Xtrinsic Battery Management System ICs for Battery Monitoring

APF-AUT-D0333b

X.T Quiao | Analog & Sensors

Apr. 09. 2014
Session Overview
What is the most probable reason for this stop in the middle of the desert?

- Most probably a battery failure!!

- Battery field failure rates are ranging from 1000 to >10000 ppm for Batteries older 3+ years!
Freescale is solving this problem with the MM912J637 Intelligent Battery Sensor!

- Provides early warning of battery discharge!
- Avoids Battery Failures in the field!
Value Drivers for Battery Management Systems

Sophistication Of Vehicle Electronics Functions
- Increase of Current Demand
- Increasing no. of Consumers in the car

Stringent Emission & Fuel Consumption Requirements
- Decrease Engine Idle Speed
- Increase of Alternator Efficiency

Energy Management
- Load Regulation
- Idle Speed Control
- Battery Charge
- Altenator Voltage Control

Battery Management System (BMS)
- Enables Power Supply Management / Power Network stabilization
- Enables Intelligent Alternator Control
- Enables Regenerative Breaking
- Provides early warning of battery discharge & avoids of battery field failures
- Enables Start / Stop automatic / Crankability prediction
- Determines current availability for critical systems and conditions

Source: Own Slide based on Internet research
Typical Energy Management System

• Battery Management System (BMS)
  - Provides Battery State
    ▪ State of Charge (SoC)
    ▪ State of Health (SoH)
    ▪ State of Function (SoF)

• Body Control Module (BCM)
  - Controls Generator
  - Controls Power Distribution

• DC/DC
  - Ensures seamless operation of consumers in the car in case of cranking event.
Intelligent Battery Sensor the BMS for 12V Lead Acid Batteries

- Both Intelligent Battery Sensor and precision Shunt Resistor are physically integrated within the terminal recess of the battery.
- Main Functions:
  1. Precision Measurements
     - Battery current measurement via an external shunt resistor at the negative pole of the battery
     - Battery voltage measurement via a series resistor at the positive pole, measured concurrently with the battery current.
     - The integrated temperature sensor combined with battery mounting allows accurate battery temperature measurement.
  2. Calculation of battery state (SoC, SoH, SoF) with embedded MCU
  3. Communication to BCM with integrated LIN Interface
Freescale’s Intelligent Precision Battery Sensors - Overview

**MM912J637 – 12V Pb (LIN)**

- **MCU** S12 (16-bit)
- **Flash** 96k/128k
- **Data Flash** 4k
- **RAM** 6k

**Mixed-Signal Chip**
- LIN Physical Layer (ESD 15kV)
- Watchdog
- Standby Current <100µA (1sec Isense)
- Vreg capability 50mA
- Operating Voltage 3.5..28V
- RAM Contents Guaranteed :2.5...3.5V
- 3x ADC (2nd Order Sigma Delta) 16bit
- Current Measurement
  - Relative Accuracy <0.5%
  - Voltage Measurement
  - Relative Accuracy <0.2%
  - Temperature Measurement
  - Relative Accuracy <2K
- Operating Temperature -40°C<Ta<125°C

**MM9Z1J638 – Multi Applications (LIN, msCAN)**

- **MCU** S12Z (32-bit ALU)
- **Flash** 96k/128k
- **EEPROM** 4k
- **RAM** 8k
- **msCAN**

**Mixed-Signal Chip**
- LIN Physical Layer
- Watchdog
- Standby Current <100µA (1sec Isense)
- Vreg capability 150mA
- Operating Voltage 3.5..28V (Vs3:52V)
- RAM Contents Guaranteed :2.5...3.5V
- 3x ADC (2nd Order Sigma Delta) 16bit
- Current Measurement
  - Relative Accuracy <0.5%
  - Voltage Measurement
  - Relative Accuracy <0.15%
  - Temperature Measurement
  - Relative Accuracy <2K
- Operating Temperature -40°C<Ta<125°C

