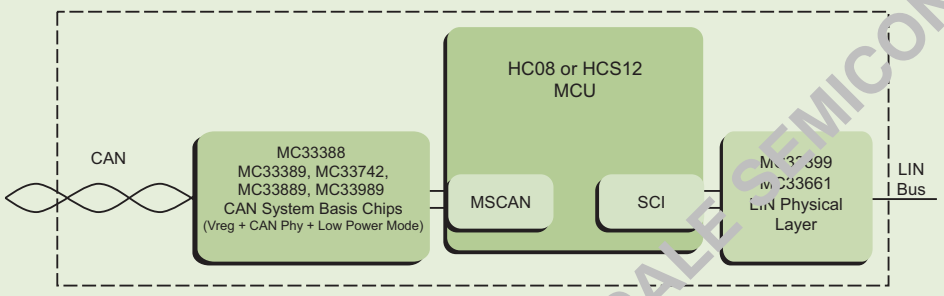
Automotive Local Interconnect Network (LIN) Applications

Overview

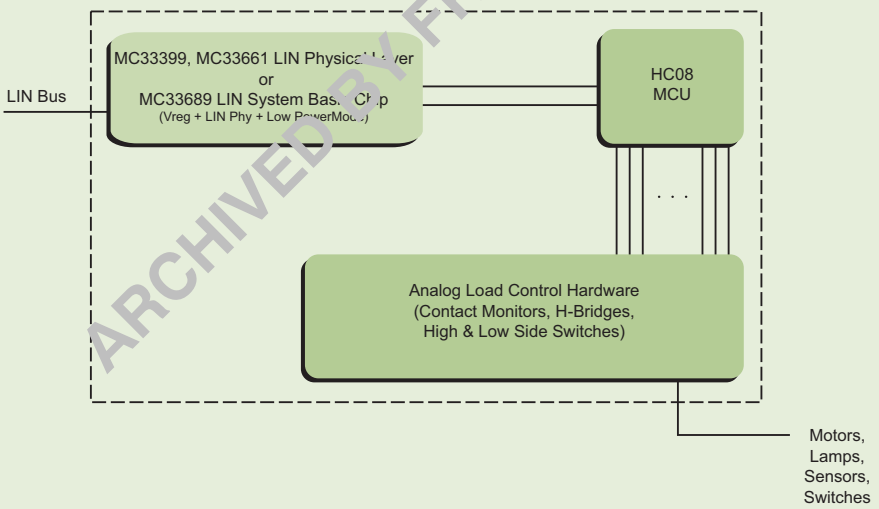
Local interconnect network (LIN) is a UART-based, single-master, multiple-slave networking architecture originally developed for automotive sensor and actuator networking applications. LIN provides a low-cost networking option for connecting motors, switches, sensors, and lamps in the vehicle. The LIN master node connects the LIN network with higher-level networks, like controller area network (CAN), extending the benefits of networking all the way to the individual sensors and actuators.

TYPICAL LIN MASTER MODULE



*The MC33742 is a system basis chip.

TYPICAL LIN SLAVE MODULE



Key Benefits

> All Freescale Semiconductor MCUs are capable of LIN communications

> LIN physical layer has critical wave shaping that aids EMC problems by reducing radiated emissions

> Mechatronics smart connector solutions offer increased integration of connectors and silicon for greater design flexibility and added feature content

> Freescale Semiconductor is a founding member of the LIN consortium and the only semiconductor provider in the steering circle

