

LIN/CAN/RF/FlexRay™ Technology

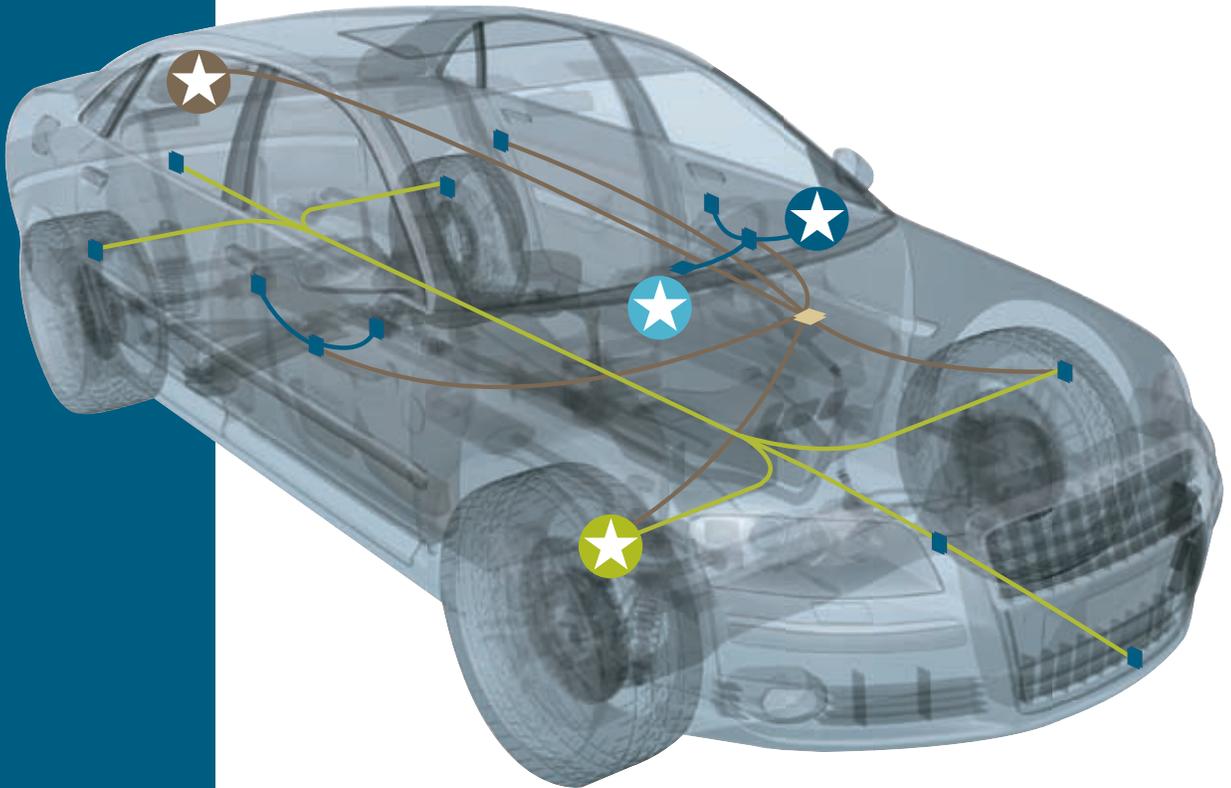
In-Vehicle Networking



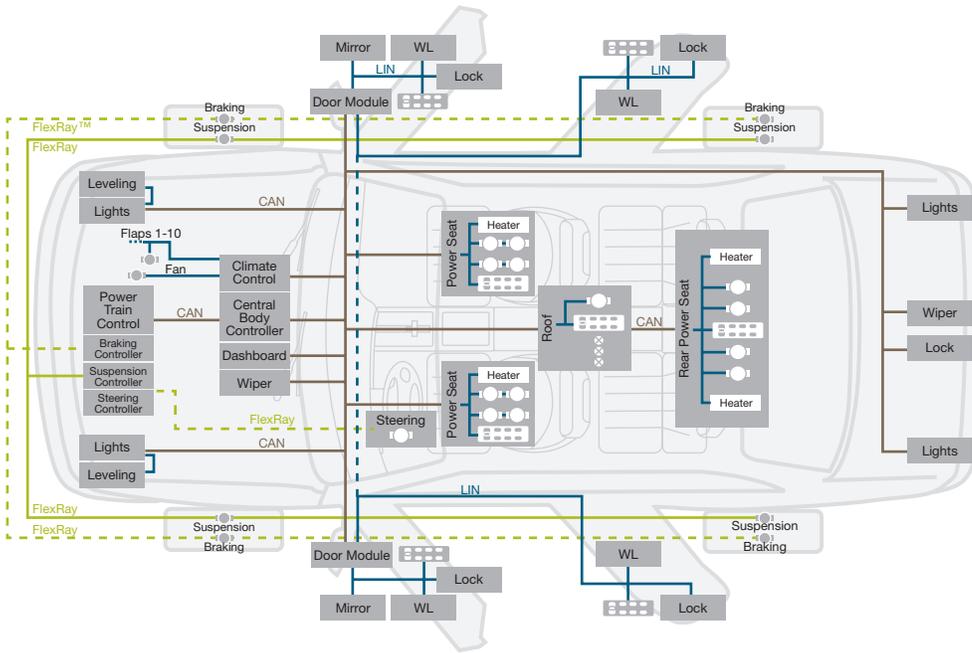
In-Vehicle Networking

As an industry leader in automotive solutions, Freescale Semiconductor has greatly contributed to in-vehicle networking by founding standards bodies, offering an extensive portfolio of products to our customers and driving the development of next-generation products. In the late 1990s, Freescale was the only semiconductor manufacturer to be a founding member of the Local Interconnect Network (LIN) Consortium. In September 2000, Freescale was one of only two semiconductor manufacturers to be founding members of the FlexRay™ Consortium.

