



Wireless Battery Management Systems Highlight Industry's Drive for Higher Reliability

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Overview

Lithium-Ion batteries require considerable care if they are expected to operate reliably over a long period. They cannot be operated to the extreme end of their state of charge (SOC). The capacity of lithium ion cells diminishes and diverges over time and usage, so every cell in a system must be managed to keep it within a constrained SOC.

To provide sufficient power for a vehicle, tens or hundreds of battery cells are required, configured in a long series generating as much as 1000V or higher. The battery electronics must operate at this very high voltage and reject common mode voltage effects, while differentially measuring and controlling each cell in these strings. The electronics must be able to communicate information from each cell in a battery stack to a central point for processing.

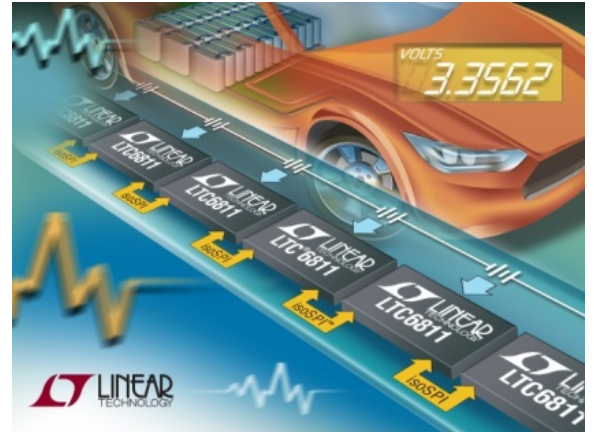
In addition, operating a high voltage battery stack in a vehicle or other high-power applications imposes tough conditions, such as operation with significant electrical noise and wide operating temperatures. The battery management electronics are expected to maximize operating range, lifetime, safety and reliability, while minimizing cost, size and weight.

Steady advances in Linear's battery cell monitoring ICs have enabled high performance, increased life and reliability of battery packs in automobiles today. Wireless BMS promises to further improve safety and reliability of the full battery system.

Battery Monitoring

In 2008, Linear Technology announced the first high performance multicell battery stack monitor, the LTC6802. Among its key features, the LTC6802 measures up to 12 Li-Ion cells with 0.25% maximum total measurement error within 13ms, and many LTC6802 ICs can be connected in series to enable the simultaneous cell monitoring of every cell of a long, high voltage battery strings. Linear Technology has improved upon the LTC6802 many times over the years. All of the devices in Linear's LTC68XX family are intended for precision battery management within hybrid/electric vehicle (HEVs), electric vehicles (EVs) and other high voltage, high power battery stacks.

The LTC6811 is Linear Technology's latest multicell battery stack monitor, incorporating an ultrastable voltage reference, high voltage multiplexers, and dual 16-bit delta-sigma ADCs. An LTC6811 can measure up to 12 series-connected battery cells at voltages with better than 0.04% accuracy. In the fastest ADC mode, all cells can be measured within 290 μ sec. With eight programmable 3rd order low pass filter settings, the LTC6811 can provide outstanding noise reduction. The result is outstanding cell measurement accuracy, enabling precise battery management for increased battery pack capacity, safety and life.



Each LTC6811 includes two built-in 1MHz serial interfaces, an SPI interface for connecting to a local microprocessor, and the proprietary 2-wire isoSPI interface. The isoSPI interface provides two communication options: multiple devices can be connected in a daisy chain to the BMS master (host processor) or multiple devices can be connected and addressed in parallel to the BMS master.

Modular Battery Packs

To accommodate the large quantity of cells required for high powered automotive systems, batteries are often divided into packs, and distributed throughout available spaces in the vehicle. With 10 to 24 cells in a typical module, modules can be assembled in different configurations to suit multiple vehicle platforms. A modular design simplifies maintenance and warranty issues, and can be used as the basis for very large battery stacks. It allows battery packs to be distributed over larger areas, for more effective use of space.

To support a distributed, modular topology within the high electromagnetic interference (EMI) environment of an EV/HEV, a robust communication system is required. Both isolated CAN Bus, and Linear's isoSPI offer road-proven solutions for interconnecting modules in this environment.

Given the success of CAN Bus in automotive applications, it provides a well-established network for interconnecting battery modules, but requires a number of additional components. For example, implementing an isolated CAN Bus via the LTC6811's SPI interface requires the addition of a CAN transceiver, a microprocessor and an isolator. The primary downside of a CAN Bus is the added cost and board space required for these additional elements.

