Battery management system

Sep 2021
Battery management system

Automotive BMS must be able to meet critical features such as voltage, temperature and current monitoring, battery state of charge (SoC) and cell balancing of lithium-ion (Li-ion) batteries.

Main functions of BMS

- **Battery protection** in order to prevent operations outside its safe operating area.
- **Battery monitoring** by estimating the battery pack state of charge (SoC) and state of health (SoH) during charging and discharging.
- **Battery optimization** thanks to cell balancing that improves the battery life and capacity, thus optimizing the driving range for hybrid (HEV), plug-in (PHEV) and full electric vehicles (BEV).

- L9963E and L9963T for cell management
- SPC57xx/SPC58xx MCUs for monitoring, control and delivery
- L9396 - Multiple Voltage Regulator
Features

- Measures 4 to 14 cells in series with 0us desynchronization delay between samples
- Synchronized High-precision cell voltage and current measurement within ±1500A range with Coulomb counter included
- Programmable scan mode: on-demand, or cyclic
- 16-bit voltage measurement with maximum error: ±2.6mV@[1.7-4.7]v in whole operating temperature range
- 2.66Mbps isolated serial communication with regenerative buffer, Less than 2us latency between start of conversion of 1st and the 15th device in daisy-chain
- Supports both uni and bi-directional daisy chain configuration
- Maximum 200 mA passive internal balance for single cell in both normal and sleep-balancing mode. Two balancing modes: Manual and Timed mode. Single or multiple channel cell balancing simultaneously
- Hardwired and communication-based fault notification
- -40°C/200°C temperature measurement range with support for NTC monitoring
- 9 General purpose digital I/O or 7 channels for analog inputs
- Cell chancels withstanding negative voltage to -6V
- Redundancy voltage measurement for limp home
- Integrated Non Volatile Memory(NVM)
- Robust hot-plug performance, No Zeners needed in parallel to each cells
- AEC-Q100 qualified, and ISO26262(ASIL-D) compliant

L9963E block diagram with its main core blocks
Technical information

- Boost Converter, 9V, up to 0.3A - 2MHz with spread spectrum
- Buck Converter, 6.5V/7.2V, up to 1.0A—465KHz with spread spectrum
- LDO VCC5 (5V +/-2%, 250mA), LDO VCC (3.3V / 5V +/-2%, 100mA), VCORE (0.8V / 5V +/-2% - µC core supply, max 1000mA in switching mode, max 500mA in linear mode)
- 4 WSS regulated interface /2 tracking regulators (120mA)
- Integrated 10-bit ADC
- HS pre-drivers for fail safe relay and for motor pump
- Configurable Watchdog (Time-out / Window / Periods) & configurable Fail-Safe Functionality
- Fail-Safe Output (FSN), Wake-up input
- Voltage monitoring UV/OV on all regulated rails
- Temp. monitoring and Thermal Shutdown

Timing information

- Commercial samples : available
- In production

Key Value

- Designed for ISO26262 compliance
- Flexible solution to 3 configurable voltage rails
- Boost - Buck topology for low battery functionality for Start/Stop systems
- BOM selection optimized on output current needs
- Low emission design

BMS key component system basis chip L9396
BMS key component
high performance MCU SPC58NG84
Block Diagram (superset)

Core
- 180MHz Power Architecture™ ISA e200z4 Core (VLE)
  - Floating Point Unit
  - 8k-Instruction Cache, 4k-Data Cache
  - 16k Local i-RAM, 64k Local d-RAM
  - Lock Step (optional)
- 180MHz Power Architecture™ ISA e200z4 Core (VLE)
  - Floating Point Unit
  - 8k-Instruction Cache, 4k-Data Cache
  - 16k Local i-RAM, 64k Local d-RAM
  - 180MHz Power Architecture™ ISA e200z4 Core (VLE)
    - Floating Point Unit & LSP(DSP)
    - 8k-Instruction Cache
    - 16k Local i-RAM, 32k Local d-RAM

Memory
- 6M byte RWW Flash with ECC
- 4x64k Data Flash with ECC
- 768kRAM (608k SRAM + 160k d-RAM) with ECC
  - Including 256k Standby