★ LIN/SAE J2602	Low-speed, single-master, multiple-slave serial networking protocol. The LIN master node typically connects the LIN network with higher-level networks.
Speed:	Max. 20 Kbps
Applications:	Door Locks, Climate Control, Seat Belts, Sunroof, Lighting, Window Lift, Mirror Control
★ CAN	Multi-master asynchronous serial network protocol for high reliability control applications
Speed:	Max. 1 Mbps
Applications:	Body Systems, Engine Management, Transmission
★ FlexRay	Next-generation, deterministic and fault-tolerant network protocol to enable high-bandwidth, safety-critical applications
Speed:	Max. 10 Mbps per channel (dual channel)
Applications:	Drive-by-Wire, Brake-by-Wire, Advanced Safety and Collision Avoidance Systems, Steer-by-Wire, Stability Control, Camera-Based Monitoring Systems
★ RF	Radio frequency transmission, on/off keying or frequency shift keying modulation
Frequency:	304 MHz to 915 MHz
Applications:	Remote Keyless Entry, Vehicle Immobilization, Passive Entry, Tire Pressure Monitoring Systems



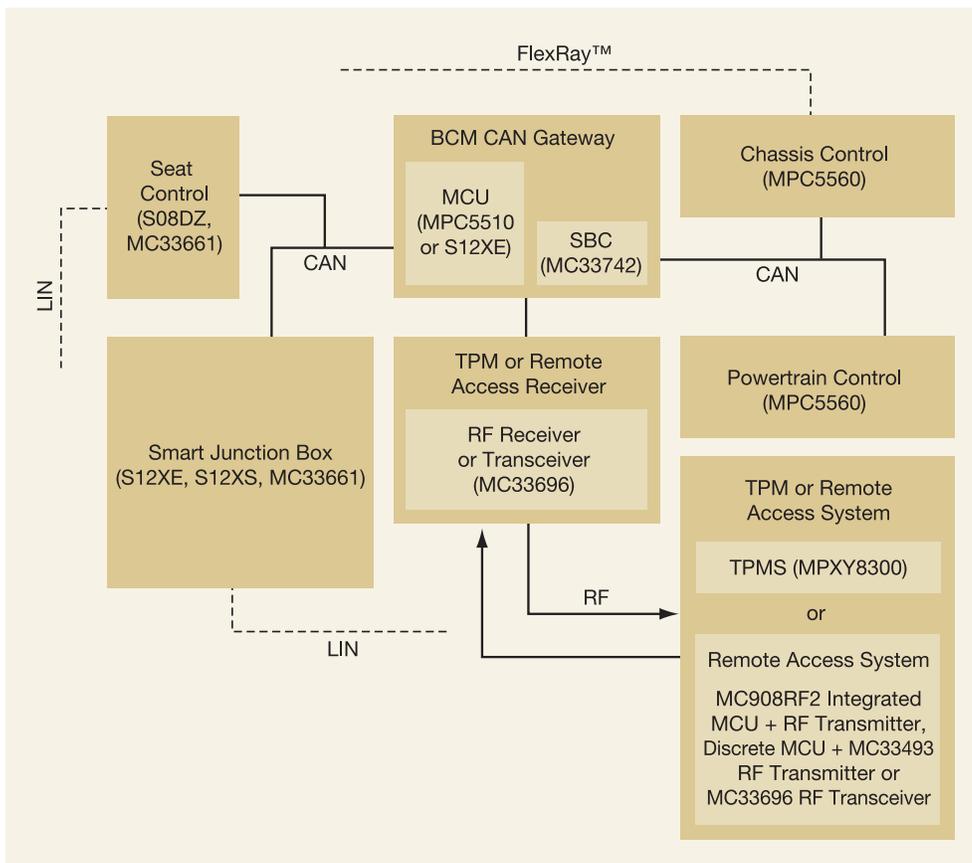
In-Vehicle Network Example



The expansion of in-vehicle networking provides many system-level benefits over previous mechanical means, including:

- Fewer wires required for each function, which reduces the size of the wiring harness and improves system cost, weight, reliability, serviceability and installation time
- Additional functions can be added by making software changes, allowing greater vehicle content flexibility
- Common sensor data available on the network so it can be shared, eliminating the need for multiple sensors

