Battery Management System

ARCHITECTURE

BMS TOPOLOGIES

Centralized: a single controller is connected to the battery cells through a multitude of wires

Distributed: a BMS board is installed at each cell, with just a single communication cable between the battery and a controller

Modular: a few controllers, each handling a certain number of cells, with communication between the controllers

Centralized BMSs are most economical, least expandable, and are plagued by a multitude of wires. Distributed BMSs are the most expensive, simplest to install, and offer the cleanest assembly. Modular BMSs offer a compromise of the features and problems of the other two topologies.

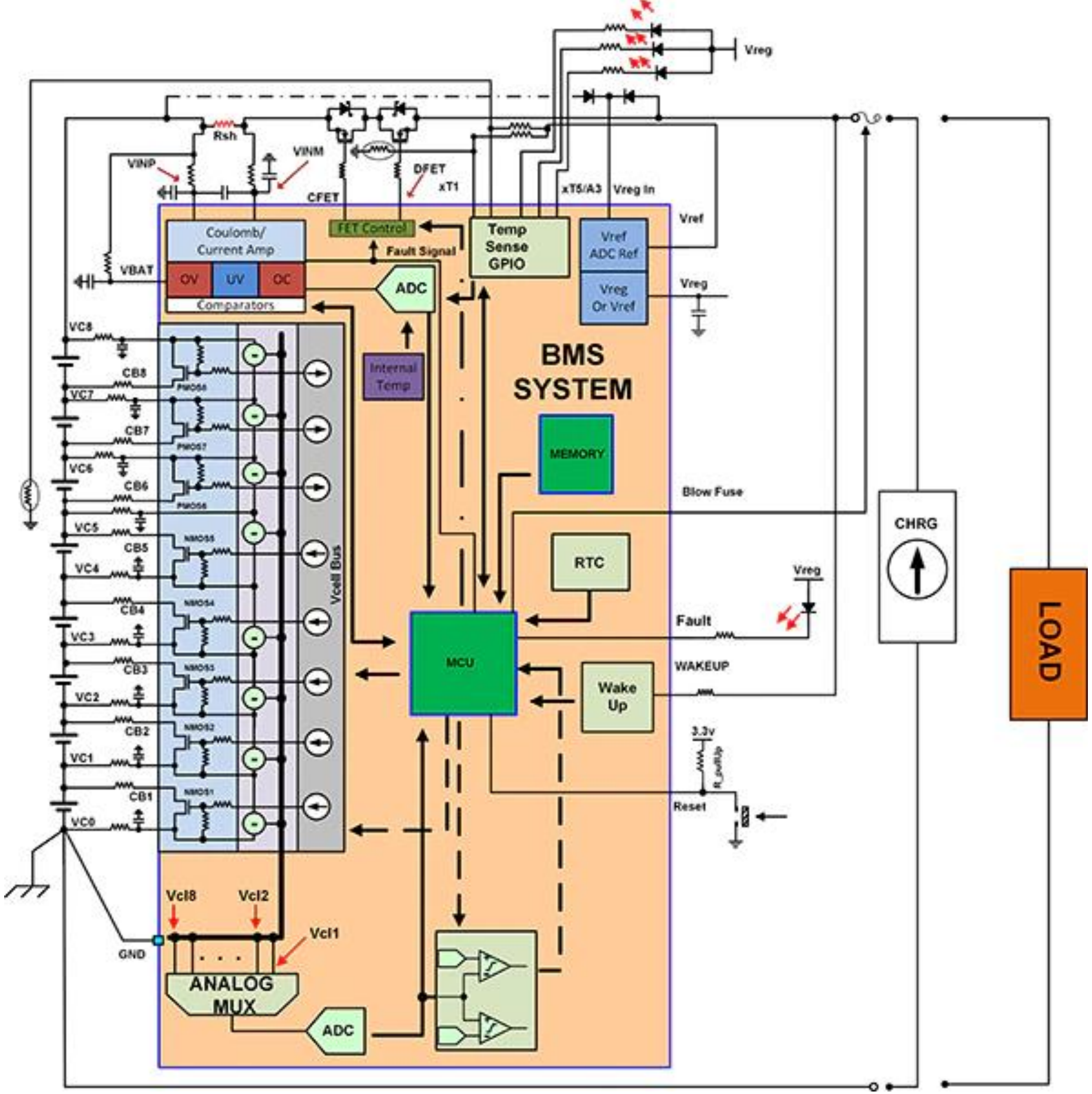
Building Blocks of a Battery Management System

Functional Blocks

- Cutoff FETs
- Fuel Gauge Monitor
- Cell Voltage Monitor
- Cell Voltage Balance
- Real Time Clock (RTC)
- Temperature Monitors

Simplified Diagram of the Building Blocks of a Battery Management System

a Battery Management System (BMS) for lithium based batteries is designed that operates more efficiently and communicates with UART between master and slave modules and can communicate via CAN protocol with external devices.



(Fig. 1). Several types of BMS ICs are available.

