NXP—Driving Ethernet® Innovations for safe and secure high speed networks

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OVERVIEW

Automotive Ethernet does more than support mobile connectivity and complex, high-bandwidth automotive applications; it's a key enabler in perfecting the completely connected car of tomorrow and creating safer, more affordable, and higher-performing vehicles. As a long-time proponent of the connected car, NXP has designed a broad portfolio of robust, flexible and cost-effective automotive Ethernet products to connect your vehicle systems faster and more efficiently.

Driving In-Vehicle Networking
Two million automotive transceivers shipped every day

Driving Ethernet
NXP offers a complete solution from safe and secure PHY transceivers and switches to development platforms and software

Driving the Network of Tomorrow
IEEE silicon standards with scalable speed grades and levels of integration

MARKET VISION

APPROACHING AUTONOMY: THE PROMISE OF FUTURE MOBILITY

Today's cars are equipped with dozens of electronic control units (ECUs), transmitters, receivers, actuators, sensors and other electronic components. Many of them work together in highly refined advanced driver assistance systems (ADAS) to support the driver and make the car safer, more connected, comfortable, energy efficient, environmentally friendly and easier to drive. To meet these goals, the car needs to gather, process and respond to an enormous amount of data that will only increase as cars take on more autonomy.

DATA DILEMMAS MEET NXP SOLUTIONS

Managing and distributing all that data in a cost-effective, efficient way is a significant challenge. ADAS functions can strain the data capacity of an in-vehicle network (IVN) already taxed by an onboard entertainment system with its own demanding bandwidth requirements. Each evolution of ADAS and infotainment systems will require even more bandwidth. For self-driving cars to become an everyday reality, designers first need to find a way to manage all the data and processing required to support autonomy. Then, they need to do it in a way that both increases safety and adds convenience, all while reducing overall cost.

NXP is an integral part of recent technological advances that help designers increase bandwidth and manage complex autonomous driving requirements. As we anticipate future requirements for ADAS, IVNs and onboard entertainment, we see enormous potential for automotive Ethernet in a distributed vehicle network as the best solution for automotive data management. It 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, enables upgrades and makes autonomous driving more affordable.

THE DISTRIBUTED VEHICLE NETWORK

In an automotive Ethernet setup, multiple vehicle systems simultaneously access high bandwidth over a single UTP cable. The Ethernet becomes the backbone of the vehicle network and supports higher levels of data processing and more communication types. Using traffic engineering features such as VLANs means each port receives dedicated bandwidth and the entire backbone is capable of IP connectivity. We envision a backbone architecture made of hierarchically organized domain controllers, with IP-based routing and high communication bandwidth.

Instead of supporting individual high-bandwidth functions, the architecture supports all the high-bandwidth functions that reside on the same physical network but use logically separated virtual networks.
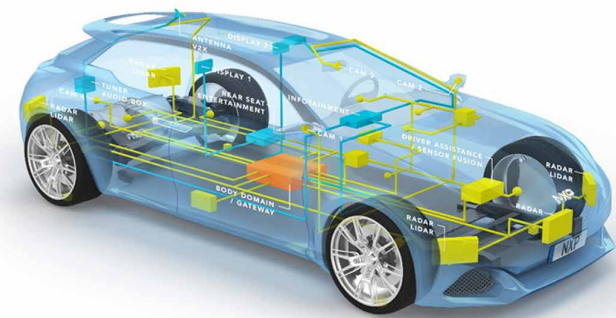
By using automotive Ethernet in a distributed vehicle network, manufacturers can move components out of the head unit and place them closer to where they're needed throughout the vehicle, freeing space in the head unit while also increasing operational efficiency and performance. For example, if a designer moves the tuner module closer to the antenna, they can reduce heat in the head unit and dashboard area and significantly reduce cabling costs.

LEADING THE WAY TO AUTONOMOUS DRIVING

Real-time processing and in-vehicle networking technologies of the next decade will likely revolutionize how we move around, how we interact with our vehicles and how our vehicles react to the infrastructure and each other. At NXP, we envision automotive Ethernet as an essential part of this revolution.

Working with Ethernet in the car, however, means a paradigm shift in next-generation IVN system designs as automotive designers connect different domain networks, transport various data (control data, streaming, etc.) and meet strict requirements for extended temperature ranges and EMC performance. We believe this new way of designing is worthwhile because it increases bandwidth, reduces vehicle weight and lowers costs so designers can introduce new and desirable functionality without enormous cost increases.

Automotive Ethernet will connect the vehicle's internal digital devices, connect the vehicle with other vehicles and even make the car a productive part of the IoT. It supports the high bandwidth and real-time processing required for today's infotainment and ADAS systems and provides a platform for the development of truly autonomous driving.