Freescale Example of Total Vehicle Networking Solution



LIN/SAE J2602

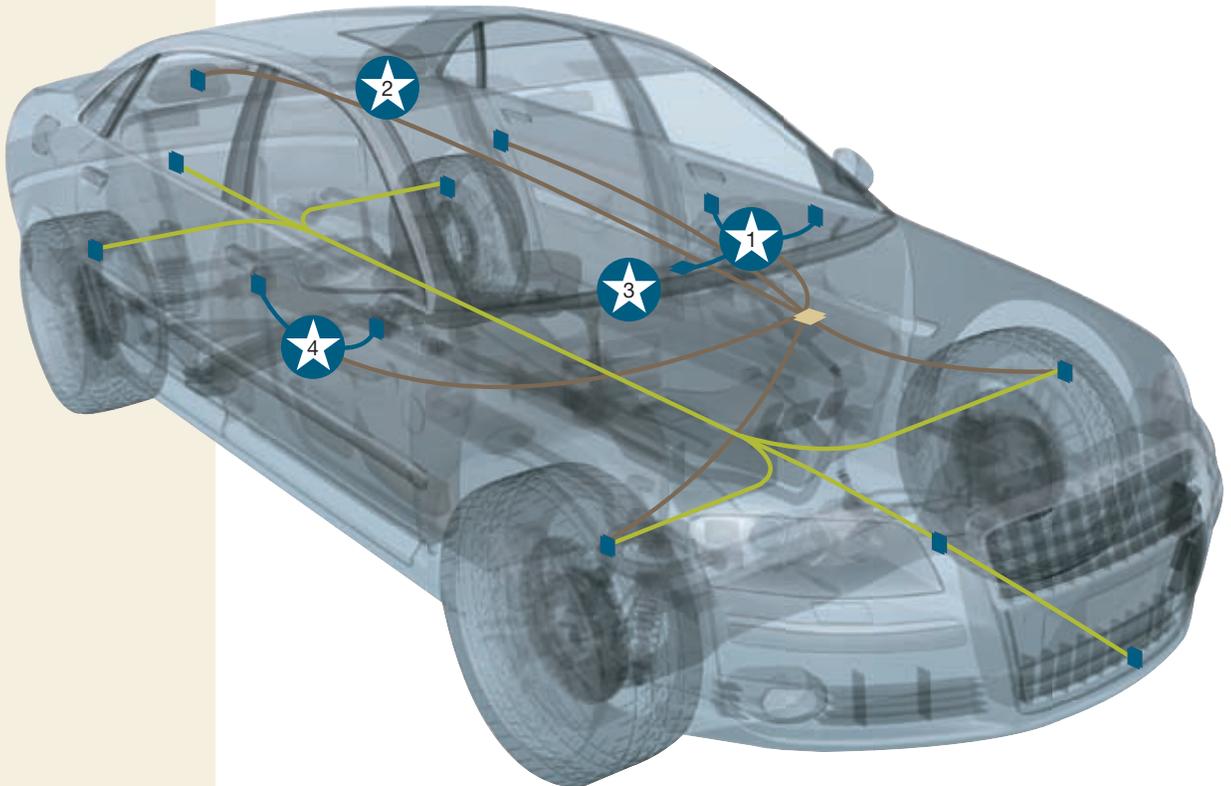
LIN is a universal asynchronous receiver-transmitter (UART)-based, single-master, multiple-slave networking architecture originally developed for automotive sensor and actuator networking applications. LIN provides a cost-effective networking option for connecting motors, switches, sensors and lamps in the vehicle. The LIN master node extends the communication benefits of in-vehicle networking all the way to the individual sensors and actuators by connecting LIN with higher-level networks, such as the controller area network (CAN). For a complete description of how LIN works, please visit www.freescale.com/automotive.

Key Benefits

- Enables effective communication for sensors and actuators where the bandwidth and versatility of CAN is not required
- Complements CAN as a cost-effective sub-network
- Synchronization mechanism means no quartz oscillator required at slaves
- The LIN protocol can be generated by standard asynchronous communication interfaces (SCI, UART)—no specific hardware required
- No protocol license fee

Typical LIN Applications

★ Steering Wheel:	Cruise Control, Wiper, Turning Light, Climate Control, Radio
★ Roof:	Rain Sensor, Light Sensor, Light Control, Sun Roof
★ Engine/Climate:	Sensors, Small Motors, Control Panel (Climate)
★ Door/Seat:	Mirror, Central ECU, Mirror Switch, Window Lift, Door Lock, Seat Position Motors, Occupant Sensors, Seat Control Panel



Freescale's Complete Portfolio of LIN Products

Microcontrollers	Freescale microcontrollers support LIN. Optimized LIN solutions include: XGATE coprocessor on S12(X) products, a combination of enhanced direct memory access (eDMA) + enhanced SCI (eSCI) on the MPC5500 family and SLIC on HC08/S08 MCUs.
System Base Chip (SBC)	Monolithic IC combining many functions found in standard microcontroller based systems, such as power management, communication interface, system protection and diagnostics
LIN Enhanced Physical Interface	Physical layer component dedicated to automotive LIN sub-bus applications (MC33661)
System in a Package (SiP) or Intelligent Distributed Control (IDC) solutions	Embedded microcontroller and power management in a single package, providing a highly integrated slave node solution for space-constrained areas, such as seats and door modules (MM908E624)

Slave LIN Interface Controller (SLIC) Enables Higher Integration

Freescale offers an exceptional embedded SLIC module that automates LIN message handling to help increase performance while reducing development time and cost. It allows you to devote more CPU to the application and gives you the ability to use ROM devices or state machines.

SLIC helps increase performance in several ways. True auto-synchronization and auto-bauding find LIN frames and automatically adjust the baud rate without CPU intervention. SLIC reduces interrupt processing up to 83 percent over UART solutions with only two interrupts for any message. This makes it possible to use SYNCH data from messages to trim the oscillator. SLIC also eliminates many steps normally required by UART solutions (trim oscillator, detect break, measure sync signal, adjust baud rate, calculate and verify checksum, handle individual data bytes, detect errors and more).

SLIC helps reduce development time by eliminating message processing steps, simplifying and minimizing driver code to as small as 120 bytes (refer to Freescale's Application Note AN2633). Minimized driver code translates into shortened debug and development time, which enables you to use your engineering time to debug the application rather than LIN communication.

SLIC helps reduce cost by using only one software driver to handle any LIN speed on any LIN bus. This allows significant code reuse for many applications, regardless of LIN bus speed. No reprogramming is required to change bus speeds, which equates to fewer part numbers to track and stock. High-speed (up to 120 Kbps) end-of-line programming through LIN allows faster module manufacturing times and field reprogrammability. Also, smaller driver code means less flash is required for LIN communication, resulting in more flash available to use for product applications. SLIC does not require oscillator trimming, unlike UART, which simplifies the design.

SLIC emphasizes hardware as an alternative to software message processing and exemplifies Freescale's technical leadership in LIN communication innovation.

