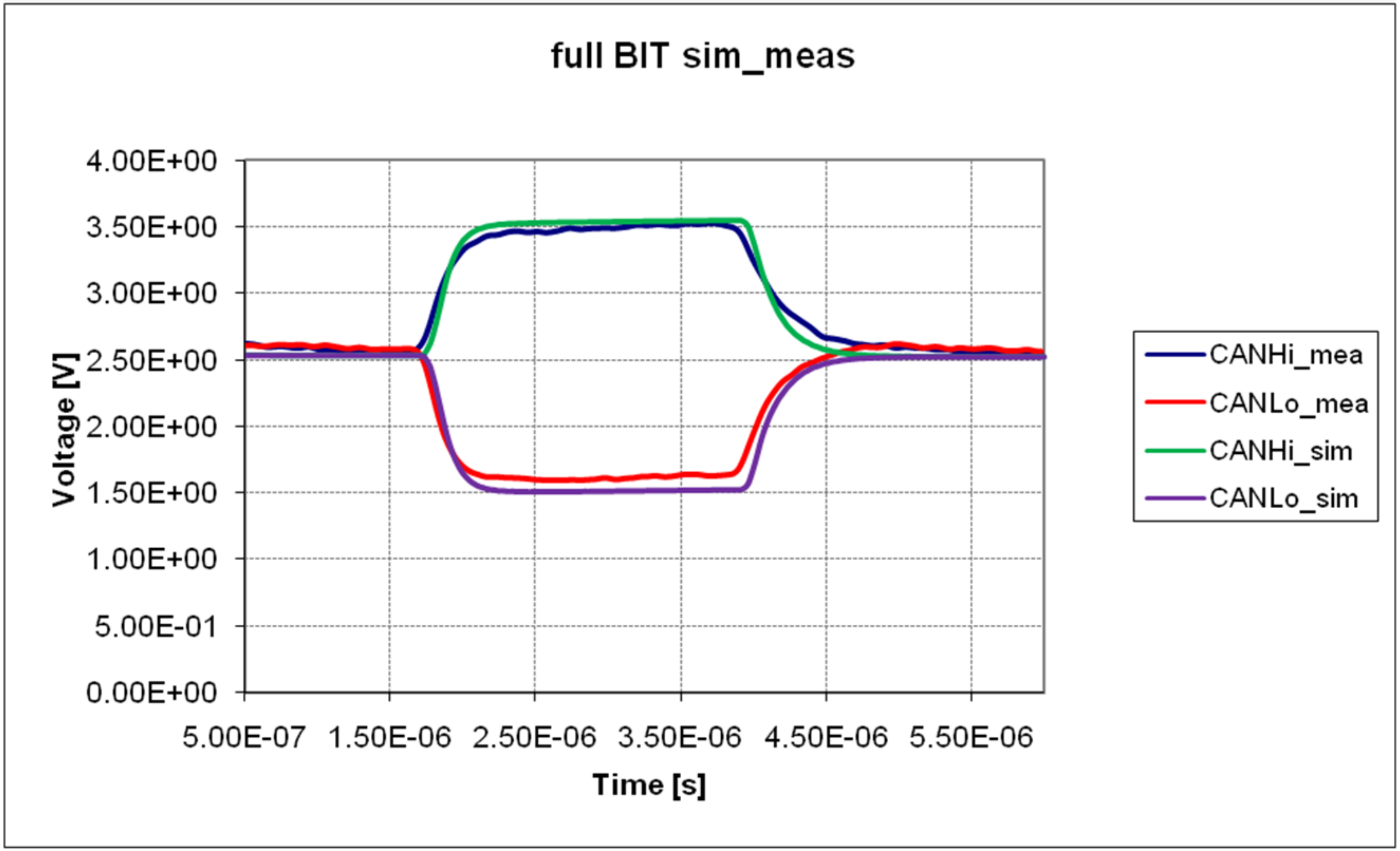
Simulation of the 24-node star network



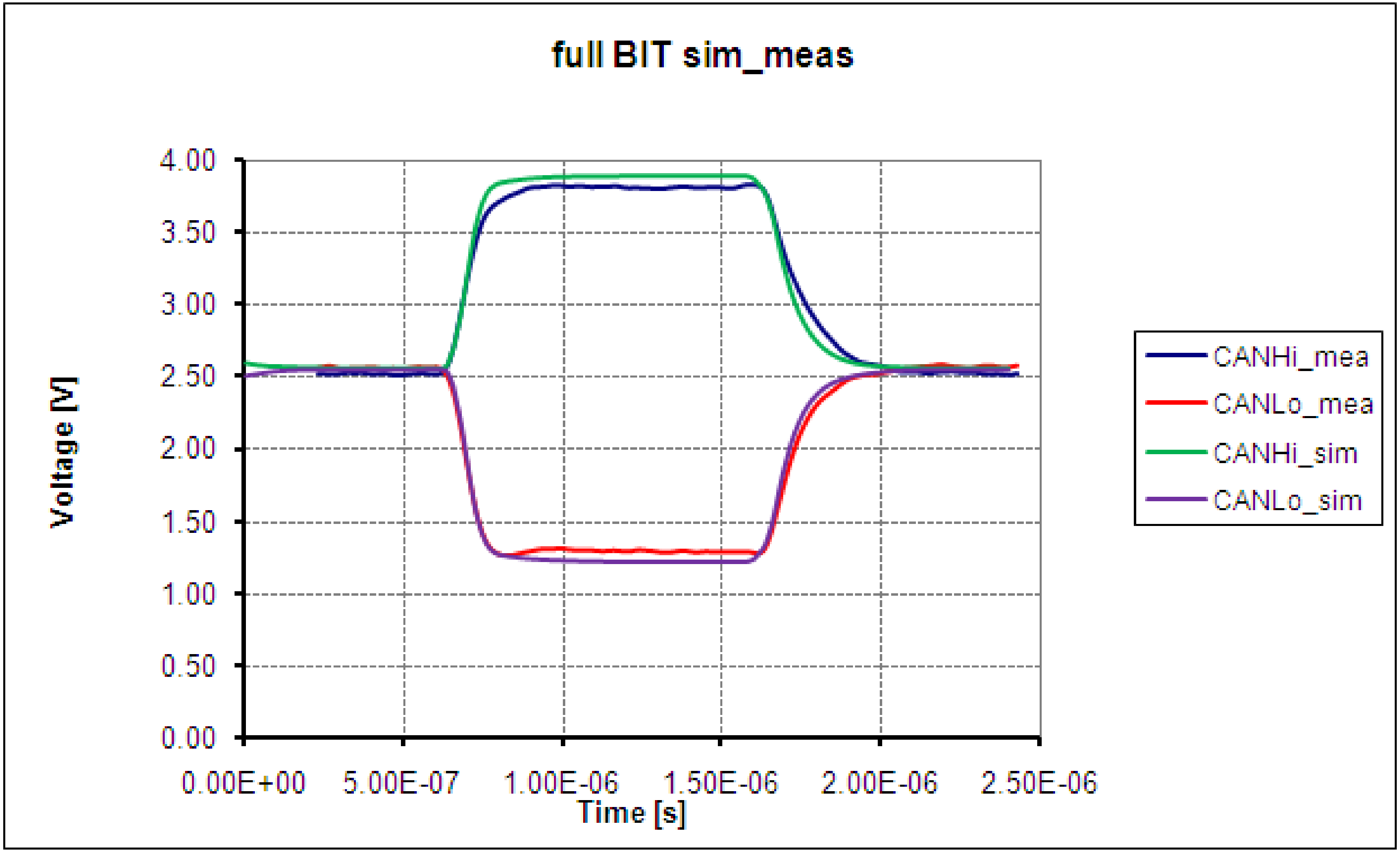
Total cable length: 50..60 m

- compatible with ISO 11898 CAN 2.0A and SAE J2289
- un-equal stub length
- 500 kb/s trans. rate
- split termination circuit at star connection point