NXP and Automotive Innovation

ROADMAP TO 1 AND MULTI GBIT/S

The IEEE® is working on an automotive-grade Ethernet PHY that can support data rates up to 1 Gbit/s. The aim is to accommodate increasingly sophisticated applications that require higher bandwidth, while eliminating potential interoperability issues between different bandwidth versions. Object detection, for example, is one of the primary applications for Gigabit Ethernet and it supports uncompressed video. On the other hand, 10 Mbits/s Ethernet is expected to substitute FlexRay, simplify network protocols and reduce cabling cost. The layered structure of Ethernet will make it relatively straightforward to upgrade cars to the higher bandwidth once it becomes available.
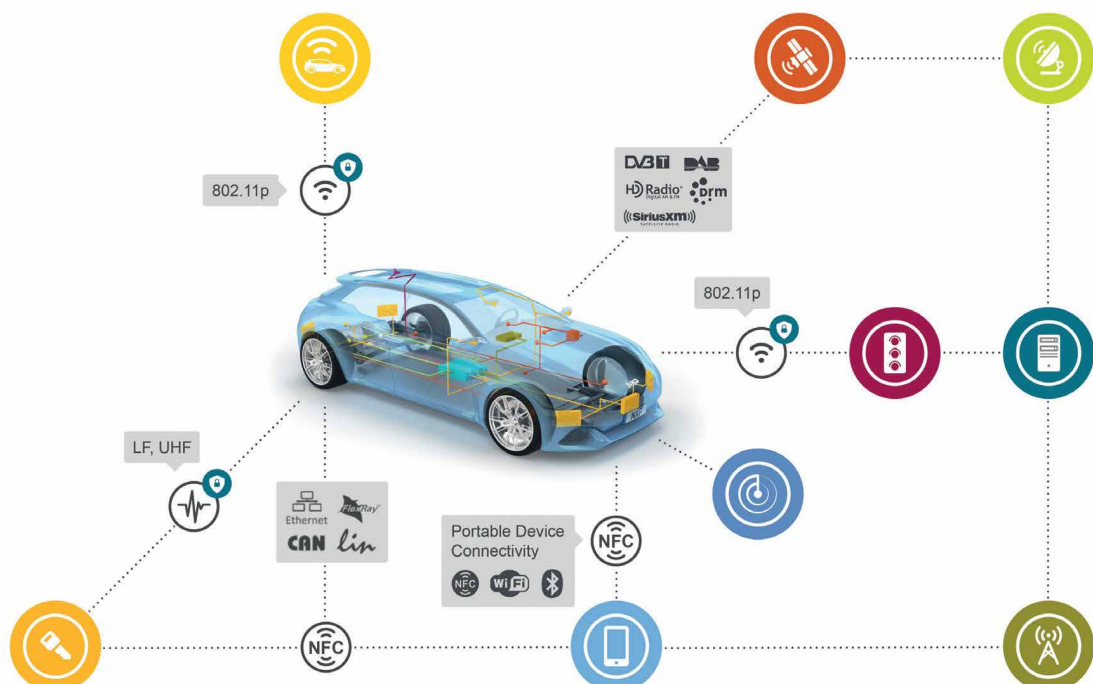
AUTOMOTIVE ETHERNET MEANS:

- Bidirectional communication over a single UTP cable
- 100 Mbits/s today, 1 Gbit/s tomorrow
- Predictable performance, deterministic behavior
- Standardized, layered and scalable systems
- Automotive-grade temperatures and EMC

NXP AND AUTOMOTIVE INNOVATION

A leading provider of semiconductors for all vehicle applications and a recognized innovator in automotive networking, NXP has a strong legacy of engagement in automotive Ethernet:

- NXP was one of the first semiconductor suppliers to develop an automotive Ethernet PHY based on and compliant to the 100BASE-T1 specification.
- We co-defined the CAN and FlexRay standards.
- We ship a total of two million automotive transceivers every day; in all, we have shipped a total of six billion CAN, LIN, and FlexRay transceivers.

In addition to our legacy of innovation, we also have a long-term strategy for creating the enabling technology in high-date-rate IVNs. Our approach offers the lowest external component count, enhanced low-power modes, small PCB area and a roadmap to Gigabit performance. We are evaluating and developing automotive Ethernet solutions and are evaluating features such as power over data lines (PoDL) to provide power from the car battery to cameras, radar sensors, and other components.

Ethernet Switches

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.

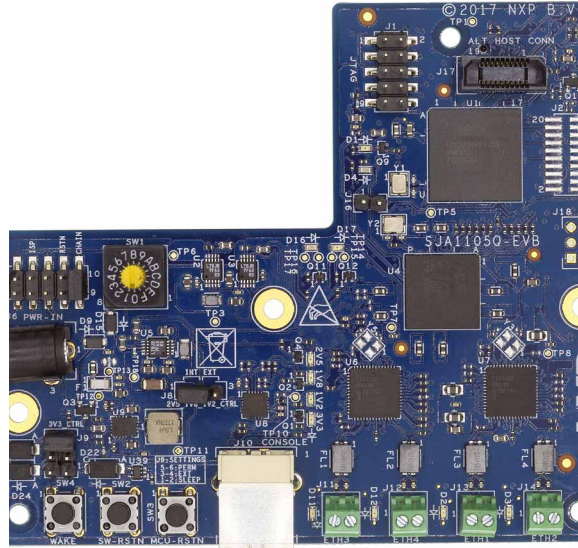## SJA1105P/ SJA1105Q/ SJA1105R/ SJA1105S ETHERNET SWITCH FAMILY

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 IO voltage supply options and a new SGMII interface. These interfaces allow the switch to support any type of external PHY such as Fast Ethernet, Gigabit Ethernet or 100BASE-T1 PHYs like the TJA1101HN and TJA1102HN transceivers. 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 a non-blocking mode.