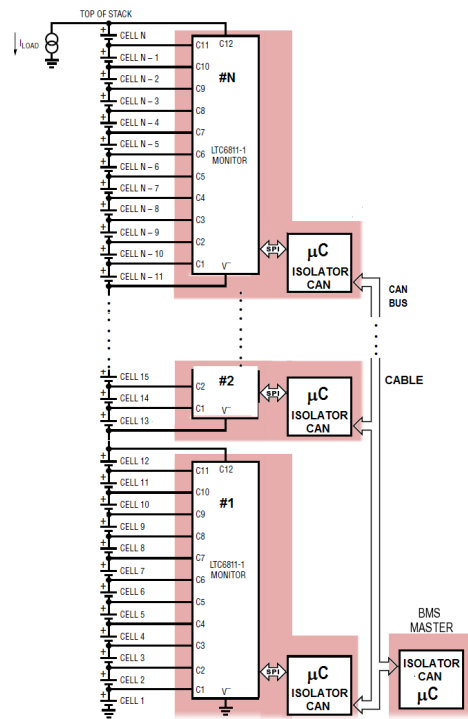


Figure 1. Modular BMS Electronics Using CAN Bus

An alternative to a CAN Bus interface is Linear Technology's innovative 2-wire isoSPI interface. Integrated into every LTC6811, the isoSPI interface uses a simple transformer and a single twisted pair, as opposed to the four wires required by CAN bus. The isoSPI interface provides a high RF noise immune interface in which modules can be connected in a daisy-chain over long cable lengths and operated at data rates up to 1Mbps.

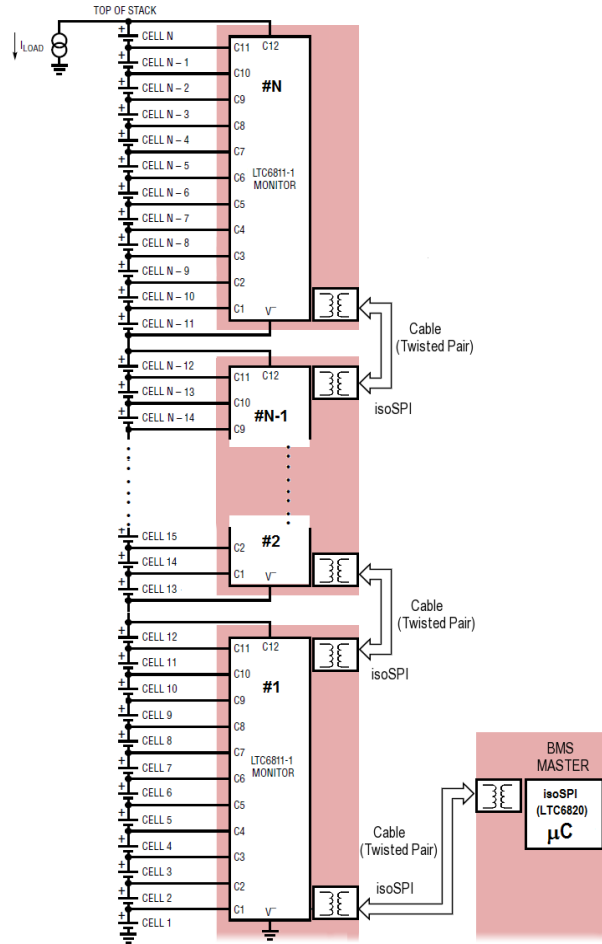


Figure 2. Modular BMS Electronics Using isoSPI Connected in a Daisy Chain

Wireless BMS

In a wireless BMS, each module is interconnected via a wireless connection instead of a CAN Bus cable or an isoSPI twisted pair. Today, Linear Technology is demonstrating the industry's first wireless automotive battery management system (BMS) concept car. This wireless BMS concept car combines the LTC6811 battery stack monitor with Linear's SmartMesh® wireless mesh networking products in a BMW i3, replacing the traditional wired connections between the battery packs and the battery management system. This demonstration of a fully wireless BMS car represents a significant breakthrough that offers the potential for improved reliability, lower cost and reduced wiring complexity for large multicell battery stacks for electric and hybrid/electric vehicles.

