Automated validation of CAN FD networks

With the Invio tool, bus systems like CAN, CAN FD, LIN, and Flexray can be validated automatically to specific evaluation criteria. Furthermore, it supports the simulator environments Saber and System Vision.

The increase of functions in vehicles, which are implemented by electronic components, has a significant influence on the communication in vehicle networks. More and more functionalities demand higher bandwidths, such as customer requirements in the areas of safety, increased comfort, and improved handling, and thus increase the relevance of automotive electronics. High transmission rates pose new challenges to network designers responsible for the implementation of the physical layers, since the dynamic behavior of the system cannot be predicted by manual calculations. On the other hand, measurements have a reduced significance due to their single result that generally reflects the typical behavior – the behavior at the limit, however, remains unknown.

Therefore the simulation can be used to predict physical behavior and to verify the implementation of the physical layer of a network in consideration of variations of the electronic components and the environment, as well as in corner case areas. In addition, developers can use the simulation to analyze network designs to find a robust layout and to investigate the influences and the interoperability of new components and ECU interfaces with the goal to improve the signal quality and to ensure accurate communication. Below, this is illustrated using the example of the validation of CAN FD networks.

Simulation

Particularly in CAN FD networks, the use of simulations is necessary, since the asymmetry of the signal edges plays an important role due to the possible higher transmission rates during the data phase in relation to the arbitration phase, in comparison to Classical CAN. Environmental conditions, such as high or low temperatures, can additionally intensify negative effects on the asymmetry of the signal edges, which can be easily analyzed via the simulation.

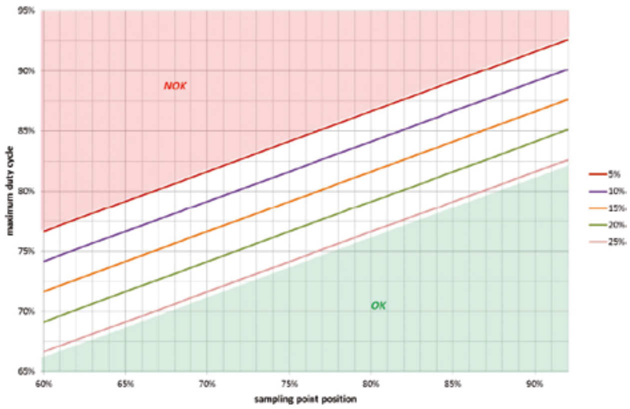

Figure 2: Example of the dependence between the duty cycle limits and the sampling point at different allowed phase shifts

CAN FD and Classical CAN use the very same arbitration method. The same rules and limits for the arbitration phase as in Classical CAN are valid. However, in order to judge the asymmetry of the signal edges, new considerations must be taken into account for the CAN FD data phase. The asymmetries of the measured edges within a CAN FD network essentially determine the choice of the sampling point during the data phase. More information about the physical interpretation of busses of the CAN FD networks can be found in [3], [4], and [5].

In a CAN FD network, the arrangement or integration of control devices or the choice of driver components and transmission lines causes an individual signal characteristic, which has effects on the asymmetry of the signal edges. This illustrates the importance and necessity of simulating such networks. To study the signal integrity in an early development phase of a vehicle, a simulation as a model-based testing of networks is necessary. This requires appropriate models [1] to create confidence in the results.

The evaluation of vehicle networks using simulations is increasingly established and it can be seen that this trend is growing continuously.