It needs to be defined, if there is a "Master" module, how it talks to "Slave" modules that amongst others are responsible for data acquisition or control of actors

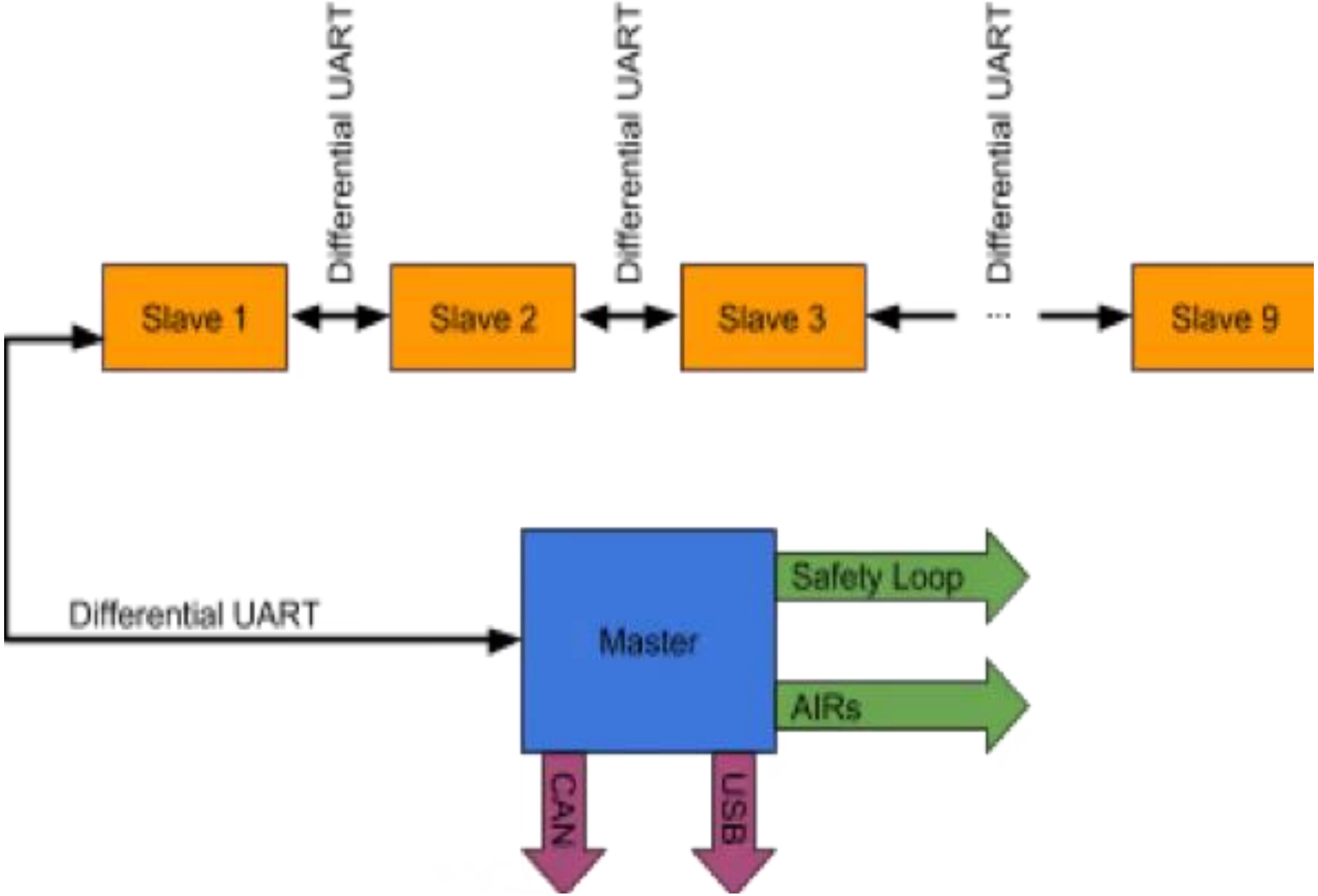
Master is a device or a process that has control over other devices or processes, whereas a **slave** is a device or a process that is controlled by another device ,The slaves are the devices that respond to the **master**.

BMS Master(Central Module):

- More Advanced Functions
- Sophisticated SOC Estimation
- Power Prediction Algorithms

BMS Slaves(Front-End IC):