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

GENERIC FEATURES

- Fully automotive AEC-Q100 qualified
- Automotive Grade 2 operation
- LFBGA-159 pin package (12 mm x 12 mm)
- Five ports capable of 10/100/1000 Mbit/s data rate including MII/RMII/RGMII and SGMII interfaces
- Non-blocking full gigabit switching capability
- Support for AVB and TSN/802.1Qbv scheduled traffic standard
- MAC address filtering and black/white listing

SJA1105Q-EVB EVALUATION BOARD

The SJA1105Q-EVB is an evaluation system that supports the SJA1105P/Q/R/S Automotive Ethernet switch family together with the TJA1102HN 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. Further the board supports the OPEN Alliance TC10 Wake-up Forwarding feature implemented by the TJA1102 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.

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 Wake Up forwarding
- Software and documentation are available on docstore.nxp.com/SJA1105Q-EVB (NDA required)

SOFTWARE AND TOOLS

- Linux drivers
- AUTOSAR 4.3.0 drivers licensed separately
- AVB/gPTP software stack licensed separately
- Customer evaluation board

SJA1105X ETHERNET SWITCH USE CASES
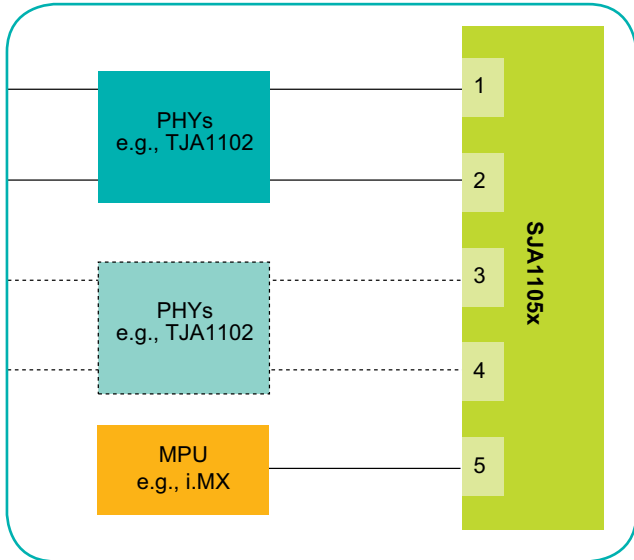
HEAD UNIT

The PHY-less automotive Ethernet switch has a low port count and offers a low bill of materials (BOM) and high degree of system flexibility to automotive Tier-1 and OEMs.

The head unit can have between 2-4 Ethernet ports to connect to different related units: head unit, instrument cluster, telematics, central gateway.
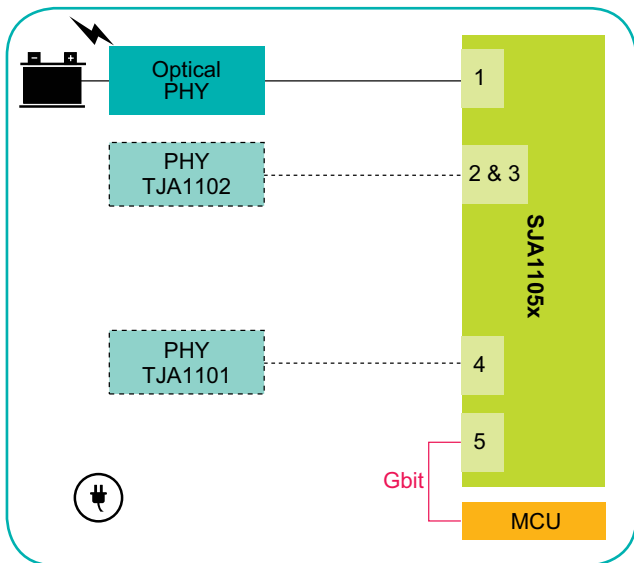
BATTERY MANAGEMENT

Each of the MII/RMII/RGMII ports of the SJA1105 series automotive Ethernet switch can operate at 10, 100 and 1000 Mbit/s speed and connect to a variety of PHYs.