Automakers are challenged to ensure the driving public that electric and hybrid/electric vehicles are both safe and reliable. Linear Technology is now looking beyond the safety and reliability of the battery monitoring IC to address the potential mechanical failure of connectors, cables and wiring harnesses in high-vibration automotive environments. To date, the metal and high-EMI surroundings in vehicles were thought to be too harsh for a wireless

system to be reliable. However, SmartMesh networking offers a truly redundant interconnect system through its use of both path and frequency diversity to route wireless messages around obstacles and to mitigate interference. Field-proven in industrial Internet of Things applications, SmartMesh embedded wireless networks deliver >99.999% reliable data transmission in harsh environments, such as railcar monitoring, mining, and industrial process plants. By delivering the reliability of wires yet eliminating mechanical connector failures, the wireless BMS concept car, shows the promise of wireless technology to significantly improve overall system reliability and simplify the design of automotive battery management systems.

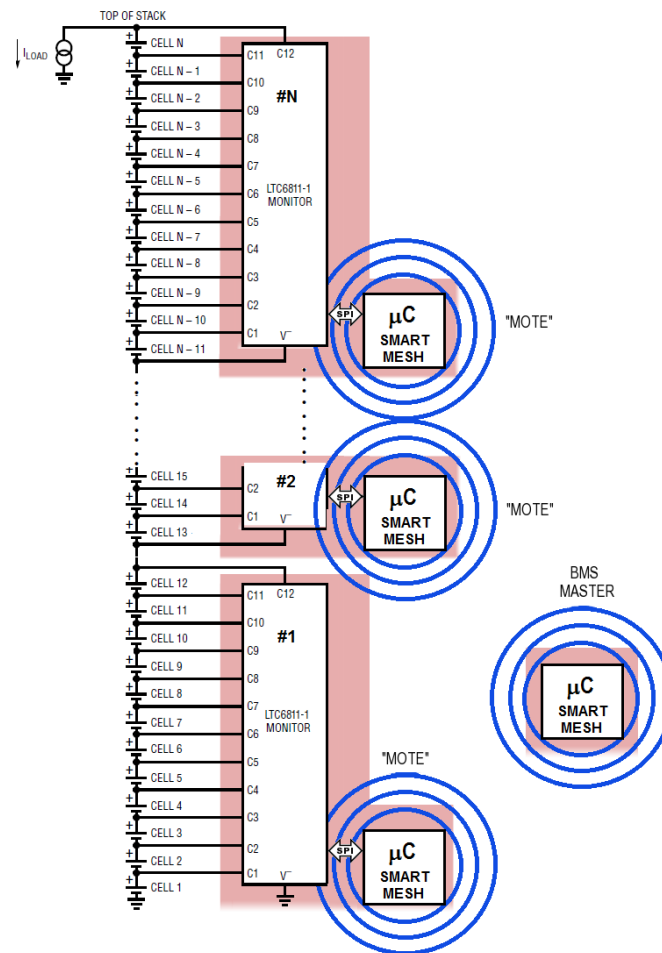


Figure 3. Modular BMS Electronics Using SmartMesh Network

Additional Benefits

A BMS with a SmartMesh network has the potential for new functionality, currently unavailable in a wired system. The wireless mesh network enables the flexible placement of battery modules, and makes possible the installation of sensors in locations previously unsuitable for a

wiring harness. Additional data germane to the accuracy of battery state of charge (SOC) calculations, such as current and temperature, may be collected by the BMS Master by simply adding SmartMesh enabled sensors. SmartMesh automatically time synchronizes each node to within a few microseconds, and accurately timestamps measurements at each node. The ability to time-correlate measurements taken at different locations in a vehicle is a powerful feature for calculating more accurately the battery state of charge (SOC) and state of health (SOH). A SmartMesh node with local processing at each module improves normal BMS operation, and also presents the potential for *smart battery modules*, where module diagnostics and communication may be available to enhance assembly and service.

About SmartMesh Networks

SmartMesh wireless sensor networking products are chips and pre-certified PCB modules complete with mesh networking software, enabling sensors to communicate in tough industrial Internet of Things (IoT) environments.

SmartMesh products are field proven, with over 50,000 customer networks deployed in 120 countries. By delivering > 99.999% data reliability in tough RF environments, SmartMesh wireless sensor networks are entrusted by industrial IoT providers to deliver critical sensor and control data reliably for many years without requiring intervention.



