Driving Ethernet: everything safe and secure

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Market vision

Re-architecting the in-vehicle network: evolution or revolution?

Today's cars are equipped with dozens of fixed-function electronic control units (ECUs) and hundreds of sensors and actuators. Typically, every new function was introduced with its own ECU and a set of sensors and actuators that were connected through CAN and LIN buses. Starting in 2015, Ethernet was introduced to the in-vehicle network and since then it has spread across most ECUs. It enabled a first revolution that moved vehicle architectures from flat CAN-based network to hierarchical network split into several functional domains such as infotainment, powertrain, assisted driving, etc.

The introduction of advanced driver assistance systems (ADAS) and autonomous driving (AD) solutions, as well as the megatrends of electrification and the service-oriented software-defined vehicles (SDVs), are driving the next innovative steps in E/E architecture. The automotive industry is undergoing a transformative shift toward SDVs—vehicles where software defines and controls most functions, enabling continuous updates, enhanced safety and greater flexibility. A key enabler of this transition is the adoption of zonal architectures, which fundamentally reshape how vehicle electronics and networks are structured.

Software-defined vehicles are reshaping the automotive landscape.

From domain to zonal E/E architectures

As software becomes the major driver for OEM differentiation, hardware is no longer optimized for a single function. Next-generation vehicles will appear more like datacenters on wheels, with the hardware as the shared platform for flexible software modification and adaptation, surrounded by a cocoon of sensors and actuators.

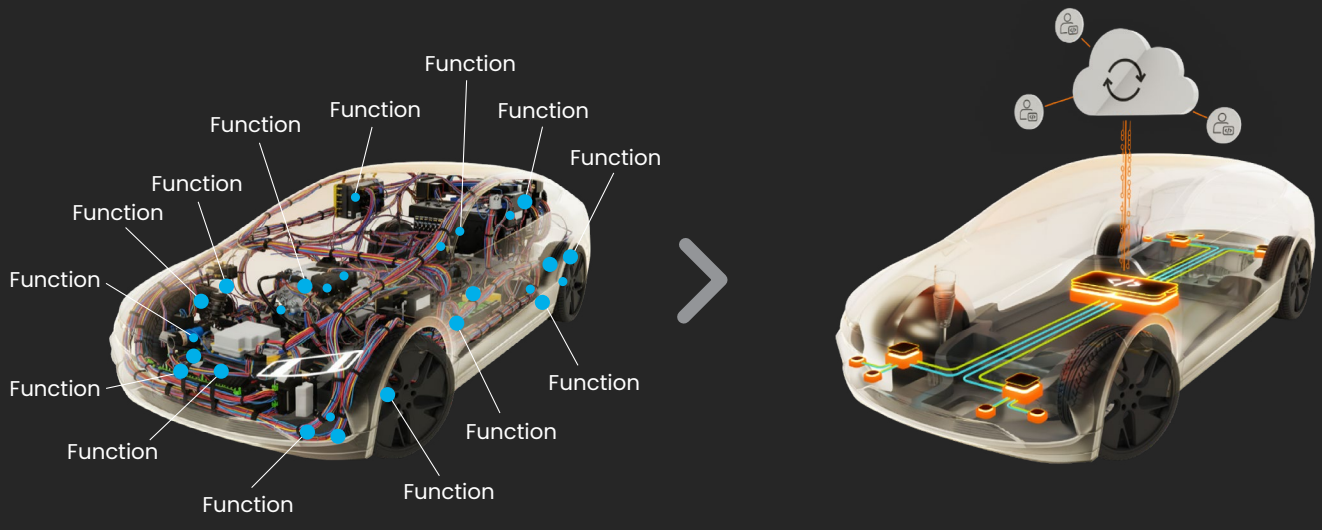
Application processing resources will be distributed and data communication between compute resources will massively increase. Further, sophisticated ADAS functions and growing demand for onboard infotainment will strain the data capacity of the in-vehicle network (IVN). Increasing data traffic, soaring overall compute power in the ECUs and the growing complexity of the wire harness (with its associated indirect cost) pose a huge challenge.

The introduction of E/E architectures purely developed for electric vehicles creates the opportunity for legacy OEMs to introduce the disruptive solutions, which are already rolled out by a few new, green-field OEMs. The so-called "zonal network" E/E architecture is such a potentially disruptive technology.

NXP is an integral part of recent technological advances that help OEMs and Tier 1s in all these transitional steps. As we anticipate future requirements for the self-driving car, the connected car and the electrified car, we see enormous potential for automotive Ethernet in a newly architected in-vehicle network as the best solution for automotive data management. Ethernet enables broadband connectivity with the necessary latency and predictability required for advanced control functions and full-motion video. At the same time, it reduces vehicle weight, saves power, increases efficiency and enables flexible software upgrades and hardware modularity. It makes autonomous driving more affordable.

Zonal E/E architectures and automotive Ethernet form the backbone of SDVs, enabling flexible software upgrades and reducing complexity.

Vehicle architecture transformation



Defined by **hardware**

Defined by **software**

The zonal vehicle network

In simple terms, a zonal IVN consists of the center and several zones, which we could also call the edge of the in-vehicle network. So rather than logically grouping the electronics, in a zonal network they are grouped by physical location. Sensors, actuators and, to some extent, functions (in terms of application processing), are locally connected to zonal input/output controllers. These can also be considered mini-gateways because this is where a CAN or LIN meets Ethernet.

The zonal I/O controllers are then connected through a high-speed Ethernet network backbone to the center, the brain of the car. It usually consists of several large, high-performance compute modules, where applications that once ran on dedicated ECUs now execute within virtual machines running on powerful multicore or even multiprocessor systems.

Zonal networks connect edge nodes to the central brain via Ethernet, reducing wiring and ensuring secure, efficient data flow.

Steering the development of efficient edge nodes

Along with higher speed grades for connections to the central brain, the creation of efficient gateway solutions for zonal nodes at the network edge is one of the key challenges in this transformation process. To reduce the complexity of the wiring harness, classic IVN buses will be terminated in the I/O controller. The conversion of bus signals to Ethernet packets enables the sharing of the same medium — a single, shielded twisted pair cable. This means that a large variety of data types simultaneously need to access the high-speed communication network.

The need to aggregate very different data types, with varying requirements in terms of criticality, safety and security is not a new problem as such. But the dissolving of functions while maintaining the data execution pipeline of sense-think-act requires to enable both: accessing and exiting of the data highway, and finally also the reconversion of Ethernet packets into CAN or LIN bus signals without impacting the criticality, safety or security requirements of each bit of information.

Over a long period of time, NXP has developed the experience and necessary competence beyond understanding the special requirements of automotive data execution pipelines. NXP is able to translate those attributes into products which make zonal architectures not just possible, but also more efficient. We are building safe and secure solutions for the edge of the network.

NXP – Driving Ethernet

Our total value proposition is based on our outstanding performance in six different dimensions:

Six pillars of excellence

Quality YoY consistent reduction of defects at OEMs	**Support** Excellent networking and application support	**Portfolio** One-stop-shop experience
Supply Multi-sourcing equals flexibility and agile supply	**Production** Planned capacity to cover market demand	**Innovation** Driving ideas for the future

and continuous improvements to exceed excellence in the future

One-shop experience, zero-defect mindset

These six IVN pillars of excellence create an effective one-shop experience for our customers who seek true automotive networking products. The continuous support strategy for all essential networking technologies — from CAN and LIN up to Ethernet — allows our customers to cover all their networking needs by NXP as trusted automotive supplier.

Total quality is a core theme within NXP. It is present in all our projects, products and everything we do in our daily business. Within IVN, we live a zero-defect mindset which has turned parts per million (PPM) into parts per billion (PPB) rates that decrease by 30% annually.

All that leads to robust, high-quality products that are well-suited for our customers' automotive applications and will help enable safe and secure connections within the car.

