Design an **Intelligent Distributed Control System** with S12 MagniV Mixed-Signal MCUs

FTF-AUT-F0085

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APR. 2014
Agenda

• Introduction
• Overview of Motor Drive Applications in Body Electronics:
  • Overview of Intelligent Distributed Control Products
    – Product architecture
    – Example of existing product applications
• Family of IDC products for Relay Driven Motors
• Tools and Product Enablement
• Conclusion
Objectives

• Educate session participants about the features and capabilities of the IDC product family based on S12 MCU
• Explain about the evolution of the IDC relay driver products
• Inform participants about the tools available to start quickly evaluating or developing applications with the product
What’s Behind Body Electronics?

- Body systems embrace a broad variety of applications inside the cabin
- Body systems cover the widest range of performance requirements
  - Small 8-bit controllers and watchdogs
  - General purpose 16-bit controllers
  - High performance 32-bit compute engines

Comfort Features
- Door Module
- Window Lift
- Seat Module
- HVAC
- Electric sunroof/shade
- Interior lighting

Vehicle Networking
- Central Body Control Module
- Central Gateways: CAN, LIN, Flexray, Ethernet, MOST

Safety Related
- Steering column lock
- Steering column adjustment
- Seat positioning
- Wipers and rain sensors
- Lighting and light sensors
- Convertible top
- Anti-pitch power windows

Security
- Immobilizer
- Keyless Entry
- Preventing hacking and counterfeit modules

Integrated BCM Gateways
What is Intelligent Distributed Control (IDC)?

- Networked motor driver system solution for body electronics optimized per application
- Designed for LIN/CAN distributed systems
- Well-suited for distributed motor control applications
- Distributed systems architecture can address both low end and high end requirements, due to its plug and play nature

LIN/CAN Distributed Systems
- **Standard interface** (LIN) allows a wide selection of products without changing door concepts, and keeping a simple wire harness
- **Optimized products** with an integrated intelligent unit (MCU)
Intelligent LIN-Based Body Electronic Motor Drivers

Windshield wipers

Sun-roof / Sun-shade

Adaptive Front-lighting System (AFS)

External Power Mirrors

Electric Windows (Window-lift)

Windshield wipers

Sun-roof / Sun-shade

Adaptive Front-lighting System (AFS)

External Power Mirrors

Electric Windows (Window-lift)
IDC / MagniV Concept

Full Discrete
- VREG
- CAN or LIN phy
- MCU or DSC
- Op-amps
- 2+
- 2+
- 20+

Semi Integrated
- MCU or DSC
- 16-24
- ASIC / ASSP
  (H-bridge+ HSD / LSD + VREG+ LIN+ Current sense)

Relay / Motor / Bulb/LED Driver

PCB space savings

IDC ASSP

IDC / MagniV Concept
Intelligent Distributed Control (IDC) Solution Architecture

**Control Unit**
- \( \mu C \text{ based solution} \)
  - MCU
  - Timer
  - A/D
  - SCI
  - Oscillator
  - Flash / ROM
  - RAM
  - EEPROM

**System Base Functionality**
- Voltage Regulator
  - LVR
- Sleep / Stop mode
- Window / Timeout
  - Watchdog
- Cyclic
  - Wake-Up
- LIN or CAN
  - Physical Layer
- Wake-up

**Application Unit**
- Half Bridges
  - Over-Current Protection
  - Over-Temperature Protection
  - Over-/Under-Voltage Shutdown
  - Current Recovery
  - Open Load
- High Side Switches
  - Over-Current Protection
  - Over-Temperature Protection
  - Over-/Under-Voltage Shutdown
  - Current Recovery
  - Open Load
- Low Side
  - Over-Current Protection
  - Over-Temperature Protection
  - Over-/Under-Voltage Shutdown
  - Current Recovery
  - Open Load
- Special I/O's
  - Hall Sensor Inputs
  - Analog Inputs
  - switched VDD
  - Gate Driver Outputs
  - Operational Amplifier
  - ...

