Vehicle network processing platform with functional safety

The NXP S32G274A vehicle network processor supports hardware security and functional safety according to ISO 26262. Microsys has integrated it in a system-on-module (SOM) with typical applications in connected vehicles, mobile machines, and automotive test equipment.

In today's age of digitalization, Industry 4.0, and the Internet of Things (IoT), high-throughput connectivity is one of the most critical functions for the interconnected devices. This particularly applies to the smart mobility sector, where the number of vehicles that is connected 24/7 via 5G to the service-oriented gateways, is growing. This continuous connectivity makes it possible to exploit the full potential of the vehicle data and to deploy new services and functional enhancements quickly and efficiently. Other domain controllers support functions such as infotainment and in-vehicle experience, body and comfort, powertrain and vehicle dynamics, as well as safety and security for ADAS (advanced driver assistance systems). Increasingly, autonomous driving functions are also required. The data transfer between the individual domain controllers or zonal computers/gateways and the local sensors and actuators must be processed and orchestrated with as little latency as possible.

The zero-downtime OTA (over-the-air updates) capability has to be considered as well. In addition, they must be real-time capable and secured in terms of ASIL D (automotive safety integrity level) safety and hardware security. This applies not only to major vehicle and mobility brands, but also to any latest commercial, construction or agricultural vehicle, overland and subway trains, and other types of mobile vehicles such as autonomous warehouse robots, and drones.

Compared to NXP's previous automotive gateway platforms, the S32G274A delivers 15900 Dhrystone Mips (million instructions per second), which translates into more than ten times faster real-time and network performance. To achieve this performance leap, the S32G2 processors integrate micro-controllers, application processors, network accelerators and a dedicated hardware security engine (HSE) on a single chip. This gives developers access

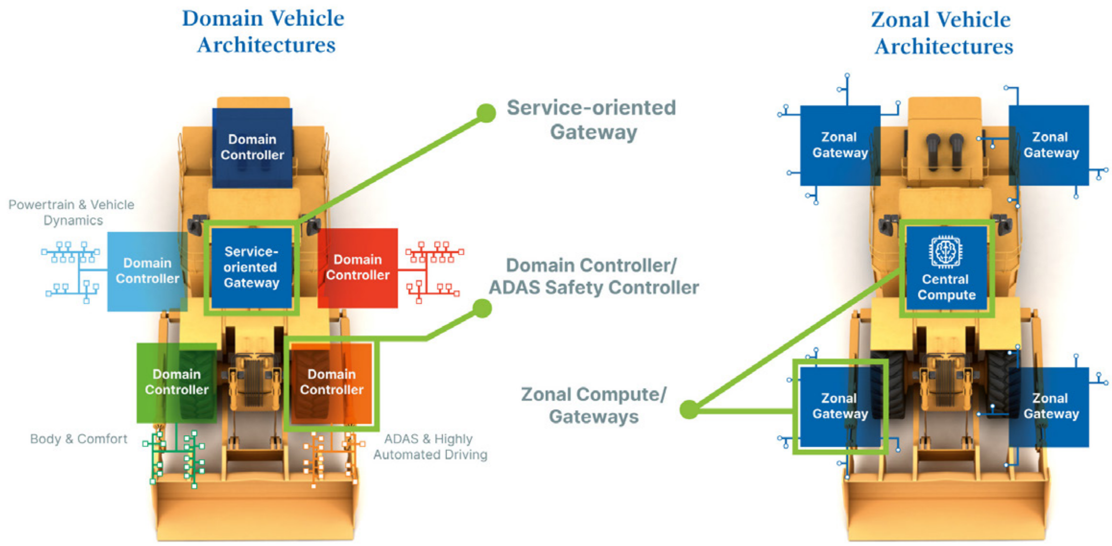


Figure 1: NXP S32G2 automotive processors power service-oriented gateways, domain controllers and ADAS safety controllers, or serve as zonal computers or gateways (Source: Microsys)

Increasing data throughput

Such gateways are expected to deliver increasing processing performance and data throughput to satisfy recent requirements such as cloud connectivity for fleet management or vehicle subscriptions, V2X (vehicle-to-everything) communication, ADAS functions, and autonomous driving.

to enough high-bandwidth processing power and high-performance connectivity to run tactile Internet applications with real-time 5G communication. The performance boost is possible by integration of several previously separate functions in a single-chip design, thereby combining more overall performance on one die. This also allows direct communication via the integrated safe fabric offers and ▷

lowers latencies. The integrated lockstep functionality for detecting errors during execution and data transmission, along with monitoring of other hardware-related faults, is yet another feature for safety applications.