Intelligent Distributed Control Solutions

The Freescale MM908E6xx family is a highly integrated System in a Package (SiP) solution that includes an HC08 high-performance microcontroller with a SMARTMOS™ analog control IC packaged in a 54-lead small-outline integrated circuit (SOIC). These solutions allow for a very small footprint and simple PCB design. The IDC solutions will replace many discrete ICs, reducing complexity, improving quality and decreasing manufacturing and logistics costs.

History

Automotive networking has always relied on standardized serial communications hardware, but it was rarely compatible. In the late 1990s, the LIN Consortium was founded by five European automakers, Volcano Automotive Group and Freescale (at the time Motorola) to solve this problem. The first fully implemented version of the new LIN specification was published in November 2002 as LIN version 1.3. In September 2003, version 2.0 was introduced to expand configuration capabilities and make provisions for significant additional diagnostics features and tool interfaces.

Some North American automakers were concerned about the rising complexity and lack of direct North American representation in the LIN Consortium. As a result of their concerns, a Society of American Engineers (SAE) task force, which was part of the committee that standardizes vehicle networking, was formed to help ensure LIN 2.0 was suitable for global implementation. Although a full consensus was never reached, the task force published the SAE J2602 Recommended Practice for LIN Networks document, which seeks to fully specify ambiguities and optional features of the LIN 2.0 specification.

Since the SAE J2602 recommended practice is still based upon LIN 2.0 and the protocol and physical layer specifications are fundamentally the same, many of the generic MCU-based hardware solutions can work on either type of network.



Freescale Semiconductor and LIN—As the only semiconductor manufacturer on the steering committee of the LIN Consortium, Freescale Semiconductor has the industry's most advanced range of devices, components, software, tools and support available.

CAN

CAN is an asynchronous serial bus network that connects devices, sensors and actuators in a system or sub-system for control applications. This multi-master communication protocol, first developed by Robert Bosch GmbH in 1986, was designed for automotive applications needing data rates of up to 1 Mbps and high levels of data integrity. Beyond automotive applications, the CAN protocol is being used as a generic embedded communication system for microcontrollers as well as a standardized communication network for industrial control systems.

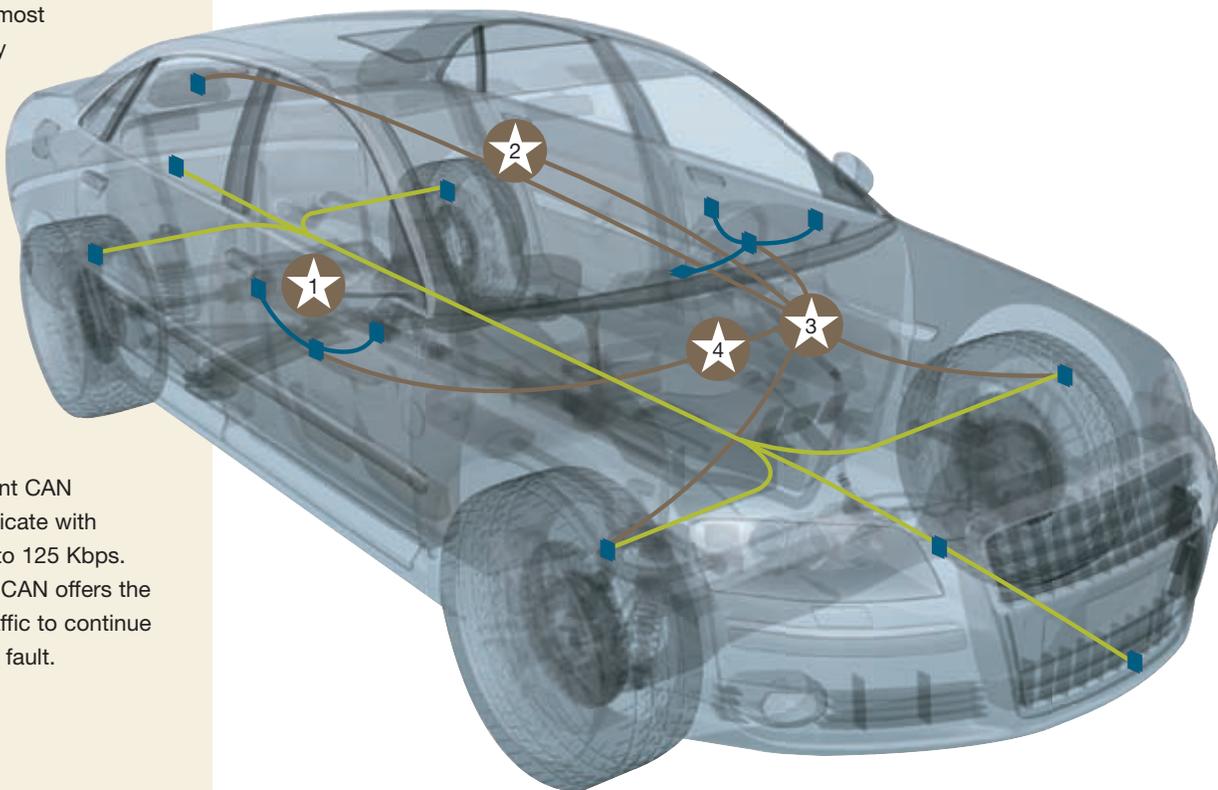
The Bosch CAN specification does not dictate physical layer specifications for implementing CAN networks. These physical layers specify certain characteristics of the CAN network, such as electrical voltage levels, signaling schemes, wiring impedance, maximum baud rates and more. Over the course of the last decade, two major physical layer designs have come forward to become the basic physical layer specifications used in most CAN applications. They both communicate using a differential voltage on a pair of wires and are commonly referred to as high-speed (ISO 11898-2, SAE J2284) and low-speed CAN (ISO 11898-3). High-speed CAN networks allow transfer rates up to 1 Mbps. Low-speed/fault-tolerant CAN networks can communicate with devices at rates of up to 125 Kbps. In addition, low-speed CAN offers the ability for CAN data traffic to continue in the event of a wiring fault.