- total cable length 58.0 m

Verification of 24-node star network at *500 kbps* transmission rate



Verification of 8-node star network at *1.0 Mbps* transmission rate

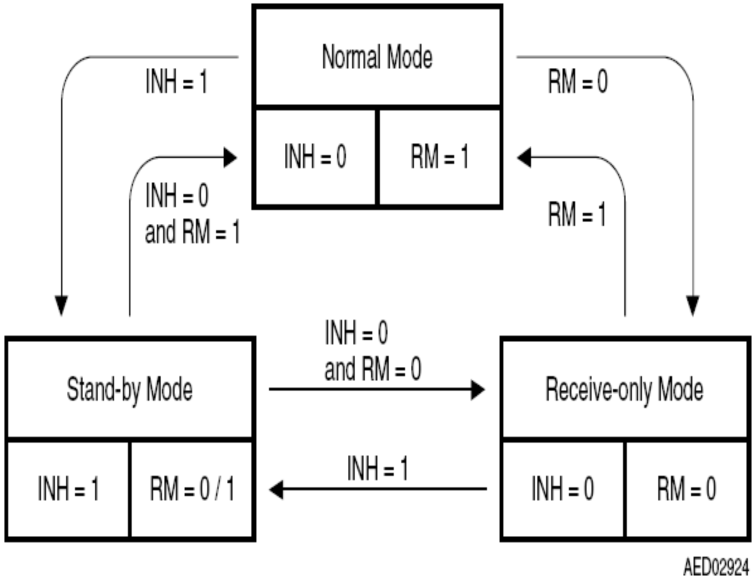


Simulation of Tx and Rx signals of the CAN Micro-controller interface

By measurement setup:

- RM is connected to 5.0V
- INH is connected to ground

→ Normal mode

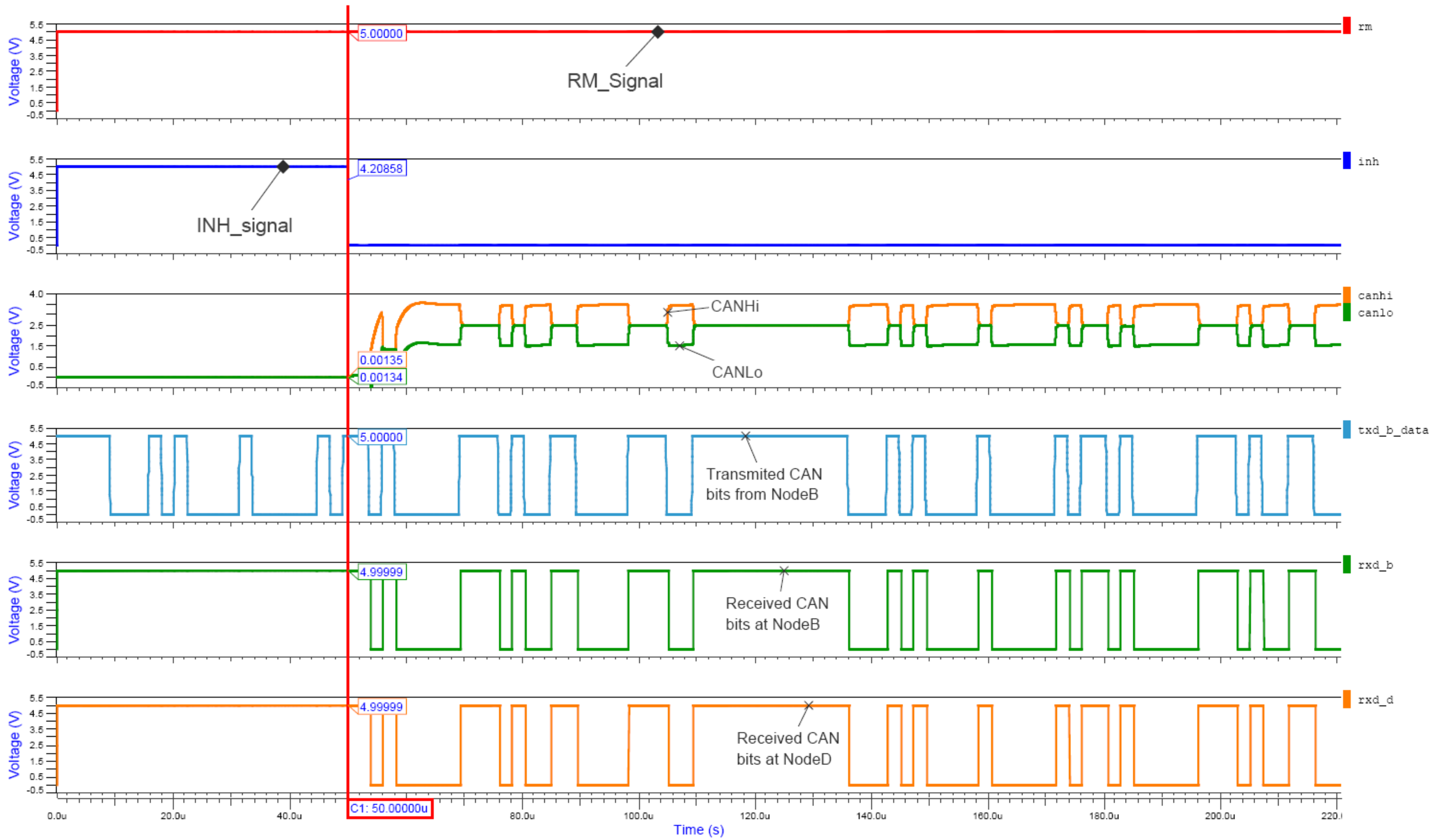


By simulation setup:

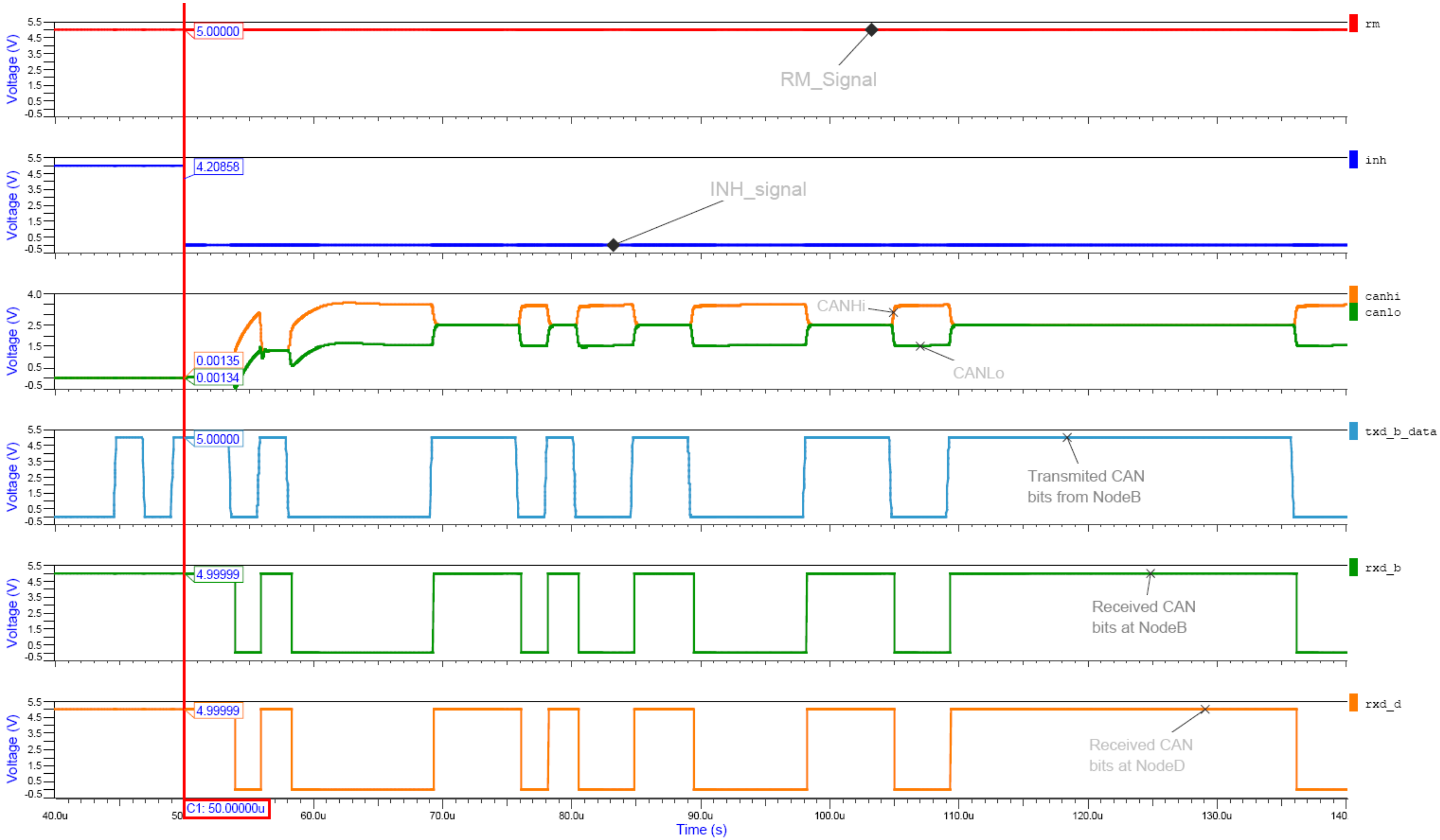
Standby mode→ Normal mode

→ RM and INH signals is modelled by a piecewise linear voltage source (V_PWL)