In an electrical vehicle, the battery management unit operates at high voltage and requires a significantly higher data rate than the traditional bus network. Optical PHY is a solution to meet the automotive EMC and bandwidth requirement.
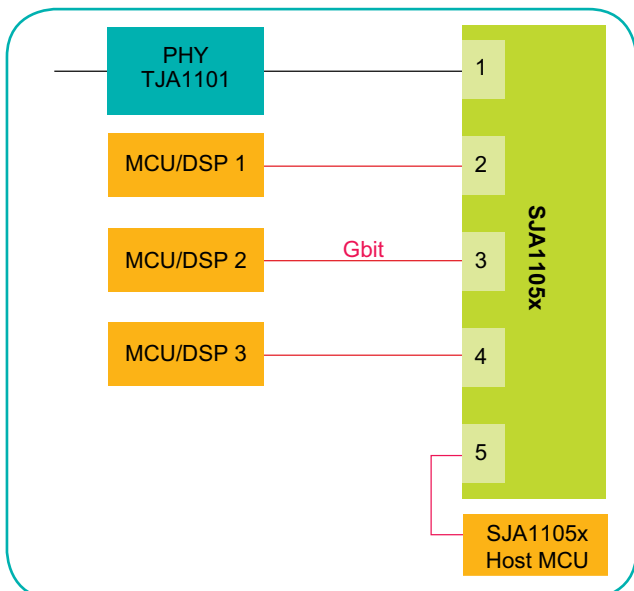
DATA FUSION BOX/ETHERNET BACKBONE

The SJA1105x series automotive Ethernet switch has full AVB hardware specifications and supports IEEE 802.1Q and IEEE 802.1AS (gPTP). In addition, a subset of SJA1105x variants supporrt TSN, the time-aware shaping IEEE 802.1Qbv and per-stream policing IEEE 802.1Qci* pre-standard.

In a distributed car network, central ECUs need to exchange data or configuration with each other within a critical time frame. The SJA1105QEL switch can build a time-sensitive network (TSN) and connects MCUs directly.

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NXP SJA1105 ETHERNET SWITCH SERIES SELECTION TABLE

	Features	SJA1105	T	P	Q	R	S	Benefits
Package and Interfaces	Operating temperature range: −40° C to +105° C (Automotive Grade 2)	●	●	●	●	●	●	Flexible ECU design • Support for any type of Ethernet PHY such as 100/1000BASE-T1 and 1000BASE-TX • Up to four cascaded switches controlled by a single host
	LFBGA159 12 x 12 mm², 0,8 mm pitch	●	●	●	●	●	●	
	MII (3V3)/RMII (3V3)/RGMII (3V3) interfaces	●	●					
	MII/RGMII (all 1V8, 2V5, 3V3) and RMII (2V5, 3V3) interfaces			●	●	●	●	
	RGMII internal delay line			●	●	●	●	
	SGMII interface					●	●	
	Pin compatibility	●	●	●	●	○	○	
	Software compatibility	●	●	○	○	○	○	
Switching	Hash-based L2 look-up table	●	●					• Fine-grained control forwarding decisions in the network • Powerful debugging and diagnostic capabilities
	TCAM-Based Frame Filtering			●	●	●	●	
	Double VLAN tagging support			●	●	●	●	
	RMON RFC 2819 Ethernet counters			●	●	●	●	
	VLAN-based egress tagging/un-tagging	●	●	●	●	●	●	
	Frame mirroring and diagnostic features	●	●	●	●	●	●	
AVB/TSN	Credit-based shaping blocks for IEEE 802.1Qav	10	10	16	16	16	16	Key hardware features to enable the implementation of a fully synchronized network for: • Lip-synched playback of audio and video streams • Data-transmission scheduling for TSN networks
	IEEE 802.1AS time stamping support	●	●	●	●	●	●	
	TSN IEEE 802.1Qbv: time-aware shaping		●		●		●	
	TSN IEEE 802.1Qci* (pre-standard): per-stream policing		●		●		●	
Security	Ingress rate limiting on a per-port and per-priority basis for unicast/multicast and broadcast traffic	●	●	●	●	●	●	Provisions for: • Authentication of the nodes connected to the network • Limiting the data generated by one or more connected devices
	Port reachability limitation and disabling address learning setting	●	●	●	●	●	●	
	MAC address whitelisting and blacklisting			●	●	●	●	
	Support for IEEE 802.1X-based authentication mechanism	●	●	●	●	●	●	
	Learn process with "one-shot "option			●	●	●	●	

Black dots: feature compatible with other similar black dots.
White dots: feature compatible with other white dots but NOT compatible with black dots.

