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HEV/EV LITHIUM-ION BATTERY MAINTENANCE SOLUTION

Application Description

Due to the impressive battery performance and power characteristics of lithium-ion batteries in hybrid electric and pure electric vehicles, the automotive industry is applying lithium-ion batteries as the general go-to solution for new energy vehicles. For plug-in hybrid electric or electric vehicles, which usually require battery units of several hundred volts, lithium-ion batteries are indeed the ideal choice.

Even though battery unit sizes may vary, these battery power systems have the following similar requirements: able to be monitored; able to maintain good performance even under extreme conditions; able to provide reliable and safe power management; able to lower the system's overall cost.

System Requirements and Design Challenges

To use the battery power of lithium-ion batteries to their maximum potential while ensuring a sufficient battery lifetime, a complex battery maintenance network has to be introduced. These electronic circuits can manage the battery unit's voltage and temperature, monitoring the voltage and current of battery units that are built from connecting multiple batteries in series. The circuits balance the voltage between the corresponding units, transmitting data signals whose goal is to ensure that the batteries can effectively and safely operate when being driven or charged, consequently prolonging their lifetime.

When there is fast-switching in high supply mode voltage and high amperage of up to several hundred amps, the battery management system (BMS) has to conduct precise measurement of varying battery units. The system's precision must reach the mV level; it must also maintain synchronized sampling within a strict time delay range. The sampling speed and precision will consequently effect the whole system's efficiency.

Reliability is one of the key requirements. The system must be able to provide a safety mechanism to detect malfunctions in the battery unit, cable, monitoring circuit, and/or communications bus. Data protection mechanisms also aid in trouble detection. With the growing emphasis on functional safety, systems gradually need to satisfy both demands of functionality and safety.

Systems' also require the BMS to consume less power to lower the load to the battery itself. In addition, there is also the need to avoid intensified battery imbalance, so the monitoring IC and quarantine circuit's power consumption should be as low as possible. This future trend requires an active balancing solution.

ADI's Solution

Analog Devices, Inc. (ADI) is a world-leading supplier in signal processing and high capability simulation technology known for excellent quality and reliability, as well as positive, cooperative relationships with the world's leading automotive electronics manufacturers. This ideal background and our deep technological strength and system knowledge allows us to provide optimized solutions to satisfy challenging BMS requirements.

