Overview
The controller area network (CAN) is a serial, asynchronous, multimaster communication protocol for connecting electronic control modules in automotive and industrial applications.

CAN was designed for applications needing high-level data integrity and data rates of up to 1 Mbit/s.

Freescale Semiconductor has a complete line of products enabling industrial electronics designers to incorporate CAN into their applications.

Key Benefits
> Provides a full range of reliable CAN products
> Integrates CAN into all levels of microcontrollers and DSPs
> Provides connectivity and increased integration through SMARTMOS™ CAN physical layers and System Basis Chips
HS-CAN Bus
CAN-Based
Industrial Network
(CANopen or DeviceNet)

MC33742
MC33989
HS CAN
SBC

VSupply

Local Wakeup Switch

VSupply

HS CAN
Physical Layer

CAN TX

CAN RX

VDD

GND

8-, 16-, 32-Bit
MCU

MSCAN,
TOUCAN,
or
FlexCAN

Analog Load Control/Conditioning Devices
(Switch Monitors, H-Bridges,
Low- and High-Side Switches...)

Sensor, Actuators, Motors

REPRESENTATIVE INDUSTRIAL CAN SLAVE NODE

MC33742
MC33989
HS-CAN
SBC

HCS12

MSCAN

SPI

MC33742
MC33989
HS-CAN
SBC

HCS12

MSCAN

SPI

MCF5272

USB
Phy

Ethernet
Mac

Ethernet Phy

REPRESENTATIVE INDUSTRIAL CAN MASTER NODE
REPRESITNFIVE INDUSTRIAL CAN NETWORK

- **Industrial CAN Master**
  - Ethernet
  - PC-Based System Controller

- **Industrial CAN Network** (Such as CANopen or DeviceNet)
  - Proportioning Valve
    - Industrial CAN Slave
  - TRIAC
    - Industrial CAN Slave
  - Relay
    - Industrial CAN Slave
  - Motor Contactor
    - Industrial CAN Slave
  - Sensor
    - Industrial CAN Slave
  - Opto-Interrupter
    - Industrial CAN Slave
  - DSP Motor Controller
    - Industrial CAN Slave

- **Additional Industrial CAN Network**
  - CAN-CAN Bridge
    - Industrial CAN Slave
### Freescale Ordering Information

#### Part Number | Product Highlights | Additional Information
---|---|---
MC33388 | Fault Tolerant CAN Interface | [www.freescale.com/analog](http://www.freescale.com/analog)
MC33389 | System Basis Chip with Low-Speed CAN
MC33742 | System Basis Chip with Enhanced High-Speed CAN
MC33889 | System Basis Chip with Low-Speed Fault Tolerant CAN
MC33897 | Single-Wire CAN Transceiver
MC33989 | System Basis Chip with High-Speed CAN

#### HC08

**HC08 Family**
- Up to 60 K of Flash or ROM Memory; Enhanced SCI for LIN; SPI; Clock Generation Module; Freescale Semiconductor Scalable CAN
- [www.freescale.com](http://www.freescale.com)

- MC68HC908AZxx Family
  - 1 MSCAN08 Module

- HC12
  - Up to 128 K of Flash or ROM, SCI, and SPI; Clock Generation Module; Up to Three CAN Modules

- XC68HC912BCxx Family
  - 1 MSCAN12 Module

- MC68HC912Dxx(A) Family
  - 2 MSCAN12 Modules

- MC68HC912DG128A
  - 2 MSCAN12 Modules

- MC68HC912DT128A
  - 3 MSCAN12 Modules

#### HCS12

**HCS12 Family**
- Up to 512K of Flash or ROM; Up to Two ESCI; Up to Three SPI; Up to 4 CAN Modules; Clock Generators; Excellent EMC and Stop Idd

- MC9S12Cx Family
  - 1 MSCAN12 (rev. 2.0) Module

- MC9S12Dxx Family
  - 1 MSCAN12 (rev. 2.0) Module

- MC9S12DGxx Family
  - 2 MSCAN12 (rev. 2.0) Modules

- MC9S12DPxx Family
  - 5 MSCAN12 (rev. 2.0) Modules

- MC9S12DTxx Family
  - 3 MSCAN12 (rev. 2.0) Modules

- MC9S12Hxx Family
  - 2 MSCAN12 (rev. 2.0) Modules

#### Hybrid Controller Devices

**DSP56F803**
- 80 MHz, 40 MIPS, CAN, SCI, SPI, ADC, PWMs, Quadrature Decoder, and Quad Timer; 31.5 K Program Flash; 512 K Program RAM; 4 K Data Flash; 2 K Data RAM; MCU-Friendly Instruction Set; OnCE for Debug; On-Chip Relaxation Oscillator; 2 K BootFLASH; External Memory Expansion; Up to 16 GPIO Available in a 100-Pin LQFP