Ethernet PHY Transceivers

TJA1102/TJA1102S TRANSCEIVER USE CASES
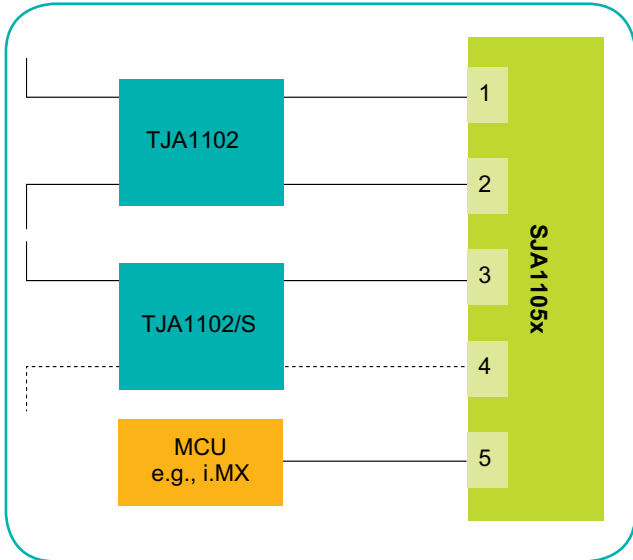
SMALLEST AREA AND HIGHEST FLEXIBILITY

- The TJA1102 transceiver has a pin-to-pin compatible single PHY variant, the TJA1102S, which gives the car OEM/Tier-1 the opportunity to scale up or down the port count without redesigning the PCB
- >30% area saving with TJA1102 compared to a 2x single port PHY solution
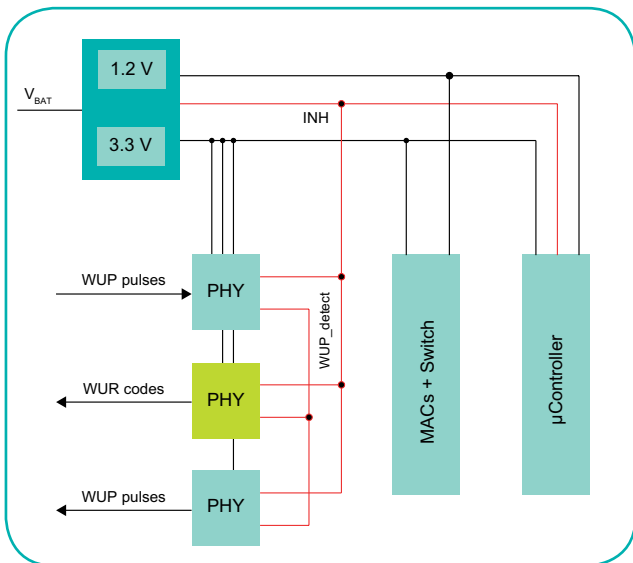
PARTIAL NETWORKING

- TJA1102 and TJA1101 enable self-contained sleep and wake-up signaling over data line
- The wake-up forwarding function allows fast signal propagation without intervention of a switch, MAC or µC
- The wake-up can be forwarded via non-active links (blue PHYs in the figure) but also active links (green PHY in the figure)
- Saves an additional wake-up line
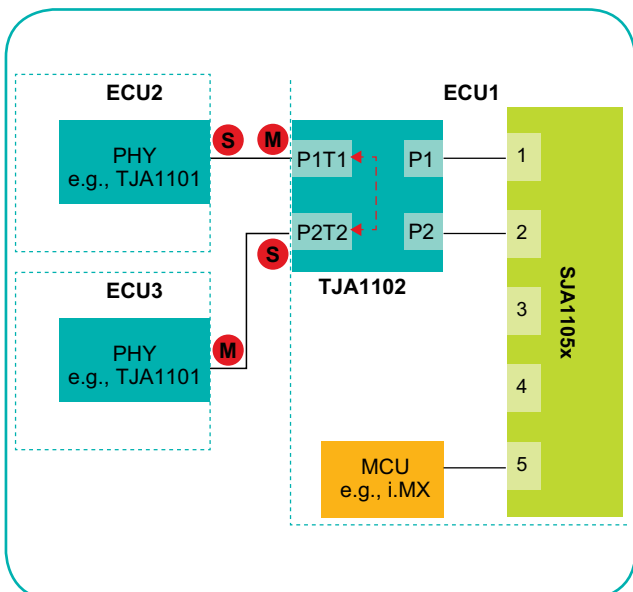
REPEATER MODE

- The TJA1102 transceiver supports internal reverse MII to operate the device in Repeater Mode
- Example applications:
  - ECU2 and ECU3 can quickly start to communicate ahead of MCU/switch boot up on ECU1
  - Fall-back mode for security purposes, bypassing the switch
  - Duplicate max cable length up to 30 m

SECURITY AND ADVANCED FEATURES

- Whitelisting and blacklisting of MAC addresses via TCAM-based table
- Learning process with one-short learn option
- Support for double VLAN tag and frame replication and retagging

SOFTWARE AND TOOLS

- NXP production-grade AUTOSAR drivers
- NXP production-grade AVB software stack available for a range of NXP processors and controllers
- Evaluation board with standardized board connector for easy attachment to NXP processor evaluation boards
- Development board with MPC57Gxx gateway processor

TJA1101 ETHERNET PHY TRANSCEIVER

The IEEE 802.3bw (100BASE-T1) compliant TJA1101 Ethernet PHY transceiver provides 100 Mbit/s transmit and receive capability over unshielded twisted pair (UTP) cables to withstand the most taxing automotive applications, while still maintaining low-power consumption and system costs.

TJA1101 APPLICATION

The TJA1101 PHY transceiver provides robust, automotive-grade signal quality with a bit error rate (BER) of at least 1E-10 or less. It is optimized for capacitive signal coupling to the UTP lines and supports a cable length of at least 15 meters. To comply with automotive EMC requirements, a common-mode choke (CMC) is typically inserted into the signal path. Communication with the media access control (MAC) unit can be realized via the MII or the RMII.