**S08**

**S12**
What’s S12 MagniV?

<table>
<thead>
<tr>
<th>Discrete Solution (Multi-package)</th>
<th>Multi-die SiP</th>
<th>Monolithic SoC</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Standard MCU</td>
<td>• Single package</td>
<td>• MCU and Analog on the same die</td>
</tr>
<tr>
<td>• Application Specific Analog IC (ASIC /ASSP)</td>
<td>• Multi-die (MCU + analog)</td>
<td></td>
</tr>
</tbody>
</table>

Body Electronics system solution integrating an S12 MCU, LIN transceiver, SBC, analog, and High Voltage power drivers in a single package.
IDC Product Portfolio

Relay-Driven DC Motors
- Window lift / Sun roof
  - MM908E624

H-bridge Driven DC Motors
- Mirror
  - MM908E621
- Light-leveling
  - MM908E625

H-bridge Driven DC & Stepper Motors

8-bit MCU
16-bit MCU

MM912_634
MM912xF634
MM908E622
MM908E624
MM908E625
MM908E626

Window lift / Sun roof
Mirror
Light-leveling

External Use | 9
> 10 Years of IDC system solutions for Body Electronics

- MM908E624
  - 8-bit HC08 + Analog Relay Driver

- MM908E626
  - HC08 + Analog AFS Stepper Driver

- MM908E622/1
  - 8-bit HC08 + Analog Relay Driver

- MM908E630
  - 8-bit HC08 (SOG) + Analog Relay Driver

- MM912F634
  - 16-bit S12I32 + Analog Relay & Switch Driver

- MM912G634
  - 16-bit S12I32 + Analog Relay & Switch Driver

- S12VR64 (first part of MagniV family)
  - S12ZV M
  - S12ZVL
  - S12ZVC

- SiP Architecture
- HC08 Microcontroller with flash (0.5um)
- SMOS5 (0.8um)
- 54ld SOIC Package

- SMOS8 (0.25um)
- QFN Package

- LL18UHV technology
- Monolithic SoC
- S12Z Core

- Architecture Repartitioning

2nd Gen
3rd Gen
4th Gen
**Key Characteristics**
- MCU / Memory: HC08 / 16K
- Power Outputs: 4 x HB / 1 XHS
- PL / WD: LIN / Yes
- Stop/Sleep current: 65μA / 35μA
- ESD: +/- 4 KV
- Operating voltage: 8V – 18 V
- Operating temp.: -40°C < Ta < 85°C
- Package: SOIC 54 EP

**Key Features**
- HC08 µC with Timer, ESCI, A/D, on chip oscillator
- 16k of Flash Memory
- 4 x Half Bridge Outputs (425 mΩ)
- 1 x High Side Output (600 mΩ)
- 1 x switched 5V output
- Voltage regulator 5V/60mA
- Protection / Diagnostic
- Current Control / Current Recopy
- LIN Physical Layer with selectable slew rate
- 3 x Hall sensor Inputs
- 1 x Analog Inputs with Current Source

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**In Production**
MM908E622: Integrated Quad Half H-Bridge / Triple High Side with Power Supply, Embedded MCU, and LIN Serial Interface

**Key Characteristics**
- MCU / Memory: HC08 /16K
- Power Outputs: 4 x HB / 3 x XHS
- PL / WD: LIN / Yes
- Stop/Sleep current: 50µA / 20µA
- ESD: +/- 4 KV
- Operating voltage: 7.5V – 20 V
- Operating temp.: -40°C < Ta < 85°C
- Package: SOIC 54 EP

**Key Features**
- HC08 µC with Timer, ESCI, on chip oscillator
- 16k of Flash Memory
- 4 x Half Bridge’s (2 x 750mΩ / 2 x 2750mΩ)
- 3 x High Side’s (2 x 440 mΩ, 1 x 185mΩ)
- 1 x Switchable 5V output
- Voltage Regulator 5V/60mA
- Protection / Diagnostic / Current Recopy
- LIN Physical Layer with selectable slew rate
- 1 x Hall sensor Input
- 1 x Analog Input with current source
- 1 x Wake Up Input
- Electro-chrome feature

In Production
Window Lift Application Background

Typical Anti-Pinch Window Lifter

<table>
<thead>
<tr>
<th>Basic Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
</tr>
<tr>
<td>DC Motor</td>
</tr>
<tr>
<td>Key Up/Down</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Additional Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
</tr>
<tr>
<td>Anti-Pinch</td>
</tr>
<tr>
<td>Ramp Up/Down</td>
</tr>
<tr>
<td>Safety Features</td>
</tr>
<tr>
<td>Communication</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technical Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motor Current</strong></td>
</tr>
<tr>
<td><strong>Nominal Voltage</strong></td>
</tr>
</tbody>
</table>
MM912_634: An Intelligent Relay Driver for DC Motors
MM912_634 Family Relay-driven Motor Driver