**DSP56F805**
- 80 MHz, 40 MIPS, CAN, SCI, SPI, ADC, PWMs, Quadrature Decoder, and Quad Timer; 31.5 K Program Flash; 512 K Program RAM; 4 K Data Flash; 2 K Data RAM; MCU-Friendly Instruction Set; OnCE for Debug; On-Chip Relaxation Oscillator; 2 K BootFLASH; External Memory Expansion; Up to 32 GPIO Available in a 144-Pin LQFP

**DSP56F807**
- 80 MHz, 40 MIPS, CAN, SCI, SPI, ADCs, PWMs, Quadrature Decoder, and Quad Timer; 60 K Program Flash; 2 K Program RAM; 8 K Data Flash; 4 K Data RAM; MCU-Friendly Instruction Set; OnCE for Debug; On-Chip Relaxation Oscillator; 2 K BootFLASH; External Memory Expansion; Up to 32 GPIO Available in Both a 160-Pin LQFP and 160 MAPBGA

**MC56F8300 Family**
- 60 MHz; 60 MIPS; Up to 576 KB Flash, 36 KB RAM, and Off-Chip Memory; SCI, SPI, ADC, and PWM; Quadrature Decoder; Quad Timer; FlexCAN; GPIO; COP/Watchdog; PLL; MCU-Style Software Stack Support; JTAG/OnCE for Debug; Temperature Sensor

*Note: Search on the listed part number.*
Design Challenges
Integration of High-Level Industrial CAN Networking Protocols
In industrial systems, factory automation, and machine controls, it is not enough for a designer to simply decide to use CAN. Often, many systems, tools, and machines use additional higher-level messaging protocols on top of the CAN network such as CANopen or DeviceNET. These messaging protocols are devised to describe the nature of the behavior of different modules on the network used for input/output, sensor monitoring, and motor controllers. They define what information passes from one node to another, when it is passed, and how often it is passed. These industrial messaging protocols can be complicated and software driver code is often difficult to create. Many customers find it easier to purchase driver software and integrate it into their application, concentrating their software design on the application itself.

In-Application Reprogramming, Network Downloads
Once a factory or machine is built, it can be difficult, expensive, or impossible to physically access certain modules that are in the network. For this reason, it is extremely desirable to be able to reprogram the devices through the network itself. This only requires access to the network at some point, rather than direct physical access to each module. In-application programming allows upgrading module software, fixing bugs, adding new features, or updating calibration data. This provides an effective way to extend the life of a module, but requires a microcontroller that is easy to remotely reprogram.

Diagnostics, Load Control, and Load Handling
In a factory automation or industrial control environment, there are generally a large number of sensors and actuators of all types. Controlling these devices intelligently and accurately is the key to controlling the system. The more control a designer has over each component in the system, the more control he or she has over the system as a whole. Motors, for example, might need to be controlled very accurately and very quickly to keep an assembly line working at top speed. If a motor can be turned at maximum efficiency, this could represent significant cost savings to the company running the system. These levels of motor control often depend on accurate and detailed sensor feedback to determine the speed of the motor or perhaps the placement of materials on the manufacturing line.
Different CAN Networks Have Physical Layer Requirements

CAN, like all major networking protocols, requires a physical layer device in order to communicate. This physical layer comes from the ISO/OSI seven layer stack model. The physical layer is responsible for current and voltage control for the bus, dealing with current and voltage transients, and signalling bus (line) faults and possibly correcting them.

The Bosch CAN specification does not dictate physical layer specifications for anyone implementing a CAN network. This is both a blessing and a curse to the designer. Over the course of the last decade, two major physical layer designs have come to the fore and become the basic physical layer designs used in most CAN applications. They both communicate using a differential voltage on a pair of wires and are commonly referred to as a high-speed and a low-speed physical layer.

The low-speed architecture has the ability to change to a single-wire operating (referenced off ground) when one of the two wires is faulted through a short or open. Although both architectures use a voltage difference on a pair of wires, the termination methods for each are different and incompatible in production systems.

Since there are no requirements on physical layer in the CAN specification, other standards organizations help designers create compatible CAN devices. The International Organization for Standardization (ISO) creates standards to ensure inter-operability of components at the physical layer and recommends design practices. ISO standards are generally followed for industrial applications.