TJA1102 DUAL ETHERNET PHY TRANSCEIVER

The TJA1102, the industry's first 100BASE-T1 compliant dual-port Ethernet PHY transceiver, enables superior system efficiency for high-speed networks. This robust and reliable transceiver offers 100 Mbit/s per port full duplex and supports lightweight UTP cables of up to 30 m in repeater mode for challenging automotive applications.

TJA1101

- Single-port IEEE 802.3bw (100BASE-T1) PHY
- HVQFN-36 pin package (6 x 6 mm^2)

TJA1102 / TJA1102S

- Dual / single-port IEEE 802.3bw (100BASE-T1) PHY
- HVQFN-56 pin package (8 x 8 mm^2)
- Drop in compatible single-port product TJA1102S

TJA1101 / TJA1102 COMMON FEATURES

- AEC-Q100 Grade 1 qualified
- MII- and RMII-compliant interfaces
- Receive and forward CLK signal
- Diagnosis of cabling errors (shorts and opens)

PARTIAL NETWORKING

- OPEN-Alliance-TC10-compliant sleep-and-wake-up forwarding solution
  - Global system wake-up
  - Robust remote wake-up detection via bus lines
  - Wake-up forwarding on PHY level
  - Go-to-sleep hand shaking
  - Saves an additional wake-up line
- Local wake-up pin for wake-up line

LOW-POWER MODE

- Sleep mode current: 45 µA
- Dedicated PHY enable/disable input pin to minimize power consumption
- Inhibit-pin for voltage regulator control
- Single 3.3 V supply
- External 1.8 V supply option

SOFTWARE AND TOOLS

- Linux and low-level drivers
- AUTOSAR 4.3.0 drivers
- Customer Evaluation Board

AUTOMOTIVE APPLICATIONS

- Gateway
- IP Camera, Radar and LIDAR links
- Driver assistance systems
- Cluster & Infotainment

NXP 100BASE-T1 PHY TRANSCEIVER FAMILY

Family	Feature	TJA1101	TJA1102S	TJA1102	Description
Automotive	Package	HVQFN36 6 x 6 mm²	HVQFN56 8 x 8 mm²	HVQFN56 8 x 8 mm²	Small size, saves PCB board space
	Temperature range	-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	Low weight cable, high flexibility and low cost Proper cable length fit for most automotive requirements
	Repeater Mode			2 x 15 m	Max cable length in repeater mode up to at least 30m
	Interface	MII/RMII	MII/RMII	MII/RMII	Standard interfaces
	Supply voltage	3.3 V	3.3 V	3.3 V	Single supply, no need for external voltage regulators
	Additional supply enabled	1.8 V	1.8 V	1.8 V	Save power on component level
	Data rate	100 Mbit/s	100 Mbit/s	100 Mbit/s	Sufficient data rate to meet infotainment, ADAS requirements
	Ethernet ports	1	1	2	Dual port solution saves ECU board place, simplifying system layout and config
	Pin-to-pin compatible		●	●	Port count scalability for platform solutions
	Pin Strapping	●	●	●	HW config during start-up, allows autonomous operation
	Signal quality indicator (SQI)	●	●	●	Makes channel effects visible
	TC-10 compliant partial networking	●	●	●	OPEN-Alliance TC-10 compliant wakeup-and-sleep concept
Diagnosis	Over-temperature protection	●	●	●	Prevent device from getting damaged by over-temperature
	Cabling error detection (shorts and opens)	●	●	●	Remote diagnosis
	Gap-free supply under-voltage 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
	Dedicated Enable (EN) pin	●	●	●	Emergency shutdown for system safety e.g. block suspicious ECU
Low Power Mode	Low-power sleep mode	50 µA	45 µA	45 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

NXP Takes Networks From Concept to Production

Product evaluation

- OM14500/TJA1101 PHY evaluation
- OM14500/TJA1102 dual PHY evaluation
- SJA1105Q-EVB switch evaluation with NXP MCU/MPU daughter card support option

System prototyping

- SJA1105SMBEVM prototyping platform
- SJA1105Q-EVB switch evaluation
- ADTJA1101-RMII adapter board to S32x and i.MX processors

