About This Issue

In this issue, co-authors Erik de Louw from DAF Trucks and Marco Putmans from Synopsys explain how the Synopsys Saber Harness streamlines the flow of wiring data and schematics from manufacturing to maintenance, reducing cost and improving the quality of data in the field. Erik de Louw, Lead Engineer in the Electrical Systems Department at DAF Trucks, and Marco Putmans, CAE for Saber at Synopsys, explain how this is done.

As a leading European manufacturer of commercial vehicles we recognize the importance of providing comprehensive and efficient after-sales service for our customers. That process depends on providing up-to-date servicing information to our workshops, for the latest trucks, as they roll off the assembly line.

We have been using Saber Harness for wire harness design for more than a decade now. Saber Harness lets us create schematic drawings and connectivity diagrams, export component and wiring data, create bundles with connector positions and generate data for manufacturing – all within a single tool.

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When we started with Saber the workshops had a very basic schematic they used to service the truck. Over the years our vehicles have become more sophisticated, and we have also standardized on universal wire harness architecture for our complete truck range. The end result is that the workshops have to work with a very complex schematic that includes all of the truck variants. This makes things difficult for the workshop mechanics when it comes to servicing the trucks.

It takes longer for them to diagnose and repair any problems because first they have to figure out the wiring arrangements using the schematic.

We soon recognized that we needed a system to deliver our schematics to the workshops in a way that a mechanic could easily understand them. The best way to do that is by giving the mechanic a schematic drawn in a consistent style that is specific to the truck that he needs to service.

In the past the development team created a drawing of their systems, but there was no consistency because the system owner would use his or her own style, and every system looked different. To address that issue, we then added another step in the process to redraw all of the schematics so that they looked the same before inserting them into the workshop documentation.
In addition, we had to redraw our harness schematics to fit into the DAF dealer system for managing after-sales servicing and maintenance, called the “Service Rapido” system.

Service Rapido Schematics
To address the schematic problem for servicing, we developed a mechanism around Saber to filter out the truck-specific information from our universal schematics by using our in-house design release system and Saber Bundle – a feature of Saber Harness.

We use two tools developed here in DAF: our design release program ensures data consistency; we have also created an Excel macro to combine the data from Saber Harness and Saber Bundle.

Our aim is to ensure that we have a consistent set of data between the manufacturing schematics and those we use for servicing. We need to have the correct schematics and bundles available during the “spec” week – when the truck rolls off the line, which we have achieved by using our custom tools in conjunction with Saber Harness to automate the process.

For the after-sales tool we also export the bill of materials that goes into that system, which is used in the workshops and at the end of the line; the last part of the fabrication line when a truck is tested. If we have any errors the data for that truck is already in our application, so we can quickly see the electrical characteristics of the truck.

After Sales can link specific service information to any location in the diagram. This information can contain troubleshooting data, location information and other descriptions. One of the benefits of using Saber Harness is that everything is in one system, which enables us to have one input from our system diagrams to our bundles. With this methodology we only draw the schematic once, and we can export it directly into our after-sales service system.

As a result of automating production of the schematics we have reduced costs and improved the quality of the data in the field. We are now confident that the drawings we produce accurately reflect what is on the truck.

Towards Whole Systems
One of the things we’re looking for in the future is support for the electrical system design flow.

The electrical system design, or functional architecture, is the design for one system, such as a brake system, for example. All variations and all signals important to that system are on one design. The key point of the schematic design flow is that everything is put into one design, so you export out the functional architecture and then integrate it with a functional design into the wiring design.

One Database Design
We now have a robust system that excels in providing the information the mechanics need for the job. We can provide the same diagrams, even the same look and feel for our system diagrams, as we do with our online parts service, which we also have as the tool within the workshops running as an app on notebooks. Providing one look-and-feel for all our electrical information to the workshops is a major benefit for servicing efficiency.

A mechanic can enter a truck’s chassis (VIN) number into the system and immediately bring up the right information and the Saber schematics for that vehicle.

Using Saber Harness allows us to do everything in one toolset and to easily share the data with our in-house systems. This “one design database” approach, where all the electrical systems are connected, enables us to enter data once and re-use it in our manufacturing and servicing processes.

http://www.synopsys.com/Systems/Saber/Pages/WireHarness.aspx
Marco Putmans
Marco is currently a Corporate Application Engineer (CAE) for the Saber product line at Synopsys. Previously, he was with DAF Trucks as a Saber Bundle Engineer in the Frame Installation Department, subsequently working with Saber Harness in the Electrical Systems Department during 2005. In 2010, he was promoted to the position of Functional Application Manager for Saber within DAF where he was responsible for testing and introducing new versions of Saber and all related software, training users, maintaining the Saber system and all documentation, and devising new Saber-related work methodologies. Marco graduated as a Bachelor of Electronic Engineering from the Fontys University of Applied Sciences in Eindhoven in 2002.