Key Benefits

- The automotive networking standard protocol
- Provides plentiful and proven Freescale CAN products and tools
- Freescale offers 8-, 16- and 32-bit microcontrollers with integrated CAN
- Provides connectivity and increased integration using Freescale SMARTMOS, CAN physical layers and system basis chips (SBCs)
- Freescale MSCAN is the most pervasive CAN controller architecture in automotive controllers

Typical CAN Applications

★ Safety:	Passenger Occupant Detection, Electronic Parking Brake
★ Body Control:	Motor Control; Power Door, Sunroof and Lift Gate; HVAC; Low-End Body Controller (Lighting, Network Control)
★ Chassis:	Motor Control, Watchdog
★ Powertrain:	Vacuum Leak Detection, Electronic Throttle Control, Watchdog



Different CAN Networks Have Different Performance Needs

To accommodate the demands of each type of CAN network, very different approaches to designing hardware and software systems must be employed to deal with variations in the nature of CAN messages on different networks. Freescale recognizes the challenges that face designers of automotive CAN devices and provides customers different hardware options to address these challenges.

Automotive CAN networks, as an example, can be divided into two distinct categories based on the nature of the traffic on the network: which are body control and powertrain.

Body control networks communicate with passenger comfort and convenience systems and deal with a wide range of message identifiers that appear in no particular order or frequency. Freescale's Scalable CAN (MSCAN) architecture is well-suited for applications where messaging can be very sporadic

and unpredictable. Messages received by MSCAN are placed in a single first-in, first-out (FIFO) storage structure. The FIFO maintains the order of received messages, allowing many messages with identical identifiers to be received in rapid succession without overflowing the receive buffers.

Powertrain networks service engine and transmission control. They deal with a low range of message identifiers, but unlike body control networks, they are predictable and appear regularly and in rapid succession. Freescale's FlexCAN™ module (CAN version 2.0 B-compliant) is well-suited for these applications where messages are very regular and predictable. The hardware module is based on the traditional mailbox, or "FullCAN," hardware architecture that offers a range of message buffers from the minimum of 16 up to a maximum of 64. When messages are received, a hardware filter match will drop each message into one of the "mailboxes" (receive buffers).

Freescale's Portfolio of CAN Products

8-bit CAN Microcontrollers S08DZ/DV families HC08AZ/GZ families	MSCAN—CAN protocol version 2.0 A, B; standard and extended data frames; receive buffers with FIFO storage scheme. Enables higher-performance by improving CAN message processing efficiency.
16-bit CAN Microcontrollers S12D/B/C families S12XD/E/S families	MSCAN—CAN protocol version 2.0 A, B; standard and extended data frames; receive buffers with FIFO storage scheme. MSCAN in combination with the XGATE coprocessor on S12X can be used to emulate FullCAN capability.
32-bit CAN Microcontrollers MPC5500 families	FlexCAN™—version 2.0 B-compliant standard and extended data frames; hybrid mailbox and FIFO architecture; up to 64 flexible message buffers of 0–8 bytes data length, each configurable as RX or TX, all support standard and extended messages; flexible, maskable identifier filter; programmable wake-up functionality with integrated low-pass filter; separate signaling and interrupt capabilities for all CAN RX/TX states.
System Base Chip (SBC) MC33742	Monolithic IC combining many functions found in standard microcontroller based systems, such as power management, communication interface, system protection and diagnostics.
CAN Fault Tolerant Physical Interface MC33897	Physical layer component dedicated to automotive CAN applications.



Freescale has shipped more microcontrollers that support CAN than any other semiconductor manufacturer. As a member of the CAN in Automation (CiA) organization, we are continuing to support CAN market development and the international standardization of CAN technology.

FlexRay™

The FlexRay Communications System is a time-deterministic communications protocol with a dual channel data rate of 10 Mbps for advanced in-vehicle control applications. It was originally developed by the founding members of the FlexRay Consortium, an industry organization that, by the end of 2005, included over 120 member companies.

The FlexRay Consortium emerged after BMW and DaimlerChrysler realized that available solutions did not meet their future needs for data throughput and determinism. In September 2000, they joined forces with Freescale and Philips and formed the FlexRay Consortium to establish FlexRay as the de facto industry standard.

The FlexRay communications protocol is designed to provide high-speed deterministic distributed control for advanced automotive applications. FlexRay's dual-channel architecture offers system-wide redundancy that meets the reliability requirements of emerging safety systems, such as brake-by-wire. The FlexRay system can also be employed as a vehicle-wide network backbone, working in conjunction with already well-established systems, such as CAN and LIN. It can drive down costs by reducing the number of parallel CAN networks that have been used to solve bandwidth bottlenecks.

Key Benefits

- Increased network throughput
- Highly deterministic response times
- Dual channel redundancy
- System-wide synchronized time base