System
- SSWU (Smart Standby Wake-up)
- Security Module: HSM (Evita Medium)
- FM-PLL
- MPU
- 64 Channel eDMA Controller
- 2 x CRC Unit
- Fault Collection & Control Unit (incl. error pin)
- 8 x PIT / 1x STM / 1x RTC/API
- 1x LFAST (Interprocessor bus)
- Nexus IEEE-ISTO 5001-2010 Class 3+
  (Aurora interface)

I/O
- 8 x MCAN / FD-CAN
- 18 x LINflex
- 2 x Ethernet (100Mb/s, time stamping, AVB, IPv4 Checksum)
- Dual Channel FlexRay (10MB/s, 128 buffers)
- 10 x DSPI, 1 x I2C
- 2x 32ch eMIOS
- 64ch CTU (Cross Triggering Unit)
- 86 channel ADC
  - 4x 12-bit ADC
  - 1x 12-bit ADC Supervisor
  - 1x 10-bit Standby ADC

System Platform
- Memory
- Timer
- Peripherals

Available

Power Architecture™ e200z4
STM
SWT
FPU
VLE
LSP
I-RAM
D-RAM
Crossbar Switch
Memory Protection Unit

System
- SSWU (Smart Standby Wake-up)
- Security Module: HSM (Evita Medium)
- FM-PLL
- MPU
- 64 Channel eDMA Controller
- 2 x CRC Unit
- Fault Collection & Control Unit (incl. error pin)
- 8 x PIT / 1x STM / 1x RTC/API
- 1x LFAST (Interprocessor bus)
- Nexus IEEE-ISTO 5001-2010 Class 3+
  (Aurora interface)

I/O
- 8 x MCAN / FD-CAN
- 18 x LINflex
- 2 x Ethernet (100Mb/s, time stamping, AVB, IPv4 Checksum)
- Dual Channel FlexRay (10MB/s, 128 buffers)
- 10 x DSPI, 1 x I2C
- 2x 32ch eMIOS
- 64ch CTU (Cross Triggering Unit)
- 86 channel ADC
  - 4x 12-bit ADC
  - 1x 12-bit ADC Supervisor
  - 1x 10-bit Standby ADC

System Platform
- Memory
- Timer
- Peripherals

Available

Power Architecture™ e200z4
STM
SWT
FPU
VLE
LSP
I-RAM
D-RAM
Crossbar Switch
Memory Protection Unit

System
- SSWU (Smart Standby Wake-up)
- Security Module: HSM (Evita Medium)
- FM-PLL
- MPU
- 64 Channel eDMA Controller
- 2 x CRC Unit
- Fault Collection & Control Unit (incl. error pin)
- 8 x PIT / 1x STM / 1x RTC/API
- 1x LFAST (Interprocessor bus)
- Nexus IEEE-ISTO 5001-2010 Class 3+
  (Aurora interface)

I/O
- 8 x MCAN / FD-CAN
- 18 x LINflex
- 2 x Ethernet (100Mb/s, time stamping, AVB, IPv4 Checksum)
- Dual Channel FlexRay (10MB/s, 128 buffers)
- 10 x DSPI, 1 x I2C
- 2x 32ch eMIOS
- 64ch CTU (Cross Triggering Unit)
- 86 channel ADC
  - 4x 12-bit ADC
  - 1x 12-bit ADC Supervisor
  - 1x 10-bit Standby ADC

System Platform
- Memory
- Timer
- Peripherals

Available

Power Architecture™ e200z4
STM
SWT
FPU
VLE
LSP
I-RAM
D-RAM
Crossbar Switch
Memory Protection Unit

System
- SSWU (Smart Standby Wake-up)
- Security Module: HSM (Evita Medium)
- FM-PLL
- MPU
- 64 Channel eDMA Controller
- 2 x CRC Unit
- Fault Collection & Control Unit (incl. error pin)
- 8 x PIT / 1x STM / 1x RTC/API
- 1x LFAST (Interprocessor bus)
- Nexus IEEE-ISTO 5001-2010 Class 3+
  (Aurora interface)

