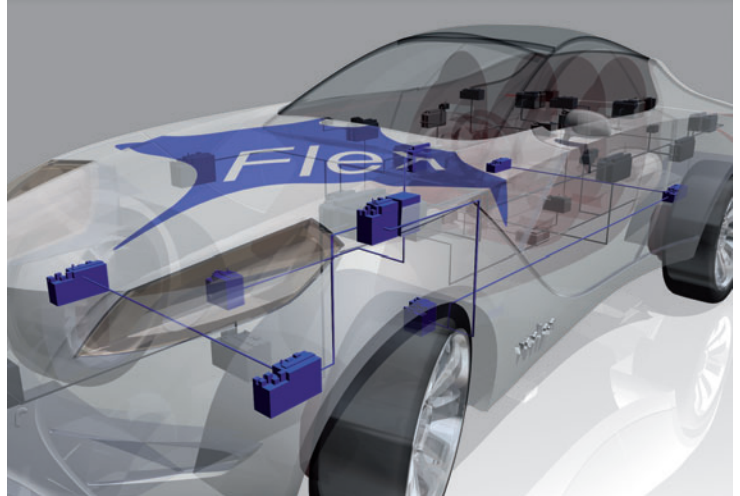


# Network Management for FlexRay

## New network topologies tested in practice

Simple and error-free startup of the communication cluster as well as high system stability over long service life are required to keep the complexity of FlexRay networks in vehicles under control. The Network Management from Vector Informatik GmbH proved its production-ready maturity in rigorous testing at the engineering subsidiary of a German automotive OEM.



The FlexRay serial high-speed communication system takes on elevated requirements for electronic networking in the car due to its greater bandwidth in data transmission, real-time capability and greater schedule reliability in data flow. In the automotive area it is the right solution for the data backbone, distributed control systems or safety-relevant applications. FlexRay exhibits deterministic behavior because it is time-triggered. Moreover the bus system already introduced on the new BMW X5 car offers a lot of flexibility in the hardware design of its network structure: The expandable and fault-tolerant network topologies may consist of a passive linear bus or of passive or active stars. Adapted to those new possibilities, the international AUTOSAR development partnership has defined amongst others a FlexRay-specific network management.

In contrast to the event-driven communication of a CAN bus, FlexRay assigns all messages to a fixed communication schedule. The design of a FlexRay network requires that certain fundamental parameters be defined for all participating network nodes in a very early phase of development. These parameters include e.g. baudrate, cycle length, number and length of the slots in the static and dynamic segments or macrotick duration. Building upon this, sender and receiver relationships for the data to be transported are defined in the cluster to yield a clear time-based availability of input data for each participating ECU. FlexRay-specific, time-triggered communication sequences must be anchored not only in the communication-specific software components but also in the application software to ensure a time-based deterministic behavior. This enables reliable distribution of control tasks among different ECUs.

### Network Management

In general three different ECU modes are differentiated in the automotive environment: Normal Operation, Low Power and Sleep. The Network Management (NM) is responsible for the cluster wide coordinated switching of the ECU nodes between those operating states. In doing so, the NM offers the communicating nodes the capa-

bility of mutually becoming informed of their need for bus communication. If communication is no longer needed on the bus system, synchronous transition to Low Power or Sleep ECU mode is initiated. As soon as the ignition is switched off, only the ECUs in Low Power ECU mode exchange information at periodic intervals. All other control modules (ECUs) are put in Sleep mode.

The NM specification of AUTOSAR V1.0.0 partitions the NM module into two parts: "Generic NM" and "FlexRay NM". It specifies that each bus node has to send periodically a NM message until it no longer requires any bus communication. If no NM messages are sent (or received) over the transmission medium within a time period defined by the system integrator, the cluster transitions synchronously to BUS\_SLEEP\_MODE. Specifically, three network management operating modes are provided for AUTOSAR-NM as shown in Figure 1:

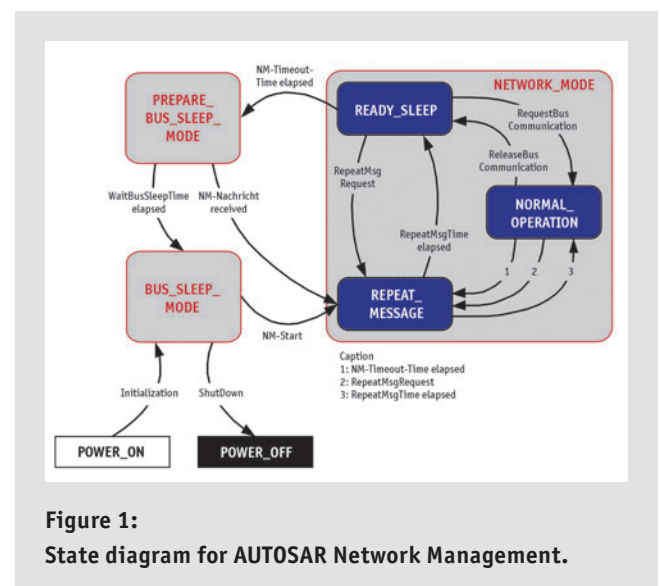


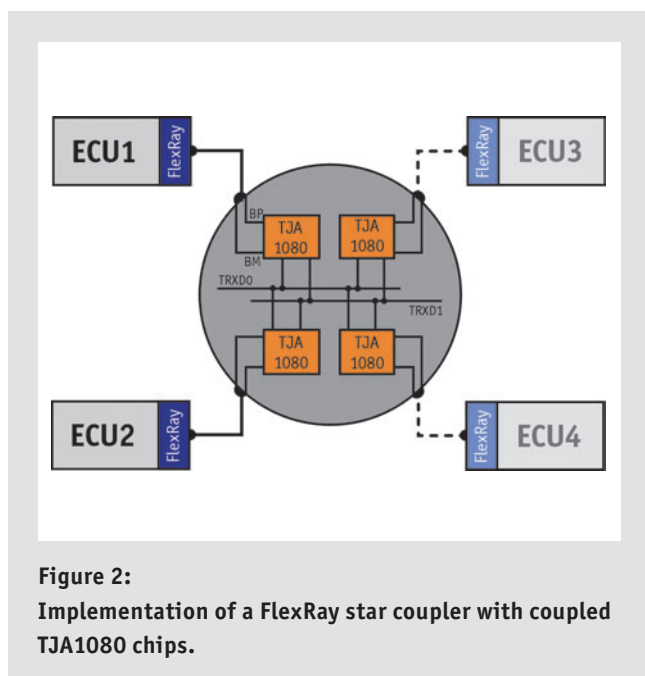
Figure 1: State diagram for AUTOSAR Network Management.

- > NETWORK\_MODE with the sub-states:
  - > NORMAL\_OPERATION
  - > REPEAT\_MESSAGE\_MODE  
(initial state upon entering NETWORK\_MODE)
  - > READY\_SLEEP\_MODE
- > PREPARE\_BUS\_SLEEP\_MODE, and
- > BUS\_SLEEP\_MODE

### Network Management put to the test

The engineering subsidiary of a German automotive OEM evaluated FlexRay in various network topologies. For this project the new AUTOSAR Network Management has been included together with other FlexRay software modules of the Vector FlexRay-Stack. Special aspects focused on AUTOSAR conformity, system stability and resynchronization behavior of the FlexRay stack when reintroducing a node into the bus system.

The laboratory setup made use of an initial, simplified stage of NXP SJA2510 (previously Philips) communication nodes an ARM9 based microcontroller with integrated FlexRay controller. The FlexRay-Stack from Vector Informatik including the NM components (generic and FlexRay) per AUTOSAR specification V1.0.0 was integrated on each microcontroller. Vector provided the FIBEX file required to configure the communication software of each individual ECU. Vector osCAN was used as operating system.



**Figure 2:**  
Implementation of a FlexRay star coupler with coupled TJA1080 chips.

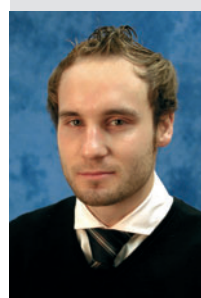
The following hardware topologies were tested:

- > A direct connection of FlexRay nodes in the linear passive bus topology, and
- > The use of an active star topology implemented in hardware by coupling multiple TJA1080 chips, Figure 2.

The goal was to set up a scalable system that could be quickly adapted to new requirements and test cases. These tests were also used to study realistic clusters with hybrid topology forms to determine their behavior with regard to the desired fault tolerance in different topologies and performance in new applications.

### Summary

The analysis of potential network topologies ran exceptionally smoothly. It was easy to implement the test cases based on the existing AUTOSAR specification to the integrated NM component within the FlexRay stack. AUTOSAR conformance, reliable resynchronization behavior of the FlexRay stack when adding nodes to the bus system, and good system stability could be successfully attested to the Network Management from Vector Informatik. The GENy configuration tool facilitated enabled startup of the FlexRay cluster without complications.



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