Freescale reserves the right to change or discontinue this product without notice.
# Freescale Intelligent Battery Sensors – Feature Comparison

<table>
<thead>
<tr>
<th>MM912J637AM2</th>
<th>MM9Z1J638BM2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application</strong></td>
<td><strong>Applications</strong></td>
</tr>
<tr>
<td>- 12V PB Battery (LIN)</td>
<td>- 12V Pb Battery (Lin, CAN), 14V Li-ion Battery, Multi-battery apps, HV Battery Junction Box</td>
</tr>
<tr>
<td><strong>Supply:</strong> 12V Vreg</td>
<td><strong>Supply:</strong> 12V Vreg</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td><strong>Communication</strong></td>
</tr>
<tr>
<td>- LIN, SCI, SPI</td>
<td>- msCAN,LIN,SCI,SPI</td>
</tr>
<tr>
<td><strong>Just Enough MCU Performance</strong></td>
<td><strong>Higher MCU Performance</strong></td>
</tr>
<tr>
<td><strong>Features</strong></td>
<td><strong>Features</strong></td>
</tr>
<tr>
<td>- Cranking mode</td>
<td>- Cranking mode</td>
</tr>
<tr>
<td>- 2nd Vsense</td>
<td>- 4 attenuated Vsense and 4 direct Voltage Pins</td>
</tr>
<tr>
<td>- External Temp sense</td>
<td>- 4 External Temp sense</td>
</tr>
<tr>
<td><strong>Full Temp Range</strong></td>
<td><strong>Full Temp Range</strong></td>
</tr>
<tr>
<td>- 40C.. 125C</td>
<td>-40C.. 125C</td>
</tr>
</tbody>
</table>
### MCU Die - comparison ‘637 vs. ‘638

<table>
<thead>
<tr>
<th>Feature</th>
<th>MCU (637)</th>
<th>MCU (638)</th>
<th>benefit/impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CPU core</strong></td>
<td>S12I</td>
<td>S12Z</td>
<td>More performance. New compiler, minor SW adoptions needed mainly on linker level. Peripheral SW modules can be reused</td>
</tr>
<tr>
<td><strong>Clock Freq</strong></td>
<td>up to 32MHz</td>
<td>up to 50MHz Bus Freq (100MHz CPU)</td>
<td>More performance.</td>
</tr>
<tr>
<td><strong>Addressing</strong></td>
<td>paging</td>
<td>linear addressing</td>
<td>simple S/W, faster access</td>
</tr>
<tr>
<td><strong>Data Flash/EEPROM</strong></td>
<td>4k Dataflash with ECC</td>
<td>4k EEPROM with ECC</td>
<td>True EEPROM. Different EEPROM Driver &amp; Data Storage System, Different Flash SW driver (only relevant if programming feature available in boot loader)</td>
</tr>
<tr>
<td><strong>RAM</strong></td>
<td>6k</td>
<td>8k with ECC</td>
<td>Extended to 8k, added ECC feature</td>
</tr>
<tr>
<td><strong>GPI0 Port A</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>added msCAN module</td>
</tr>
<tr>
<td><strong>msCAN</strong></td>
<td>no</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- Change vs. previous version, Validated on previous silicon/pizza mask
- No Change vs. previous version, AEC Q100 qualified

Freescale reserves the right to change or discontinue this product without notice.
## Analog Die - comparison ‘637 vs. ‘638