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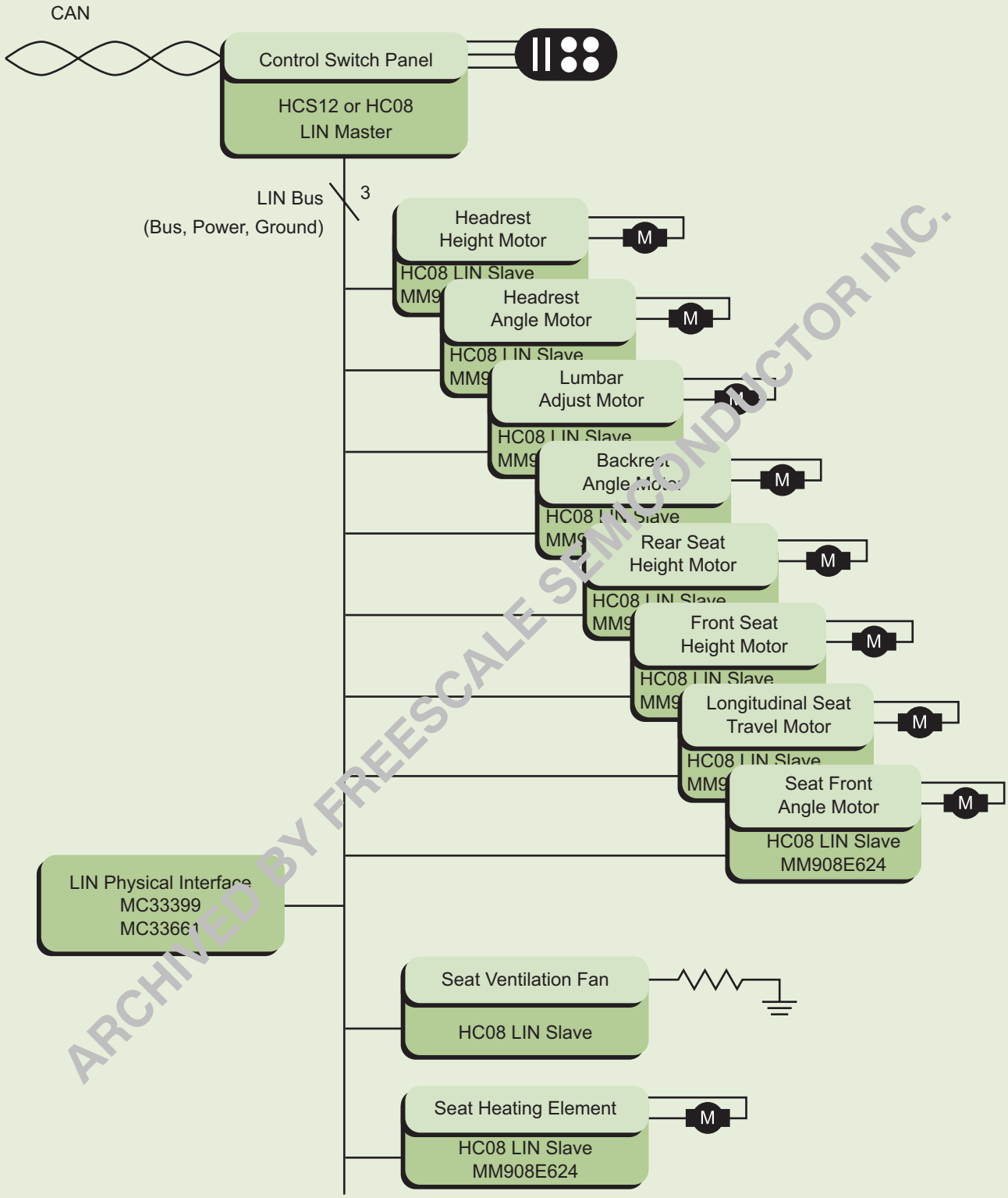
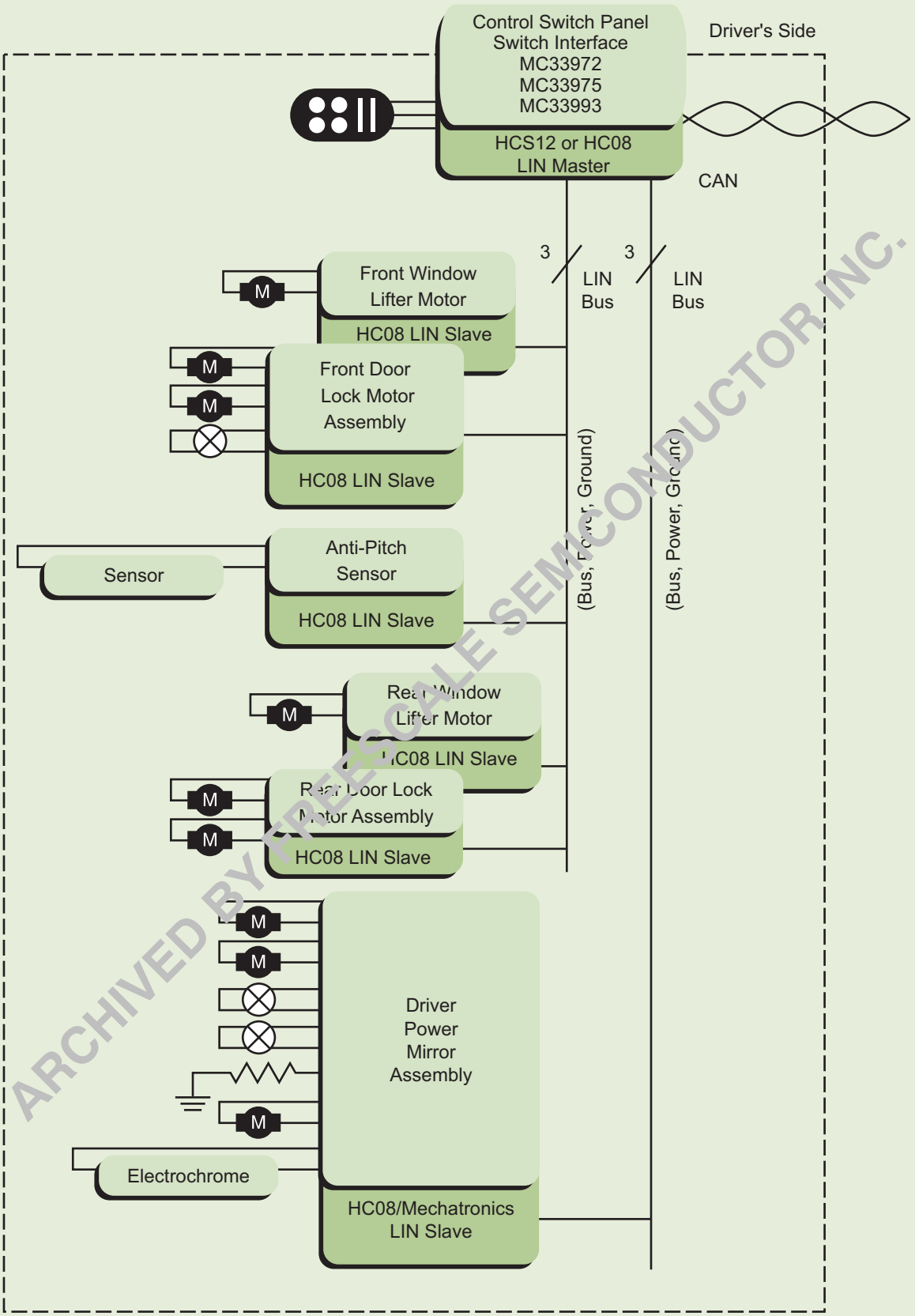