Figure 4. SmartMesh IP Wireless Sensor Network

SmartMesh Features

- PROVEN: Field proven >99.999% reliability in Industrie 4.0 applications
- ROBUST: Time synchronized, channel hopping mesh technology automatically mitigates faults based on self-diagnostics
- SECURE: Robust security includes NIST certified AES128 encryption

Comparison of Interconnects

The following diagrams highlight the various electrical connections between CAN Bus, isoSPI and SmartMesh networks:

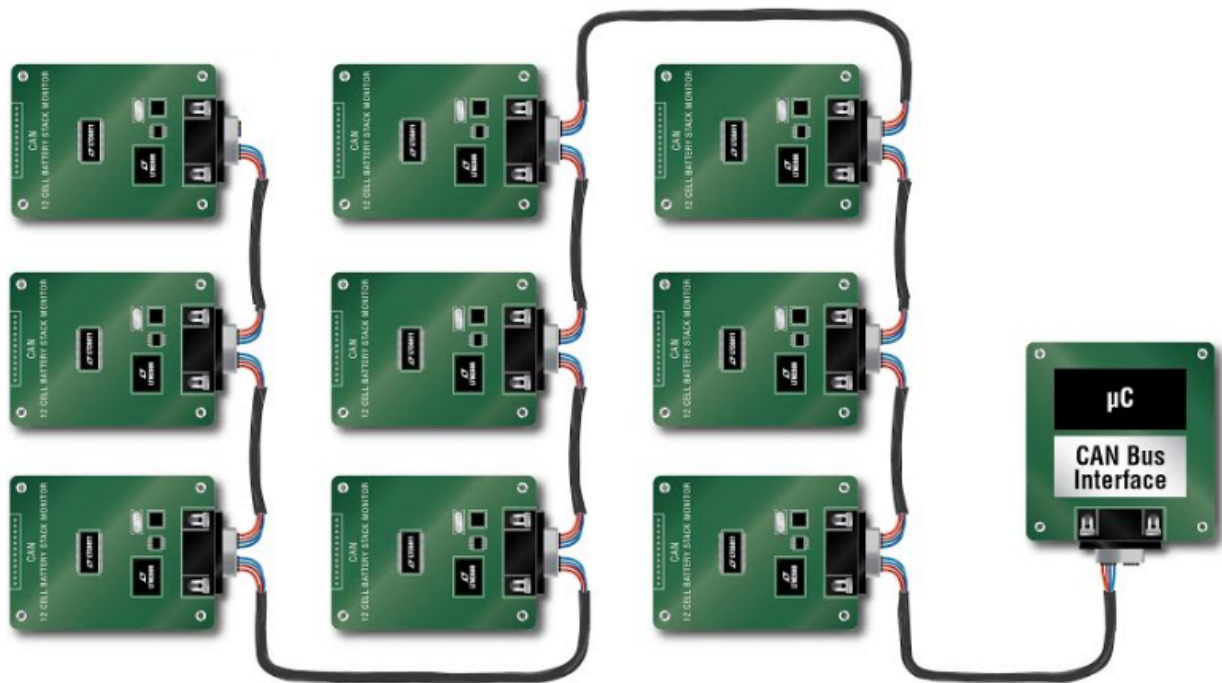


Figure 5. Battery Monitoring Interconnections with CAN Bus

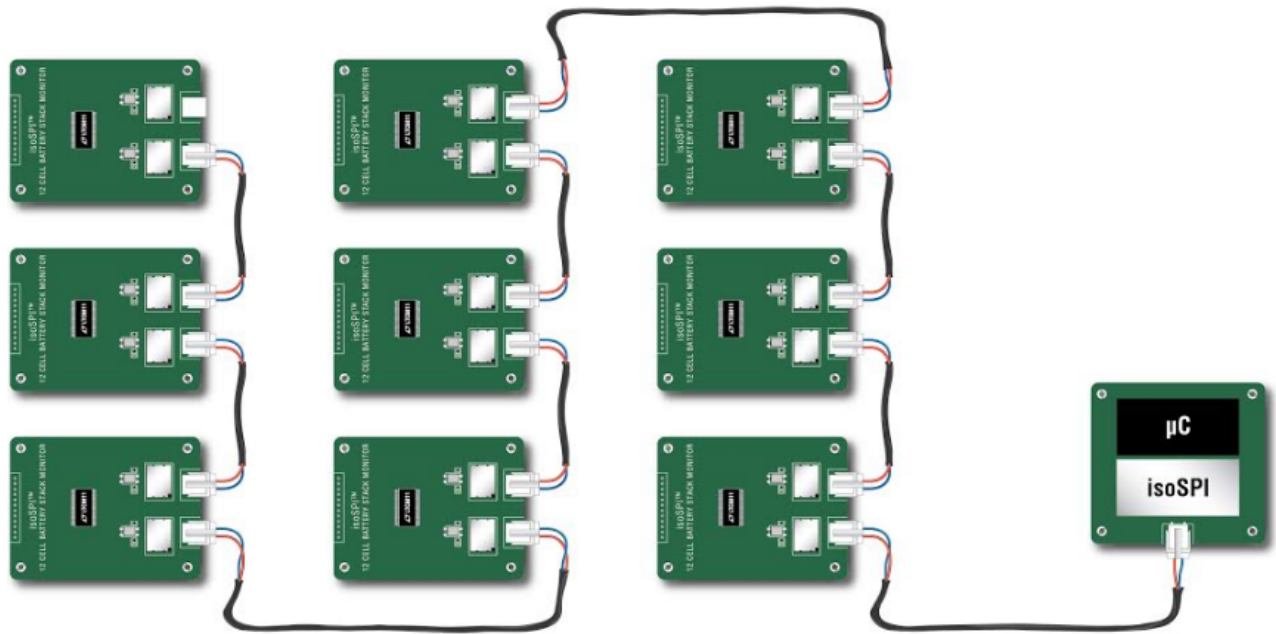