About the Authors

Erik de Louw
Erik de Louw has been working at DAF Trucks since 2010 and is currently the Lead Engineer in the Electrical Systems Department. In addition to his responsibilities for developing electrical system schematics for heavy trucks, he also serves as the administrator for the Saber systems and Libraries. Before joining DAF, he worked as an Electrical Engineer and Service Engineer for Spierings Mobile Cranes developing electrical system schematics and was the first line support for electrical issue for the workshops. Erik received his Bachelor of Electrical and Electronic Engineering in 2002 from Fontys University of Applied Sciences in Eindhoven, the Netherlands.
Harnessing Simulation for Robust CAN Design

Nicolas Morand, automotive communication network and protocol expert, explains how PSA Peugeot Citroen uses Synopsys’ Saber Platform to enable robust design for low- and high-speed controller area networks (CAN).

The controller area network (CAN) is today’s standard for vehicle bus communication. We use CAN extensively across our vehicle range to convey data between multiple electronic controller units (ECUs).

As the complexity of automotive electronics has grown, the number of ECUs that we design into each vehicle has proliferated. Consequently, validating the CAN bus has become increasingly time consuming, and we are using more simulation in an effort to reduce the amount of prototyping that we perform. The alternative, which is to build physical prototypes, is both time consuming and costly.

**Pushing the Limits**

Simulating the CAN bus (Figure 1) enables our design teams to validate their implementation against the specification. If a network is not compliant with the specification we have written, we can use simulation to investigate the design further. Additionally, we use simulation to help us create the specifications in the first place. We make extensive use of the Synopsys Saber Platform to find the limits of the CAN topology.

When refining the specification, our aim is to guarantee that the network is going to work under all conditions, including when electromagnetic interference (EMI) is acting on the bus. In order to achieve this, we need to develop an accurate understanding of the design margins – especially for the design of high-speed CAN networks.

We validate all high-speed networks for new vehicle designs. A typical specification for a CAN bus will determine factors such as the maximum distances between ECUs on the wire harness. The distances will also depend on other variables, such as whether the design uses the maximum specified number of ECUs. Once we have understood and characterized a network, we can more easily predict the behavior of the network under different circumstances.

![Figure 1: Example of a CAN network](image)
A CAN bus scenario that we regularly encounter arises as a result of having several variants of vehicle within any particular range. In practice, it isn’t always possible to adhere exactly to the specification on all models; a designer may have to situate a particular ECU beyond the maximum recommended distance on the harness, for example, or exceed the recommended maximum number of ECUs at the end of long stubs. We need to know whether these variations on the recommended topology are allowable and if the CAN bus will continue to function properly, which we confirm using simulation.

**Example: Multi-ECU Controller Area Network**

Figure 2 shows a real example of how we simulate a network incorporating a number of ECUs, including the engine ECU, electronic stabilization program (ESP), power steering, gearbox, low tire pressure sensor and body controller. Lines connect ECUs’ CAN H together and connect ECUs’ CAN L together. The simulated network includes a diagnosis stub, starting at the body controller, which is terminated by the diagnosis socket. We also have added some high-value resistors, in order to help the simulator to converge, with no visible effect on the result.

We simulated the design with Saber based on HS CAN transceivers, interconnected with segments of lines simulating wire harnesses. All models were available in the Saber library, except ones of transceivers, which were created by the chip manufacturers that supply physical transceivers to PSA.

The “wire_em4” is the line model used extensively in Figure 2. We have been observing results close to measurements in the lab and on vehicles for quite a long time, which has enabled us to calibrate the line model with values that give us a high degree of confidence in the accuracy of our Saber simulations. At
frequencies of CAN analog signals, it is necessary to use the maximum number of elements in each line model and to put several models in series to increase this number for long lines. For example, we can use three line models in series, each incorporating 20 elements (the maximum value), instead of a line model with 60 segments (which is not available). At these frequencies, each use of the line model should simulate a line of length 1m or less.