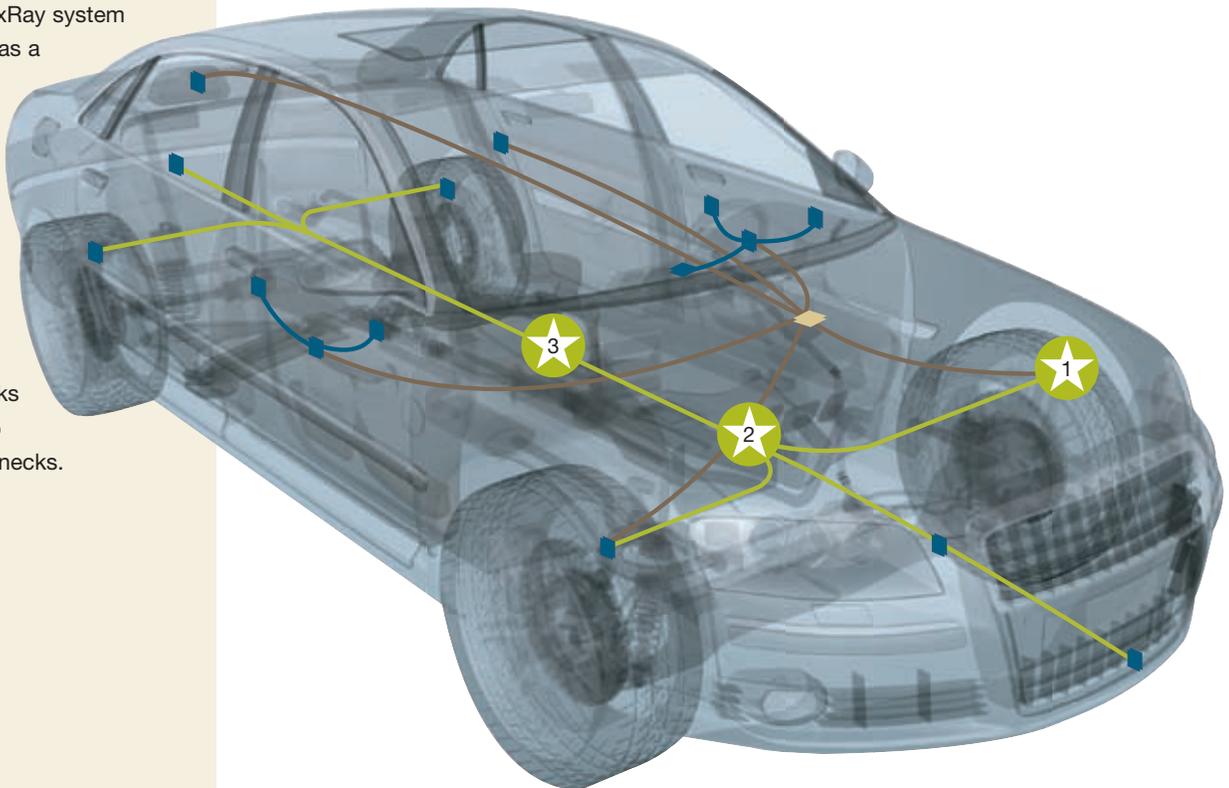
These benefits result in:

- Simplified vehicle network architectures
- Increased enhanced control intelligence
- Reduced wiring requirements
- Reduced weight of networked subsystems
- Distributed computing through a global time clock
- Electromechanical systems (X-by-wire) replacing hydraulic components

The combination of all these benefits enables next-generation vehicle designs that are safer, more intelligent, more reliable, more environmentally friendly and offer an improved overall driving experience.

Typical FlexRay Applications

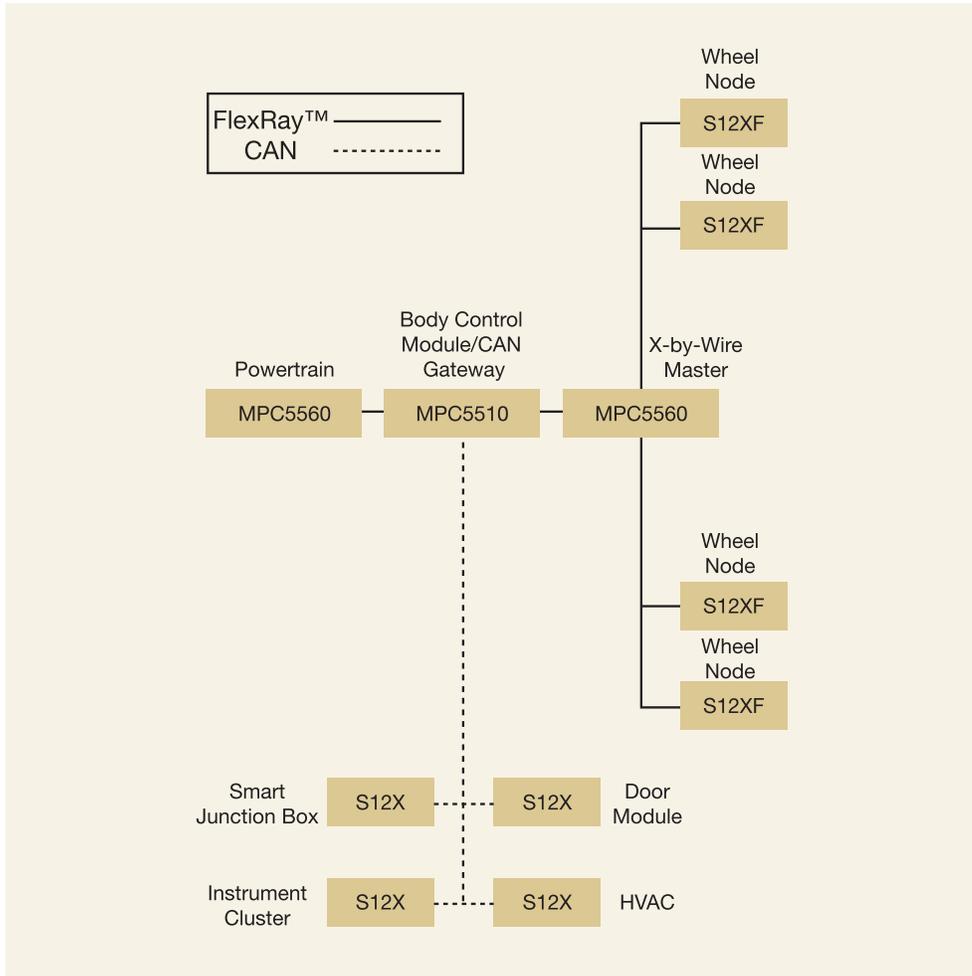
★ Wheel Node:	Fail-Safe, Low to Medium Performance (S12XF Family MCU)
★ Body Control Module (BCM):	High Performance, Low Power (MPC5510 Family MCU)
★ X-by-Wire Master:	Highest Level of Fault Tolerance (MPC5560 Family MCU)



