Industrial Controller Area Network (CAN) Applications

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

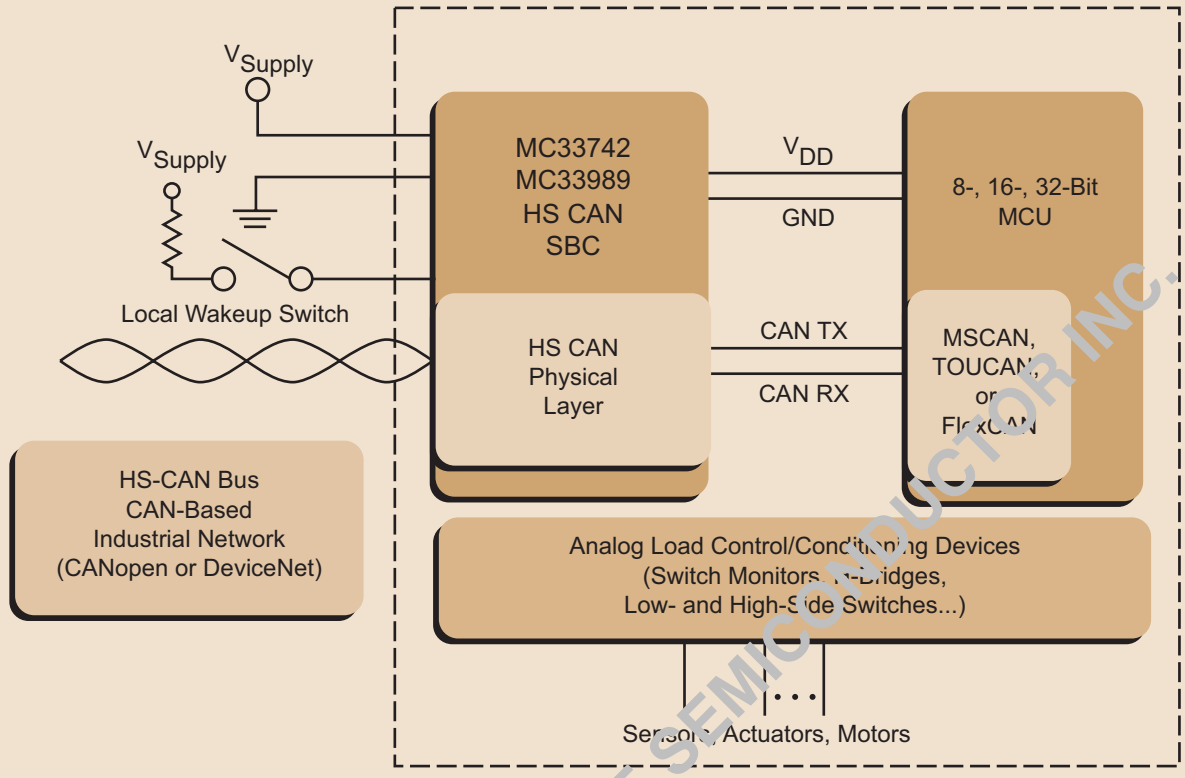
> Provides a full range of reliable CAN products