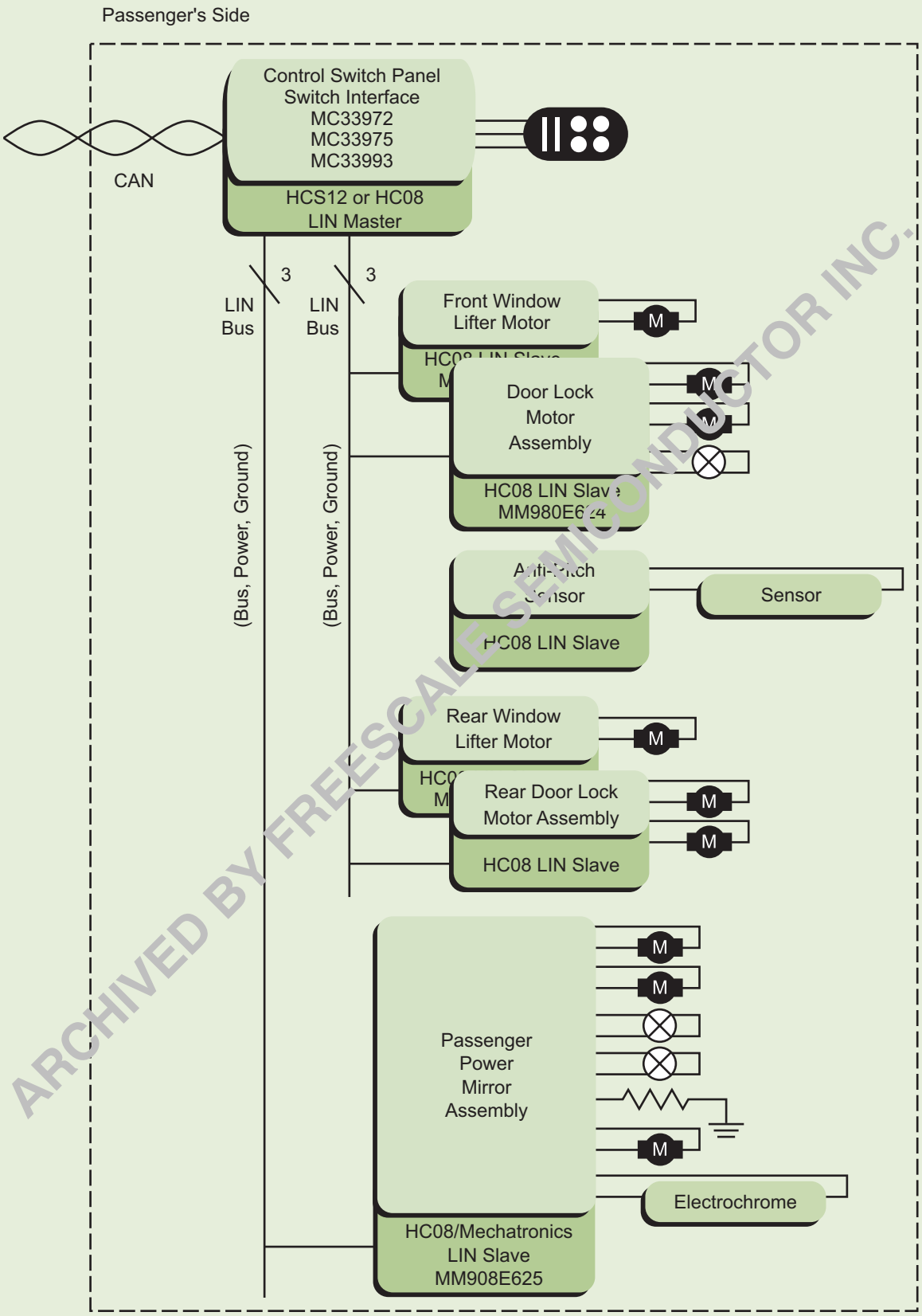
AUTOMOTIVE LIN DOOR SYSTEM BLOCK DIAGRAM