<table>
<thead>
<tr>
<th>Benefit/Impact</th>
<th>Analog Die (637)</th>
<th>Analog Die (638)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vsense</strong></td>
<td>2 inputs, with attenuation</td>
<td>Extend to 4 inputs with attenuation, and 4 direct inputs without attenuation (external resistor divider)</td>
</tr>
<tr>
<td><strong>Vsense3 max rating</strong></td>
<td>42V</td>
<td>Vsense3 rated 65V, for truck application</td>
</tr>
<tr>
<td><strong>PGA</strong></td>
<td>8 different gains, auto gain switching</td>
<td>Reduced to 4 gains, changed layout to improve noise, auto gain switching</td>
</tr>
<tr>
<td><strong>External Temp sense</strong></td>
<td>1 ext. channel</td>
<td>up to 5 ext channels. Routed via port B</td>
</tr>
<tr>
<td><strong>VDDX</strong></td>
<td>5V - 50mA capability extended to 150mA</td>
<td>CAN phy consumption</td>
</tr>
<tr>
<td><strong>Vdda</strong></td>
<td>2.5V, capability less than 2mA</td>
<td>VDD a extended up to 4mA</td>
</tr>
<tr>
<td><strong>LIN</strong></td>
<td>LIN IP for LIN 2.0-2.1 and J2602-1</td>
<td>Latest LIN IP</td>
</tr>
<tr>
<td><strong>GPIO Port B</strong></td>
<td>4 input output ports</td>
<td>Port B extended to 5 pins</td>
</tr>
<tr>
<td><strong>CAN Wake up</strong></td>
<td>No msCAN</td>
<td>CAN wake up via PTB</td>
</tr>
</tbody>
</table>

### Legend:
- Change vs. previous version, Validated on previous silicon/pizza mask
- No Change vs. previous version, AEC Q100 qualified

Freescale reserves the right to change or discontinue this product without notice.
Target Applications

12V PB Battery (LIN)

12V PB Battery (CAN)

Multi- Battery

Multiple Cells

HV Battery Junction Box

Freescale reserves the right to change or discontinue this product without notice.
Hardware Features
MM9Z1_638 Intelligent Battery Sensor Features Summary

• Current sensing (up to +/-2000 A with 100 µΩ shunt resistor)
• Voltage sensing (up to 9 inputs)
• Temperature sensing (up to 5 external inputs, 1 internal sensor)
• Embedded MCU (16-bit S12Z MCU w/ 128 kByte Flash, 8 kByte RAM, 4 kByte EE PROM all with ECC)
• Embedded power management
• LIN/CAN/SPI/UART communication
Overview

Figure 14. Analog Die Block Overview

Freescale reserves the right to change or discontinue this product without notice.
Timers – 4 channel 16-bit timer module

- General purpose timer
- 4 independent channels
- Input capture
- Output compare
- Interrupts
  - 1 per channel
  - Timer overflow
- Clock prescaler (1-128)
- 16-bit counter
- Normal mode clock:
  - D2DCLK / 4 (8 MHz max.)
- Low power mode clock:
  - ALFCLK (0.125 – 1 kHz)
- Optional Timer counter reset on channel 3 output compare event
- Optional wake-up over PTB0-3 (GPIO)
Timers – life time counter

- Flexible up-counter running in normal and low power mode
- ALWAYS based on ALFCLK
- Overflow interrupt and wake-up
GPIO – General purpose input output

- 4 pins (PTB0-3)
  - PTB0-2
    - 5V
    - Input / output
  - PTB3
    - High voltage capable (42 V)
    - Input only
- Wake up detection
- SCI Rx/Tx
- Timer 0-3 IC/OC
- LIN Tx/Rx
- PIN direct control
- Optional pull-up (PTB0-2)
- Optional pull-down (PTB3)
Interrupts

- Common vector on S12 for all analog die interrupts
  - INT_VECT register shows individual source
- Interrupt mask register for each source
- All interrupts are nestable
- Fixed priorities