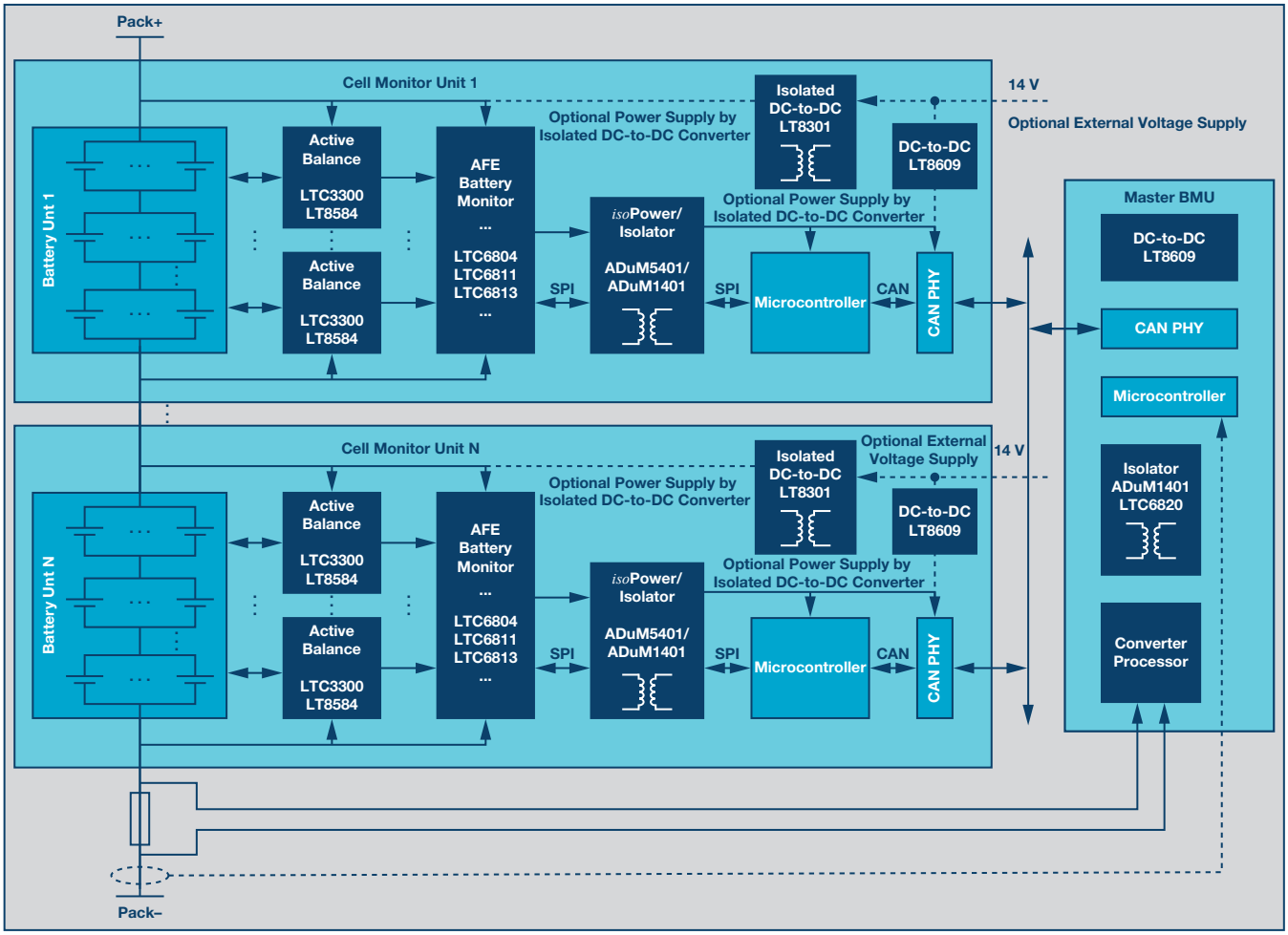
In 2008, Linear Technology (now a part of ADI) began producing lithium-ion battery monitoring IC products, and these products are now in their 4th generation. With enhancements in safety, precision, and functionality, ADI has consistently been the industry's best choice.

The latest 4th-generation lithium-ion battery monitor IC product, LTC6811, can manage and monitor up to 12 channels of voltage and temperature (future generations will provide more flexible channel numbers), with a high precision of over 1.2 mV. Multiple LTC6811s can be supported via daisy chaining. This IC provides the industry's fastest conversion rate and best data protection. It is able to measure 12 channels of data within 290 µs. In addition, the IC provides passive battery unit balance control functions.