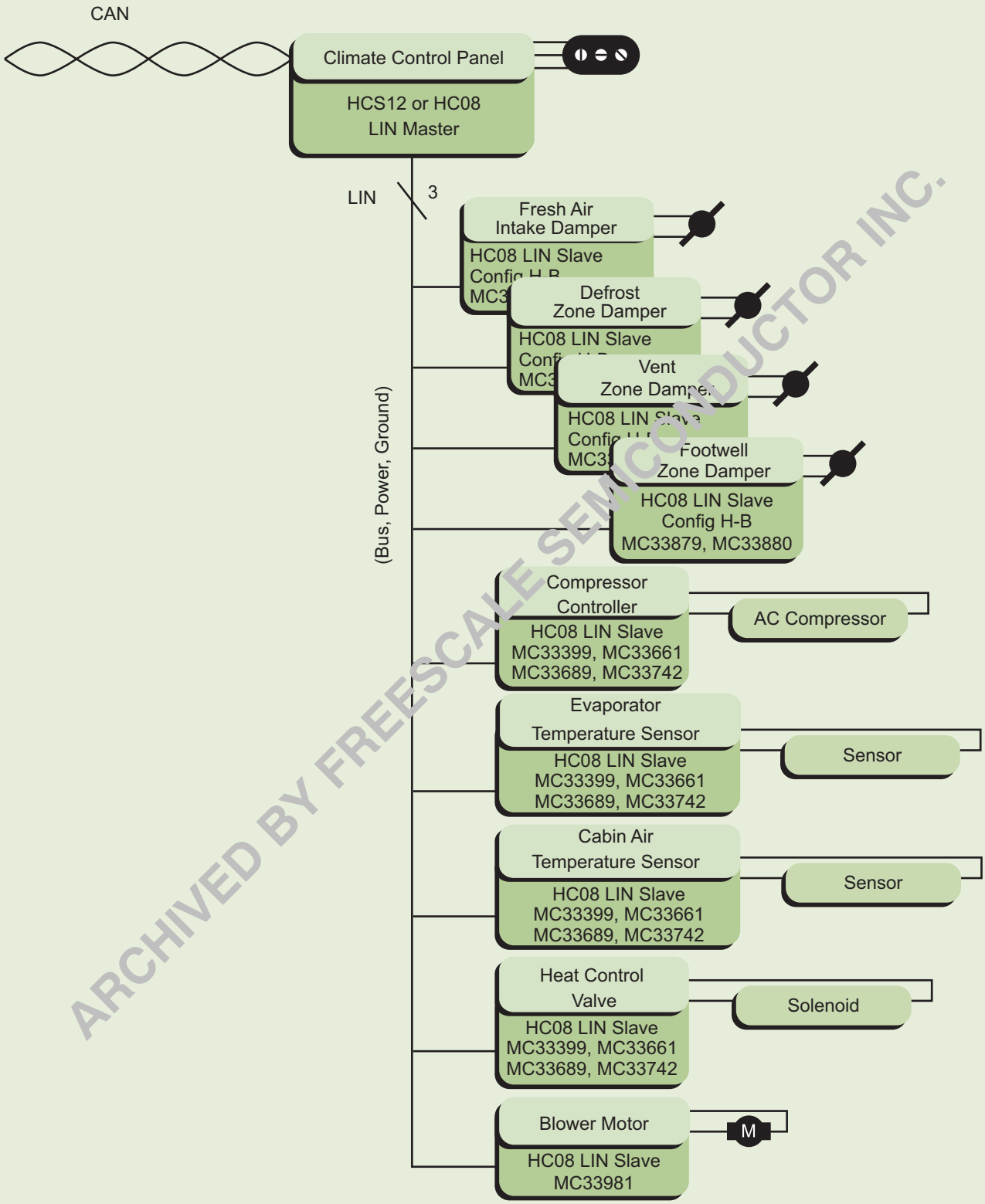
DRIVER'S SIDE: LIN DOOR SYSTEM BLOCK DIAGRAM



