

# FlexRay Simulations Safeguarding proper operation of real network architectures

## Overview

- ▶ FlexRay, the new standard for data communication in vehicles:
  - deterministic, fault-tolerant, high-speed
- ▶ New enhanced applications such as brake-by-wire and steer-by-wire demand higher performance. Therefore special techniques are necessary to verify reliability, flexibility and high data throughput
- ▶ Solution - modeling of FlexRay networks and random-test based simulations (Monte-Carlo)
- ▶ For the first time FlexRay network simulations have been successfully applied for series-production vehicles

## Challenges

**How do we ensure correct FlexRay operation over the entire range of configuration parameters, environmental conditions and device tolerances while optimizing data throughput?**

- ▶ System behavior is the result of the interplay between numerous configuration parameters (e.g. termination, cable parameters, cable length, topology structure) and cannot be predicted analytically
- ▶ Stable and robust network operation has to be verified for each configuration
- ▶ High bandwidth (10Mbit/s). So bus signal integrity / quality is crucial for communication system robustness
- ▶ Huge multi-dimensional parameter space due to variation of environmental and device tolerances can hardly be covered by lab measurements. Worst-case scenarios not completely visible in the lab

## Solution: TJA1080 Monte-Carlo Simulation

- ▶ Simulation of complete FlexRay physical layer networks using behavioral Saber models for NXP FlexRay transceivers (e.g. TJA1080)
- ▶ Monte-Carlo simulations – taking into account tolerances of the system and environmental parameters – show the area of stable and robust network operation

- ▶ Simulation allows corner cases to be investigated, normally very difficult to access under laboratory conditions (see figure 1)
- ▶ Optimization of network performance in terms of robustness and EMC by simulation-based analysis
- ▶ Safeguarding network topologies prior to series production

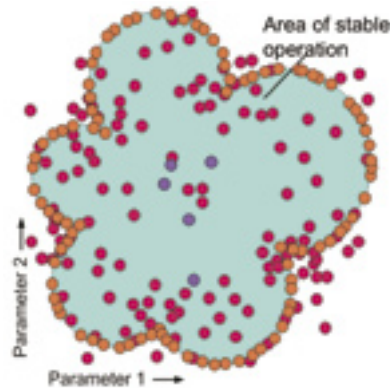


Figure 1: Area of stable and robust network operation (here example of two-dimensional parameter space)

## Example: FlexRay linear bus topology

- ▶ Performance of the network configuration (linear bus) below has been validated by simulations

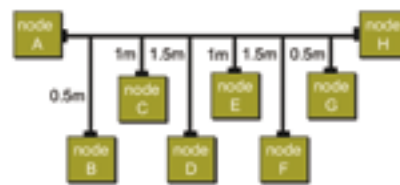


Figure 2: FlexRay example linear bus

- ▶ Simulation results show good matching to laboratory measurements, e.g. under typical conditions bit timing within bounds

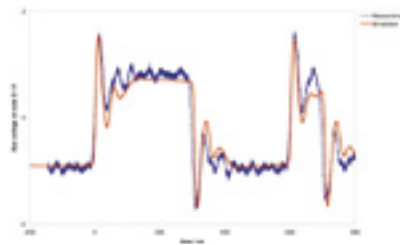


Figure 3: Good matching between simulation and measurement

- ▶ Monte-Carlo simulations including parameter variations (cable impedance, device tolerances, temperature range) reveal bit violations → robustness not sufficient

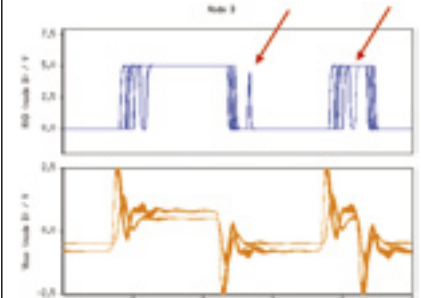


Figure 4: Monte-Carlo simulation reveals bit violations of RXD signal at node D

- ▶ Corrective action is to reduce the stub length of node D from 1.5m to 0.4m

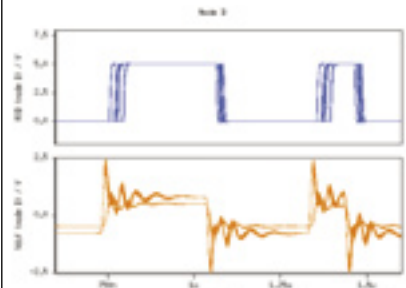


Figure 5: No bit violations after reducing the stub length of node D from 1.5m to 0.4m

## Benefits

- ▶ Simulation of complete FlexRay networks safeguards the integrity of real implementations in series-production vehicles
- ▶ Carmakers and Tier 1 suppliers save considerable effort by using simulation results instead of time-consuming lab investigations
- ▶ NXP network experts support carmakers and Tier 1 suppliers in developing complete FlexRay network architectures for new car models
- ▶ Existing method has already been successfully used for the investigation of several carmaker projects including the BMW X5 and others