> Integrates CAN into all levels of microcontrollers and DSPs

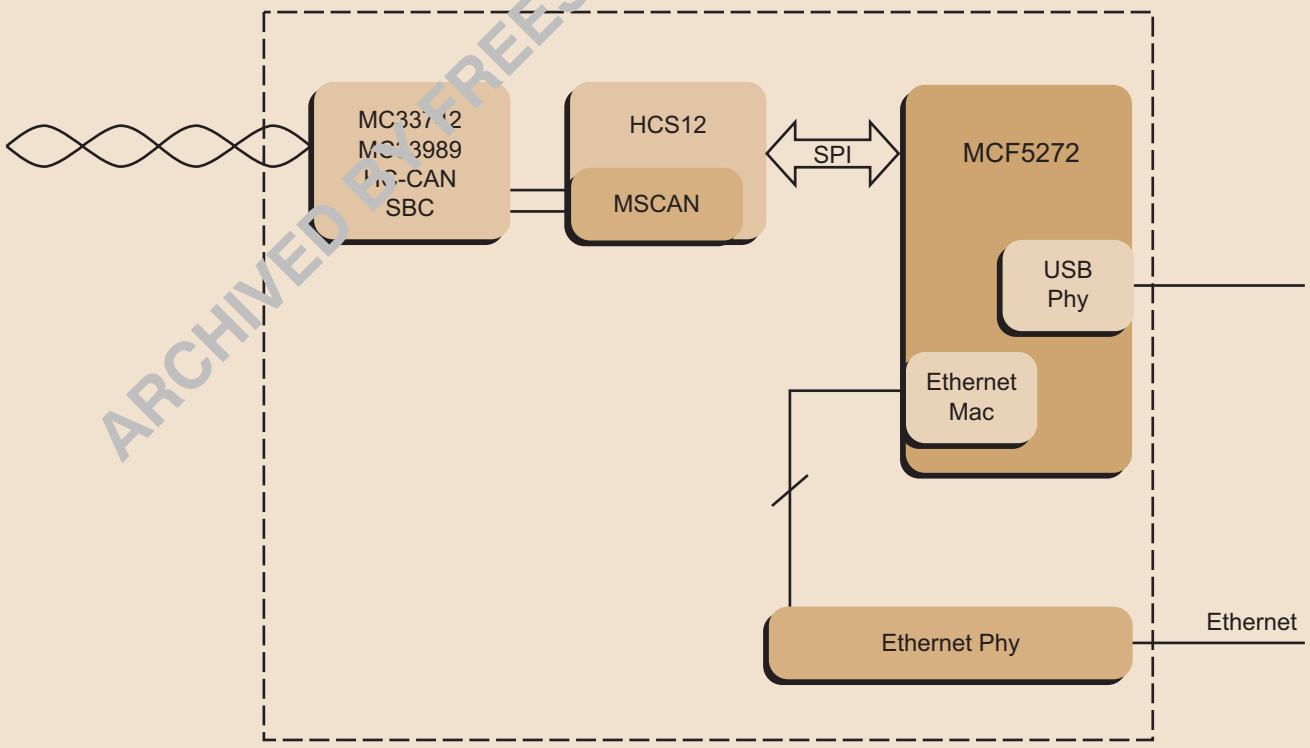
> Provides connectivity and increased integration through *SMARTMOS*™ CAN physical layers and System Basis Chips