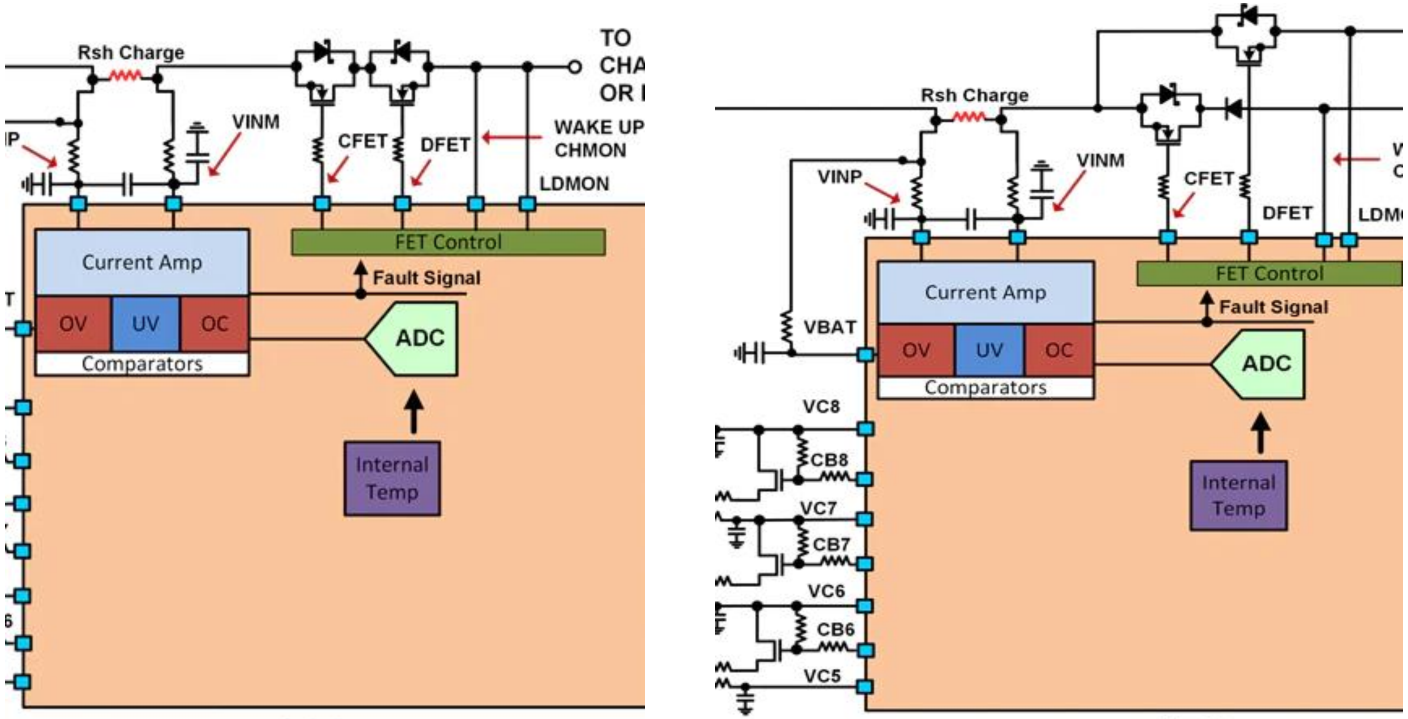
- More Basic Functions
- Signal Acqusation, Filtering



Cutoff FETs and FET Driver

Shown are cutoff FET schematics for single connection between the load and charger (A), and a two-terminal connection that allows for simultaneous charging and discharging (B).

FET-driver functional block is responsible for the battery pack's connection and isolation between the load and charger. The FET driver's behavior is predicated on measurements from battery-cell voltages, current measurements, and real-time detection circuitry. Figure 2 illustrates two different types of FET connections between the load and charger, and the battery pack.