Table 95. Interrupt Vector / Priority

<table>
<thead>
<tr>
<th>IRQ</th>
<th>Description</th>
<th>IRQ</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>No interrupt pending or wake up from Stop mode</td>
<td>0x01</td>
<td>1 (highest)</td>
</tr>
<tr>
<td>0x02</td>
<td>High temperature interrupt</td>
<td>0x03</td>
<td>2</td>
</tr>
<tr>
<td>0x04</td>
<td>LIN driver over-temperature interrupt</td>
<td>0x05</td>
<td>3</td>
</tr>
<tr>
<td>0x06</td>
<td>TIM channel 0 interrupt</td>
<td>0x07</td>
<td>4</td>
</tr>
<tr>
<td>0x08</td>
<td>TIM channel 1 interrupt</td>
<td>0x09</td>
<td>5</td>
</tr>
<tr>
<td>0x0A</td>
<td>TIM channel 2 interrupt</td>
<td>0x0B</td>
<td>6</td>
</tr>
<tr>
<td>0x0C</td>
<td>TIM channel 3 interrupt</td>
<td>0x0D</td>
<td>7</td>
</tr>
<tr>
<td>0x0E</td>
<td>TIM timer overflow interrupt</td>
<td>0x0F</td>
<td>8</td>
</tr>
<tr>
<td>0x10</td>
<td>SCI error interrupt</td>
<td>0x11</td>
<td>9</td>
</tr>
<tr>
<td>0x12</td>
<td>SCI transmit interrupt</td>
<td>0x13</td>
<td>10</td>
</tr>
<tr>
<td>0x14</td>
<td>SCI receive interrupt</td>
<td>0x15</td>
<td>11</td>
</tr>
<tr>
<td>0x16</td>
<td>Acquisition interrupt</td>
<td>0x17</td>
<td>12</td>
</tr>
<tr>
<td>0x18</td>
<td>Life time counter interrupt</td>
<td>0x19</td>
<td>13</td>
</tr>
<tr>
<td>0x1A</td>
<td>Calibration request interrupt</td>
<td></td>
<td>14 (lowest)</td>
</tr>
</tbody>
</table>
Window watchdog

- Can be used as conventional or window watchdog
- Clocking based on low power oscillator (independent from S12 MCU)
- Active after reset or wake-up
- Disabled during low power mode
  - During stop mode, the S12 watchdog can be used instead (inactive by default)
- Configurable timeout (4ms – 2048ms)
Serial Communication Interface - SCI

- Digital part of serial communication (e.g. for LIN)
- Full-duplex, standard non-return-to-zero (NRZ) format
- Double-buffered transmitter and receiver with separate enables
- Programmable baud rates (13-bit modulo divider)
- Interrupt-driven or polled operation:
  - Transmit data register empty and transmission complete
  - Receive data register full
  - Receive overrun, parity error, framing error, and noise error
  - Idle receiver detect
  - Active edge on receive pin
  - Break detect supporting LIN
- Hardware parity generation and checking
- Programmable 8-bit or 9-bit character length
- Receiver wake-up by idle-line or address-mark
- Optional 13-bit break character generation / 11-bit break character detection
- Selectable transmitter output polarity
- Single wire mode
Operating Modes & Wakeup
Operating modes - overview

- **Normal Mode**
  - All device modules active
  - MCU fully supplied, D2DCLK active analog die clock source
  - Window Watchdog clocked on independent clock

- **Stop Mode**
  - MCU in low power mode, MCU-Regulator Supply reduced current capability, D2D interface supply disabled (VDDH=OFF)
  - Unused Analog Blocks disabled, watchdog disabled
  - Optional: wake-up capabilities
  - Optional: Current and temperature measurements

- **Sleep Mode**
  - MCU powered down (VDDH and VDDX = OFF)
  - Unused Analog Blocks disabled
  - Watchdogs = OFF
  - Optional: wake-up capabilities
  - Optional: Current and temperature measurements

- **Intermediate Mode**
  - Transition from Stop/Sleep to normal mode

- **Reset Mode**
  - Reset state (driven by both analog and MCU)

- **Power On Reset Mode**
  - Indicate a loss of internal state

- **Cranking Mode**
  - Special Mode implemented to guarantee the RAM content being valid though very low power conditions.