We implement transceivers with peripheral components as in real ECUs. CAN H and CAN L interfaces include common mode chokes and/or capacitors, as well as termination resistors, depending on the ECU. Tx is driven by rectangular signals generated by a model we have developed. The simulation results (Figure 3) show that CAN signals at the gearbox are sufficiently distorted to lead to a small parasitic pulse at Rx. Other signals shown have good integrity. We can consider these to be good results, because the pulse occurs at the beginning of the bit, with no risk of bit inversion at the sampling point, which is situated much later. We know that this is the beginning of the bit because it is situated 2μs later than the preceding edge, which corresponds to the bit’s duration.

**Characterizing Failures**

Simulation is an essential tool to help us analyze high-speed CAN bus designs. However, simulation has also proven its worth in helping us to understand failure modes in low-speed CAN designs. We have analyzed many different circuits to reproduce various failures, including open circuits in very long wiring harnesses and other types of failures under poor operating conditions, such as EMI. By using simulation to characterize low-speed network failures under bad conditions, we can predict when they are likely to occur again. This knowledge enables us to write specifications in a way that covers all cases — building more margin into our low-speed network designs in specific areas where we know them to be vulnerable.

![Figure 3: Saber simulation results for CAN](image)
Developing a deeper understanding of networks has given us the capability to devise heuristic rules that enable us to design low-speed CANs more cost-effectively and efficiently. For example, to produce a robust network, we know that we must not exceed a certain branch length when the number of ECUs is below a certain minimum.

Before simulation, the only way we could analyze networks was by building physical prototypes either on the bench or in the car. Prototyping is time-consuming and costly, and when something appears to be wrong, you have to determine whether it’s a problem with the design or with the prototype itself.

Towards Higher Frequencies

The CAN clock frequencies that we simulate are of the order of 500kHz, while the harmonic components that we analyze are probably up to 10MHz, which we can support using line models in Saber.

However, we are using more electronics in each new generation of vehicle to support increasingly sophisticated command and control, which means more data and a need for higherbandwidth networks to carry the data. Ethernet is favored to replace CAN for high-speed data by some car manufacturers. We will need higher frequency-line capabilities, including models that use S-parameters, in order to support the high-speed standards once they are completely defined.

Although we don’t take advantage of Saber’s multi-domain capabilities in order to simulate the CAN bus, as our product line also incorporates more electric vehicles (EVs), other development teams within the company will have a need for simulation of power networks and power electronic components, including motors, sensors, controllers and batteries.

The use of simulation in CAN buses and embedded transmission lines has numerous benefits compared with physical prototyping. As automotive networks become faster and more sophisticated, we expect to make even more use of simulation to validate our designs and specifications.

We have been using this simulation method to complete CAN designs for about 10 types of vehicles so far, so we are able to accurately calibrate simulation results with measured data from the vehicles. As a result we have a high level of confidence in the ability of the simulation process to accurately predict what will happen in the vehicle.

We have been able to validate all of our simulations that predict a positive outcome using physical measurements. We have also been able to prove that predictions of negative outcomes were justified when we consider that there is a high risk of having a corrupt CAN signal in the worst-case scenarios.

In terms of results, this approach has avoided any crisis at the start of vehicle production and any need for last minute topology changes. In addition, we have been able to reduce our investment in physical prototyping.

Project Profile

CAN bus simulation: Synopsys Saber

www.psa-peugeot-citroen.com

About the Author

Nicolas Morand is an electronic systems engineer at PSA Peugeot Citroen and has been involved in analog and digital electronic design for military and transportation applications. Prior to joining PSA Peugeot Citroen, he worked for Thales and Alcatel.

In 2011, Mr. Morand contributed to the fifth edition of “CAN, Controller Area Network” book edited by Prof. Wolfhard Lawrenz and Nils Obermoller, published at VDE VERLAG. That same year he also presented “Power Line Communication for Electrical Vehicles” at the Synopsys Saber Seminar.

Mr. Morand is an expert in communication networks and protocols, including CAN, LIN, PLC communication, Ethernet and IP protocols. He is the chairman of the ISO TC22/SC31 subcommittee, in charge of data communication in road vehicles. He graduated from Polytech Paris-Sud in 1989.
Using Ethernet in Automotive Networks

Will Ethernet become the dominant interconnect for automotive applications? John Swanson, Synopsys, looks at the market trends and standards, and explains how the latest enhancements to Synopsys’ Ethernet IP solution supports automotive applications.