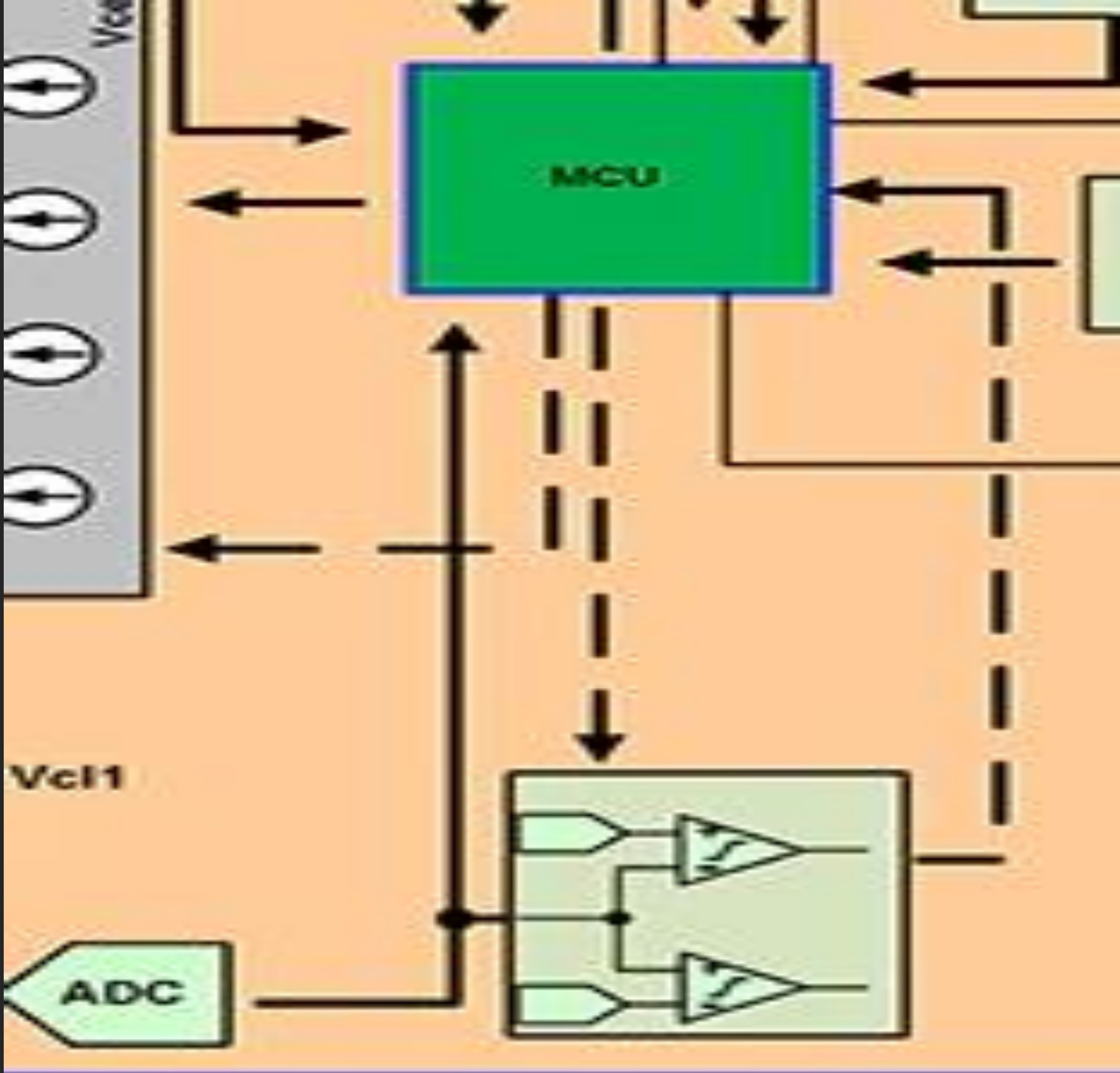


(A)

(B)

Fuel-Gauge

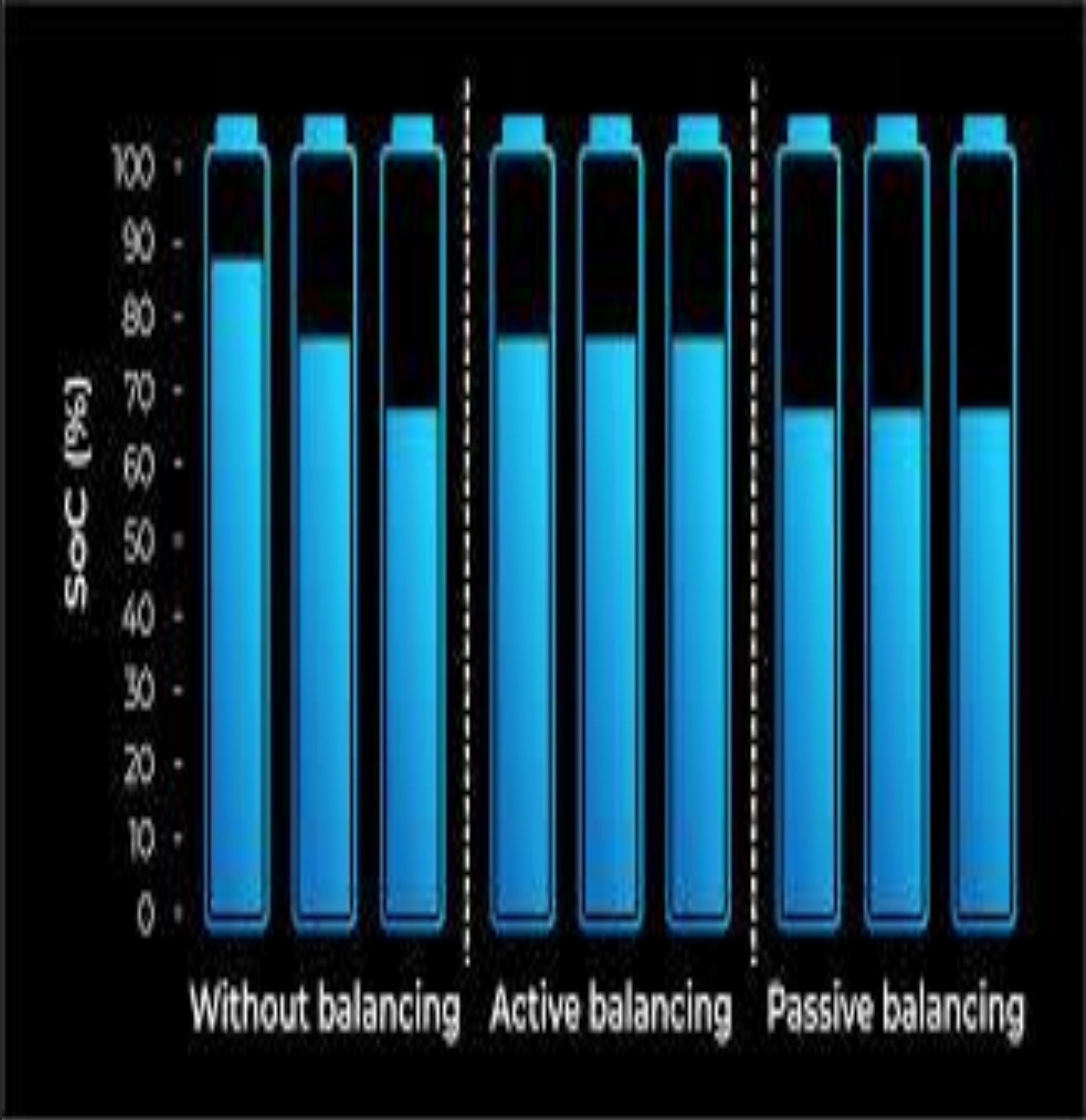
A **battery fuel gauge**, also known as a **battery gas gauge**, determines **battery** state-of-charge (SOC) and state-of-health. A **battery fuel gauge** IC can predict how much longer, under specific operating conditions, the **battery** can continue to provide power. The fuel-gauge functional block keeps track of the charge entering and exiting the battery pack. Charge is the product of current and time. Several different techniques can be used when designing a fuel gauge.