PASSENGER'S SIDE: LIN DOOR SYSTEM BLOCK DIAGRAM



AUTOMOTIVE HVAC SYSTEM USING LIN



Freescale Ordering Information[Note]		
Part Number	**Product Highlights**	**Additional Information**
HC08 Family	Refer to SG187 for 8- and 16-Bit Microcontroller Part Numbers; Capable of LIN Communication; Smaller and Less Expensive for Creating LIN Slave Node Applications (when sized appropriately); Up to 60K of Flash or ROM Memory; Enhanced SCI for LIN; Serial Peripheral Interface; Clock Generation Module; Freescale Semiconductor Scalable CAN	www.freescale.com
HC12 Family	Refer to SG187 for 8- and 16-bit Microcontroller Part Numbers; Capable of LIN Communication; Powerful Choice for LIN Master Node Application; Up to 128 K of Flash or ROM; SCI, SPI, Clock Generation Module; Up to Three CAN Modules	
HCS12 Family	Refer to SG187 for 8- and 16-bit microcontroller Part Numbers; Capable of LIN Communication; Powerful Choice for LIN Master Node Application; Up to 512 K of Flash or ROM; Up to Two ESCI; Up to Three SPI; Up to 4 CAN Modules; Clock Generators; Excellent EMC and Stop Idd.	
MC33399	Local Interconnect Network (LIN) Physical Layer	www.freescale.com/analog
MC33661	eLIN – Enhanced LIN Physical Layer (Local Interconnect Network)	
MC33689	LIN System Basis Chip: LIN physical interface, voltage regulation, two local wake-up inputs, power drive outputs	
MC33742	System Basis Chip with Enhanced High Speed CAN	
MC33879	Configureable Octal Serial Switch with Open Load Detect Current Disable	
MC33880	Configurable Eight Output SPI Controlled Switch (1.0 Ω $R_{DS(ON)}$)	
MC33972	22 Input Multiple Switch Detection Interface with Suppressed Wake-Up	
MC33975	22 Input Multiple Switch Detection Interface with Higher Wetting Current	
MC33981	High-Frequency, High-Current, Self-Protected 4 mΩ $R_{DS(ON)}$ High-Side Switch	
MC33984	Self Protected 4 mΩ Switch with Diagnostic and Protection	
MC33993	22 Input Multiple Switch Detection Interface	
MC56F801x Family (Slave functionality only)	Up to 32 MHz, 32 MIPS, and up to 16KB Flash; 4KB Unified Data/Program RAM; EEPROM emulation capability; SCI with LIN, SPI, I^2C, ADC, PWM, GPIO, COP/Watchdog; MCU-Style software stack support; JTAG/OnCE for debug	www.freescale.com
MM908E624	Integrated Triple High-Side Switch with Embedded MCU and LIN Serial Communication for Relay Drivers	
MM908E625	Integrated Quad Half H-Bridge with Power Supply, Embedded MUC, and LIN Serial Communication.	
Note: Search on the listed part number.		

Design Challenges

Form Factor, Manufacture Capability, Load Control, and Diagnostics

Challenges exist when integrating LIN networking into an automotive environment. Most applications, where LIN could be used, are currently implemented using discrete, point-to-point wiring systems with no allocation for silicon, circuits, or components at the load. The load, whether a lamp, motor, or sensor, is usually connected with a simple connector to wires in the tangle of the wiring harness. As a result, little room remains to incorporate the components to enable LIN. For example, in a power mirror, a supplier might place as many as three motors, heater element, electrochromic glass, and multiple lamps. These components do not leave much room for other potential requirements.

The capability to manufacture control modules is another significant challenge to automotive electronics manufacturers. This problem is not unique to LIN developers but it is a problem not always faced by manufacturers of motors, sensors, and actuators.

Finally, when distributing the intelligence of the system using LIN, new options become available to designers. Motor, lamp, and solenoid loads can now be controlled at the origin. Diagnostic data can be easily rejected through the LIN network providing an unprecedented level of control and system level information. The challenge is how to provide the silicon content to control and diagnose these loads in a small form factor that can fit in a very small space.

Stringent EMC Radiated Emissions Requirements

Electromagnetic Compatibility (EMC) deals with how multiple electronic devices interact based on the electromagnetic emissions they radiate (radiated emissions) and how they respond to radiated emissions from outside sources (susceptibility). This is of enormous concern in the automotive environment due to the close proximity of a very wide range of electronic systems and devices.