Learn more about our **zero defects methodology**

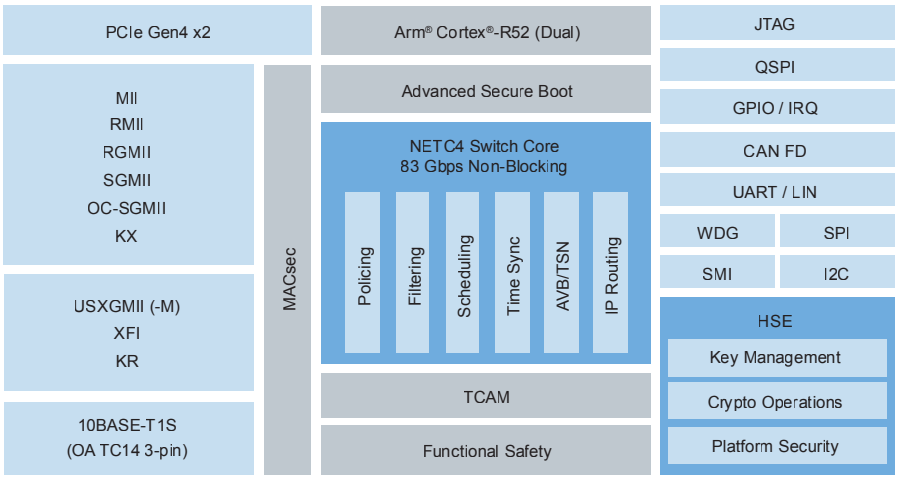
S32J100 Ethernet switch and network controller

S32J100 Ethernet switch and network controller provides dynamic and automated configuration options, making it an optimal solution for a wide variety of in-vehicle applications. Whether for central compute, zonal controllers, ADAS or IVI systems, it consistently delivers the performance and flexibility essential for supporting zonal architectures and software-defined vehicles (SDVs).

With high non-blocking switching capacity, S32J100 offers a range of port interfaces with speeds from 10 Mbps to 10 Gbps. Supporting the latest TSN standards, it optimizes data flows to ensure safe, secure, and real-time communication, while the embedded hardware security engine provides advanced, hardware-accelerated protection for sensitive data streams.

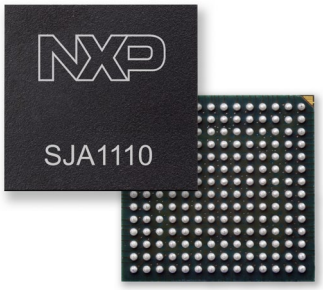
PCIe integration ensures high-bandwidth, low-latency connectivity for real-time processing and high-performance applications. The high-performance dual-core CPU, capable of operating in lockstep or split-lock modes with dedicated on-chip memory, delivers robust processing power.

As part of the NXP S32 platform, S32J100 maximizes software reuse, streamlining development and integration across diverse automotive systems.



Key features

- High-performance 83 Gbps non-blocking switch core
- Flexible port speeds from 10 Mbps to 10 Gbps
- PCIe Gen4 x2 for fast and efficient data delivery to high-end SoCs
- Full support for latest time-sensitive networking (TSN) standards
- Dual Arm® Cortex®-R52 cores with lockstep/split-lock modes
- ASIL D compute and ASIL B networking compliance
- Extensive TCAM and advanced stream classification
- Configurable switch memory allocation for tailored use cases
- Advanced secure boot with adaptable security levels
- Integrated MACsec and powerful Hardware Security Engine (HSE)
- System solution with S32x processors and FS25 PMIC



SJA1110 safe and secure TSN switch

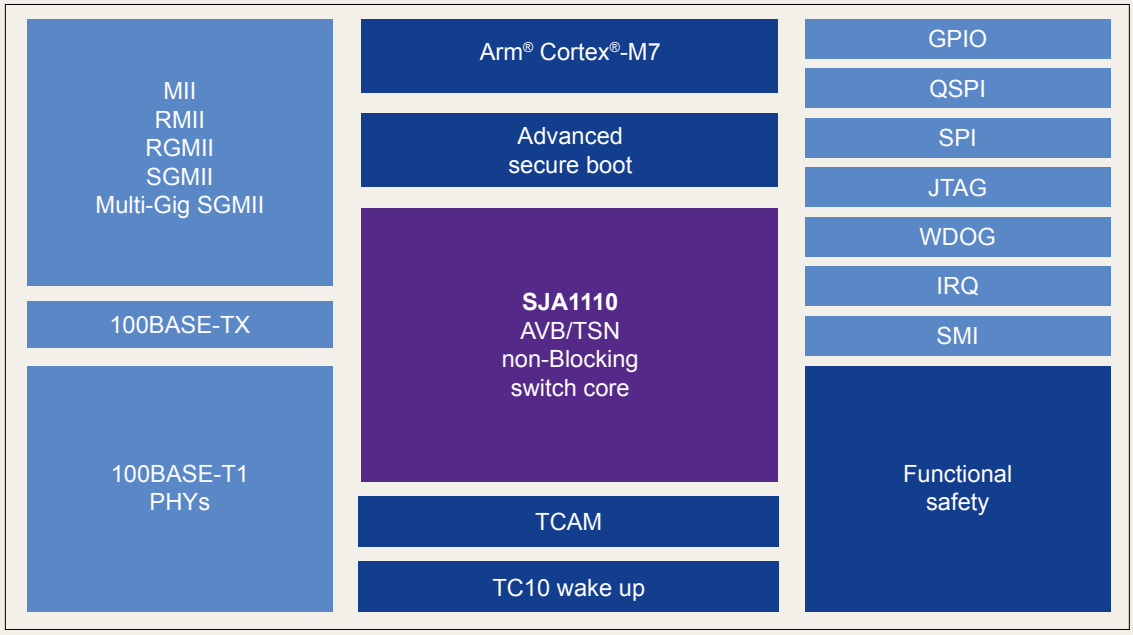
The SJA1110 automotive Ethernet switch family offers innovative and dedicated safety and security features designed for optimal integration in auto ECUs. The four switch variants enable modular ECU design and platforms and support different automotive applications such as gateways, ADAS boxes and infotainment ECUs.

For more information visit **nxp.com/sja1110**

Key features

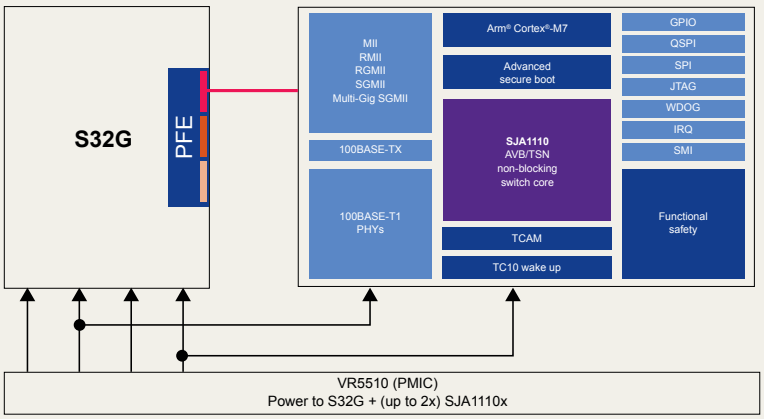
- Integrated 100BASE-T1 and 100BASE-TX PHYs
- ASIL B rating
- Integrated Arm® Cortex®-M7 based core
- Layer 2/3/4/5 packet inspection and DoS prevention capabilities
- Advanced secure boot capabilities
- Support for wake-over-Ethernet (OPEN TC10)
- Rich set of time-sensitive networking (TSN) standards
- Rich set of NXP original audio-video bridging (AVB) and AUTOSAR® software
- System solution with S32G vehicle networking processor and VR5510 power management unit
- Optional AEC-Q100 Grade 1 (ambient temperature range: -40 °C to +125 °C) operation

SJA1110 Ethernet switch block diagram



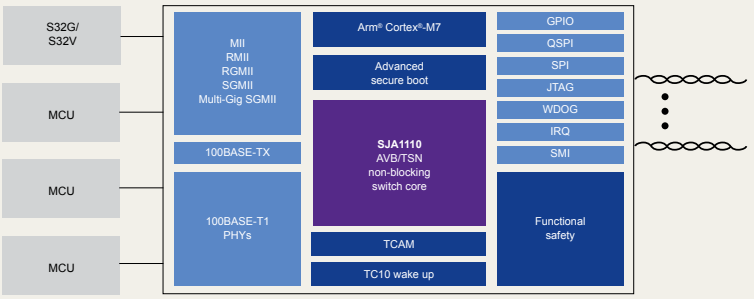
Networking applications

- Optimized NXP chipset solution with S32G processor enables unmatched routing, firewalling, intrusion / detection / prevention capabilities
- Exceptional TCAM-based frame inspection for IDPS support, DOS prevention and advanced frames management
- BoM optimization features include compatibility with VR5510 PMIC, four pin-compatible variants and optimized cascaded configuration