On-chip interfaces and processing cores

Connected vehicles and mobile machines also require native support of all relevant peripheral interfaces, such as CAN (FD), Flexray, and LIN. Alternative connected vehicle designs using generic extension components to connect CAN controllers generate high interrupt loads that slow the main processor down unnecessarily. FPGAs (field-programmable gate arrays) are not a cost-effective alternative either and require additional development resources for FPGA programming. Providing on-chip automotive interfaces (up to 20 CAN FD, 2 Flexray, and 7 LIN) ensures that the most complex sub-systems are addressed without the latencies caused by the otherwise required USB-to-network components. This also avoids the need for expensive FPGA designs. The low-latency communication engine (LLCE) for CAN (and others), and the packet forwarding engine (PFE) for processing IP packets from Ethernet networks, reduce the CPU (central processing unit) workload. A fire-walled hard-ware security engine (HSE) for secure boot, security services, key management, and encrypted data transfer provides a root of trust, which is essential for secure IoT edge systems.

The processor orchestrates four 1-GHz Arm Cortex-A53 cores organized in two clusters for applications and services. They provide up to 23 Dhrystone Mips per core for multi-purpose applications. In addition, there are also three integrated Arm Cortex-M7 dual-core lock-step processors. Applications requiring dedicated co-processors, e.g. for motion control applications, can take advantage of the three dual-cores. They support real-time operating systems such as Autosar or FreeRTOS.

Integrated functional safety and safe communication

For safety-critical applications, the Arm Cortex-M7 and A53 cores can be operated in lock-step mode. Where required, the M7 cores can work in a 2oo3 (two-out-of-three) voting mode to ensure that when the three core pairs provide different results, the same result provided by two core pairs is valid. This way, the heterogeneous computing cores can support ASIL D applications as well as any other functional safety standard according to IEC 61508.

The integrated HSE provides comprehensive security functions for data and application security. These include data encryption and decryption as well as the generation and verification of MACs (media access control), and signatures. Secure boot provides a memory check at system startup. In addition, the engine pro-vides real-time, hardware-accelerated SSL/TLS (secure