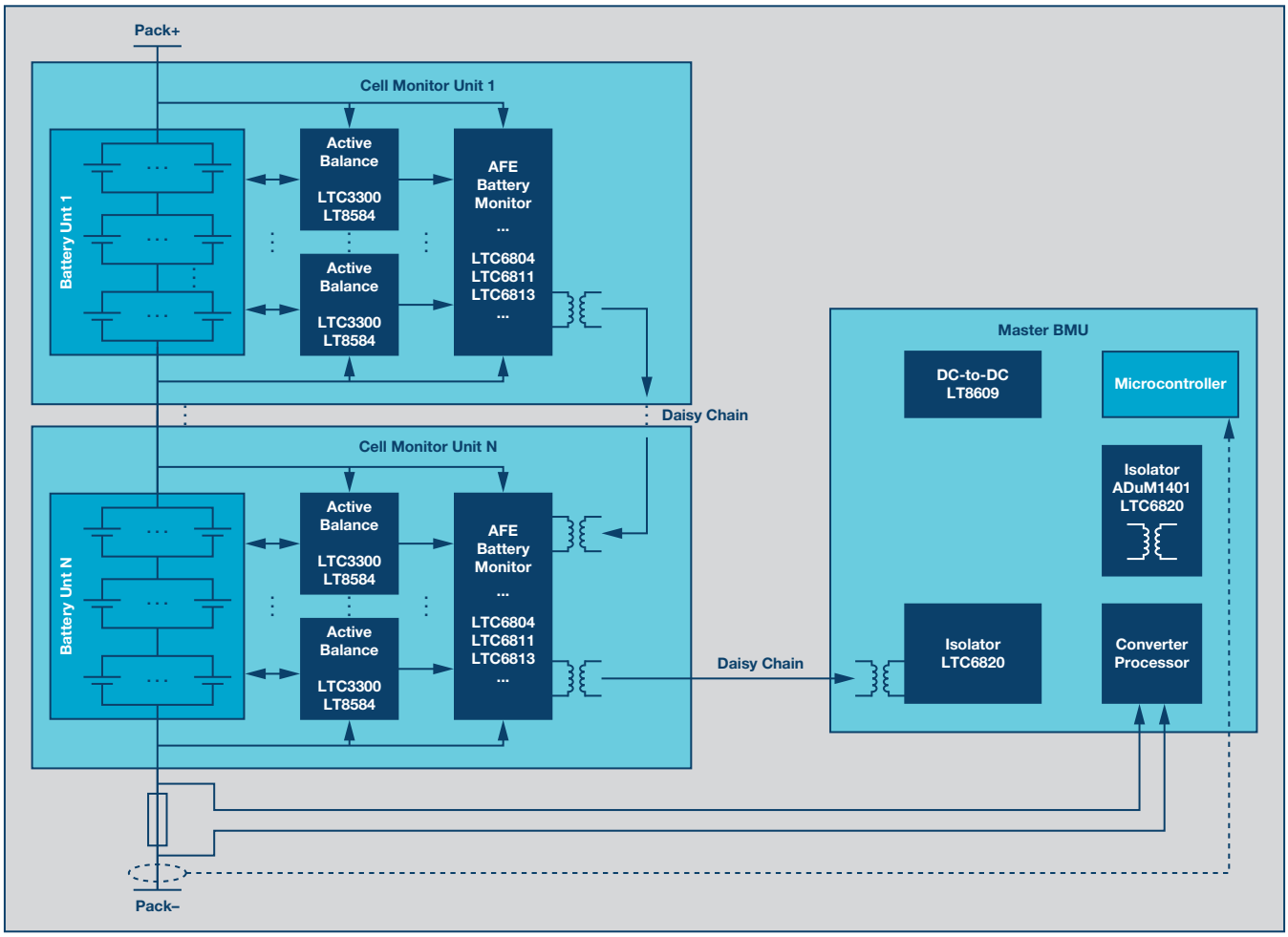
Quarantine Type Product

ADI's *i*Coupler® digital isolator is optimized for automotive uses and is able to realize the lowest power consumption for high speed data systems. It has a small package size with multiple channels to choose from. As a result, the components and required circuit surface area have been minimized. In addition, the whole series can enhance reliability and quality during the vehicle's entire lifetime. This series has been widely applied for the SPI/GPIO/isolated directional clock between high voltage and low voltage circuits. The *iso*Power® portfolio is our exclusive integrated power isolation solution. It provides isolated power and multichannel digital isolation functions, as opposed to similar solutions that combine a discrete dc-to-dc isolator and a digital isolator, our *iso*Power products are more cost competitive and smaller in surface area. We provide multiple combined solutions and expand on our product variety.