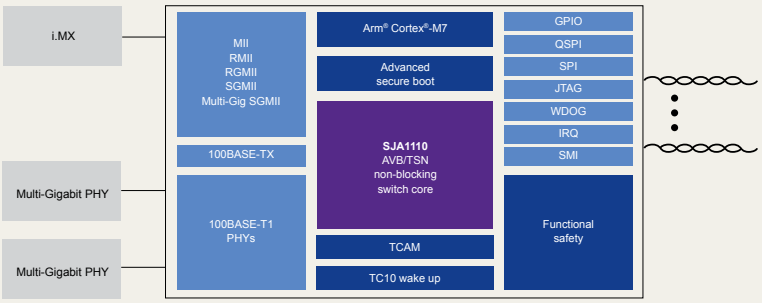
ADAS applications

- Functional safety-dedicated features improving ECU safety design
- Safety manual enable optimized safety design up to ASIL D ECUs
- Automotive Grade 1 (-40 °C to +125 °C) capability for optimized PCB design
- High-SGMII count for EMC friendly design
- Production-grade AUTOSAR® drivers
- Compatible with TTTech® MotionWise® middleware



Infotainment / cluster applications

- Multi-gigabit SGMII for external gigabit and multi-gigabit PHYs
- Autonomous operation support avoids dependency from untrusted external host
- Avnu®-Certified* AVB/gPTP stack for integrated controller
- Support for wake over Ethernet (OPEN TC10)
- Integrated controller with programmable GPIOs



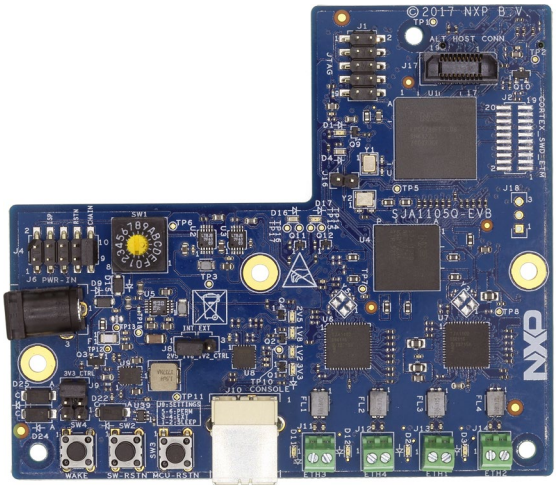
SJA1105 Ethernet switch family

Ethernet switches: enabling faster in-vehicle networks

The five-port automotive gigabit Ethernet switch SJA1105x series targets automotive applications such as gateway, infotainment and ADAS fusion boxes with an array of configurable ports, advanced security features and a comprehensive, production-grade development ecosystem. Each switch's audio-video bridging support (AVB) feature fully leverages infotainment and advanced driver assistance systems.

Key features

- Fully automotive AEC-Q100 qualified
- Automotive Grade 2 operation
- LFBGA-159 pin package (12 mm x 12 mm)
- Five ports, 10/100/1000 Mbit/s MII/RMII/RGMII and SGMII interfaces
- Non-blocking
- Support for AVB and TSN/802.1Qbv
- MAC address filtering
- TCAM based allow-listing/ deny-listing of MAC addresses
- Learning process with one-short learn option
- Double VLAN tag, frame replication and retagging



SJA1105Q-EVB
evaluation board

SJA1105P/ SJA1105Q/ SJA1105R/ SJA1105S Ethernet switch family

This Ethernet switch family extends the capability of the previous SJA1105EL/TEL switches with improved security- related features and extended interface options. The new frame listing feature limits the switch data processing to known sources, preventing the forwarding of erroneous or malicious data. The updated interfaces offer extended I/O voltage supply options and a new SGMII interface. These interfaces allow the switch to support any type of external PHY such as 100BASE-T1 (TJA1103/TJA1104) or 1000BASE-T1 (TJA1120/TJA1121). The switch can also operate as an inter-processor communication device between multiple processors and the DSPs on the same board. All ports can operate at gigabit speed in non- blocking mode.

Finally, the switches are delivered with a rich set of tools, including an evaluation board; original, production-grade AUTOSAR drivers and an AVB software stack.

The SJA1105Q-EVB is an evaluation system that supports the SJA1105P/ Q/R/S automotive Ethernet switch family together with the TJA1102A Ethernet PHY. The board enables the evaluation of the features common to the four switch family variants and facilitates the early development of the software required for the switch applications.

In addition, the board supports the Open Alliance TC10 wake-up forwarding feature implemented by the TJA1102A dual 100BASE-T1 PHY. Finally, the board also offers a connector capable of mating with NXP processor motherboards such as i.MX 6, i.MX 8 and S32x processors families.

For more information visit

nxp.com/SJA1105Q-EVB

Key features

- Enables evaluation of SJA1105P/Q/R/S series (with exception of SGMII)
- Directly connect to PC via USB
- Connect to i.MX 6, i.MX 8 and S32x processor evaluation boards
- Compatible with OPEN Alliance TC10 wakeup-forwarding output

Ethernet networking software

The transition to SDVs fundamentally shifts the automotive value chain toward software-centric architectures, where continuous updates, feature scalability and network efficiency are critical. NXP's software offerings for Ethernet PHYs and Ethernet switches directly support this transformation by providing production-grade real-time drivers, real-time operating systems and advanced networking stacks. These software solutions enable dynamic configuration, secure communication, and over-the-air update capabilities—key enablers for SDV ecosystems. By integrating tools like S32 design studio, Ethernet configuration tool and virtual development kits, NXP ensures that OEMs and Tier-1s can accelerate development cycles, maintain compliance with ISO 26262 and ISO/SAE 21434, and deliver future-ready, software-driven vehicle platforms. Moreover, the NXP CoreRide networking solution complements the software offerings by providing a unified, scalable platform that integrates hardware and software for next-generation E/E architectures. Built on the S32J family of Ethernet switches, NXP CoreRide networking leverages a common NETC switch core across NXP devices, enabling seamless software reuse and simplified integration.

For Ethernet PHYs, in general, NXP offers Linux and real-time drivers (AUTOSAR and non-AUTOSAR), fully integrated with EB Tresos and S32 design studio. To simplify evaluation and configuration, NXP provides Python-based tools and a dedicated PHY GUI.

For Ethernet switches, in general, the software offering includes real-time drivers (RTDs), Linux drivers, RTOS, TCP/IP and gPTP stack. Advanced tools such as the Ethernet configuration tool (ECT) and Python scripts enable efficient device bring-up and configuration. Integration with S32 design studio ensures streamlined development, while extensive compiler and debugger support (GCC, IAR, GHS, Lauterbach, PEmicro) enhances flexibility.

S32J1 Ethernet switch software

The S32J1 Ethernet switch software is offered primarily in two variants. Firstly, for the customers who prefer a software stack approach, a Software Development Kit (SDK) is provided. Secondly, for the customers who prefer a firmware out-of-the-box approach, a reference firmware is provided.

The Software Development Kit (SDK) provides customizable software components that customers can use to build firmware. It includes a set of reference applications and is delivered mostly as source code, free of charge for evaluation purposes. SDK requires more integration effort from customers and offers flexibility for tailoring solutions.

In contrast, firmware is integrated software that runs out-of-the-box on the S32J1 switch, requiring minimal customer effort and customization. Firmware is delivered primarily in binary form and is available in three variants: reference firmware, which is free for evaluation and intended for demonstration; pre-qualified firmware, designed for safety and security compliance and available under a production license; and custom-made firmware, tailored for production use on customer boards, also under a production license. Moreover, NXP has an extensive software partner network who mainly supports AUTOSAR integration and offers additional services based on customer requirements.

The S32J1 Ethernet switch software includes software stacks like gPTP, MKA, TCP/IP, and TLS, along with safety and security components such as safety software framework (SAF), structural core self-test (SCST), and premium HSE firmware. Real-time operating system support is provided through NXP RTOS, complemented by hardware enablement tools like EL2 monitor, IPCF, and various real-time drivers. Development is supported by a rich tool chain, including S32 design studio, S32 debugger, S32 trace, and FreeMASTER, along with a virtual development kit (VDK) for early prototyping.

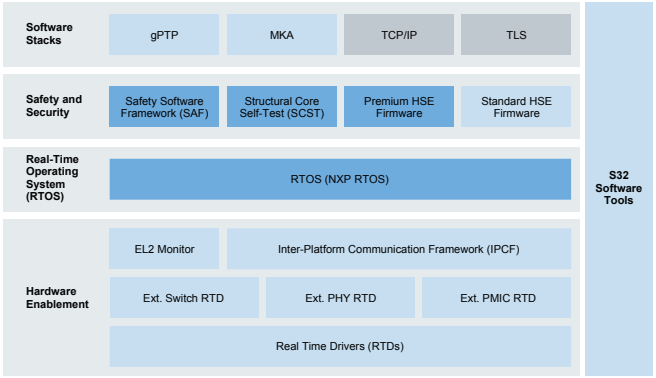
SJA1110 Ethernet switch software

The SJA1110 Ethernet switch software offering includes the gPTP stack for precise time synchronization across the network. Moreover, the TCP/IP stack ensures compatibility with standard IP-based communication.