Cell Voltage

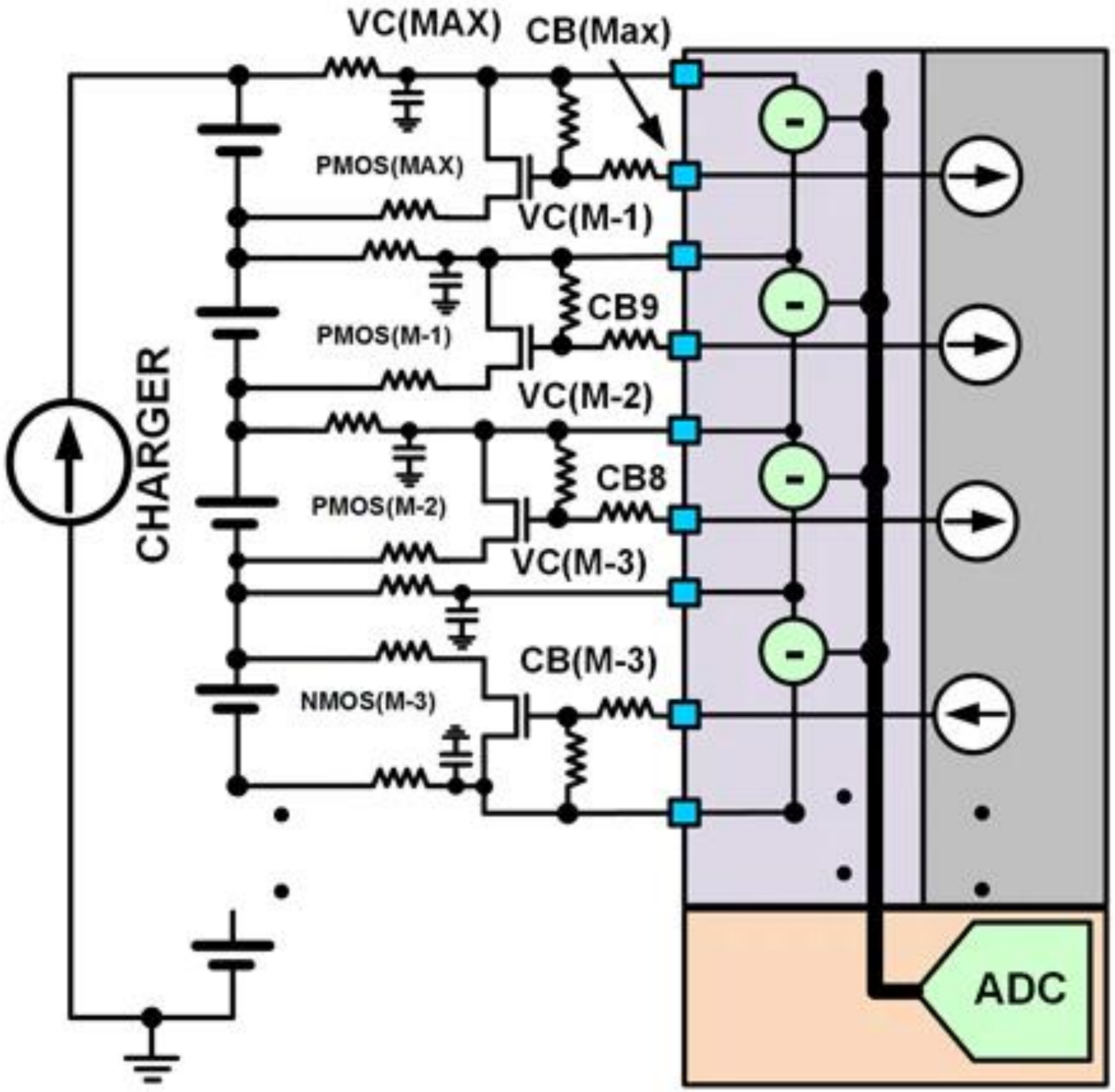
Monitoring the cell voltage of each cell in a battery pack is essential to determine its overall health. All cells have an operating voltage window where charging/discharging should occur to ensure proper operation and battery life. If an application is using a battery with a lithium chemistry, the operating voltage typically ranges between 2.5 and 4.2 V. Voltage range is chemistry-dependent. Operating the battery outside the voltage range significantly reduces the lifetime of the cell and can render it useless.