These days, consumers expect their cars to be extensions of their living rooms. They want to enjoy access to the same devices as they do at home – the smartphone and its apps, social networking, GPS and personal navigation, with an entertainment system that includes video in the back for the kids. Access to this is often delivered, and controlled, through the driver’s console, along with real-time information and control of the safety and comfort systems including air conditioning, tire pressure warnings, collision avoidance and a growing number of “driver-assist” features.

The growing complexity of in-vehicle infotainment (IVI) systems is putting pressure on automotive design teams to create faster networks with more traffic and network interdependencies. Increasingly, manufacturers are turning to Ethernet for IVI networks alongside their traditional controller area networks — such as CAN, which have been proven for deployment in safety critical automotive subsystems.

Ethernet Standards for Automotive

Ethernet is fundamentally a packet-based protocol. Providing support for streaming audio-visual data requires more “real-time” behavior from the Ethernet protocol, which can be achieved using audio-video bridging (AVB). AVB devices enable precise synchronization of data on multiple Ethernet streams.

The IEEE’s specifications for AVB that support streaming audio-visual content include IEEE 802.1AS, IEEE 802.1Qat, IEEE 802.1Qav, IEEE 1722, IEEE 1733 along with several newer study groups such as IEEE 802.1Qbu and IEEE 802.1Qbv. In addition, the IEEE updated the 1588 standard in 2008 to support real-time networks in a much more precise level. These updates will help to ensure that Ethernet becomes the network of choice for an increasing number of IVI applications. Whereas the CAN bus is capable of running at 1Mbps and FlexRay at 10Mbps, Automotive Ethernet delivers data rates of 10Mbps to 1Gbps with 10/100Mbps already in production use today. Additionally, Ethernet is a long-running, proven networking interface with an enormous amount of infrastructure to support it.

One disadvantage of Ethernet is that it’s a 4-wire protocol. This is a serious issue for automotive applications because every extra wire adds weight to the vehicle. The OPEN (One Pair Ethernet) Alliance special interest group has released a standard for reduced twisted pair Ethernet and currently there is an active effort to extend this to gigabit Ethernet (RTPGE), which will enable design teams to use a single twisted pair and still achieve 1Gbps speeds over a single twisted pair cable enabling broader deployment of faster automotive networks. There are PHY chips in production supporting single twisted pair Ethernet already.

Research firm, IC Insights, predicts that the automotive market will claim the accolade of being the second fastest growing IC market, forecasting a $28B sector in 2016. Given its potential benefits, it’s not surprising that Strategic Analysis, Inc., is predicting exponential growth of Ethernet deployment in automotive.

Extending Reach

Meeting the demands of car networking today means applying the right standard for each application: CAN bus for powertrain; FlexRay for chassis and safety systems; and Ethernet for IVI. Having to implement multiple networks, each running its own software, adds significant complexity to the system design and qualification effort.

Many manufacturers are exploring the capabilities of Ethernet for the whole car (Figure 1). A unified hardware standard network is an attractive proposition for the industry because it opens up the possibility of having one chipset for all vehicles, using software to control features and simplify wiring in the automotive network. This approach will substantially reduce manufacturing and test costs for automotive networks.
Design Team Needs
Primarily, automotive design teams need support for the latest AV bridging standards, including hardware support for the IEEE 1588 time synchronization standard and software drivers to enable these features.

The implementation of Ethernet is completely new to many automotive manufacturers and there is a lack of experience and understanding of how to integrate Ethernet with existing chipsets.

The increasing sophistication of IVI systems is changing the market pressures in automotive; consumers are now looking for more features for their budget. While reducing cost has always been a major driver for design teams, a consequence of this “consumerization” trend is that time-to-market is becoming a more important issue in the automotive industry, Chipset vendors who have products such as GPUs (Graphics Processing Units) that are already qualified for use in automotive subsystems are now looking to extend the functionality of their existing devices by adding Ethernet networking capabilities to them. For these vendors, being first to market can make a big difference to their ability to secure “socket” wins for these products.

To meet their time-to-market goals, design teams want to get their systems up and running quickly. Having the ability to prototype IVI systems enables them to integrate and test software earlier in the design phase.

Ethernet Solutions for Automotive
Synopsys has a silicon-proven IP solution for Ethernet in IVI applications. The solution includes hardware and software IP, as well as configuration, prototyping tools and software drivers which were initially released in 2009 when the IEEE specifications for AVB were first published. Since then Synopsys has enhanced the Ethernet IP to enhance the features required in IVI applications, including support for additional dedicated audio-video channels, one-step time stamping and segmentation offloading. Synopsys provides worldwide support for the IP, including delivery of design services.