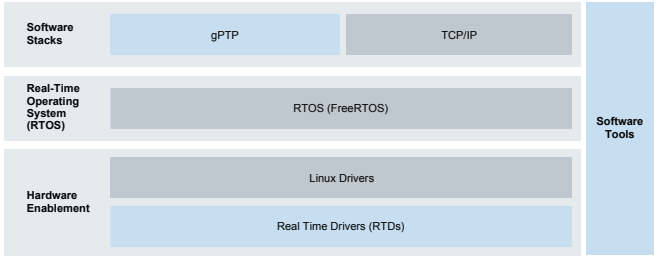
To achieve real-time responsiveness, the software stack incorporates a lightweight operating system environment like FreeRTOS, which provides deterministic task scheduling for time-critical functions. Complementing this, Linux drivers enable robust connectivity and integration with higher-level software components, supporting both embedded and external host environments.

The software stack also includes real-time drivers (RTDs), which are production-grade, safety-compliant software components designed to interface directly with Ethernet switches and PHYs. These drivers ensure compliance with AUTOSAR and non-AUTOSAR environments, offering flexibility for diverse system designs.

Example: S32J1 software offering



Example: SJA1110 software offering



Automotive target applications

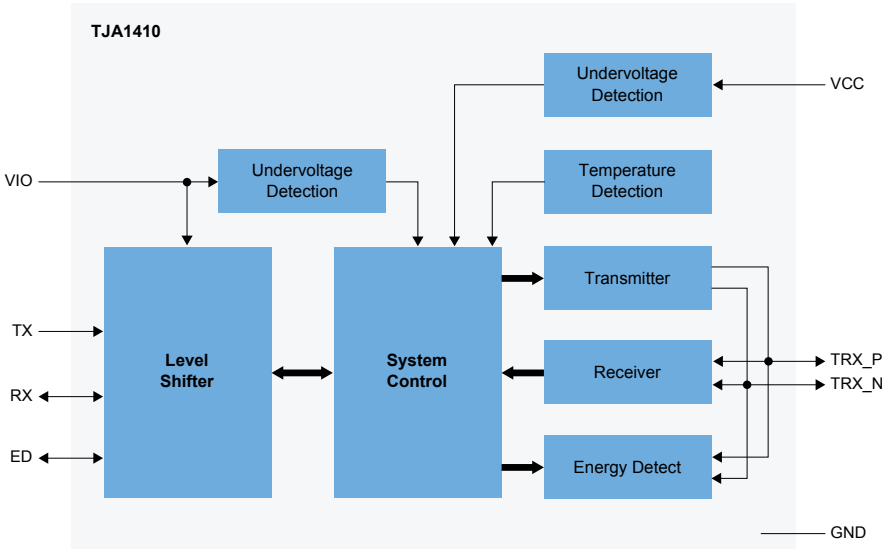
- Central compute 10BASE-T1S ports
- Zonal controller 10BASE-T1S ports
- Interior & exterior lighting
- Megawatt charging stations
- Body applications (e.g. door, seat)
- Short range radar
- X-by-wire (steering/braking)
- And many more...

TJA1410
ASIL B compliant 10BASE-T1S PMD transceiver

The 10BASE-T1S PMD transceiver is a low-cost connectivity solution for 10BASE-T1S. NXP's PMD transceiver TJA1410 is an Open Alliance TC14 compliant ASIL B PMD transceiver. It is made for proven EMC performance in-car ensuring highly reliable error-free in-car 10BASE-T1S communication under harsh automotive environments. It is a small footprint (3 x 3 mm) solution with communication over the OA TC14 standardized 3-pin interface.

TJA1410 complies with all state-of-the-art conformance test specifications for EMC and interoperability and is designed according to ISO 26262 to meet ASIL B, for achieving system functional safety. It supports Open Alliance TC14-TC10 remote wake-up over the Ethernet data line as well as local wake. It is specifically designed to achieve ultra-low quiescent currents for reduced power consumption in low power mode and fulfills requirements for automotive AEC-Q100 Grade 1.

TJA1410 10BASE-T1S PMD transceiver block diagram



Ready to explore TJA1410?

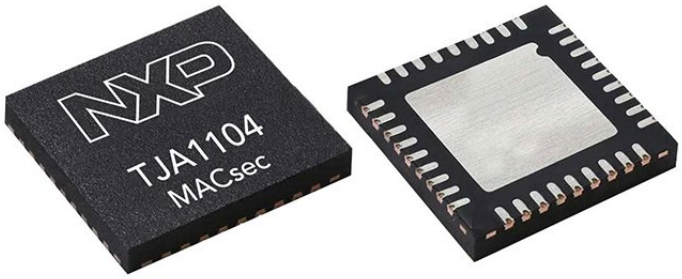
Get details & sample info

Key features

- Compliant to
  - IEEE 802.3cg
  - OA TC14 PMD specifications
- Functional safety ISO 26262 ASIL B compliant
- Open Alliance TC-14 topology discovery
- Proven EMC performance in vehicle
- Passing all OA TC14 EMC specifications
- Proven interoperability
- Low footprint HVSON8 (3 mm x 3 mm) package
- Low quiescent current
- OA TC10-TC14 local & remote wake
- AEC-Q100 grade 1

Notes

- Compatible with PoDL implementations



TJA110x
ASIL B compliant 100BASE-T1 Ethernet PHYs with MACsec option

TJA1103/04 100BASE-T1 PHY family offer data rates of up to 100 Mb/s and the option for MACsec. The latest 100BT1 PHY family is drop-in compatible with TJA112x PHYs, enabling platform designs with optimized PHY product for up to 1 Gbps data rates. The TJA1104 adds MACsec functionality to NXP's 100BASE-T1 automotive Ethernet PHY portfolio and addresses the security concerns for future networks. Moreover, TJA1104 provides an efficient HW based solution for MACsec at 100 Mbps line rate. To enable easy data rate and security scaling, both TJA1103 and TJA1104 are kept drop-in compatible with TJA1120 and TJA1121. The TJA1103/04 are available in an RGMII (TJA110xA) and SGMIII (TJA110xB) variant and come in compact package HVQFN36 (6 x 6 mm) for space constraint use cases.

TJA1103/04 complies with all state-of-the-art conformance test specifications and are designed according to ISO 26262 to meet ASIL B, providing enhanced monitoring and diagnostic features. Further, they integrate OPEN Alliance TC-10 compliant wake-up forwarding over the Ethernet data line. They support shielded (STP) and unshielded twisted pair (UTP) cable applications.

Key features

- **Flexible interfaces:** RGMII (TJA110xA) or SGMII (TJA110xB)
- **Security:** Option for MACsec (TJA1104)
- **Same compact package for all versions:** 36-pin, 6 mm x 6 mm HVQFN, wettable flanks
- **Ready to go software:** real time drivers (AUTOSAR® and low-level) and Linux

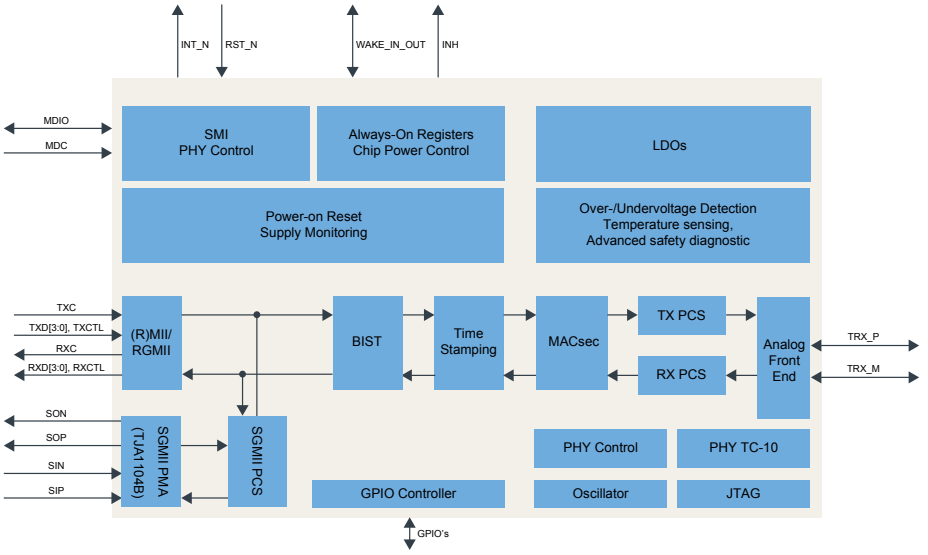
Fulfilling automotive requirements

- AEC-Q100 Grade 1
- OPEN Alliance TC10
- EMC/ESD for all WW OEM standards (IEC 62228-5, IEC 61000-4-2. SAE 2962-3:2024)