Cells are connected in series and parallel to form a battery pack. A parallel connection increases the battery pack's current drive, while a series connection increases the overall voltage. A cell's performance has a distribution: At time equal zero, the battery-pack cell's charge and discharge rates are the same. As each cell cycles between charge and discharge, each cell's charge and discharge rates change. This results in a spread distribution across a battery pack.



Passive Balancing

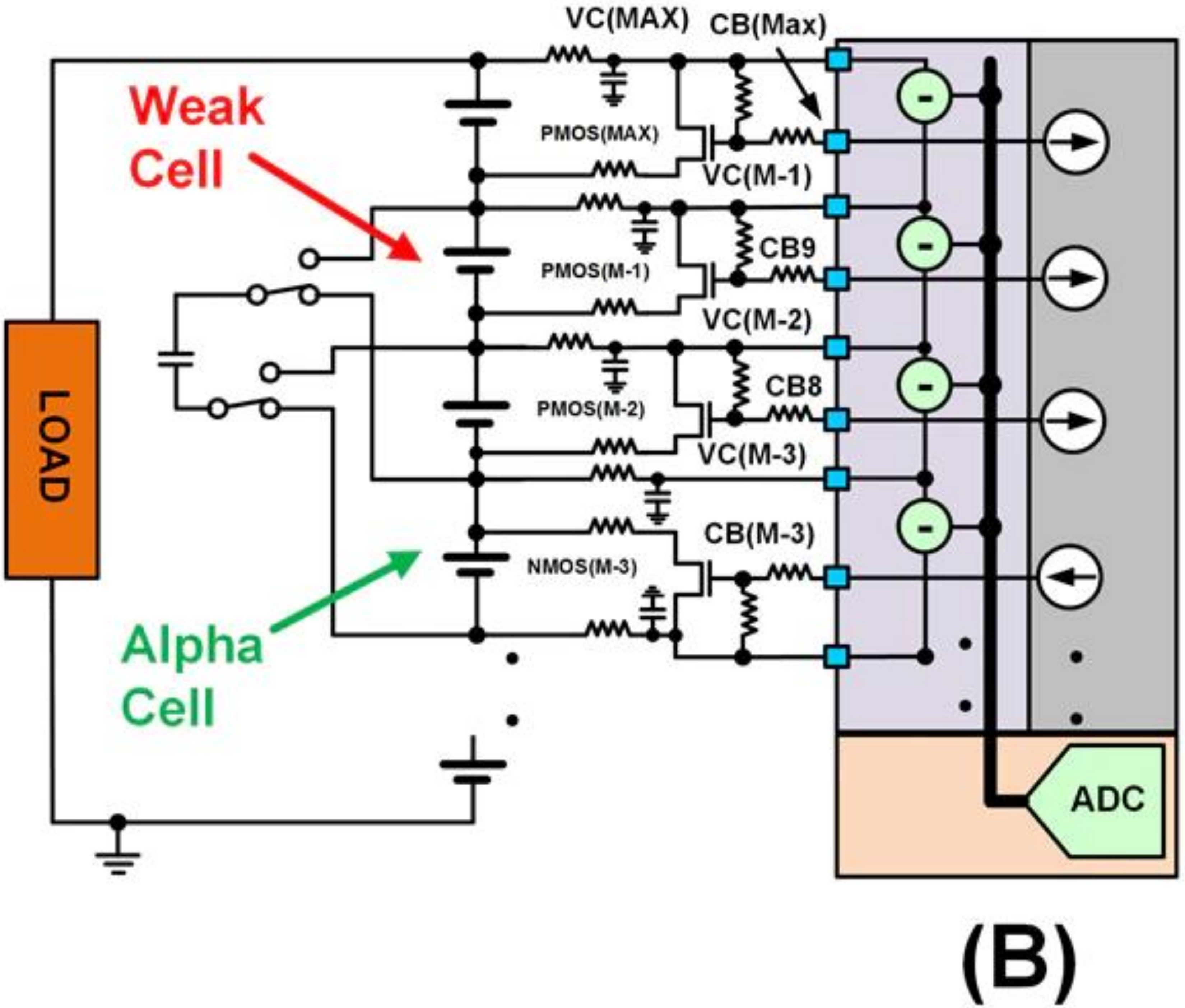
Bypass cell balancing FETs help slow the charge rate of a cell during the charge cycle (A).



(A)

Active Balancing

Active balancing is used during the discharge cycle to steal charge from a strong cell and give the charge to a weak cell



Voltage Measurement

In battery packs assembled from lithium-ion cells, typically each cell voltage, as well as the overall pack voltage, is measured. While the cell voltages are just a few volts, the pack voltage can reach voltages of more than 800 V. Therefore, it has to be distinguished between cell voltage measurement and pack voltage measurement.

Cell Voltage Measurement

The acquisition of cell voltages is usually done by integrated BMS Frontend chips.