The Synopsys DesignWare Ethernet IP portfolio includes the Enterprise MAC and PCS, Enterprise 10G and 12G PHY(s), XAUI PHY, 1G/2.5G/10G XG-MAC, Ethernet xPCS, Ethernet QOS, 10/100/1G GMAC Universal, 10/100 MAC, and Verification IP. Synopsys ships the cores with comprehensive documentation, which assists design teams in achieving ISO 26262 certification. The core most often selected for automotive designs is the Ethernet QOS core, shown in Figure 2.
Design teams can configure the core for their exact needs by using a menu-driven configuration wizard to select data bus width, CSR port options and clocking, and other parameters. The configuration wizard automatically generates an RTL description that is “correct by configuration”.

**System Prototyping Solutions**

Prototyping plays a major role in the development of automotive subsystems. Synopsys’ Virtualizer for early software development and the HAPS family of FPGA-based prototyping solutions enables automotive design teams to quickly and easily create prototypes of their designs for early software development, interoperability testing and system verification.

With HAPS, the design teams can take their existing GPUs and design a daughterboard that can plug into a HAPS system. They can synthesize the new design onto the FPGA in the HAPS environment and quickly get a prototype up and running. Virtualizer allows designers to run virtual simulations of the design prior to hardware being ready giving the software a jump-start and providing more time to develop a unique look and feel for the end product.

**Future Trends**

More and more automotive design teams are choosing to work with Synopsys when deploying Ethernet for the first time because of our experience and proven solutions for Ethernet IP.

Today, many manufacturers are currently designing or planning Ethernet networks for their IVI systems. If Ethernet is to become the dominant interconnect for all automotive applications, the industry must continue to look at extending its use to safety critical automotive subsystems.

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**About the Author**

John Swanson has been working in the IP business since 1990 when he joined Logic Automation/Modeling, which was acquired by Synopsys. John has worked in the design, verification, integration and implementation aspects of complex IP in engineering methodology, business development and marketing. He has been working on System-on-a-Chip technologies and methodologies for over ten years with Synopsys in a variety of assignments. Currently, he is the product line manager for the DesignWare Ethernet family of digital cores as well as JPEG, 1394, datapath and the IP reuse tools. In addition to his current assignments at Synopsys, he also is currently active in The SPIRIT Consortium, having chaired the Verification Technical Working Group until July 2007, and currently acting as vice-chairman of the marketing counsel.

Prior to joining Synopsys he worked for Amoco Oil Company designing wellhead automation and control systems. He is an Honor graduate from DeVry Institute of Technology where he completed his engineering degree with Presidents List honors.
Additional Resources

Saber website:
www.synopsys.com/saber

SaberRD Student/Demo Edition
FREE software download:
www.synopsys.com/saber-sw-demo

SaberRD Datasheet:
www.synopsys.com/saber-ds

Virtual Prototyping website:
www.synopsys.com/virtualprototyping

Virtualizer Datasheet:
www.synopsys.com/virtualizer-ds

Certitude Functional Qualification
website:
www.synopsys.com/certitude

Certitude, Functional Qualification
System Datasheet:
www.synopsys.com/certitude-ds

FPGA Design website:
www.synopsys.com/fpga

HAPS FPGA-based Prototyping
Solutions:
www.synopsys.com/haps

Automotive Solution website:
www.synopsys.com/automotive

Automotive Solution Datasheet:
www.synopsys.com/automotive-ds

Synopsys Automotive Webinars:
www.synopsys.com/automotive-webinars

Advanced Mixed-Signal Design and Verification of Smartcar ICs
In this webinar, Micronas and Synopsys discuss the breadth of automotive IC applications, challenges in design implementation and verification and the solutions that stemmed from their collaboration.

Implementing Ethernet QoS for use in Automotive Networking Designs
Learn about Ethernet in automotive designs, Audio Video Bridging (AVB), the driving forces and predictions for Ethernet in the automotive market, and Synopsys’ DesignWare Ethernet QoS IP solution.

Synopsys Automotive Solutions
The electrical and electronic content of modern vehicles continues to grow creating many significant design and verification challenges for automotive OEMs and Tier 1 companies. This webinar provides an overview of these challenges and how Synopsys’ automotive solutions for under-the-hood and driver assistance applications are helping automotive companies worldwide manage the increasing software content and system complexity due to the proliferation of electronic hardware and power systems in modern automobiles.