Production

- TJA1101/TJA1102 single/ dual 100BASE-T1 PHYs
- SJA1105P/Q/R/S Ethernet switch series
- AUTOSAR drivers
- AVB software stack
- Linux drivers

www.nxp.com/ethernet
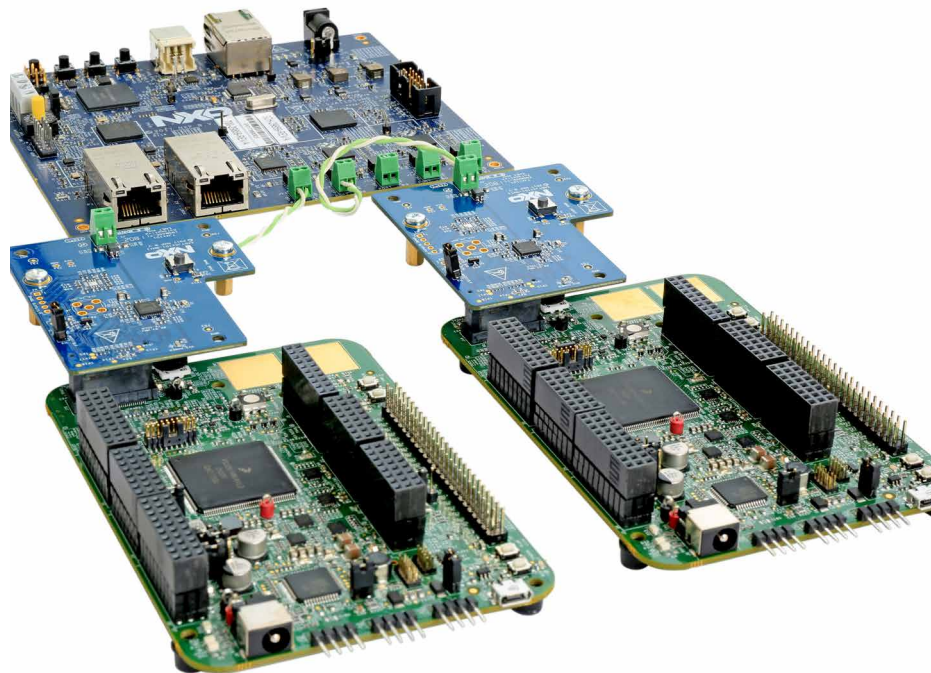
Automotive Ethernet Now

THE SJA1105SMBEVM NXP ETHERNET GATEWAY PROTOTYPING PLATFORM

The new SJA1105SMBEVM prototyping platform is a ready-to-go solution to jump-start your true-automotive design.

The board includes the NXP MPC574xG ultra-reliable MCUs for Automotive & Industrial Control and Gateways, the NXP SJA1105S safe and secure Ethernet TSN Switch, the NXP TJA1102 Automotive 100BASE-T1 dual PHY and the NXP TJA1145FD CAN transceiver. The board also offers three 100/1000BASE-T PHYs for easy connect to a PC and network equipment.

The board is OPEN TC10 ready and comes with an SDK based on NXP S32 Design Studio enabling you to start your project within minutes after receiving it.

Finally, the board is compatible with NXP-original AUTOSAR OS and AUTOSAR Ethernet drivers, licensed separately.

TARGET APPLICATIONS

- Gateway and Body controllers
- Autonomous vehicles
- TC10 Wake up evaluation

ADVANTAGES

- Jump-start ECU development
- Evaluate CAN-to-Ethernet communication
- Network diagnostics and media converter

Part Number	Description
MPC574xG	Ultra-reliable MCU
SJA1105S	Ethernet Switch
TJA1102	Dual/Single 100BASE-T1 PHY
TJA1145FD	CAN Transceiver

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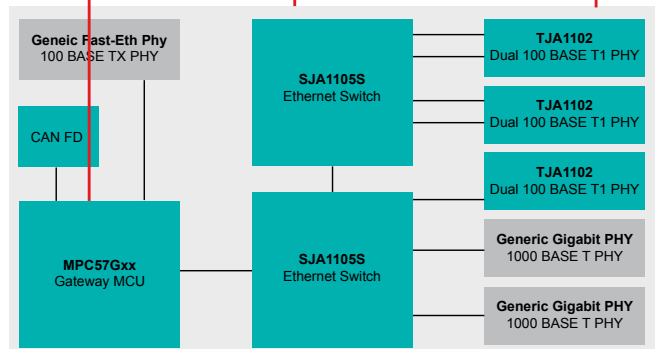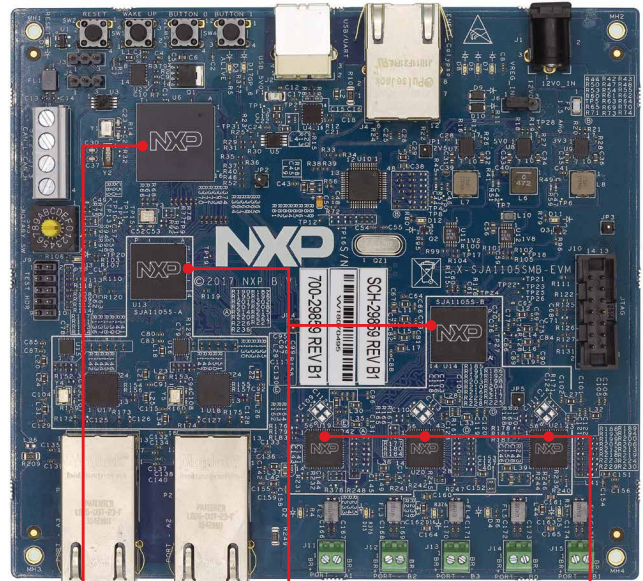
TC10 Sleep/Wake Forwarding System Development Kit

NXP'S ETHERNET PHY TRANSCEIVER WITH SLEEP AND WAKE UP FORWARDING OVER DATA LINE. STANDARD COMPLIANT AND INTEROPERABLE ACCORDING TO OPEN ALLIANCE TC-10.