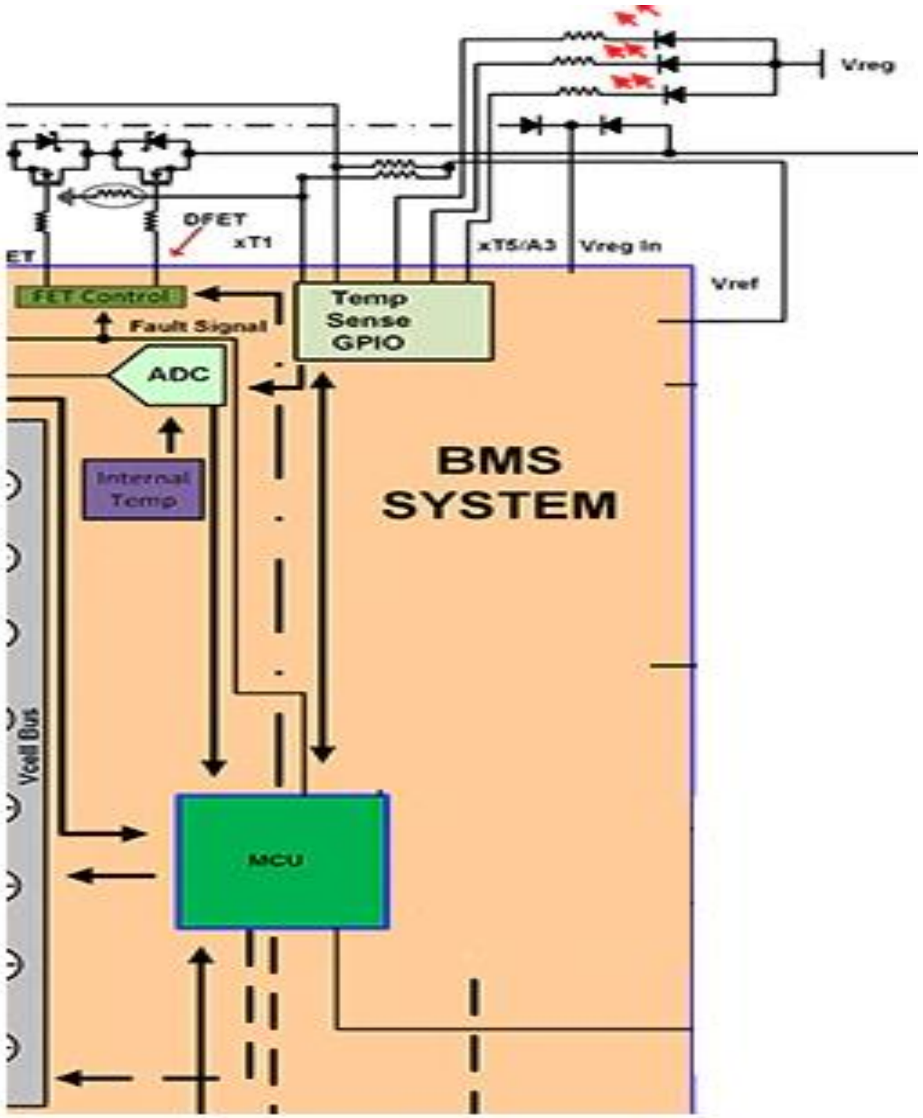
Pack Voltage Measurement

The pack voltage acquisition is done by a separate measurement unit, typically consisting of a voltage divider, an impedance converter, a filter, and an Analog-Digital Converter (ADC). The voltage divider is necessary for scaling down the pack voltage to an adequate measuring voltage, which is in the range of the ADC. Depending on the pack voltage and on the electric strength of the resistors, it may be necessary to use several resistors for a safe voltage divider. In addition, a Zener diode should be placed in parallel to the measuring resistor for protecting the following measurement circuits against overvoltage. Since the voltage divider is designed to be highly resistive in order to keep the losses low, the voltage tap of the measuring resistor should be very high-resistance in order not to load the voltage divider. For this reason, an impedance converter that is followed by the filter circuit and the ADC should be used to tap the voltage.

Temperature Monitoring

Today’s batteries deliver lots of current while maintaining a constant voltage. This can lead to a runaway condition that causes the battery to catch
fire.Thermistors powered by an internal ADC vol tage reference are commonly used to monitor e ach circuit’s temperature.

Common temperature sensors for the measure ment of temperatures in the region that is releva nt for battery management applications are of N egative Temperature Coefficient or Positive Tem perature Coefficient type. These sensors chang e their resistance as
a function of the temperature–
for NTC, the resistance decreases with increasin g temperature, for PTC .



Data Transfer

Communication between individual BMS-modules, as well as between BMS and the overall system, is required. Nowadays, the CAN bus is one of the most prominent buses used in vehicle environments because it is very flexible regarding the number of bus members, as well as offering a good noise resistance.