It is very important that the LIN network not radiate very much energy, since these busses pass information through

long wires that result in antennae that send emissions to the rest of the vehicle. LIN is designed as a single-wire bus, switching from ground to battery-level voltages. This large voltage swing can be a potential source of large amounts of radiated emissions, particularly if little care or attention is paid to physical layer device design.

Freescale Semiconductor Solution

Freescale Semiconductor Mechatronics Address Form Factor, Manufacture Capability, Load Control, and Diagnostics Issues

LIN, as an open standard UART protocol, enables Freescale Semiconductor to create a complete line of highly integrated mechatronic components. These components integrate all of the silicon components needed for a particular slave application and connector housings into one very compact assembly. This approach offers tremendous benefits to the LIN slave node designer.

The high level of integration offers a solution to many customer design challenges. The compact size and integration of connector technologies means control units can be easily placed directly into the wiring harness without having to place the control circuitry into a separate box with more connectors and mounting issues. Control units can be attached directly to motors and other loads, eliminating connections and wiring.

In addition to the reduced form factor, these smart connectors increase the ease of manufacture because the module vendor no longer must deal with designing a circuit board, manufacturing that board assembly, and testing it for faults. All of this process is done for the customer through the manufacturing process of the mechatronics components.

One option with these mechatronic components is to have the MCU, physical layer, and load handling silicon placed onto an insulated metal substrate (IMS) that serves as a small printed circuit board. The advantage to this option is superior thermal performance. The IMS is thermally coupled to all of the load handling, communication, and logic silicon, providing unparalleled heat dissipation capability.

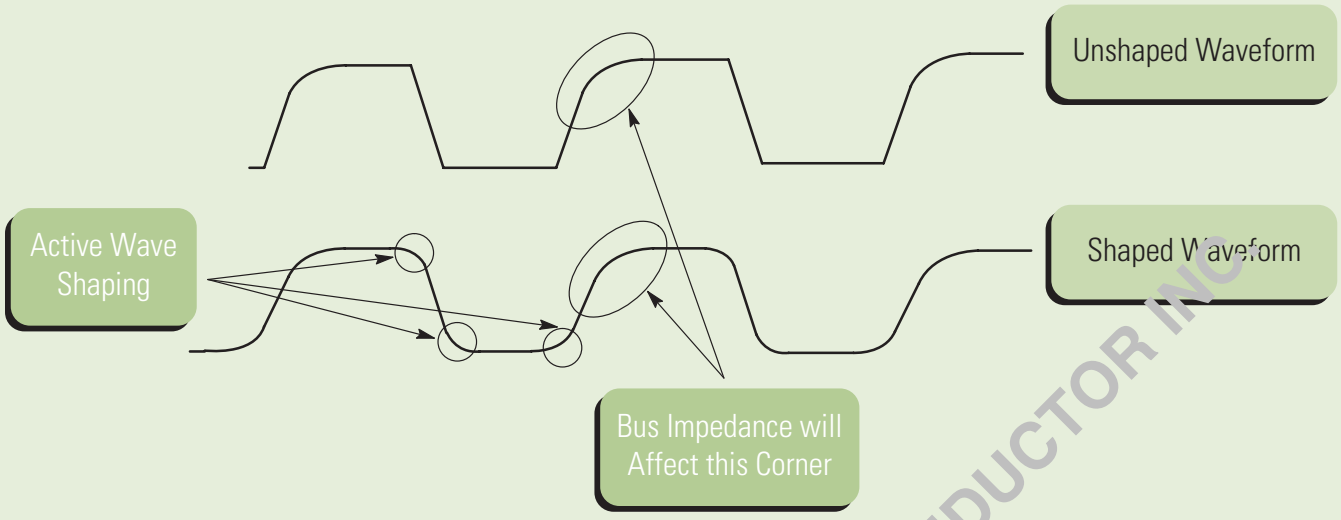
Intrinsic to the mechatronics products is the incorporation of Freescale Semiconductor *SMARTMOS*™ products for sensing, load handling and diagnostics. These products are also available as peripheral devices for MCUs and provide features such as current control and limitation, full thermal and electrical protection, and advanced load diagnostics. The application designer can measure and control exactly how much current goes to a particular load and perform these advanced operations directly at the load, rather than over long wire lengths.