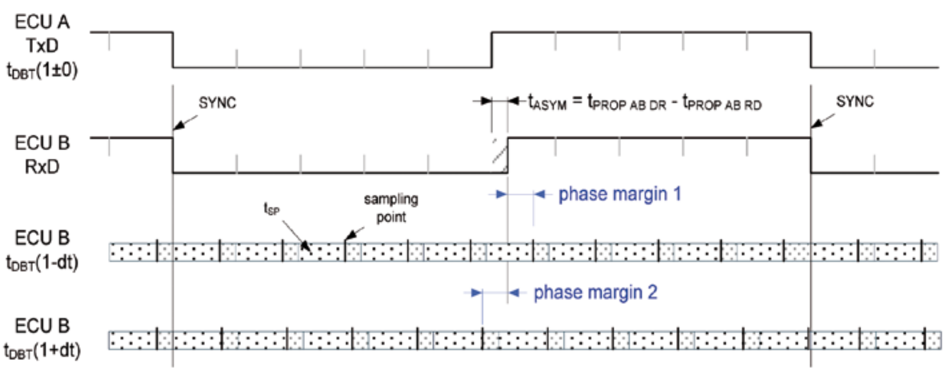

Figure 1: Principle of phase shift of the signal edges before and after the sampling point

With the need of simulations of CAN FD networks, this trend is further intensified. Although car manufacturers have the necessary expertise when it comes to vehicle networks, there aren't always enough experts or resources available to secure and release the networks at an early stage, whether through measurement, simulation or to analyze improvement measures and to make appropriate recommendations.

The following example of the analysis of a CAN FD network should explain the extent that is necessary for a final review and release. For a simulation of the example CAN FD network with ten control units, all required models must be configured and the networking of the control devices including the stimulus and measurement components must be created, e.g. on code level or via a schematic editor. In addition, the simulator must be configured and the entire model of the CAN FD network, referred to as a test bench, must be simulated.

To investigate the CAN FD network in extreme conditions such as high and low temperatures, the overall test bench of the network must be reconfigured. A variation of the temperature in two steps is assumed for the following considerations. The number of ten nodes in the network results in 100 transmitter-receiver combinations per simulation run. To study the delay times during the arbitration phase as well as the asymmetry during the data phase, four single measurements for every transmitter-receiver combination arise for each dominant-to-recessive and recessive-to-dominant edge.

In summary, 800 single measurements with an assessment of the results are produced, of which, if required, an image with the signal representation must be created. Finally, a test report must be generated. Even with only a few minutes for each measurement, the overall effort shouldn't be underestimated. Hence, if various networking options (e.g. for possible improvements of the signal quality or model variants) as well as different transmission rates during the data phase are to be examined, the amount of analyses multiplies accordingly. Thus, it appears that through the use of an automated implementation of the simulation, the required resources could be reduced dramatically.

Automation through simulation

This need for an automated validation of bus systems, which allows automating the evaluation of networks through simulations, is covered by the tool "Integrated Network Validation Studio" (Invio) [2]. It allows the validation of CAN, CAN FD, LIN, and Flexray networks according to specific evaluation criteria. The tool supports the simulator environments Synopsys' Saber and Mentor Graphics' System Vision, which are most commonly used in the automotive sector, since the simulation is performed in the hardware description language VHDL-AMS.

The focus of Invio is the comprehensive support of network engineers during the evaluation of network layouts. The automation starts with managing model components that are used conjointly and several times and so-called control unit templates to allow different mountings of model components in the control units. The next step is to define the networks and their variation and to further configure the test cases and setting up the evaluation criteria. With Invio, the network engineer receives support during the development of complete network test benches, their respective simulation and evaluation through measurements, and subsequent calculations up to the result report in the desired file format. ◀

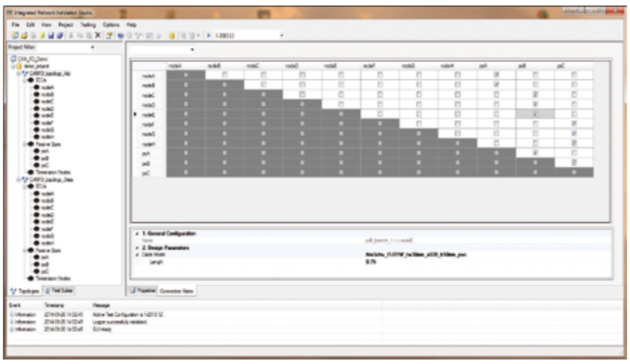

Figure 3: Example of the networking matrix in the "Integrated Network Validation Studio" (Invio)

References

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