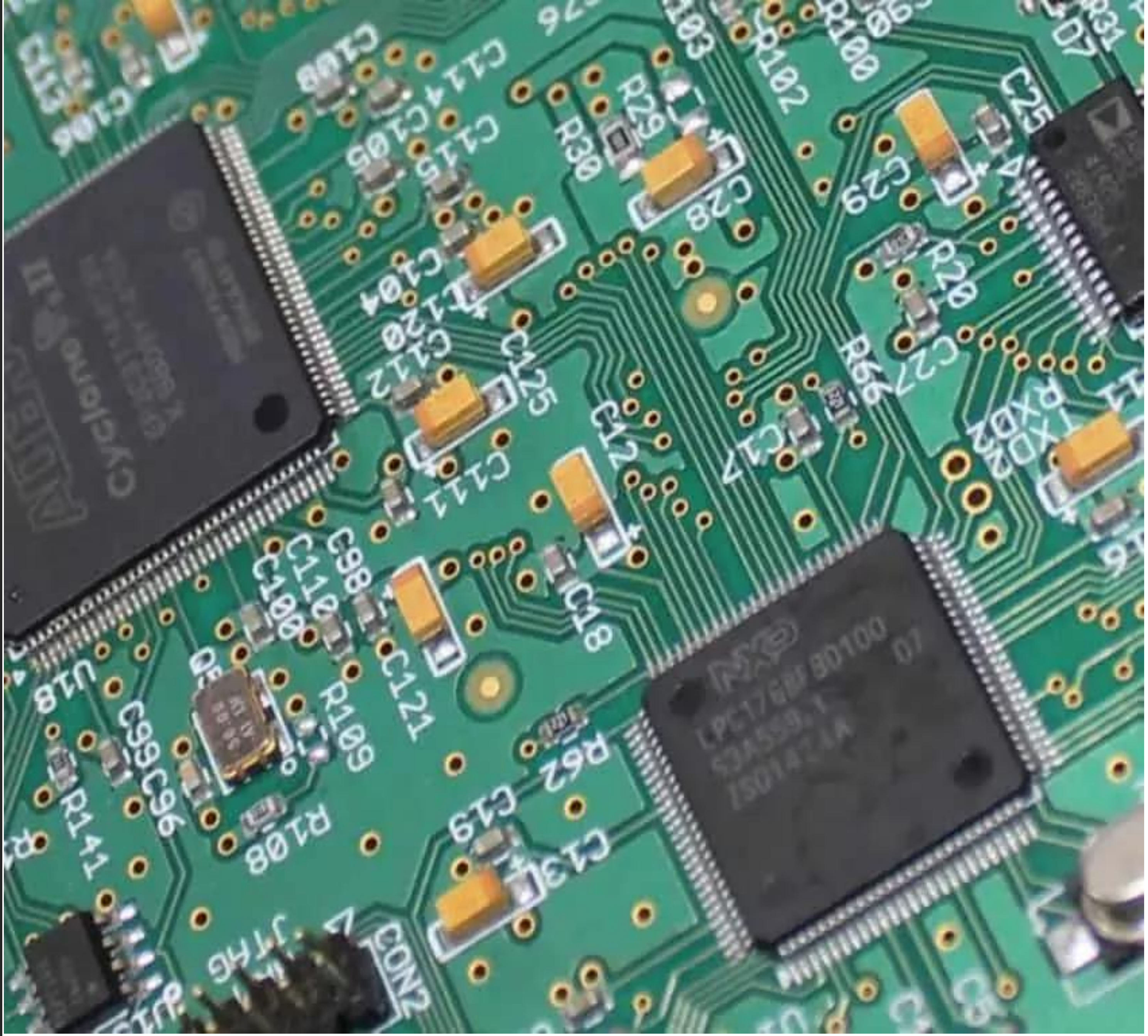
Other buses that are mostly used on short distances, such as chip to chip communication (see above), is the SPI interface, I^2C interface or the Onewire bus. Due to their non-differential signals, they are not robust against disturbances on a longer, more exposed line, such as inter-module buses.

For the latter task, the previously mentioned CAN bus is a good choice. If the CAN bus at its highest speed of 1 Mbps is too slow, or the demand for real-time deterministic capability exists, then the FlexRay bus seems adequate. An Ethernet connection is also sometimes used to connect the battery system with the application, especially when high communication speed and large data volumes required.

Multiple Cell Interfaces are connected together in a daisy-chain that increases in height as pack voltage increases. This daisy-chain is connected to a single Stack Controller that manages all cells in the chain.

State Machines / Algorithms

Most BMS systems require a microcontroller (MCU) or a field-programmable gate array (FPGA) to manage information from the sensing circuitry, and the n make decisions with the received informati on. In certain devices, an algorithm that is digitally encoded enables a standalone solution with one chip. Standal one solutions are also valuable when mated t o an MCU, because the standalone’s state machin e can be used to free up MCU clock cycles and me mory space.



Other BMS Building Blocks

Other functional BMS blocks may include battery authentication, real-time clock (RTC), memory, and daisy chain. The RTC and memory are used for black-box applications—the RTC is used as a time stamp and memory is used for storing data. This lets the user know the behavior of battery pack prior to a catastrophic event. The battery authentication block prevents the BMS electronics from being connected to a third-party battery pack. The voltage reference/regulator is used to power peripheral circuitry around the BMS system. Finally, daisy-chain circuitry is used to simplify the connection between stacked devices. The daisy-chain block replaces the need for optical couplers or other level-shifting circuitry.

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