Freescale FlexRay Controllers and Microcontrollers

FlexRay™ Enabled Product Family	Target Applications
MFR4300	Paired with External MCU
S12XF	16-bit Wheel/Corner Nodes
MPC5510	32-bit Body, Chassis Control
MPC5560	32-bit Engine Control, Safety or Chassis Control

Example FlexRay Networking Map



Freescale FlexRay Implementation

In 2004, Freescale introduced the industry's first stand-alone FlexRay controller, the MFR4100, which has been followed by the more advanced MFR4200 and MFR4300. These FlexRay controllers can be paired with existing 16- or 32-bit MCUs to enable communications over a FlexRay network. In addition, we now offer 16- and 32-bit MCUs with integrated FlexRay controllers.

Processing the large amount of data circulating on the FlexRay network is a key challenge. Freescale's innovative solutions include the S12X 16-bit processor and MPC5500 family of 32-bit processors built on Power Architecture™ technology. The S12X family incorporates an XGATE coprocessor to off-load certain tasks from the main CPU, resulting in higher overall performance levels. The MPC5500 family connects the FlexRay controller directly to the internal crossbar switch for efficient data processing transfers within the device.

By offering a selection of stand-alone and integrated solutions, we give our customers a number of options to help them make smarter integrated active safety systems. Freescale continues to invest in our FlexRay portfolio to provide next-generation automotive solutions for future in-vehicle applications.



As a founding member of the FlexRay Consortium, Freescale Semiconductor is positioned to help car manufacturers make smarter, faster and more reliable active safety systems. Freescale has made it a priority to proliferate this network protocol and is the first manufacturer to offer stand-alone and integrated FlexRay devices.

Radio Frequency

Radio frequency (RF) communications can provide additional vehicle functionality and driver convenience, enabling a wide variety of safety and comfort features, including:

- Remote keyless entry (RKE)
- Passive entry (PE)
- Tire pressure monitoring systems (TPMS)
- Vehicle immobilization systems

Freescale's system-level approach to vehicle access and remote control is the key to new levels of driver convenience and security. Our solutions bring together all the components needed for automotive access and remote control applications with optimal system partitioning. Our extensive product portfolio includes industry-leading microcontrollers, analog and RF products, application-enabling encryption software and tire pressure monitoring sensors.

As the leading automotive semiconductor manufacturer, Freescale understands the challenges that different regional standards can bring. Our broad portfolio offers the flexibility to meet the needs of engineers designing RF control applications worldwide. Specifically, our chipsets and system solutions can handle both the frequency band and modulation differences among the US, Europe and Asia/Pacific regions.

RKE Systems

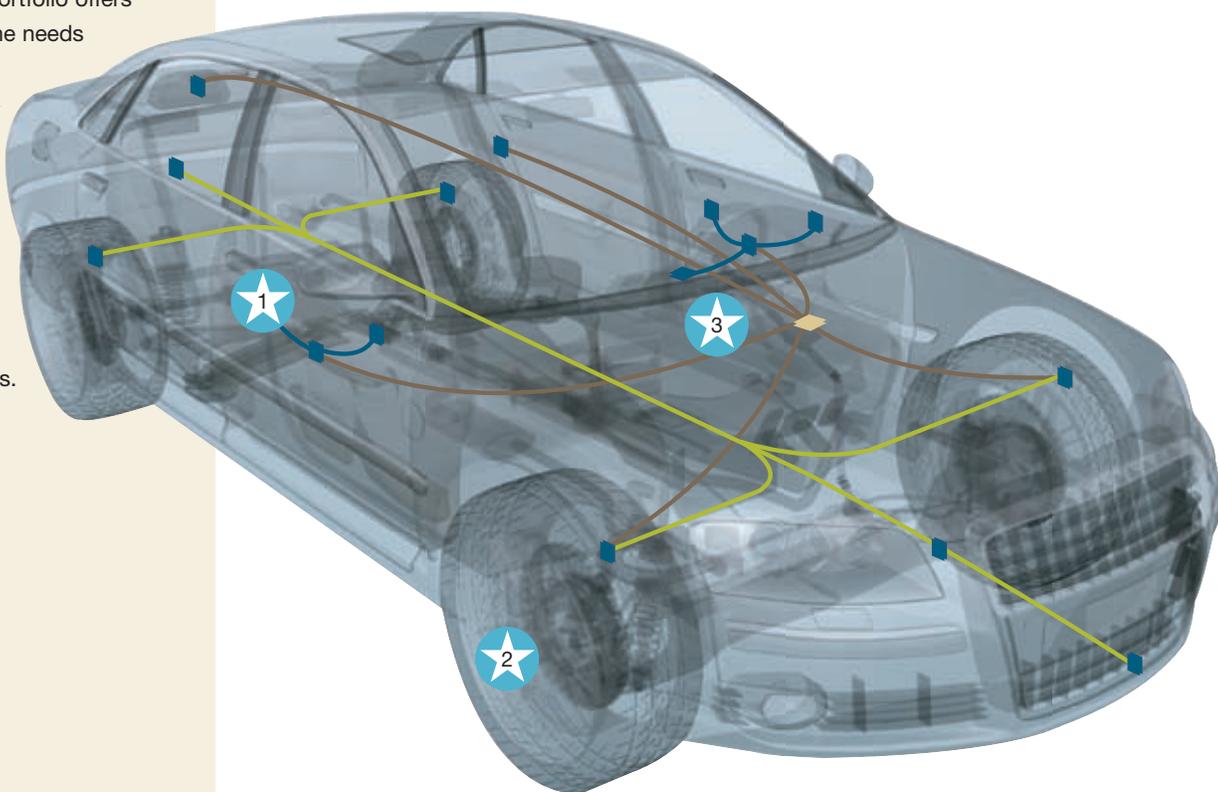
RKE systems make it possible to unlock doors and release trunk latches remotely using a key fob or other similar device. Many include some security functionality, such as anti-theft alarms, remote start and panic buttons. Freescale was an early pioneer in RKE system development and is now the first to offer an integrated low-voltage microcontroller with embedded RF for RKE applications developers.