Freescale Semiconductor LIN Physical Layer Designed to Meet Stringent EMC Radiated Emissions Requirements

Freescale Semiconductor has a long history of dealing with single wire automotive communication busses. The experience and insight from working with the J1850 physical layer has proven invaluable in developing the MC33399, MC33661, and LIN physical layer.

Freescale Semiconductor was one of the first to market a LIN physical layer in production quantities and the first to market a LIN physical layer with critical wave-shaping circuitry (essential for reducing radiated emissions). Wave shaping takes the traditional trapezoidal waveform and rounds the corners to reduce harmonic components in the resulting waveform. Originally, the LIN specification did not take these corners into account, but Freescale Semiconductor has gone beyond requirements to produce a superior

WAVE-SHAPED WAVEFORM



Development Tools[Note]

Tool Type	Product Name	Vendor	Description	Additional Information
Software drivers	LIN software drivers	Metrowerks	LIN Master and Slave Driver Software for HC08, HC12, and HCS12, Including both the LIN Standard API and Freescale Semiconductor Custom API.	www.metrowerks.com
Hardware development tools	EVBs and other development tools for respective MCUs and DSCs	Metrowerks	Helps Developers Simplify and Speed Development for High-Performance Microcontrollers and Digital Signal Controllers.	
Development kit	CodeWarrior development system, HC08 LIN edition	Metrowerks	CodeWarrior Development Tools for HC08, Complete with LIN Master and Slave Driver SW, Sample Application SW, HC908GP32 Reference Board (Master Module), HC908KX8 Reference Board (Slave Module).	
Evaluation Kit	KIT33388DEVB	Metrowerks	Fault Tolerant CAN Interface	
Evaluation Kit	KIT33389DWEVB	Metrowerks	System Basis Chip	
Evaluation Kit	KIT33399DEVB	Metrowerks	Local Interconnect Network (LIN) Physical Layer	
Evaluation Kit	KIT33661DEVB	Metrowerks	LIN Enhanced Physical Interface	
Evaluation Kit	KIT33742DWEVB	Metrowerks	System Basis Chip with Enhanced High-Speed CAN	
Evaluation Kit	KIT33790DWEVB	Metrowerks	System Basis Chip with Low-Speed CAN	
Evaluation Kit	KIT33989DWEVB	Metrowerks	System Basis Chip with High-Speed CAN	
Evaluation Kit	KIT908EINTFC	Metrowerks	PC Interface for MM908Exxx	

Note: Search on the listed product name.

Third Party Support

Vendor	Description	Additional Information
Vector CANtech		
CANoe (option LIN)	System Level Networking Tool	www.vector-cantech.com
CANalyzer (option LIN)	Network Monitoring, Emulation, Verification	www.vector-cantech.com
Volcano Automotive Group		
VNA/L (Volcano network architect for LIN)	System Level Networking Tool	www.volcanoautomotive.com
LINspector tool	Network Monitoring, Emulation, Verification	www.volcanoautomotive.com
LIN graphical objects (LINgo)	Graphical Add-On to LINspector	www.volcanoautomotive.com

Disclaimer

This document may not include all the details necessary to completely develop this design. It is provided as a reference only and is intended to demonstrate the variety of applications for the device.

Related Documentation[Note]		
Document Number	**Description**	**Additional Information**
AN2103	Local Interconnect Network (LIN) Demonstration	www.freescale.com
AN2205	Car Door Keypad Using LIN	
AN2264	LIN Node Temperature Display	
2002-01-1298	Implementing Local Interconnect Network (LIN) Slave Nodes (Society of Automotive engineers (SAE) Technical Papers)	www.sae.org
Note: Search on the listed document number.		

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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**.

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