Having this technology integrated in NXP's 100BASE-T1 PHYs - TJA1101 and TJA1102 - the power modes of the individual PHY and whole ECU can be dynamically managed.It propagates sleep requests and forwards wake up pulses over the Ethernet data line (single twisted pair cable). It saves a dedicated wake up line, and hence additional cost, weight and real estate for cables and connectors.
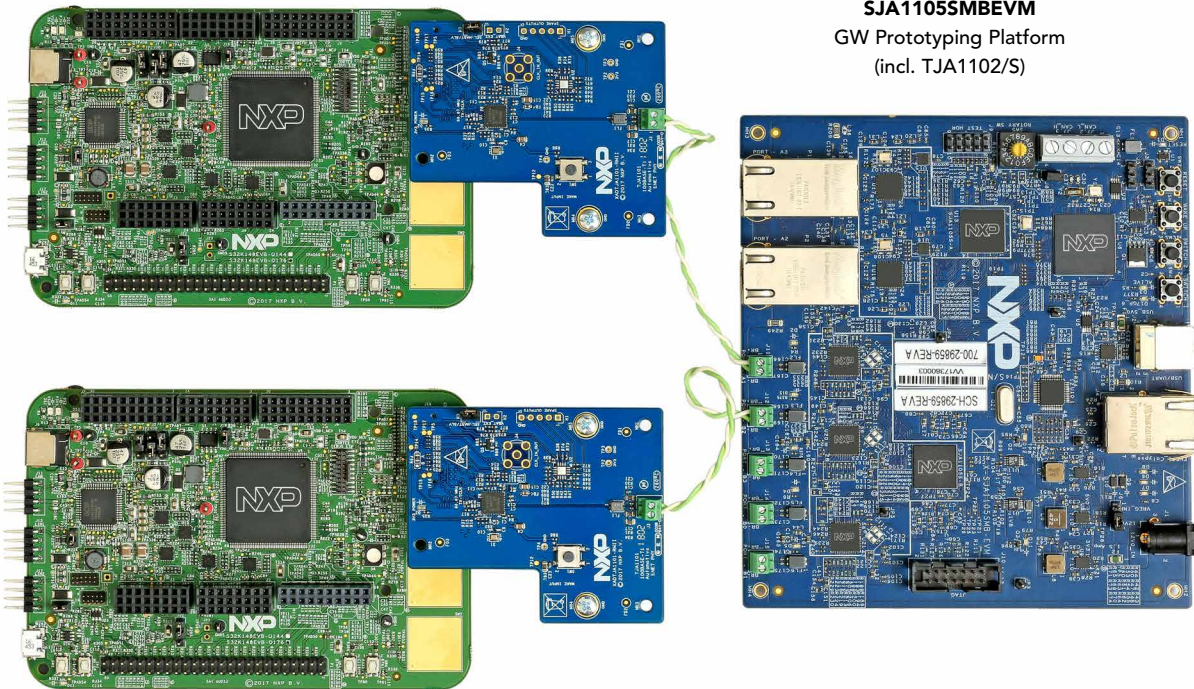
The system level evaluation of the technology is now simplified by this new development kit, which is available on nxp.com. The kit combines OPEN TC10 enabled HW with out of the box SW examples: easy to load, configure and modify via common SDK, NXP's S32 Design Studio.

System engineers may scale the complexity up or down and adjust the sample code to apply full custom system requirements, to orchestrate the wake up sequence and define forwarding rules.
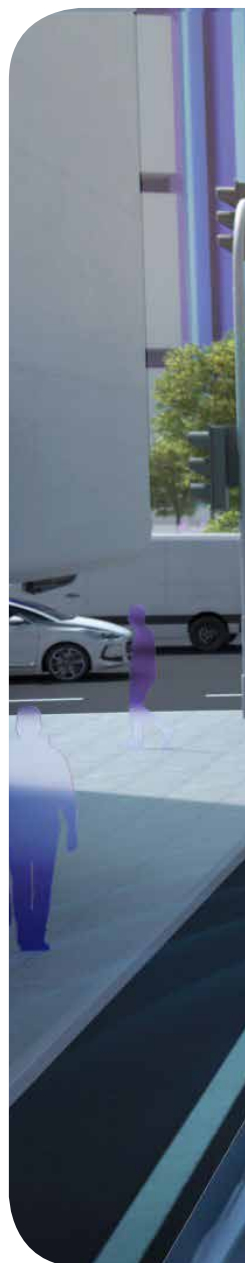

S32K148EVBQ176
(S32K Eval Board)

ADTJA1101-RMII
(TJA1101 Daughter Card)

SJA1105SMBEVM
GW Prototyping Platform
(incl. TJA1102/S)

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