### Industrial CAN Physical Layer Standards

<table>
<thead>
<tr>
<th>CAN Physical Layer Type</th>
<th>Description</th>
<th>Additional Information</th>
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<tr>
<td>Low-Speed Fault Tolerant CAN</td>
<td>ISO 11519-2 Low-Speed Serial Data Communication—Part 2: Low-Speed Controller Area Network (CAN)</td>
<td>ISO Standards (Europe) <a href="http://www.iso.org">www.iso.org</a></td>
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<tr>
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<td>Road vehicles—Low-Speed Serial Data Communication—Part 2: Low-Speed Controller Area Network (CAN) (ISO 11898-3 is likely soon to replace 11519-2)</td>
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<tr>
<td>High-Speed CAN</td>
<td>ISO 11898 High-Speed CAN</td>
<td><a href="http://www.freescale.com">www.freescale.com</a></td>
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<tr>
<td></td>
<td>Road vehicles—Interchange of Digital Information—Controller Area Network (CAN) for High-Speed Communication</td>
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</table>

**Freescale Semiconductor Solution**

**Integration of High-Level Industrial CAN Networking Protocols**

Freescale Semiconductor offers a complete development tools environment for creating embedded applications in C-based software. This environment allows application designers to create embedded applications and easily integrate existing C-based software drivers to support industrial CAN networks such as DeviceNet or CANopen.

**In-Application Reprogramming**

With a large portfolio of Flash memory-based MCUs with CAN networking capability, Freescale Semiconductor has an excellent selection of devices that are perfectly suited to creating nodes that can be upgraded through the network. In addition to having the Flash memory, there are additional features that make in-application reprogramming even easier. Freescale Semiconductor Flash MCUs operate from -40°C to 125°C, and can be reprogrammed quickly and easily without any additional power supplies. One voltage supply can support the MCU and provide programming voltage for the Flash array. This capability eliminates the need for additional circuitry and management of a separate programming voltage supply.
Diagnostics, Load Control, and Load Handling

Freescale Semiconductor SMARTMOS (SMOS) products bring an unparalleled level of control and diagnostic capabilities for connecting to motors, lamps, sensors, and other types of industrial loads. Protection features that are difficult, expensive, or impossible to implement in discrete components are available in products such as H-bridge drivers for motors. SMOS H-bridge drivers are fully protected against conditions of over-current, over-voltage, over-temperature, and low voltage, automatically shutting off outputs to prevent damage. Additionally, monitoring features such as current recopy allow the monitoring of current through the low-side of the bridge to determine how much current is going to the motor. This can be used to indicate motor stall conditions or other application-specific diagnostics. Die temperature and supply voltage can also be measured and monitored, allowing previously unattainable diagnostics capabilities. SMOS also offers load control capabilities by controlling the amount of current delivered to a load by setting current limits and driving the outputs with controllable pulse-width modulation. Another essential component to many motor control applications provided for in SMOS is inputs for Hall Effect sensors, used to measure motor speeds.

Other SMOS products allow monitoring of high-voltage switches, allowing an MCU with 5 V input/output requirements to interface to higher-voltage switches. The devices provide pulse-wetting current to clean the switch contacts and allow an MCU to interface to 12 switches at one time, while only using 4 pins of the MCU for communication with the device.

Freescale Semiconductor SMOS CAN Physical Layer Products to Meet Industrial Customer Needs

To address the need for multiple types of CAN physical layers, Freescale Semiconductor offers a range of CAN physical layer devices designed to meet or exceed the performance standards set out by ISO.

But a simple physical layer device is not always enough. Modules in the system might need to run from a regulated power supply, for example. Sometimes a local switch or sensor might need to be able to wake up the module from sleep state to active running state very quickly. That switch or sensor might be running at higher than digital logic voltage levels. This is where the Freescale Semiconductor System Basis Chip (SBC) brings power and value to the industrial design table. SBCs combine the CAN physical layers needed for CAN connectivity with voltage regulation, independent watchdog timer, and local wake-up circuitry to allow greater flexibility with fewer components. Since these circuits can be made with the same semiconductor processes, it makes sense to combine these functions into one package and reduce the number of components needed in the final design. This reduces assembly costs, increases reliability, and increases design flexibility.