Two Recommended BMS Solution Architectures:



ISO SPI Architecture



Daisy-Chain Architecture

Part Number	Description	Features
AFE Battery Monitor		
LTC6811	Multicell battery stack monitor	▶ LTC6804's lead-compatible upgrade component ▶ Can measure up to 12 batteries connected in series ▶ Maximum measurement error of 1.2 mV overall ▶ Stackable architecture supports hundreds of cells ▶ Built in isoSPI™ port • 1 MB isolated series communication • Single twisted pair cable of up to 100 meters • Low EMI susceptibility and emissions ▶ Able to complete all battery measurement within 290 µs ▶ Synchronized voltage and current measurement ▶ 16-bit Σ-Δ ADC with frequency programmable third order noise filter ▶ Engineered for ISO 26262-compliant systems ▶ Passive cell balancing with programmable timer ▶ Five general-purpose digital I/O or analog inputs • Temperature and other sensor input • Can be configured as an I^2C or SPI main controller ▶ 4 µA sleep mode power supply current ▶ 48-lead SSOP packaging
LTC6813	Multicell battery stack monitor	▶ Can measure up to 18 batteries connected in series ▶ Maximum measurement error of 2.2 mV overall ▶ Stackable architecture supports hundreds of cells ▶ Built-in isoSPI port: • 1 MB isolated serial communication • Uses a 100 meter, single twisted pair cable • Low EMI susceptibility and emissions • Dual lane operation used for cable breakdown protection ▶ Can complete measurement of all batteries within the system within 290 µs ▶ Synchronized voltage and current measurement ▶ 16-bit Σ-Δ ADC with frequency programmable third-order noise filter ▶ Engineered for ISO 26262-compliant systems ▶ Applies a passive battery balance of up to 200 mA (maximum) built from a programmable impulse ▶ Nine general-purpose digital I/O or analog inputs ▶ Temperature and other sensor inputs ▶ Can be configured as an I^2C or SPI main controller ▶ 6 µA sleep mode power supply current ▶ 64-lead eLQFP packaging
Active Balance		
LTC3300	High efficiency bidirectional multicell battery balancer	▶ Can realize bidirectional synchronous flyback balancing in up to six serial connected lithium-ion or lithium iron phosphate (LiFePO) batteries ▶ Balance current of up to 10 A (setup via external components) ▶ Seamless connection with the LTC680x series multicell battery stack monitor ▶ The bidirectional structure lowers the required balancing time and consumption power factor to the greatest extent ▶ Electric charge transfer rate of up to 92% ▶ Stackable structure can be applied to >1000 V systems ▶ Applies simple double winding transformer ▶ 1 MHz serial port supports daisy-chain connection and has 4-bit CRC error check ▶ High noise margin serial communication ▶ Multiple malfunction protection functions ▶ 48-lead exposed pad QFN and LQFP package
LT8584	2.5 A monolithic active cell balancer with telemetry interface, unidirectional 2.5 A monolithic active cell balancer with telemetry interface	▶ 2.5 A typical average cell discharge current ▶ Integrated 6 A, 50 V power switch ▶ Integrates seamlessly with the LTC680x family: no additional software required ▶ Selectable current and temperature monitors ▶ Ultralow quiescent current in shutdown ▶ Engineered for ISO 26262-compliant systems ▶ Isolated balancing • Can return charge to top of stack • Can return charge to any combination of cells in stack • Can return charge to 12 V battery for alternator replacement ▶ Can be paralleled for greater discharge capability ▶ All quiescent current in operation taken from local cell ▶ 16-lead TSSOP package