Freescale reserves the right to change or discontinue this product without notice.
Differences between sleep- and stop mode
(SW perspective)

- Differences between sleep- and stop mode:
  - Starting point for the software after wake-up
  - Current consumption (different values for analog and MCU die)

- Sleep mode
  - MCU is not powered (disconnected from the supply)
  - First instruction is fetched from power-on reset vector
  - All hardware and software initialization code is executed
  - Longer wake-up time but less current consumption compared to sleep mode (see next slides for details)

- Stop mode
  - MCU is in stop mode but still supplied
  - First instruction is fetched from the wake-up ISR. After the ISR, the first instruction after the STOP command (to go to stop mode) is executed in the main program
  - No software initialization, minor hardware initialization (mainly wait for PLL-lock)
  - Faster wake-up but more current consumption compared to sleep mode
Reduced Avg. Current Consumption Due to Embedded Low-power Features

- Device is put into stop/sleep mode most of the time to decrease current
- Regularly, the system wakes-up and performs updates of SoC/SoH
- Cyclic measurements allow coulomb counting and detect any activity in the car (typically every second)
## MM9Z1_638 Intelligent Battery Sensor
### Low power - Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ.</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM9Z1_638 COMBINED CONSUMPTION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal mode current measured at $V_{SUP}$ excluding external load current, ($3.5 \leq V_{SUP} \leq 28$ V; $-40 ^\circ C \leq T_A \leq 125 ^\circ C$) parameter tested up to $T_A = 85 ^\circ C$</td>
<td>$I_{RUN}$</td>
<td>–</td>
<td>35</td>
<td>40</td>
<td>mA</td>
</tr>
<tr>
<td>Normal mode current measured at $V_{SUP}$ - analog die contribution - excluding mcu and external load current, ($3.5 \leq V_{SUP} \leq 28$ V; $-40 ^\circ C \leq T_A \leq 125 ^\circ C$) parameter tested up to $T_A = 85 ^\circ C$</td>
<td>$I_{NORMAL}$</td>
<td>–</td>
<td>1.5</td>
<td>4.0</td>
<td>mA</td>
</tr>
<tr>
<td>Stop mode current measured at $V_{SUP}$</td>
<td>$I_{STOP}$</td>
<td>–</td>
<td>105</td>
<td>125</td>
<td>µA</td>
</tr>
<tr>
<td>• Continuous base current ($^6$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T = -40 ^\circ C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T = 85 ^\circ C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T = 125 ^\circ C$ ($^7$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Stop current during Cranking mode ($^6$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T = -40 ^\circ C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T = 85 ^\circ C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T = 125 ^\circ C$ ($^7$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep mode measured at $V_{SUP}$</td>
<td>$I_{SLEEP}$</td>
<td>–</td>
<td>65</td>
<td>85</td>
<td>µA</td>
</tr>
<tr>
<td>• Continuous base current ($^6$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T = -40 ^\circ C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T = 85 ^\circ C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T = 125 ^\circ C$ ($^7$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudo stop current</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T = -40 ^\circ C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T = 85 ^\circ C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T = 125 ^\circ C$ ($^7$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current adder during current trigger event in stop or sleep modes - (typ. 10 ms duration ($^6$), temperature measurement = OFF)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>–</td>
<td>1500</td>
<td>1750</td>
<td>µA</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
5. Typical values noted reflect the approximate parameter mean at $T_A = 25 ^\circ C$.
6. From $V_{SUP}$ 6.0 to 28 V
7. Guaranteed by design and characterization
8. Duration based on channel configuration. 10 ms typical for Decimation Factor = 512, Chopper = ON.

Freescale reserves the right to change or discontinue this product without notice.
Wake-up Sources overview

- **Cyclic Current Acquisition / Calibration Temperature Check**
  - Three wake-up conditions are implemented.
    - Current Threshold Wake-Up
    - Current AmpHour Threshold Wake-Up
    - Calibration Request Wake-Up

- **Timed wake-up**
  - Programmable wake up timer with integrated 4 Channel Timer Module available during both low power modes

- **Wake Up from LIN/CAN**
  - Wake Up on Pin: PBT3/L0 with pin 0 to 1 transition (rising edge)

- **Wake Up on Life Time Counter Overflow**
  - The life time counter can be configured to run during low power mode, Once the counter overflows with the life time counter wake up enabled, a wake up is issued.

