



## Validating Automotive Ethernet Conformance and Performance

### Company

BMW Group  
Automotive Manufacturer

### Key Issues

- Validate switch ECU and data logger performance and reliability
- Validate conformance of protocol suites such as AVB and TCP/IP

### Solutions

- IxNetwork with AVB suite
- IxANVL Automotive suite

### Results

- Characterized switch performance, robustness, and reliability
- Detected that automotive data loggers were losing traffic at high speeds
- Measured that gPTP time synchronization quality is within desired bounds
- Validated ECU TCP/IP stack conformance based on OPEN Alliance specifications

To overcome in-car network speed challenges, the BMW Group released the world's first vehicle with Ethernet in 2008 and added more in-car communication on Ethernet in 2013. To make the additional features in 2013 possible, a new physical layer for Ethernet was created that was more suitable for automotive electro-magnetic interference (EMI) requirements. This version, standardized in IEEE as 100BASE-T1, runs over one single twisted pair, compared to traditional copper Ethernet that runs over two or four pairs, depending on link speed.

Defining a new communication network so different than existing automotive networks brings huge challenges. Adding to the challenges of validating this new physical layer, the BMW Group had a paradigm change in network design to deal with - automotive networks are moving from a bus or ring topology, from technologies like CAN/FlexRay or MOST to a star topology that is achieved with Ethernet switches. And besides testing the actual network itself, one needs to ensure that automotive electronic control units (ECUs) properly implement the higher layers that traditionally run over Ethernet (the TCP/IP stack), new protocols that had been adapted for automotive use such as Audio Video bridging (AVB), as well as new automotive-specific protocols like SOME/IP.



## VALIDATING AUTOMOTIVE ETHERNET

There are four classes to validate automotive Ethernet:

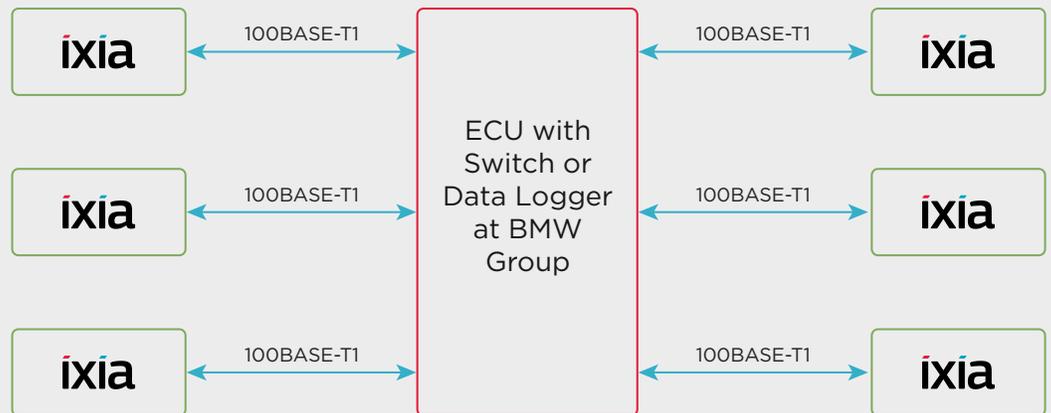
1. PHY or physical layer validation, for which tests are usually run for days or weeks
2. Validation of multiple PHYs in an ECU – an implementation of classic Ethernet switch
3. Validation of conformance for the various protocols used in the ECU
4. Validation of deployed networks and debugging using automotive data loggers

Because Ethernet is a switched network, it opens up a lot of flexibility compared to traditional automotive busses when it comes to network design. The majority of the automotive ECUs in production have multiple ports, which allows them to connect to other ECUs. For such an ECU, it's very important to validate that incoming frames are forwarded on the correct ports under all conditions.

IxNetwork, Ixia's flagship product for Layer 2-3 network testing is a tool to validate automotive Ethernets. IxNetwork relies on hardware purpose-built to generate and measure traffic at line rate on hundreds of Ethernet ports. Even though speeds in the automotive field are not currently very high (100Mbps and 1Gbps), to test the performance and robustness of such switches, the BMW Group must be able to very accurately and predictably generate both expected and unusual traffic patterns for the car network, all using standard defined tests like RFC 2544 or RFC 2889. IxNetwork predictably and precisely generates traffic on multiple ports, which allows the customer to discover and reliably reproduce any network problems found.