Advanced features for future requirements

- IEEE 1588v2 / 802.1AS compliant PTP (2-step; 4 ns accuracy)
- OPEN TC-1 advanced PHY features

TJA1103/04 Ethernet PHY block diagram



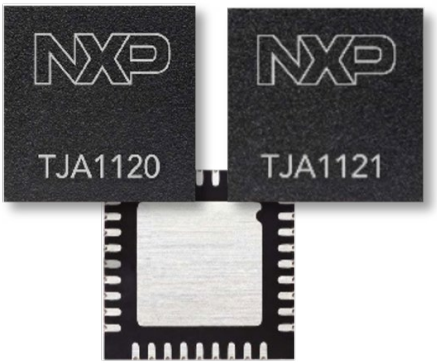
Automotive target applications

- Radar systems
- Sound system
- Vision systems & cameras
- Car radio
- E-cockpit & head unit
- Remote tuner
- TCU
- Gateway & domain controller
- And many more...

For more information visit

nxp.com/TJA1103

nxp.com/TJA1104



Key features

- **Flexible interfaces:** RGMII (TJA112xA) or SGMII (TJA112xB)
- **Security:** option for MACsec (TJA1121)
- **Same compact package for all versions:** 36-pin, 6 mm x 6 mm HVQFN, wettable flanks
- **Ready to go software:** real time drivers (AUTOSAR® and low-level) and Linux

Fulfilling automotive requirements

- AEC-Q100 Grade 1
- OPEN Alliance TC10
- EMC/ESD for all WW OEM standards (IEC 62228-5, IEC 61000-4-2, SAE2962-3:2024)

Advanced features for future requirements

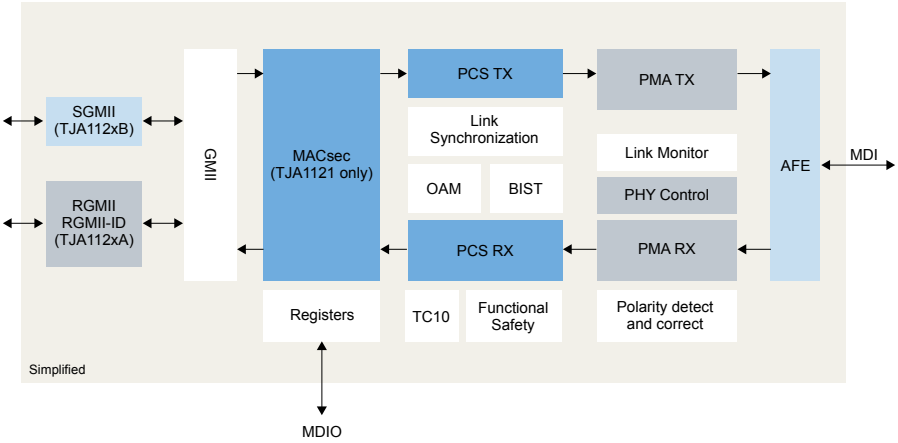
- IEEE 1588v2 / 802.1AS compliant PTP (2-step; 4 ns accuracy)
- IEEE 802.3bu – PoDL Class 3
- OPEN TC-12 advanced PHY features

TJA112x ASIL B compliant 1000BASE-T1 Ethernet PHYs with MACsec option

TJA112x 1000BASE-T1 PHY family offers data rates up to 1 Gb/s and the option for MACsec. This latest PHY family is drop-in compatible to the earlier released TJA1103 and TJA1104 100BASE-T1 PHYs, enabling platform designs with optimized PHY product for 100 Mbps or 1 Gbps data rates. The TJA1120 is a standard 1000BASE-T1 PHY, while the TJA1121 adds MACsec functionality to NXP's 1000BASE-T1 automotive Ethernet PHY portfolio. It addresses the security concerns for future networks and provides an efficient HW based solution for MACsec at 1 Gbps line rate. To enable easy data rate and security scaling, the TJA1121 is kept drop-in compatible with TJA1103, TJA1104 and TJA1120. Both the TJA1120 and TJA1121 are available in an RGMII (TJA112xA) and SGMIII (TJA112xB) variant and come in compact package HVQFN36 (6 mm x 6 mm) for space constraint use cases.

TJA112x complies with all state-of-the-art conformance test specifications and is designed according to ISO 26262 to meet ASIL B, providing enhanced monitoring and diagnostic features. Further, it integrates OPEN Alliance TC-10 compliant wake-up forwarding over the Ethernet data line. It supports shielded (STP) and unshielded twisted pair (UTP) cable applications.

TJA112x Ethernet PHY block diagram



For more information visit

nxp.com/TJA1120

nxp.com/TJA1121

Automotive target applications

- Radar systems
- Sound system
- Vision systems & cameras
- Car radio
- Ecockpit & head unit
- Remote tuner
- TCU
- Gateway & domain controller
- And many more...

MACsec for automotive applications

A modern high-end car can have up to 150 electronic control units (ECUs). The data is shared, aggregated, pre- and post-processed in different locations around the network.

Cybersecurity principles apply here. They call for a thorough check on whether the received data is from a trusted source, that it was not modified enroute, and that all cryptographic operations in MACsec, i.e. encryption, decryption, authenticity check, are done as prescribed in the AES standard. In short, the data's confidentiality, integrity and authenticity need to be ensured.

These concerns are all addressed by the IEEE 802.1AE standard, which is also known as MACsec. It is a new element in the security toolbox that is now available to OEMs. MACsec is generally applicable to any Ethernet link inside the car, as an alternative to application or IP protocol layer-based security. This standard was first published in 2006 and rolled out in mission critical enterprise. The automotive industry is tailoring IEEE 802.1AE-2018 to automotive applications.

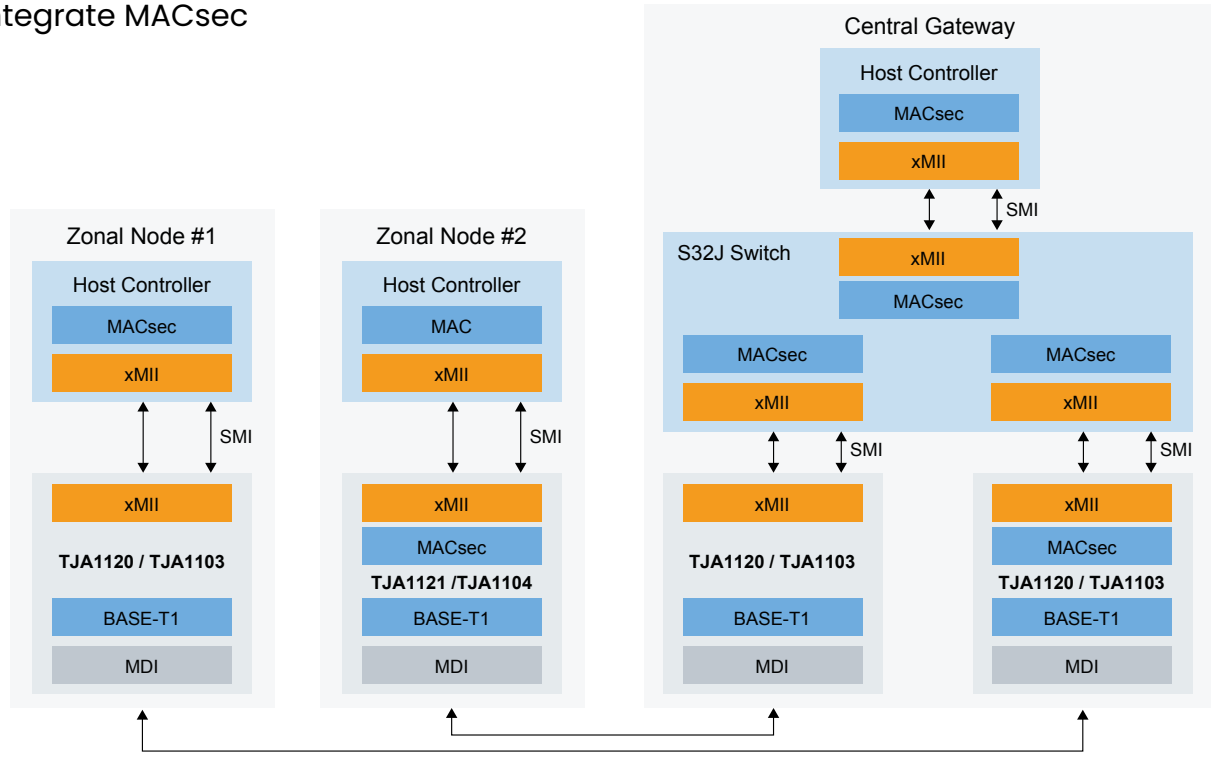
Different ways in which MACsec can be integrated into the system

The MACsec protocol can run in different locations within a motor vehicle, including on the host controller, in switches and in PHYs (see figure 1). The first element of this illustration shows how the zonal node 1's host control has MACsec integrated to the MAC. In the second zonal node, the MACsec is integrated to the PHY (100BASE-T1 and 1000BASE-T1). In the central gateway, both the switches and host controller have MACsec integrated.