Passive Entry Systems

A passive entry system requires no specific user action, such as inserting a key in a lock, for secure vehicle entry. Freescale is paving the way for new applications in hands-free passive entry by developing complete system-level solutions with optimized hardware and software partitioning.

Typical RF Applications

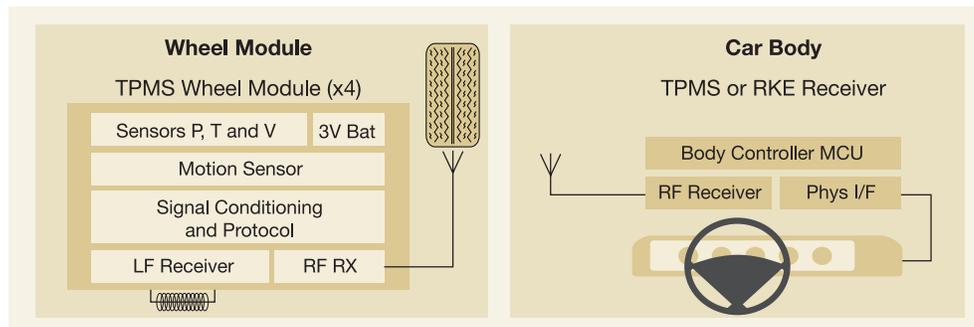
Access and Remote Control:	Remote Keyless Entry, Passive Entry, Two-Way Keyless Entry
Safety:	Tire Pressure Monitoring Systems
Security:	Vehicle Immobilization Systems



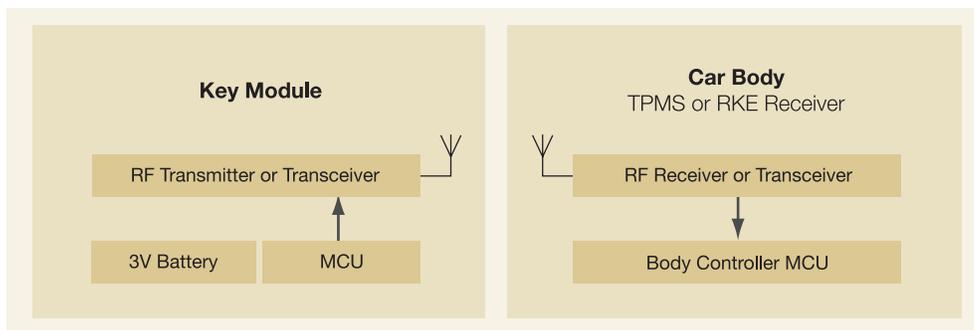
Regional Variations in RF Transmission Frequencies Used

Region	Frequency Band	Modulation
US	315 MHz, 434 MHz	Amplitude or frequency shift keying
Europe	434 MHz, 868 MHz	Amplitude or frequency shift keying
Asia/Pacific	304 MHz, 315 MHz	Amplitude or frequency shift keying

Typical Tire Pressure Monitoring System (TPMS) Architecture



Typical Remote Access System



Products Suitable for Vehicle RF Systems

Features	MC33493	MC33596	MC33696	MC33690
Product Type	Transmitter	Receiver	Transceiver	TAG Reader
Frequency	315/434/868/915 MHz	304–915 MHz	304–915 MHz	125 KHz
Operating Temp Range	-40°C to +125°C	-40°C to +85°C	-40°C to +85°C	-40°C to +125°C
Data Rate (max)	11 Kbps	20 Kbps	20 Kbps	8 Kbps
Tx Output Power	5 dBm	N/A	7 dBm	150 mA
Tx Current	4.4 mA	N/A	13.5 mA	N/A
Rx Sensitivity	N/A	-108 dBm	-108 dBm	8 mV
Rx Current	N/A	9.2 mA	9.2 mA	1.5 mA

Vehicle Immobilization Systems

More and more automotive manufacturers worldwide are incorporating anti-theft vehicle immobilization technology into their designs. As a result of European commission directive number 74/61/EEC, European automakers have been mandated to include immobilization systems in all new vehicles because European insurance companies now require them as a coverage condition. This trend is expected to become the de facto standard for the entire auto industry in just a few short years. Our vehicle access control solutions offer quick design-in solutions by combining microcontrollers, tag readers, transmitters and receivers into one RKE and vehicle immobilization system.

TPMS

Freescale's innovative automotive technologies address a steadily growing need for reliable semiconductor solutions that live up to today's high engineering standards. For example, our TPMS wheel module products are designed to conform to the Federal Motor Vehicle Safety Standard (FMVSS138) and existing car manufacturer requirements throughout the world. They offer a high level of functional integration by combining the following into a single, 20-pin, small-outline, wide body package (SOIC 20 WB):

- Low-power surface micromachined capacitive pressure sensor
- 8-bit MCU
- Motion detector
- RF transmitter
- LF receiver

To provide greater flexibility for automotive designers and greater convenience for their customers, our system-in-a-package device integrates seamlessly with existing RF receivers.

Learn More: For more information about Freescale products
please visit www.freescale.com/automotive

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