- **General Wake Up Indicator**
  - To indicate the system has been woken up after power up
Hardware and Software Tools
Development Tools Overview

- Compilers
  - CodeWarrior
  - Cosmic

- IDE
  - CodeWarrior v10.3 (Eclipse based)
  - Cosmic Win IDEA
  - Eclipse

- Programmers
  - P&E PROGS12Z

- Debugger
  - CW & P&E S12Z Debugger
  - Cosmic Zap Debugger

- Debug Interface
  - P&E USB Multilink Debug Interface
  - Cyclone Pro Programmer
  - 3rd Party Debug Interfaces
    (iSYSTEM/Lauterbach)
Hardware

- Standard EVB - KIT9Z1J638EVM
  - Status: available

KIT912J637EVME
KIT9Z1J638EVM – Hardware Features

• MM9Z1_638 Xtrinsic Battery Sensor in a 48-QFN package with wet able flank.
• On-board BDM connection via open source OSBDM circuit using the MC9S08JM60 microcontroller. See www.pemicro.com/osbdm for OSBDM source code.
• High-speed CAN interface
• LIN interface
• Customizable GPIOs for voltage and temperature sensing
• LED indicators
• Support for USB Multilink Interface BDM

Block diagram of the KIT9Z1J638EVM design with the primary components.
12V Lead Acid IBS Application with MM9Z1_638

Datasheet 12V Application

Application diagram

Precision shunt

- Measured current
  = Vehicle current + IC current

- Resistance value: 100μΩ +/-5%
- Manufacturer: Isabellenhütte
- PCB is soldered on it
- PCB matches the shunt shape

Freescale reserves the right to change or discontinue this product without notice.
MM9Z1_638 Intelligent Battery Sensor
12V Lead-Acid with LIN, PCB Layout

- Single point grounding
- Car chassis ground
- Battery minus

Temperature measurement
- NTC located above shunt for better battery heat transfer

Current measurement

Voltage measurement

External Use | 35

Freescale reserves the right to change or discontinue this product without notice.
Final HW Solution (PCB + Shunt)
12V Lead Acid IBS – Basic Enablement Drivers

- QuIBS+Z startup
  - MCU die init, analog die init
  - Measurement channel setup for evaluation
- Communication
  - LIN 1.3 slave driver
  - LIN 2.1 slave driver
  - SPI
  - CAN
  - 2-wire serial (UART)
- Runtime SW
  - Flash/ EEPROM SW
  - TIMERs SW
  - STOP / SLEEP mode SW , using wake up from LTC, LIN or L0-PTB3
- Startup trimming
  - Complete startup trimming procedure as described in datasheet
  - Including temperature based gain compensation
- Module calibration
  - Test for IBS module calibration (like at end-of-line at customer)
  - On-Chip & external (in Excel) calculation of compensation values
  - Storage of compensation values in DFLASH
- Test software
  - LIN Master/Slave test using DEMO9S08DZ60 board
Availability

• 12V PB IBS- Development Kits (Example SW) :
  – Development Kit (1st Milestone): Available Now
    ▪ Reference Design HW (LIN Only)
    ▪ LIN 2.1 Driver
    ▪ msCAN Driver
  – Development Kit (Final Milestone): Available Now
    ▪ Basic Enablement Drivers
    ▪ Basic SoC Calculation
    ▪ Basic SoF Calculation

• AUTOSAR OS (FSL Production SW): Available Now
• CAN Stack (3rd Party Production SW): Available Now
• LIN Stack (3rd Party Production SW) : Available Now

• Low-level Drivers (3rd Party Production SW) Beta Release : Q1 2014

• P & E Multilink : Available Now
• Cosmic WinIDEA (3rd Party Production SW) : Available Now
• CodeWarrior 10.3 (FSL Production SW) : Available Now