MACsec can generally be implemented in SW, but the implementation becomes less efficient, for higher bandwidth requirements. Hardware acceleration is generally required for speed grades higher than 10 MB. The MACsec IP can be integrated in PHY, Switch or µC. Several NXP processor roadmaps are already adopting MACsec.

Figure 1

Designers have multiple options to integrate MACsec



NXP's MACsec implementation

NXP MACsec-enabled Ethernet devices fully support the IPG, as shown in figure 2A; it is a standard Ethernet stack compliant solution. In case host microcontroller does not support the IPG to the required extent, we offer a proprietary alternative called TLV, as shown in figure 2B.

NXP intentionally does not support alternatives, specifically we do not support flow control by pause frame and stall signaling, which are not compatible with time aware protocols such as AVB and TSN.

To summarize, every link in the modern vehicle is a potential point of attack for malicious hackers and must be protected. For such man-in-middle attacks, MACsec (IEEE 802.1AE) offers multiple counter-offensives. It protects data against corruption, authenticates messages from untrusted devices, inspects the data's source and provides replay protection against frame retransmission. Although MACsec is a complex response, if understood thoroughly and deployed with intent, it will prove to be an effective defense against external attacks. For these reasons, NXP is integrating several of its upcoming Ethernet products with MACsec and will continue to expand this offering in the future.

NXP Ethernet with MACsec delivers authentication, integrity, and replay protection.

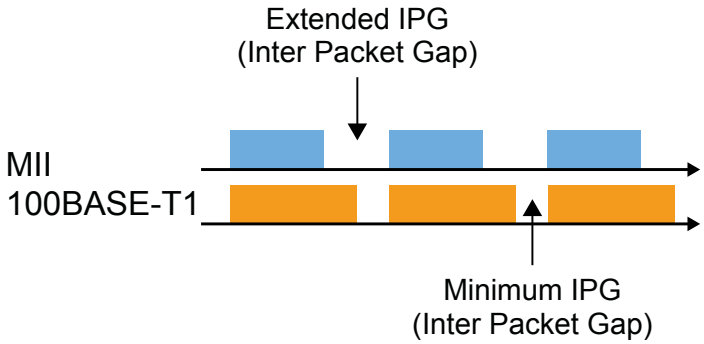


Figure 2A

An example of extended IPG

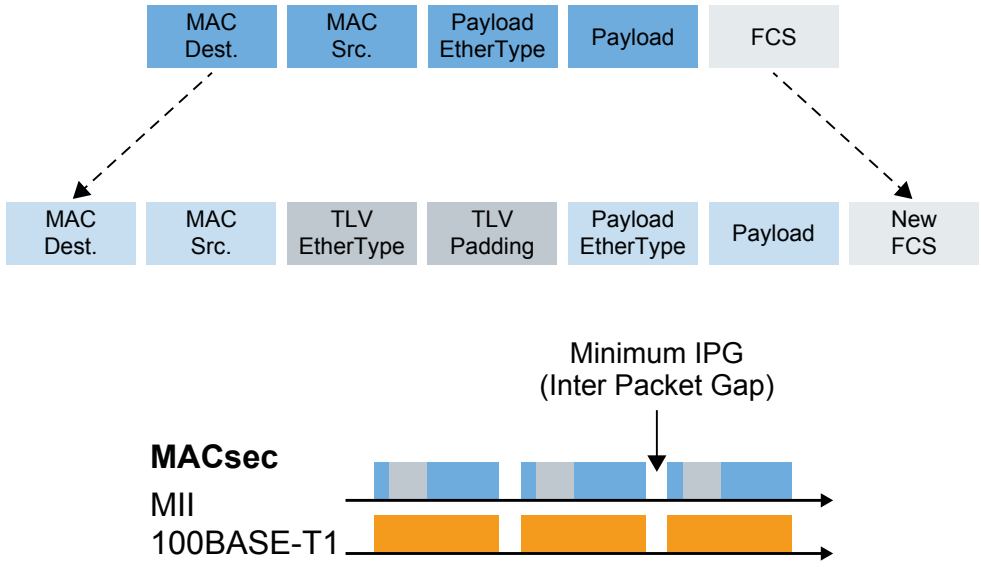


Figure 2B

As an alternative to the IPG approach, NXP proposes using a proprietary header

NXP 100BASE-T1 Ethernet PHY family

Family	Feature	TJA1103	TJA1104	TJA1120	TJA1121	Description
Automotive	Data rate	100 Mbit/s	100 Mbit/s	1000 Mbit/s	1000 Mbit/s	Sufficient data rate to meet infotainment, ADAS requirements
	Package	HVQFN36	HVQFN36	HVQFN36	HVQFN36	Small size, saves PCB board space
	Package size	6 x 6 mm	6 x 6 mm	6 x 6 mm	6 x 6 mm	
	Temperature range	-40 to +125 °C	-40 to +125 °C	-40 to +125 °C	-40 to +125 °C	Automotive grade 1, high robustness to support automotive applications
	Unshielded twisted pair (UTP) channel length up to at least	15 m	15 m	15 m	15 m	Low-weight cable, high flexibility and low-cost Proper cable length fit for automotive requirements
	Interface	MII/RMII/ RGMII(-ID)/ SGMII	MII/RMII/ RGMII(-ID)/ SGMII	RGMII/SGMII	RGMII/SGMII	Standard interfaces
	Supply voltage	3.3 V or 2.5 V	3.3 V or 2.5 V	3.3 V, 1.8V, 1.1V	3.3 V, 1.8V, 1.1V	TJA1103/04 allows for single supply, removing the need for external voltage regulators
	Additional supply enabled	2.5 V, 1.1 V	2.5 V, 1.1 V	3.3V 2.5 V, 1.8 V (VIO)	3.3V 2.5 V, 1.8 V (VIO)	Save power on component level
	Ethernet ports	1	1	1	1	Dual port solution saves ECU board place, simplifying system layout and config
	Pin strapping	✓	✓	✓	✓	Hardware config during start-up, allows autonomous operation
	Signal quality indicator (SQI)	✓	✓	✓	✓	Makes channel effects visible
	PTP time stamping	✓	✓	✓	✓	Industry leading accuracy for global time synchronization
	ISO262622	ASIL B	ASIL B	ASIL B	ASIL B	Adequate safety features have been implemented on-chip, to support functional safety concepts on system level.
	TC-10 compliant partial networking	✓	✓	✓	✓	OPEN-Alliance TC-10 compliant wakeup- and-sleep concept

NXP 100BASE-T1 Ethernet PHY family

Family	Feature	TJA1103	TJA1104	TJA1120	TJA1121	Description
Diagnosis	Overtemperature protection	✓	✓	✓	✓	Prevent device from getting damaged by overtemperature
	Cabling error detection (shorts and opens)	✓	✓	✓	✓	Remote diagnosis
	Supply undervoltage detection with fail- silent behavior	✓	✓	✓	✓	Prevents the PHY from running in an undefined state Increases system-level functional safety
	Internal, external and remote loopback mode	✓	✓	✓	✓	Allows system diagnostics of the communication path
	OPEN TC1 advanced PHY features	✓	✓	✓	✓	Specification for advanced features of an 100BASE-T1 automotive Ethernet PHY,
Low Power Mode	Low-power sleep mode	35 µA	35 µA	35 µA	35 µA	Low power consumption to ensure battery level
	INH switch controls ECU supply	✓	✓	✓	✓	Set automotive power modes
	Local wake-up support	✓	✓	✓	✓	Most common and secured wake-up option

TJA11xx Ethernet PHY evaluation kit

To enable easy evaluation and use of our TJA11xx 100BASE-T1 and 1000BASE-T1 PHYs our Ethernet PHY evaluation kit follows a common board strategy. The kit consists of two parts, namely TJA11xx-EVB and TJA11xx-SDBx. The TJA11xx-EVB, also referred to as the base board, is common between the PHY transceivers i.e. TJA1103, TJA1104, TJA1120 and TJA1121. Whereas TJA11xx-SDBx, also called the SABRE card, is specific to the Ethernet PHY. Different board versions are provided for RGMII (xSDBR) and SGMII (xSDBS).