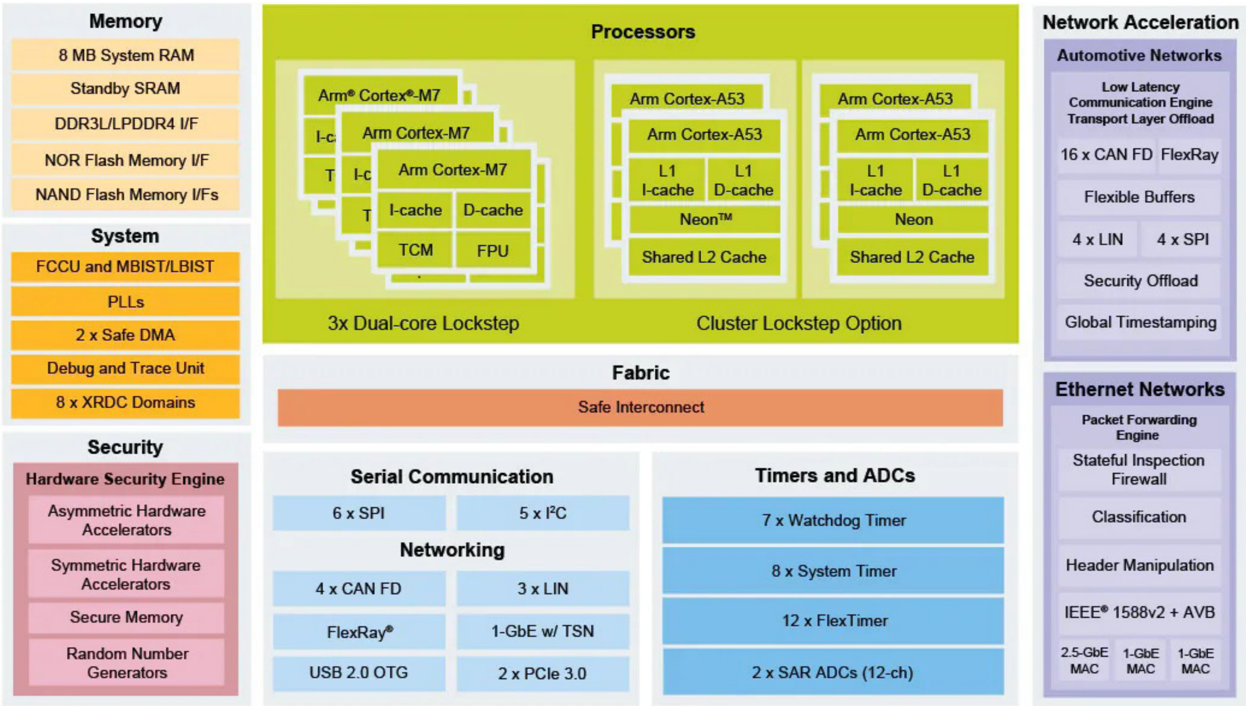


Figure 2: NXP S32G2 processor block diagram (Source: NXP)