Part Number	Description	Features
isoSPI		
LTC6820	isoSPI isolated communications interface	▶ 1 Mbps isolated SPI data communications ▶ Simple galvanic isolation using standard transformers ▶ Bidirectional interface over a single twisted pair ▶ Supports cable lengths of up to 100 meters ▶ Very low EMI susceptibility and emissions ▶ Configurable for high noise immunity or low power ▶ Engineered for ISO 26262-compliant systems ▶ Requires no software changes in most SPI systems ▶ Ultralow (2 µA) idle current ▶ Automatic wake-up detection ▶ Operating temperature range: –40°C to +125°C ▶ 2.7 V to 5.5 V power supply ▶ Interfaces to all logic from 1.7 V to 5.5 V ▶ Available in 16-lead QFN and MSOP packages
Isolator		
ADuM1401	Quad-channel digital isolator (3/1 channel directionality)	▶ Vehicle application version has received AEC-Q100 certification ▶ Low power operation ▶ Bidirectional communication ▶ 3 V/5 V voltage conversion ▶ Highest operating temperature of up to 125°C ▶ High data speed: dc of up to 90 Mbps (NRZ) ▶ Precise timing characteristics ▶ High common mode transient immunity: >25 kV/µs ▶ For more information, please refer to the data sheet
isoPower		
ADuM5401	Integrated quad-channel digital isolator (3/1 channel directionality)	▶ For more information on AEC-Q100's vehicle application component, please refer to the ADuM540xW data sheet ▶ *iso*Power integrated, isolated dc-to-dc converter ▶ Regulated 3.3 V or 5.0 V output ▶ Up to 500 mW output power ▶ Quad dc-to-25 mbps (NRZ) signal isolation channels ▶ Schmitt trigger input ▶ 16-lead SOIC package with creepage of greater than 8.0 mm ▶ Highest operating temperature of up to 105°C
ISO-CAN		
ADM3054	5 kV rms signal isolated CAN transceiver, bus integrated protection	▶ 5 kV rms signal isolated controller area network (CAN) physical layer transceiver ▶ Operation voltage 1 (V_{DD1}): 5 V or 3.3 V ▶ Operation voltage 2 (V_{DD2}): 5 V ▶ $V_{DD2SENSE}$ is used to check if V_{DD2} is losing power ▶ Complies with ISO 11898 standard ▶ Data speed of up to 1 Mbps ▶ Short-circuit protection on CANH and CANL against shorts to power/ground in 24 V systems ▶ Unpowered nodes do not disturb the bus ▶ Connect 110 or more nodes on the bus ▶ Thermal shutdown protection ▶ High common-mode transient immunity: >25 kV/µs ▶ Safety and legal certifications • UL recognition ○ 5000 V rms for 1 minute per UL 1577 • VDE certificates of conformity ○ DIN V VDE V 0884-10 (VDE V 0884-10): 2006-12 ○ V_{IORM} = 846 V peak ▶ Industrial operating temperature range: –40°C to +125°C ▶ 16-lead wide-body SOIC package ▶ Qualified for automotive applications

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ez.analog.com

Customer Interaction Center

cic.asia@analog.com

Free Samples

analog.com/sample

Technical Hotline

1-800-419-0108 (India)

886-2-2650-2888 (Taiwan)

82-2-368-2500 (Korea)

Analog Devices, Inc.
Worldwide Headquarters

Analog Devices, Inc.
One Technology Way
P.O. Box 9106
Norwood, MA 02062-9106
U.S.A.
Tel: 781.329.4700
(800.262.5643, U.S.A. only)
Fax: 781.461.3113

Analog Devices, Inc.
Europe Headquarters

Analog Devices GmbH
Otl-Aicher-Str. 60-64
80807 Munich
Germany
Tel: 49.89.76903.0
Fax: 49.89.76903.157

Analog Devices, Inc.
Japan Headquarters

Analog Devices, KK
New Pier Takeshiba
South Tower Building
1-16-1 Kaigan, Minato-ku,
Tokyo, 105-6891
Japan
Tel: 813.5402.8200
Fax: 813.5402.1064

Analog Devices, Inc.
Asia Pacific Headquarters

Analog Devices
5F, Sandhill Plaza
2290 Zuchongzhi Road
Zhangjiang Hi-Tech Park
Pudong New District
Shanghai, China 201203
Tel: 86.21.2320.8000
Fax: 86.21.2320.8222

BR20443-0-6/18

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