freescale semiconductor

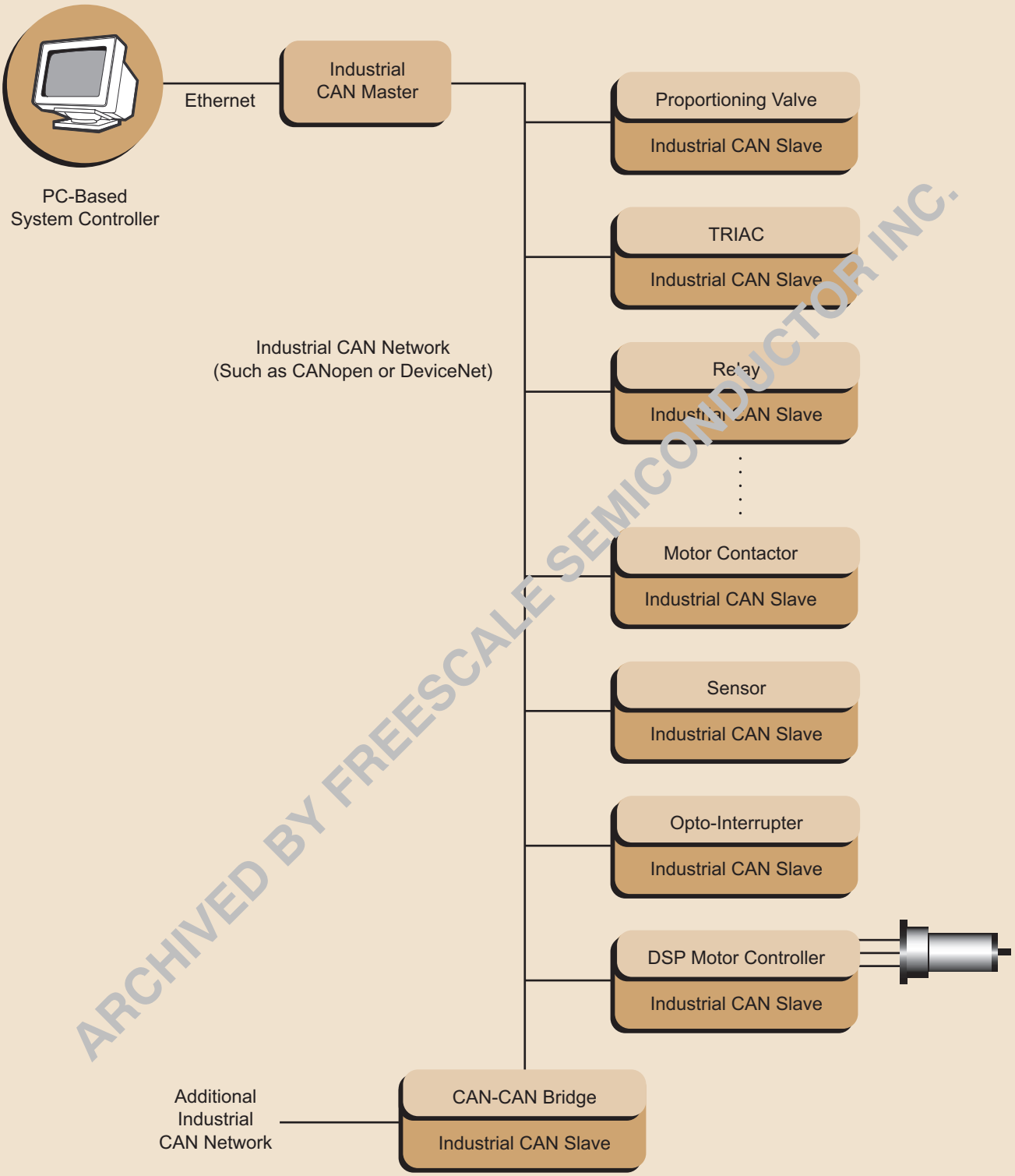
REPRESENTATIVE INDUSTRIAL CAN SLAVE NODE



REPRESENTATIVE INDUSTRIAL CAN MASTER NODE



REPRESENTATIVE INDUSTRIAL CAN NETWORK



Freescale Ordering Information [Note]		
Part Number	**Product Highlights**	**Additional Information**
Analog Devices		
MC33388	Fault Tolerant CAN Interface	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
MC68HC908AZxx Family	1 MSCAN08 Module	
HC12		
HC12 Family	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	
MC9S12Cxx Family	1 MSCAN12 (rev. 2.0) Module	
MC9S12Dxx Family	1 MSCAN12 (rev. 2.0) Module	
MC9S12DGxx Family	2 MSCAN12 (rev. 2.0) Modules	
MC9S12DJxx Family	2 MSCAN12 (rev. 2.0) Modules; 1 BDLC (J1850) Module	
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, SCIs, SPI, ADC, PWMs, Quadrature Decoder, and Quad Timer; 15.5 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, SCIs, 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.