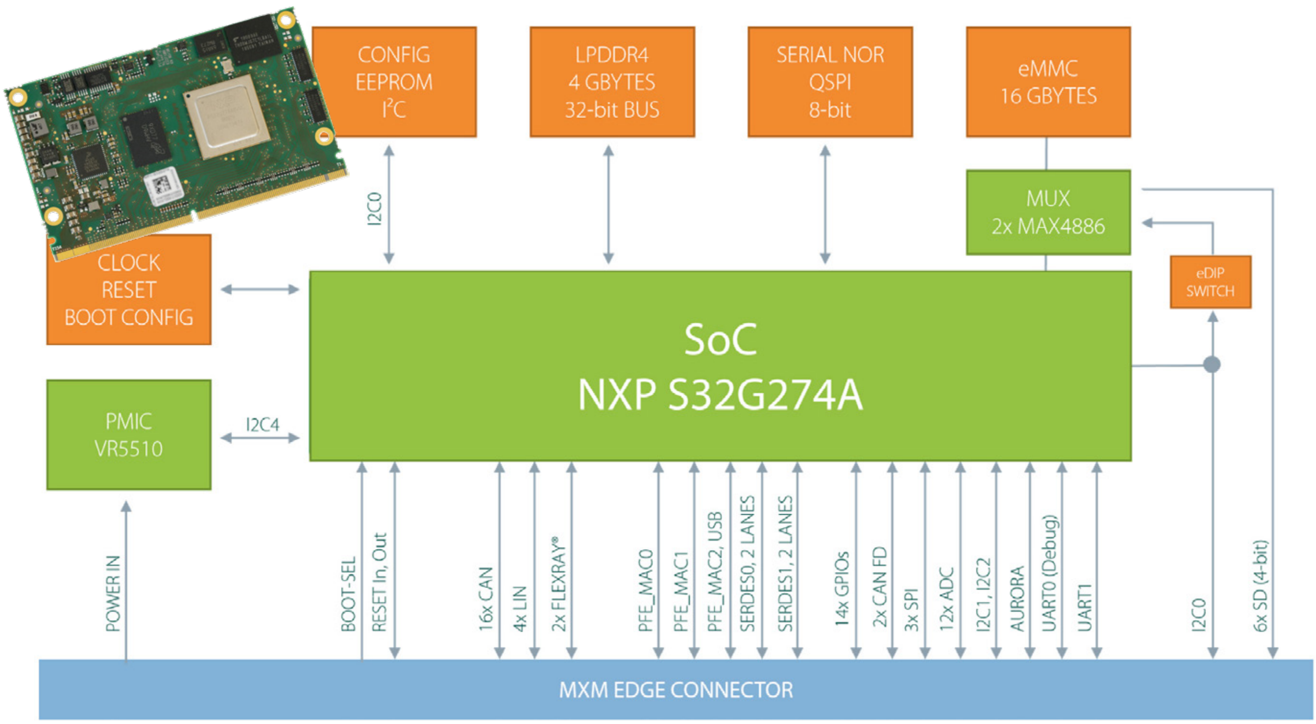


Figure 3: The Microsys Miriac MPX-S32G274A is the world's first system-on-module integrating the recent NXP S32G2 automotive processor. It provides developers with an easy-to-integrate platform including required core components and interfaces. (Source: Microsys)

socket layer, transport layer security) network communication and supports IPsec. It also provides random number generation capabilities and secure key management capabilities, along with resistance against side-channel attacks.

System-on-module

Developers of applications for commercial vehicles, mobile machines and e-mobility solutions that are only manufactured in industrial batch sizes, cannot afford to develop and integrate such complex gateway processor technology, along with all the required additional components and complex BSP (board support packages), into their systems from scratch. Instead, they have to concentrate on their core competencies, which are primarily in application development and which differentiate them from the competition. This is where application-ready COTS (commercial off-the-shelf) platforms help as they enable the development of customized solutions without the need to ▷

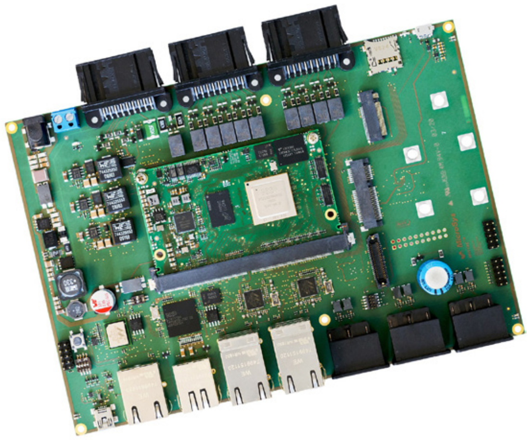


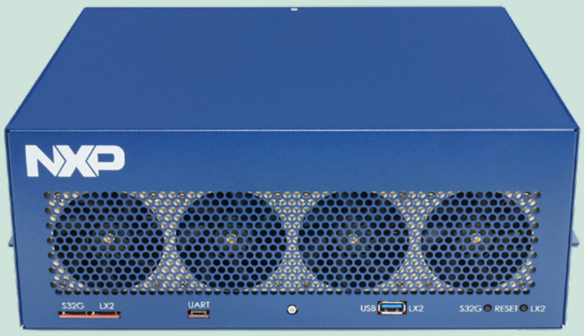
Figure 4: The application-ready Miriac SBC-S32G274A single-board computer is also available as a starter kit serving as an evaluation and target system for development (Source: Microsys)

spend a lot of time on the design of the central computing core. System-on-modules, which are delivered as COTS components with everything needed for application development and certification, are increasingly popular for this purpose. They already integrate function-validated drivers for all supported interfaces and provide ready-to-use OS (operating system) images from boot up to login. This saves time and increases design security, especially since the modules are not just used for one but different designs and therefore come with a comprehensive set of pre-validated functions. As a result, they provide a solid basis for the efficient design and implementation of customized control and gateway solutions for vehicles as well as mobile and stationary machines.