Figure 6. Battery Monitoring Interconnections with isoSPI

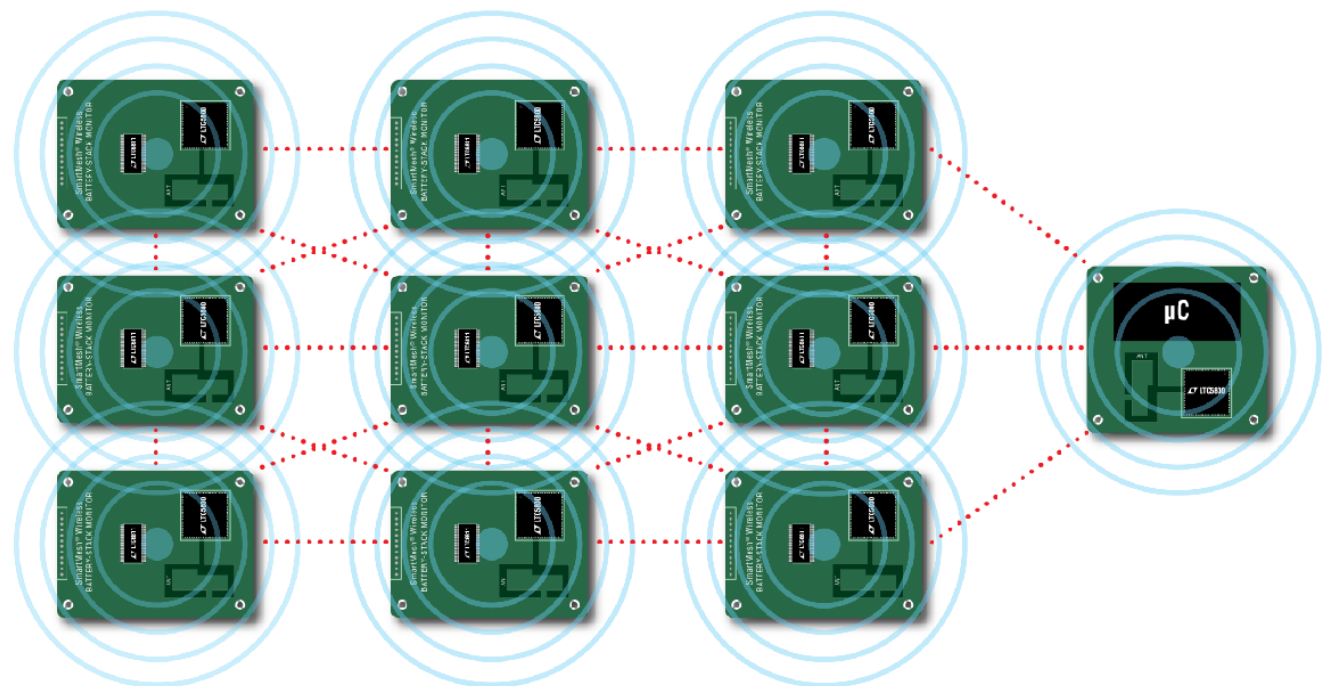


Figure 7. Battery Monitoring Interconnections with SmartMesh WSN

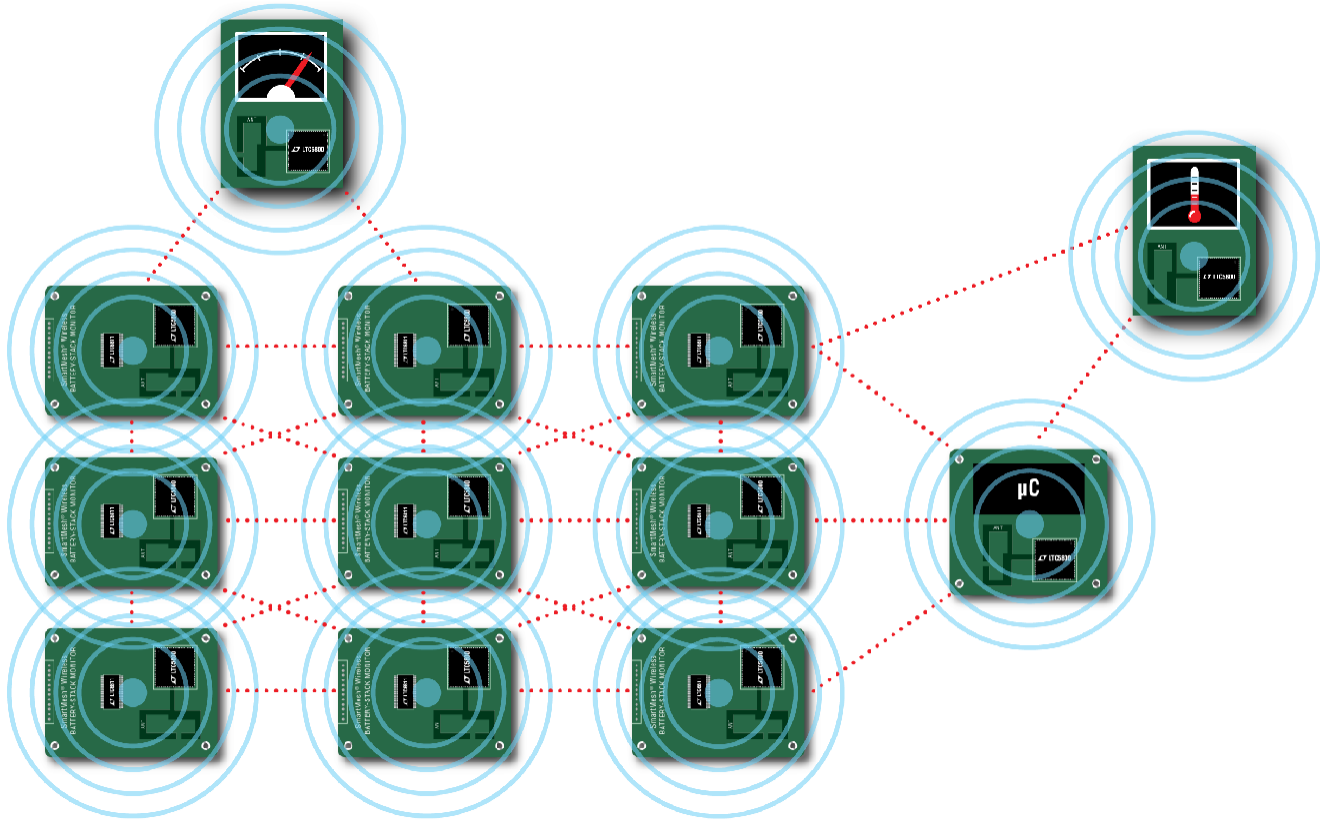


Figure 8. Battery Monitoring & Additional Sensor Interconnections with SmartMesh WSN

Summary

With leading technology in battery monitors and reliable wireless networking, Linear Technology is well positioned to assess how, when, and where wireless BMS can be deployed. A SmartMesh wireless BMS promises to eliminate maintenance-prone connectors, cables and harnesses. Wireless BMS enables expanded BMS functionality via SmartMesh scalability and time-stamped data acquisition capability. Linear Technology continues to collaborate with customers, providing high performance analog and power solutions.

Benefits of Wireless BMS

- Eliminates maintenance-prone connectors, cables and harness.
- Permits the addition of new sensors to further improve reliability.
- Simplifies auto assembly and battery maintenance and provides designers with additional mechanical design flexibility.
- Allows for precise time-stamped data collection, which may also further improve SOC/SOH calculation.