Simulation of Tx and Rx signals of the CAN Micro-controller interface – Result 1



Simulation of Tx and Rx signals of the CAN Micro-controller interface – Result 2



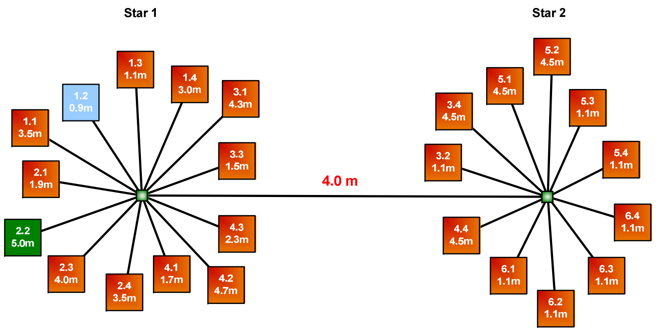
Conclusion

- Small deviation between measurement and simulation → the simulation models are accurate
- Implemented star topology shows a stable behavior of electrical signal on the CAN bus
- Models of CAN measurement environment must be taken into consideration
- It is possible to simulate up to the interface of the CAN microcontroller without having to model and simulate the CAN controller.

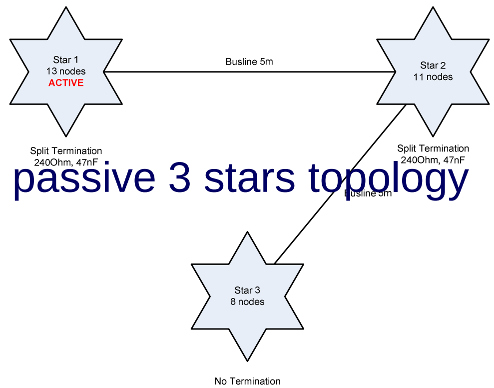
Future work

- Non-standard CAN network topologies validation
- Bus error detection under
  - Extreme temperature condition
  - Maximum number of nodes vs. high speed transmission rate
- Provide methodology for automation of CAN physical layer verification of complex network

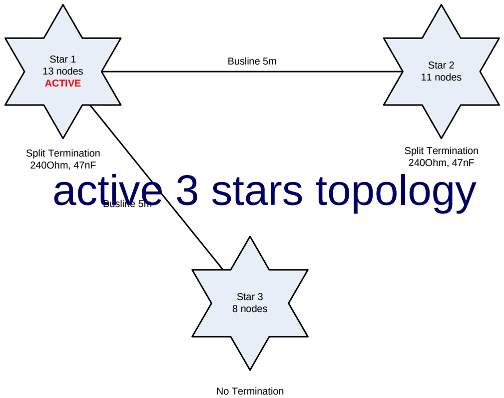
Non-standard CAN network topologies



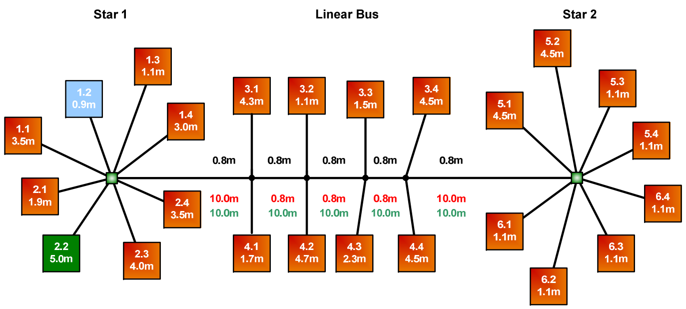
2 stars



passive 3 stars topology

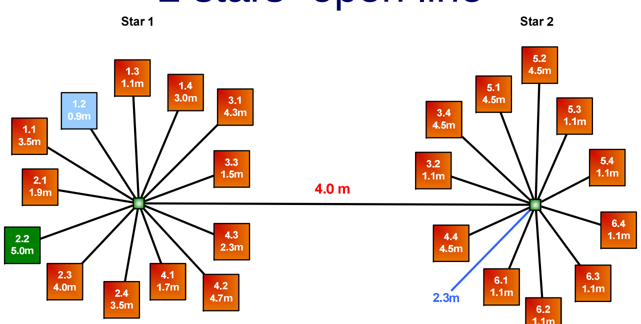


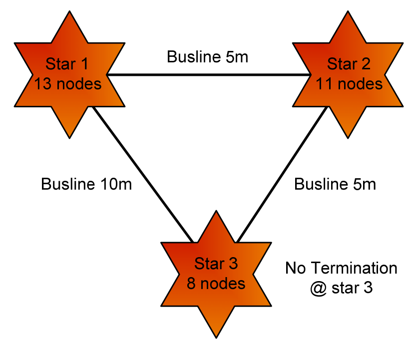
active 3 stars topology



Hybrid 1

2 stars+open line





Hybrid 2

Thank you for your attention