NXP's partner Microsys Electronics has integrated the S32G2 on the Miriac MPX-S32G274A system-on-module with a guaranteed availability of at least 15 years. This is a sufficient length of time to allow for the average 2-3 year integration and acceptance period for such solutions, while also ensuring a long product life and sustainable spare-part procurement. All components on the module are specified for the temperature range of -40 °C to +85 °C. The processor is designed for the AEC-Q100 Class 2 temperature range (at least from -40 °C to +115 °C). A low TDP (thermal design power) also makes passive cooling an option. The system platform is therefore optimized by design for the challenging operating conditions in mobile vehicles. The SOM is available as an application-ready, off-the-shelf component or as a development kit with a carrier board, cable set, and cooling solution. It integrates 4 GiB of soldered LPDDR4 RAM at 3200 MT/s (mega transfers per second), a 32-GiB eMMC non-volatile memory, and a 64-MiB QuadSPI flash. External SD card storage can be multiplexed with the onboard eMMC.

For connectivity, the SOM offers 18 CAN FD ports, four Serdes interfaces configurable as PCIe, four 1-Gbit/s Ethernet, two Flexray, and four LIN. 14 GPIOs, 12 analog inputs, three SPI, two UART, an USB and three I^{2}C complete the interface range. For trace and debug tasks, the module supports Aurora and JTAG interfaces.
A board support package for Linux, including bootloader configuration and the required drivers, rounds off the ▷

Example SOM implementation



NXP's Bluebox 3.0 computing platform (Source: NXP)

NXP's Bluebox 3.0 is an example implementation that illustrates the efficiency of SOM-based designs. The processor manufacturer NXP has chosen this approach and integrated the Miriac MPX-S32G274 SOM into the scalable development platform for safe automotive high-performance computing. The reason: It is much easier and more efficient to design-in an application-ready component that already integrates the processor, RAM, and flash than to start a full custom design from scratch. Developers are therefore well advised to use SOMs when designing their own board. One major challenge, for example, is ensuring signal integrity and quality. At very high frequencies, length matching, line impedance and impedance jumps are particularly taxing. Therefore, it is necessary to use a special PCB (printed circuit board) material. And, as the BGAs (ball grid arrays) are packed extremely densely, the PCBs need to have more layers. With SOMs, customers get a less complex PCB for the custom carrier board. The result: a simpler layout, lower PCB costs, and high signal integrity.

feature set. Besides standard automotive support from NXP, Microsys also offers optional support for dedicated FreeRTOS implementations for the Arm Cortex-M7 processors.

The modules come with the necessary documentation to simplify reuse in customers' certifications and documentation. This reduces the complexity of the approval process for customers. Another benefit is that OEMs (original equipment manufacturers) have access to competent experts helping them with any questions, for instance regarding safety-relevant software implementation, which is crucial for developers of IEC 62443 compliant industrial cyber security as well as ISO 26262 compliant functional safety solutions. The company also offers customer-specific design services at carrier board and system level. These extend to SIL (safety integrity level) certification for all sectors in which functional safety standards analog to IEC 61508 are required. This includes railway technology (EN 50155), stationary and mobile machinery (ISO 13849), industrial robots (ISO 10218), control systems (IEC 62061), and drive systems (IEC 61800-5-2). Approvals in the aviation context (DO-254/DO-160) are also simplified by the existing manufacturer documentation.

Suited for different applications

Due to extended temperature support, the Miriam SOMs are suited for industrial applications at a fixed outdoor location. Possible applications include e-mobility charging stations, critical infrastructures (Kritis) for trains, electricity, oil and gas pipelines, public safety systems, etc.

Anything that is deployed in vehicles must be extensively tested and logged in the prototype phase to track down errors and optimize the entire vehicle electronics. Microsys develops individually customized carrier boards and system designs for automotive test equipment and service providers. Since such platforms do not require complex certifications due to their intended use, the company's development teams can quickly deliver them in small to large quantities, not least thanks to close collaboration with the local component manufacturers.

The stationary and car-mounted test and measurement equipment used in automotive workshops must keep up with the rising performance of the chips installed in vehicles and be able to take more and more measurements at ever higher data rates and data depths. Test systems built on the same platforms as those used in the vehicles can keep up providing support of the given vehicle interfaces. If test and measurement systems are already developed for the prototype phase, the path to certified series production is not long. ◀

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