The use of the SABRE interface allows for quick application prototyping with various NXP system development boards that feature the common SABRE connector; for example, our S32x EVBs and latest radar SoCs. The boards also represent a reference design for scaling from 100 to 1000BASE-T1 with or without MACsec within the TJA11xx PHY family. The same board design is populated with either TJA1103, TJA1104, TJA1120 or TJA1121.

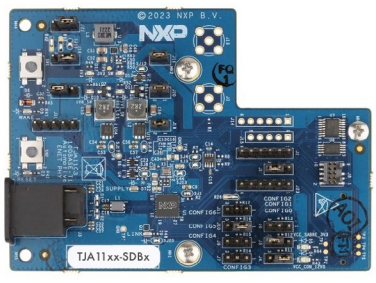
The TJA11xx-EVB baseboard board acts as a hardware evaluation baseboard for 100BASE-T1 or 1000BASE-T1 PHYs. The evaluation board is designed to be a breakout board that can be used as host board for SABRE daughter boards. Moreover, the EVB allows access to all relevant signals that the baseboard exposes on the SABRE connector and also provides power to the SABRE daughter board. Together, the two boards form the Ethernet PHY evaluation kit.

NXP MCU/MPU boards with SABRE

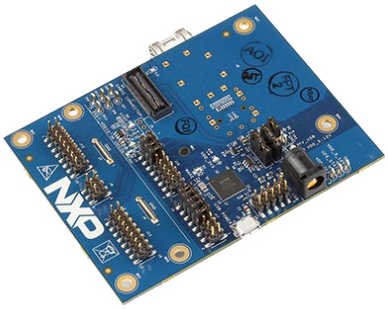
- S32K3: S32K3 microcontrollers for automotive general purpose
- S32G vehicle network processors
- S32Z/E: safe and secure high-performance real-time processors

Benefit of using NXPs TJA11xx PHY boards

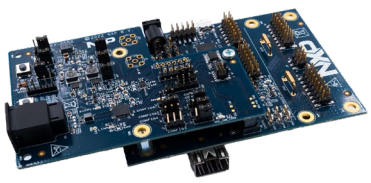
- Simple evaluation of multiple different PHY variants
- Scalable solution for data rate (100 Mbps/1 Gbps) and security (MACsec option)
- SW drivers available
- Flexibility in connectivity with multiple NXP MCU/MPU EVBs



Picture of TJA11xx-SDBx



Picture of TJA11xx baseboard with SABRE connector on top



Picture of TJA11xx EVB kit Baseboard (lower) + SDBx (upper) board

Hardware features

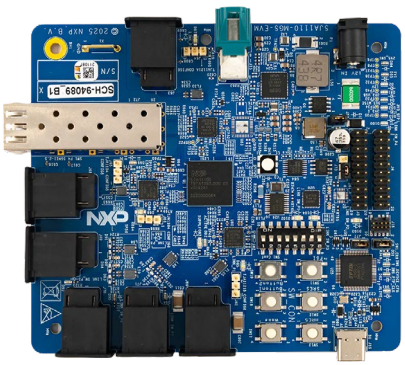
- Secure variant of SJA1110 switch
- 100BASE-T1 (SJA1110 internal PHYs)
- 1x 100BASE-T1 Ethernet port using the TJA1104 automotive Ethernet PHY
- 2x 1000BASE-T1 Ethernet port using the TJA1121 automotive Ethernet PHY
- 1x SFP+ cage
- JTAG connector
- Several LEDs for status indication
- DIP switches for easy configuration
- USB-C connector for SPI access
- Power supply based on VR5510 PMIC

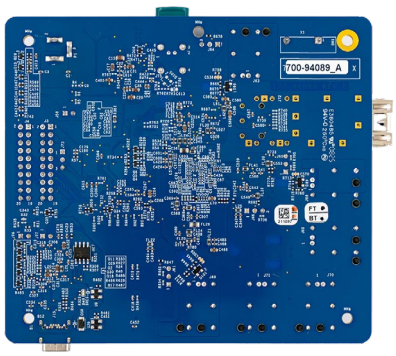
Software features

- Software examples based on real time drivers (RTDs)
- gPTP software stack
- TCP/IP software stack

SJA1110 Ethernet switch multi-gig secure evaluation board (SJA1110-MGS-EVM)

The SJA1110-MGS-EVM is a compact, cost-effective multi-gig secure evaluation board, ideal for automotive Ethernet use cases. Consisting of the SJA1110 switch along with TJA1121 and TJA1104 PHYs, the board demonstrates MACsec security on both PHYs and enables rapid prototyping with integrated software examples based on real time drivers (RTDs).





S32R45 PurpleBox reference design for distributed radar architectures

Single NXP reference design for full distributed radar solution

The PurpleBox is a reference design for distributed radar sensor architectures designed to aggregate and process four corner radar sensors at once, receiving compressed range FFT data and producing a high-density surround point cloud. The PurpleBox can be used as a reference ECU and is a key component of a radar bridge proof-of-concept based on NXP's S32R45 radar processor. It comes with a comprehensive software development environment as well as with an M.2 PCIe interface which can be used to attach a mass storage device or a machine learning accelerator.

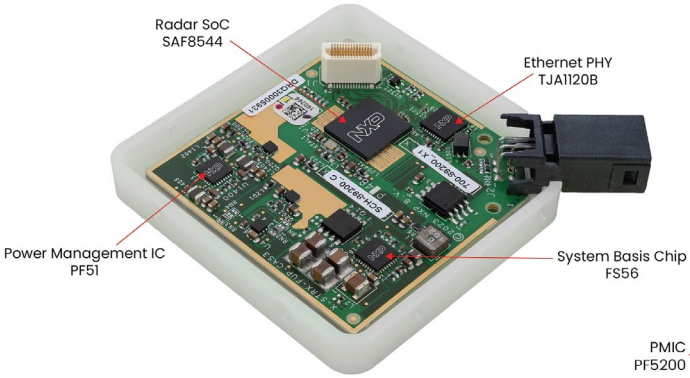
To evaluate a distributed radar architecture, our Pluto radar sensor can be used together with the PurpleBox. The Pluto radar sensor reference design enables customers to evaluate corner and front radar applications.

Learn more at: **nxp.com/purplebox**

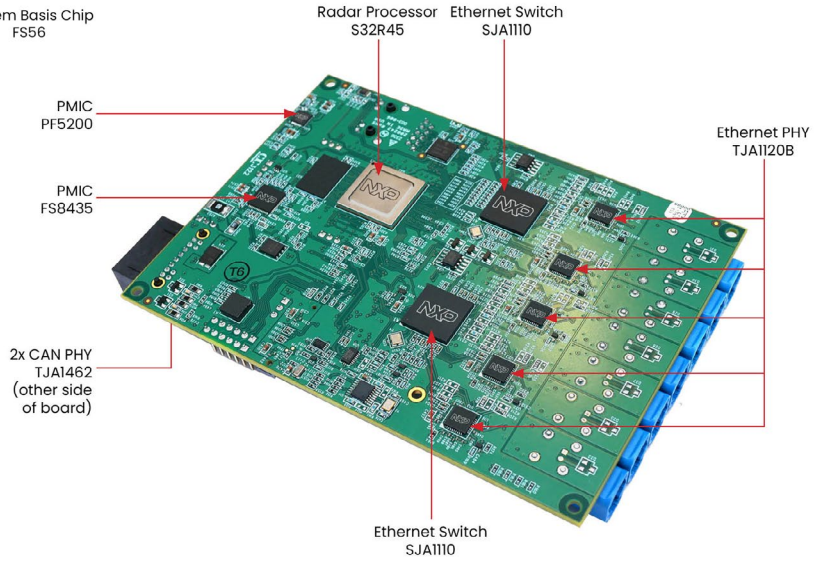
Technical highlights

- SJA1110 ASIL B automotive Ethernet switch with TSN and advanced security capabilities
- 5x TJA1120 1000BASE-T1 capabilities to underface with Pluto sensors
- Aggregation and central processing of four corner radar sensors at once
- Produces a high-density surrounding point cloud
- Optional AI acceleration up to 26 tera-operations per second (TOPS) enabling enhanced point clouds
- Optional NVMe storage facilities for data gathering and playback
- Full example radar processing chain:
  - Range, Doppler
  - DDMA
  - Coherent/non-coherent combining
  - OS CFAR
  - Accelerated DoA algorithms such as iterative adaptive approach (IAA)
  - ISO 26262 support by using safety components and architecture