Key Features

- S12 16-bit CPU (up to 20 MHZ)
- Operating voltage: 5.5V to 18V (functional up to 27V)
- Voltage regulator operating directly from car battery. Vreg capable of driving 18V/80 mA for off-chip components (E-Vreg)
- LIN physical layer: LIN 2.x / J2602 compliant; ±8kV ESD rated
- Two protected low-side drivers: Drive relays with 10 kHz PWM, energy clamp, and current limit for motor and device protection (Eclamp = 10 mJ @ 125°C)
- Two protected high side drivers: 50 kHz PWM and current limit. Used for driving control switches and indicator LEDs
- 6 high voltage inputs: 12V inputs for switch monitoring
- On-chip RC oscillator: trimmed to ±1.3% tolerance over full temperature range
- On-chip SRAM: 2kB to 6kB
- Integrated current sense: Used for sensing motor position/load
- 10-bit ADC with 15 inputs
Target Applications:
- Automotive electric window-lift/sunroof motors with anti-pinched
- Generic LIN-controlled relay-driver
- LIN nodes

Family Options:
- Flexible flash options:
  - 32 kB, 48 kB, and 64 kB
- Flexible SRAM options:
  - 2 kB to 6 kB
- 48-pin LQFP package with/without exposed pad
  - (EP) EP used for better thermal performance
- C*/ V / M temperature options (up to 125°C Ta)
  - C* is for IMM market and will operate up to 30V supply
# IDC MM912_634 Relay Driver Product Family Overview

<table>
<thead>
<tr>
<th>Products</th>
<th>MM912F634</th>
<th>MM912xF634</th>
<th>MM912G634</th>
<th>MM912G634 / MM912H634D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- up to 16MHz</td>
<td>- up to 20MHz</td>
<td>- up to 16MHz</td>
<td>- up to 32MHz</td>
</tr>
<tr>
<td></td>
<td>- up to 2k RAM</td>
<td>- up to 2k RAM</td>
<td>- up to 2k RAM</td>
<td>- up to 6k RAM</td>
</tr>
<tr>
<td></td>
<td>- LIN Tx/Rx</td>
<td>- LIN Tx/Rx</td>
<td>- LIN  Tx/Rx</td>
<td>- Up to 4k Data Flash</td>
</tr>
<tr>
<td></td>
<td>- Battery Sense</td>
<td>- Battery Sense</td>
<td>- Battery Sense</td>
<td>- LIN  Tx/Rx &amp; CAN</td>
</tr>
<tr>
<td></td>
<td>- Vreg</td>
<td>- Current Sense</td>
<td>- Vreg</td>
<td>- Battery Sense</td>
</tr>
<tr>
<td></td>
<td>- 4 HVIOs</td>
<td>- 6 HVIOs</td>
<td>- Current Sense</td>
<td>- Current Sense</td>
</tr>
<tr>
<td></td>
<td>- 6 GPIOs</td>
<td>- 6 GPIOs</td>
<td>- Vreg</td>
<td>- Vreg</td>
</tr>
<tr>
<td></td>
<td>- 3 ADC/TIMERS</td>
<td>- 3 ADC/TIMERS</td>
<td>- 4 HVIOs</td>
<td>- 6 HVIOs</td>
</tr>
<tr>
<td></td>
<td>- 2 HS Switches</td>
<td>- 2 HS Switches</td>
<td>- 8 GPIOs</td>
<td>- 8 GPIOs</td>
</tr>
<tr>
<td></td>
<td>- 2 Relay drivers (LS)</td>
<td>- 2 Relay drivers (LS)</td>
<td>- 3 ADC/TIMERS</td>
<td>- 3 ADC/TIMERS</td>
</tr>
<tr>
<td></td>
<td>- SPI</td>
<td>- SPI</td>
<td>- 2 HS Switches</td>
<td>- 2 HS Switches</td>
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<tr>
<td></td>
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<td></td>
<td>- 2 Relay drivers (LS)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- SPI</td>
<td>- SPI</td>
</tr>
</tbody>
</table>

**MCU**
- Freescale S12 (16-Bit)

**Mixed-Signal Die**
- Implemented in FSL SMOS process Technology

**Package**
- LQFP 48 - NEP
- LQFP 48 - EP
- LQFP 48 - NEP
- LQFP 48 - EP
MagniV Product Positioning

**S12VR**
- 12V-Vreg
- LIN-PHY
- 2 HSD / 2 LSD
- 4 HV Inputs
- 5V Hall Supply
- 48 LQFP
- 12V-Vreg
- LIN-PHY
- 2 HSD / 2 LSD
- 5V Hall Supply
- S12 Core
- 48-64K Flash*
- 2K RAM
- 512 EEPROM
- Additional SCI
- 32 LQFP