Freescale Ordering Information (continued)[Note]		
Part Number	**Product Highlights**	**Additional Information**
MPC5200 32-bit Processors		
MPC5200	2 MSCAN12 2.0a/2.0b	e-www.freescale.com/files/abstract/overview/SPSMPC5200.htm[NOTE]
32-Bit Microcontrollers		
MPC555/6LFMZP40(R2)	2 TouCAN Modules	www.freescale.com
MPC561/2LFMZP40(R2)	3 TouCAN Modules	
MPC563/4LFMZP40(R2)	3 TouCAN Modules	
MPC565/6LFMZP40(R2)	3 TouCAN Modules	
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

CAN Physical Layer Type	Description	Additional Information
Low-Speed Fault Tolerant CAN	ISO 11519-2 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)	ISO Standards (Europe) www.iso.org
High-Speed CAN	ISO 11898 Road vehicles—Interchange of Digital Information—Controller Area Network (CAN) for High-Speed Communication	www.freescale.com

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 designable. 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 [Note]

Tool Type	Product Name	Vendor	Description	Additional Information
Software	CW568X	Freescale Semiconductor	CodeWarrior™ Development Studio for 56800/E Controllers with Processor Expert (Metrowerks)	www.freescale.com
Software Drivers	MSCAN Low-Level Software Drivers	Metrowerks	Low-Level Driver Software for MSCAN08, MSCAN12, and MSCAN for HCS12	www.metrowerks.com
Configuration Tool	MSCAN Filter Generation Tool	Metrowerks	Calculates Optimal Hardware Filter Settings for MSCAN Architecture for Customer Application	
Hardware	56F800DEMO	Freescale Semiconductor	56F800 Demonstration Kit	www.freescale.com
Hardware	MC56F8300DS.X	Freescale Semiconductor	56F8300 Developers Start Kit	
Hardware	MC56F8322EVM	Freescale Semiconductor	Evaluation Module for 56F8322 and 56F8323	
Hardware	MC56F8367EVM	Freescale Semiconductor	Evaluation Module for the 56F834x, 56F835x, 56F836x	
Hardware	EBs and Other Development Tools for Respective MCUs	Metrowerks	www.metrowerks.com	www.metrowerks.com
Evaluation Kit	KIT33388DEVB	Metrowerks	Fault Tolerant CAN Interface	
Evaluation Kit	KIT33389DWEVB	Metrowerks	System Basis Chip	
Evaluation Kit	KIT33742DWEVB	Metrowerks	System Basis Chip with Enhanced High-Speed CAN	
Evaluation Kit	KIT33889DWEVB	Metrowerks	System Basis Chip with Low-Speed CAN	
Evaluation Kit	KIT33989DWEVB	Metrowerks	System Basis Chip with High-Speed CAN	

Note: Search on the listed product name.

Third Party Support

Vendor	Description	Additional Information
Vector CANtech	CAN Network Analysis and Development Tool	www.vector-cantech.com
Dearborn Group Technology	CAN Development and Analysis Tools	www.dgtech.com
Hitex Development Tools	Toolbox for CAN Applications	www.hitex.de
IXXAT, Inc.	CAN Development and Analysis Tools, DeviceNet and CANopen Drivers	www.ixxat.com
NSI	CAN, VAN, KWP20002	www.nsi.fr
National Instruments	CAN Test and Measurement Tools	www.ni.com
PHYTEC	32-Bit Power (using PowerPC ISA) with Dual TouCAN in Credit Card Sized Package, Providing Rapid Development with MPC555 in a Cost-Effective, High-Performance Single Board Computer	www.phytec.com

Related Documentation[Note]

Document Number	Description	Additional Information
AN1776	Stereo Audio transmission with TouCAN™	www.freescale.com
AN1798	CAN Bit Timing Requirements	
AN1828	Flash Programming via CAN	
AN2010	Using The Freescale Semiconductor msCAN Filter Configuration Tool	
AN2011	The MSCAN on the MCS912DP256 vs. HC12 family	
AN2255	MSCAN Low Power Applications	
AN2283	Freescale Semiconductor Scalable Controller Area Network (MSCAN) Interrupts	
APDPAK	Analog ICs Integrated Solutions Pitch Pack	
EB376	A Comparison of the MC9S12DP256 (Mask Set 0K36M) versus the HC12	
SG187	Automotive Product Selector Guide	
SG1002	Analog Product Selector Guide	
SG1004	DSP Selector Guide	
SG1006	Microcontrollers Product Selector Guide	

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.

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**.

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