Freescale reserves the right to change or discontinue this product without notice.
14V 4 cells Li-ion BMS application with MM9Z1_638

Switch terminals to be tied @ GND or @ VDDx

MC33879 Configurable Octal Serial Switch with Open Load Detect

Passive Cell Balancing

Connector

Connector

PA3 VDDx
Vsense3
PTB3
Vsense2
PTB2
Vsense1
PTB1
Vsense0
PTB0

MC33901 CAN Transceiver

Connector

GND

PAx, x=0,1,2
PA7VDDx
PA5
PA4
PTB4
PA6

LIN Port

LIN

TxDRxDTWB
STB

16B ADC Voltage
16B ADC Temp
16B ADC Current

PTB5 EXTAL XTL

Quartz

Current Sense

Freescale reserves the right to change or discontinue this product without notice.
4-Cell Li-Ion Application with MM9Z1_638
Overview

- Features:
  - Current Sense Input through shunt (+/-1500A with 100µΩ shunt)
  - 4 Cell Voltage Sensing
  - Cell Passiv Balancing
  - 2 LS and 2 HS switches
  - S12Z microcontroller with 96/128 kByte Flash, 8.0 kByte RAM, 4.0 kByte EEPROM
  - CAN and/or LIN Bus
14V 4 cells Li-ion BMS – Basic Enablement Drivers

• Startup
  – MCU die init, analog die init
  – Measurement channel setup
    (current, 4 voltage, 4 temperature channels)
• Communication
  – LIN 1.3 slave driver
  – LIN 2.1 slave driver
  – SPI
  – CAN
  – 2-wire serial (UART)
• Runtime SW
  – EEPROM SW
  – TIMERs SW
  – STOP / SLEEP mode SW, using wake up from LTC, LIN or L0-PTB3
• Startup trimming
  – Complete startup trimming procedure as described in datasheet
  – Including temperature based gain compensation
• Module calibration
  – Test for IBS module calibration (like at end-of-line at customer)
  – On-Chip & external (in Excel) calculation of compensation values
  – Storage of compensation values in DFLASH
• Test software
  – LIN Master/Slave test using DEMO9S08DZ60 board
Availability

• 14V 4 cells Li-ION BMS Development Kit:
  – Development Kit (1st Milestone): Available Now
    ▪ Reference Design HW
    ▪ Basic Enablement Drivers
    ▪ LIN 2.1 Driver
    ▪ msCAN Driver
    ▪ SoC Appl (Basic)
  – Development Kit (2nd Milestone): Available Now
    ▪ SoC Appl (Full)
    ▪ Balancing Appl SW
    ▪ Charge ctrl Appl SW
  – Development Kit (Final Milestone): Oct 2013
    ▪ SoF Appl
    ▪ Battery parameter configuration
    ▪ Matlab Models
• AUTOSAR OS (FSL Production SW): Available Now
• CAN Stack (3rd Party Production SW): Available Now
• LIN Stack (3rd Party Production SW): Available Now
• Low-level Drivers (3rd Party Production SW) Beta Release: Q1 2014
• P&E Multilink: Available Now
• Cosmic WinIDEA (3rd Party Production SW): Available Now
• CodeWarrior 10.3 (FSL Production SW): Available Now
Useful Links

• **Compilers / Debugger / Debugging Interface:**

• **FSL HW:**

• **FSL SW Drivers and Libraries:**
    in near future will be also added to [www.freescale.com/LIN](http://www.freescale.com/LIN)

• **FSL Tools:**
  - FreeMASTER Run time debugger – [www.freescale.com/FreeMASTER](http://www.freescale.com/FreeMASTER)
Intelligent Precision Battery Sensors

• Embedded **MCU + Precision Analog solutions** in a single device
• **Highly Integrated** to allow BOM optimization
• Designed to **reduce SW complexity and current consumption** compared to existing solutions
• **AECQ-100 qualified**, meets **Automotive Robustness** and **Zero defect Quality** levels

• Samples available
• EVBs available
• Product Demonstrator available