I/O
- 8 x MCAN / FD-CAN
- 18 x LINflex
- 2 x Ethernet (100Mb/s, time stamping, AVB, IPv4 Checksum)
- Dual Channel FlexRay (10MB/s, 128 buffers)
- 10 x DSPI, 1 x I2C
- 2x 32ch eMIOS
- 64ch CTU (Cross Triggering Unit)
- 86 channel ADC
  - 4x 12-bit ADC
  - 1x 12-bit ADC Supervisor
  - 1x 10-bit Standby ADC

System Platform
- Memory
- Timer
- Peripherals

Available

Power Architecture™ e200z4
STM
SWT
FPU
VLE
LSP
I-RAM
D-RAM
Crossbar Switch
Memory Protection Unit

System
- SSWU (Smart Standby Wake-up)
- Security Module: HSM (Evita Medium)
- FM-PLL
- MPU
- 64 Channel eDMA Controller
- 2 x CRC Unit
- Fault Collection & Control Unit (incl. error pin)
- 8 x PIT / 1x STM / 1x RTC/API
- 1x LFAST (Interprocessor bus)
- Nexus IEEE-ISTO 5001-2010 Class 3+
  (Aurora interface)

I/O
- 8 x MCAN / FD-CAN
- 18 x LINflex
- 2 x Ethernet (100Mb/s, time stamping, AVB, IPv4 Checksum)
- Dual Channel FlexRay (10MB/s, 128 buffers)
- 10 x DSPI, 1 x I2C
- 2x 32ch eMIOS
- 64ch CTU (Cross Triggering Unit)
- 86 channel ADC
  - 4x 12-bit ADC
  - 1x 12-bit ADC Supervisor
  - 1x 10-bit Standby ADC

System Platform
- Memory
- Timer
- Peripherals

Available

Power Architecture™ e200z4
STM
SWT
FPU
VLE
LSP
I-RAM
D-RAM
Crossbar Switch
Memory Protection Unit

System
- SSWU (Smart Standby Wake-up)
- Security Module: HSM (Evita Medium)
- FM-PLL
- MPU
- 64 Channel eDMA Controller
- 2 x CRC Unit
- Fault Collection & Control Unit (incl. error pin)
- 8 x PIT / 1x STM / 1x RTC/API
- 1x LFAST (Interprocessor bus)
- Nexus IEEE-ISTO 5001-2010 Class 3+
  (Aurora interface)

I/O
- 8 x MCAN / FD-CAN
- 18 x LINflex
- 2 x Ethernet (100Mb/s, time stamping, AVB, IPv4 Checksum)
- Dual Channel FlexRay (10MB/s, 128 buffers)
- 10 x DSPI, 1 x I2C
- 2x 32ch eMIOS
- 64ch CTU (Cross Triggering Unit)
- 86 channel ADC
  - 4x 12-bit ADC
  - 1x 12-bit ADC Supervisor
  - 1x 10-bit Standby ADC

System Platform
- Memory
- Timer
- Peripherals

Available

Power Architecture™ e200z4
STM
SWT
FPU
VLE
LSP
I-RAM
D-RAM
Crossbar Switch
Memory Protection Unit

System
- SSWU (Smart Standby Wake-up)
- Security Module: HSM (Evita Medium)
- FM-PLL
- MPU
- 64 Channel eDMA Controller
- 2 x CRC Unit
- Fault Collection & Control Unit (incl. error pin)
- 8 x PIT / 1x STM / 1x RTC/API
- 1x LFAST (Interprocessor bus)
- Nexus IEEE-ISTO 5001-2010 Class 3+
  (Aurora interface)

I/O
- 8 x MCAN / FD-CAN
- 18 x LINflex
- 2 x Ethernet (100Mb/s, time stamping, AVB, IPv4 Checksum)
- Dual Channel FlexRay (10MB/s, 128 buffers)
- 10 x DSPI, 1 x I2C
- 2x 32ch eMIOS
- 64ch CTU (Cross Triggering Unit)
- 86 channel ADC
  - 4x 12-bit ADC
  - 1x 12-bit ADC Supervisor
  - 1x 10-bit Standby ADC

System Platform
- Memory
- Timer
- Peripherals

Available

Power Architecture™ e200z4
STM
SWT
FPU
VLE
LSP
I-RAM
D-RAM
Crossbar Switch
Memory Protection Unit