### Development Tools

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<thead>
<tr>
<th>Tool Type</th>
<th>Product Name</th>
<th>Vendor</th>
<th>Description</th>
<th>Additional Information</th>
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<tr>
<td>Software</td>
<td>CW568X</td>
<td>Freescale</td>
<td>CodeWarrior™ Development Studio for 56800/E Controllers with Processor Expert</td>
<td><a href="http://www.freescale.com">www.freescale.com</a></td>
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<td>(Metrowerks)</td>
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<tr>
<td>Software</td>
<td>MSCAN Low-Level</td>
<td>Metrowerks</td>
<td>Low-Level Driver Software for MSCAN08, MSCAN12, and MSCAN for HCS12</td>
<td><a href="http://www.metrowerks.com">www.metrowerks.com</a></td>
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<tr>
<td>Drivers</td>
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<td>Configuration</td>
<td>MSCAN Filter</td>
<td>Metrowerks</td>
<td>Calculates Optimal Hardware Filter Settings for MSCAN Architecture for</td>
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<td>Generation Tool</td>
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<td>Customer Application</td>
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<tr>
<td>Hardware</td>
<td>56F800DEMO</td>
<td>Freescale</td>
<td>56F800 Demonstration Kit</td>
<td><a href="http://www.freescale.com">www.freescale.com</a></td>
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<tr>
<td>Hardware</td>
<td>56F8300DEMO</td>
<td>Freescale</td>
<td>56F8300 Developers Start Kit</td>
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<tr>
<td>Hardware</td>
<td>M56F8322EVM</td>
<td>Freescale</td>
<td>Evaluation Module for 56F8322 and 56F8323</td>
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<tr>
<td>Hardware</td>
<td>M56F8347EVM</td>
<td>Freescale</td>
<td>Evaluation Module for the 56F834x, 56F835x, 56F836x</td>
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<tr>
<td>Hardware</td>
<td>EVDs and Other</td>
<td>Metrowerks</td>
<td>Fault Tolerant CAN Interface</td>
<td><a href="http://www.metrowerks.com">www.metrowerks.com</a></td>
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<td>Development Tools</td>
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<td>for Respective MCUs</td>
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<td>Evaluation Kit</td>
<td>KIT33388DDEVB</td>
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<td>System Basis Chip</td>
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<td>Evaluation Kit</td>
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<td>Evaluation Kit</td>
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<td>Evaluation Kit</td>
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<td>System Basis Chip with High-Speed CAN</td>
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Note: Search on the listed product name.
### Third Party Support

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<tr>
<td>Vector CANtech</td>
<td>CAN Network Analysis and Development Tool</td>
<td><a href="http://www.vector-cantech.com">www.vector-cantech.com</a></td>
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<tr>
<td>Dearborn Group Technology</td>
<td>CAN Development and Analysis Tools</td>
<td><a href="http://www.dgtech.com">www.dgtech.com</a></td>
</tr>
<tr>
<td>Hitex Development Tools</td>
<td>Toolbox for CAN Applications</td>
<td><a href="http://www.hitex.de">www.hitex.de</a></td>
</tr>
<tr>
<td>IXXAT, Inc.</td>
<td>CAN Development and Analysis Tools, DeviceNet and CANopen Drivers</td>
<td><a href="http://www.ixxat.com">www.ixxat.com</a></td>
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<tr>
<td>National Instruments</td>
<td>CAN Test and Measurement Tools</td>
<td><a href="http://www.ni.com">www.ni.com</a></td>
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### Related Documentation

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<td>AN1776</td>
<td>Stereo Audio transmission with TouCAN™</td>
<td><a href="http://www.freescale.com">www.freescale.com</a></td>
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<td>AN1798</td>
<td>CAN Bit Timing Requirements</td>
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<td>AN1828</td>
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<td>AN2010</td>
<td>Using The Freescale Semiconductor msCAN Filter Configuration Tool</td>
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<td>AN2011</td>
<td>The MSCAN on the MCS912DP256 vs. HC12 family</td>
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<td>EB376</td>
<td>A Comparison of the MC9S12DP256 (Mask Set 0K36N) Versus the HC12</td>
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<td>SG187</td>
<td>Automotive Product Selector Guide</td>
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<td>SG1002</td>
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<td>SG1004</td>
<td>DSP Selector Guide</td>
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<td>SG1006</td>
<td>Microcontrollers Product Selector Guide</td>
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*Note: Search on the listed document number.*

See also the CAN in Automation (CiA) - international users’ and manufacturers’ group Web site at www.can-cia.org.

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**Learn More:** Contact the Technical Information Center at +1-800-521-6274 or +1-480-768-2130.

For more information about Freescale products, please visit [www.freescale.com](http://www.freescale.com).