**MM912G634**
- 12V-Vreg
- LIN-PHY
- 2 HSD / 2 LSD
- 4/6 HV Inputs*
- 5-18V Hall Sup.
- S12 Core
- 48K Flash
- 2K RAM
- Current Sense*
- 48 LQFP / LQFP-EP*

**MM912F634**
- 12V-Vreg
- LIN-PHY
- 2 HSD / 2 LSD
- 4/6 HV Inputs*
- 5-18V Hall Sup.
- S12 Core
- 32K Flash
- 2K RAM
- Current Sense*
- 48 LQFP / LQFP-EP*

**MM912H634**
- 12V-Vreg
- LIN-PHY
- 2 HSD / 2 LSD
- 6 HV Inputs
- 5-18V Hall Sup.
- S12 Core
- 64K Flash
- 4K Data
- Current Sense
- 48 LQFP / LQFP-EP

* Optional Feature  EP = Exposed Pad

Digital Components  5V Analogue Components
MCU Core and Memories  High-Voltage Components
MM912_634 EcoSystem: Evaluation Kit

- Fast evaluation of performance: EVBs for MM912_634
- Easy to use debugging tool (register or module access)
- CodeWarrior compiler
- Programs S12 P&E

1. LEDs indicate HS and LS switching
2. Input power connectors
3. Prototype area
4. TBDML interface
5. LIN connector
6. Wake-up button
7. Reset button
8. BDM connector for external programming/debugging BDM interface
9. MM912_634
### MM912_634 EcoSystem: Evaluation Kit Documentation

**Orderable Part Numbers**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Flash (kB)</th>
<th>Data Flash (kB)</th>
<th>RAM (kB)</th>
<th>Temperature Range (°C)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM912F634CV1AE/R2</td>
<td>32</td>
<td>-</td>
<td>2</td>
<td>-40°C to 105°C</td>
<td>48 LQFP-EP</td>
</tr>
<tr>
<td>MM912F634CV2AE/R2</td>
<td>48</td>
<td>2</td>
<td>2</td>
<td>-40°C to 125°C</td>
<td>48 LQFP</td>
</tr>
<tr>
<td>MM912F634CV2AP/R2</td>
<td>64</td>
<td>4</td>
<td>6</td>
<td>-40°C to 125°C</td>
<td>48 LQFP-EP</td>
</tr>
</tbody>
</table>

**Development Tools**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIT912F634EVME</td>
<td>Evaluation board to demonstrate the key features of the MM912F634</td>
</tr>
<tr>
<td>KIT912H634EVME</td>
<td>Evaluation board to demonstrate the key features of the MM912G634 and MM912H634</td>
</tr>
</tbody>
</table>

**Documentation**

<table>
<thead>
<tr>
<th>Document Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM912F634</td>
<td>Data Sheet for the MM912F634</td>
</tr>
<tr>
<td>MM912_634D1</td>
<td>Data Sheet for the MM912G634 and MM912H634</td>
</tr>
<tr>
<td>MM912F634ER</td>
<td>Errata for the MM912F634</td>
</tr>
<tr>
<td>MM912_634ER1</td>
<td>Errata for the MM912G634 and MM912H634</td>
</tr>
<tr>
<td>SG1002</td>
<td>Analog and power management device comparison Selector Guide</td>
</tr>
<tr>
<td>SG187</td>
<td>Automotive device comparison Selector Guide</td>
</tr>
</tbody>
</table>

- Complete technical documentation to ease design
- Datasheets, EVB contents
- Official EMC reports from external laboratories
MM912_634 EcoSystem: Tools and Software

**FreeMASTER Direct Register Access Control Page**

1. Six tabs with registers
2. Register address
3. Register name
4. Bit field - by clicking the button the bit value is toggled
5. Numerical value of the register
6. Read and Write buttons
7. BDM communication error
8. Back button to return to the start page
9. Read all Registers button
10. Selection of number format for all read register values
11. Message box stating whether the correct register value was entered

**FreeMASTER Modules Access Control Page**

1. Status Field: last reset and wake-up events, volatile monitor & watchdog enabler
2. LIN module
3. High side, low side switches and PWM control
4. ADC module
5. Low power modes control
6. BDM communication error
7. Back button to return to the start page
Session Summary

• You have been introduced to Freescale’s IDC product line for body electronics motor drivers.
  – Relay Driven DC motors (window-lift)
  – Power Mirrors
  – AFS (Adaptive Front-lighting System)
• This architecture has evolved in to the S12 MCU based MagniV product moniker
• Introduction to available enablement tools to assist customers in getting started quickly in using the product.