System
- SSWU (Smart Standby Wake-up)
- Security Module: HSM (Evita Medium)
- FM-PLL
- MPU
- 64 Channel eDMA Controller
- 2 x CRC Unit
- Fault Collection & Control Unit (incl. error pin)
- 8 x PIT / 1x STM / 1x RTC/API
- 1x LFAST (Interprocessor bus)
- Nexus IEEE-ISTO 5001-2010 Class 3+
  (Aurora interface)

I/O
- 8 x MCAN / FD-CAN
- 18 x LINflex
- 2 x Ethernet (100Mb/s, time stamping, AVB, IPv4 Checksum)
- Dual Channel FlexRay (10MB/s, 128 buffers)
- 10 x DSPI, 1 x I2C
- 2x 32ch eMIOS
- 64ch CTU (Cross Triggering Unit)
- 86 channel ADC
  - 4x 12-bit ADC
  - 1x 12-bit ADC Supervisor
  - 1x 10-bit Standby ADC

System Platform
- Memory
- Timer
- Peripherals

Available

Power Architecture™ e200z4
STM
SWT
FPU
VLE
LSP
I-RAM
D-RAM
Crossbar Switch
Memory Protection Unit
BMS key component
high performance MCU SPC574S

Core
- Up to 140 MHz Power Architecture™ ISA e200z4 Core (VLE)
  - Dual Issue Core with Floating Point Unit
  - 12k Cache (8k-Instruction Cache, 4k-Data Cache)
  - 32k TCM (32k d-RAM)
- ASILD SEooC

I/O
- 1 x FlexRay Dual Channel with 128MB (optional)
- 3x MCAN (with ISO CAN-FD on Cut2.0)
- 4 x LINFlex (3x master only)
- 4 x DSPI
- 2 x SENT (2x3ch overall)
- 2 x FlexPWM (4x3ch each) + 2 x FlexPWM (2ch each)
- 4 x eTimer (6ch each)
- ADC – 2x (3+1)x 12Bit, 18/32/33Ch. (on QFP100/144/BGA)
  - fast 10Bit conversion & supervisor ADC concept
- 2 x ADC enh’d cross triggering unit (eCTU)

Memory
- 1.5Mbyte + 4x16k Flash with ECC
- 128k RAM with ECC (96k SRAM + TCM)
- Crossbar with MPU (16 regions)

System
- 16Ch eDMA
- CRC Unit
- Fault Collection & Control Unit
- Software watchdog timer (inc. window mode, flow monitoring)
- 3.3V or 5V advanced supply (internal or external logic supply)
- FM-PLL, FlexRay PLL and 16MHz internal RC OSC
- Nexus Class 3+ / JTAG (2 pin or 5 pin)
- 100-144 pins LQFP package (0.5mm pitch)
- -40°C ~ + 150°C Tj

- 16k-i Cache
- 8k-d Cache
- VLE
- FPU
- LSP
- MPU
- 32k-d TCM
- SW1
- SM
- 16k DMA
- 96K SRAM
- 1.5M
- 4x 16k FLASH
- 1* SENT
- 1* Pit
- PWM Synch.
- eCTU
- 2* DSPI
- 2* CAN-FD
- 2* SENT
- 2* FlexPWM
- 2* Timer
- 3* ADC
- 3* TSENS
- 16k Cache
- 8k Data Cache
- Crossbar Switch
- Memory Protection Unit
- Power Architecture™ e200z4d
- JTAG
- IRIS
- Nexus
- Debug

Qualified

Product / Application Specific
- Connectivity
- Memory
- System / Platform
Easy connection, quick evaluation and low-cost demonstration kit

- To quick check 1x L9963E cell voltage/GPIO/current sense ADC conversion performance and diagnosis/safety function by periodically running conversion
- To check/understand ISOSPI daisy chain communication interface with L9963(T) and several L9963Es in ISOSPI mode.

Evaluation GUI

- Register write / read function
- Easy multi L9963E device ID assignment and clear
- Friendly interface to configure OV/UV threshold and get the ADC conversion and diagnostic return data through configurable periodically running.
- Configuration and data save / load function

Reference code on SPC5Studio
BMS demo support package

- Databrief / Datasheet
- Application notes
- FMEDA / DFA
- Safety manual
- Evaluation board
- User GUI
- EMC report
Our technology starts with You

Find out more at www.st.com