**Figure 1.**

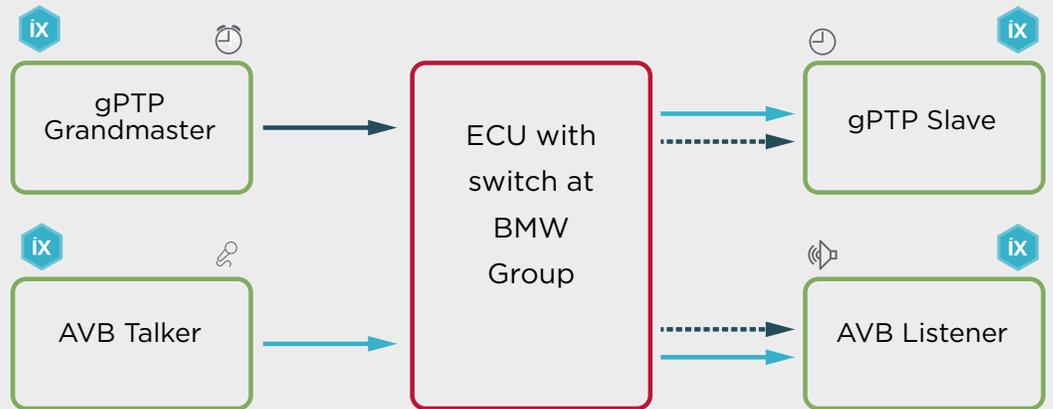
Test switch performance and robustness—bandwidth, packet loss, and latency



In a sense, automotive data logging works by duplicating traffic of the in-car network links and saving the duplicated traffic to static storage, such as a hard disk drive (HDD) or a solid state drive (SSD). Using the predictability of IxNetwork, customers validate the data loggers by generating high-volume traffic patterns to characterize performance limits and bottlenecks, finding that in some cases, data loggers were actually dropping packets.

Because IxNetwork also supports AVB, the BMW Group can also test that the switches that support AVB aren't dropping or delaying critical media traffic. They precisely measure and validate that endpoint devices that integrate AVB have the appropriate time synchronization quality, which is the foundation for proper media playback.

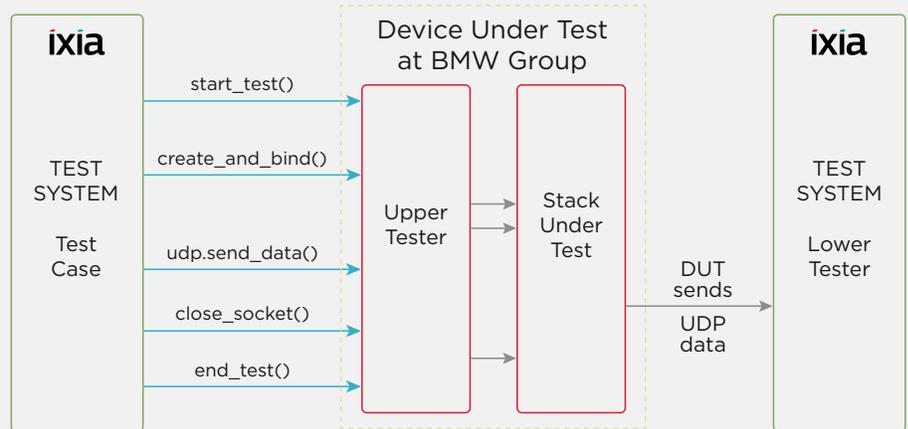
**Figure 2.**  
Test AVB Bridge for time synchronization and bandwidth/latency guarantees



Automakers implementing a best-of-breed approach use components from different suppliers, so they must ensure that all ECUs speak the exact same language. The BMW Group requires its vendors to follow the OPEN Alliance Technical Committee no. 8. (TC8) test process. To achieve this, the BMW Group was the main supporter of the TC8, which oversaw the development of the test specification for the TCP/IP protocol suite. To this, Ixia contributed about 90% of the 800 test cases that validate protocols such as IP, ARP, ICMP, TCP, UDP, DHCP, and SOME/IP from its time-proven protocol conformance Automated Network Validation Library (IxANVL). Besides the Test House process, IxANVL is used by the BMW Group to run secondary in-house validation to ensure flexibility in certain development situations.

**Figure 3.**

AUTOSAR testability  
protocol/service  
primitives for TCP/IP stack  
conformance and robustness  
testing



## CONCLUSION

Using Ixia's IxNetwork and IxANVL products, customers like the BMW Group are successful in validating their automotive Ethernet toolchain, getting visibility into the performance and robustness of the switches integrated in ECUs. With Ixia's L2-3 test solutions, the BMW Group ensures delivery of the premium-quality vehicle communications that their car owners expect from the BMW brand.

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