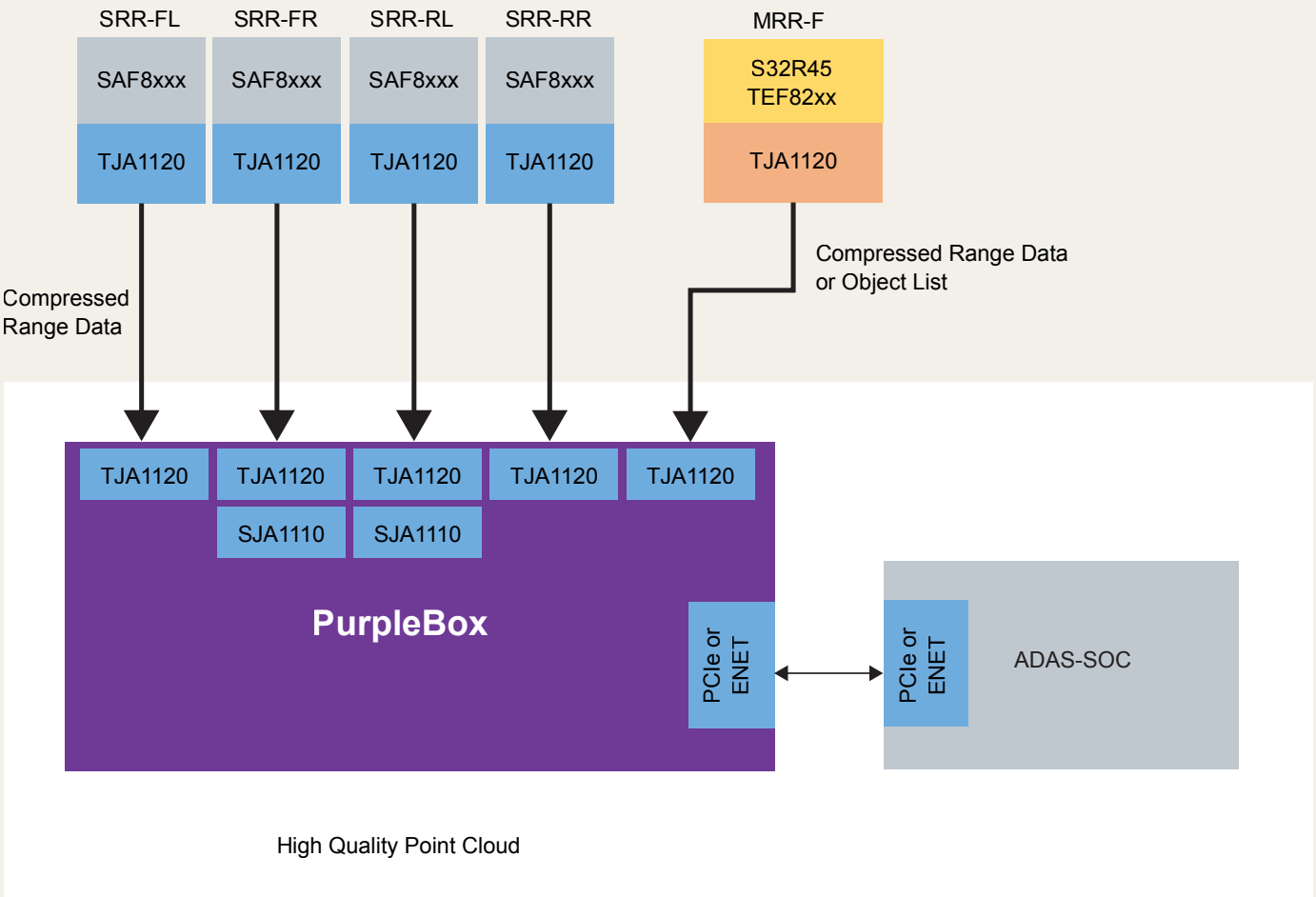
Pluto radar sensor

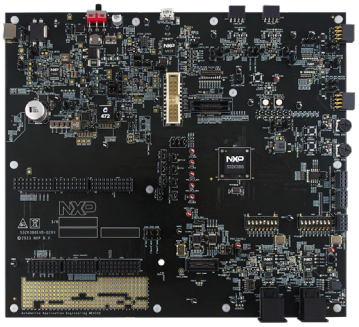


PurpleBox contains SJA1110 + 5x TJA1120 1G PHY



System block diagram





S32K388-Q289 EVB including TJA1120

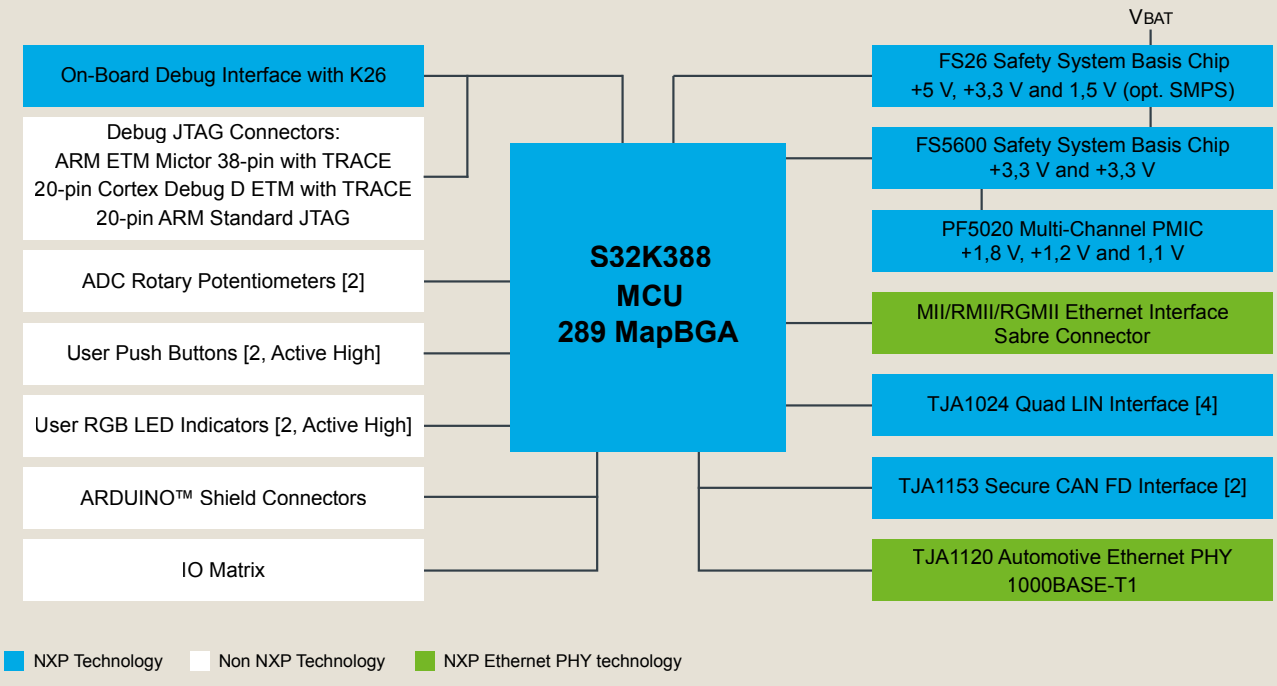
The S32K388EVB-Q289 is an evaluation and development board for general-purpose industrial and automotive applications.

Based on the 32-bit Arm® Cortex®-M7 S32K3 MCU in a 289 MAPBGA package, the S32K388EVB-Q289 offers a multicore mode, HSE_B security engine, OTA support, advanced connectivity, 2 x 1 Gbit Ethernet ports, populated with TJA1120.

Key features

- 1x 1000 gigabit Ethernet TJA1120
- 1x SABRE connector to external Ethernet interface
- JTAG connector
- Free of charge real time drivers (RTD) for AUTOSAR® and non-AUTOSAR use and ASIL D compliant
- Free of charge S32 design studio IDE (Eclipse, GCC and debugger) and S32 config tool (pins, clocks, peripherals) with third-party compilers and debuggers
- Configuration tools for both AUTOSAR and non-AUTOSAR user

System block diagram



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