BMS Active-balance Application and Products Solution

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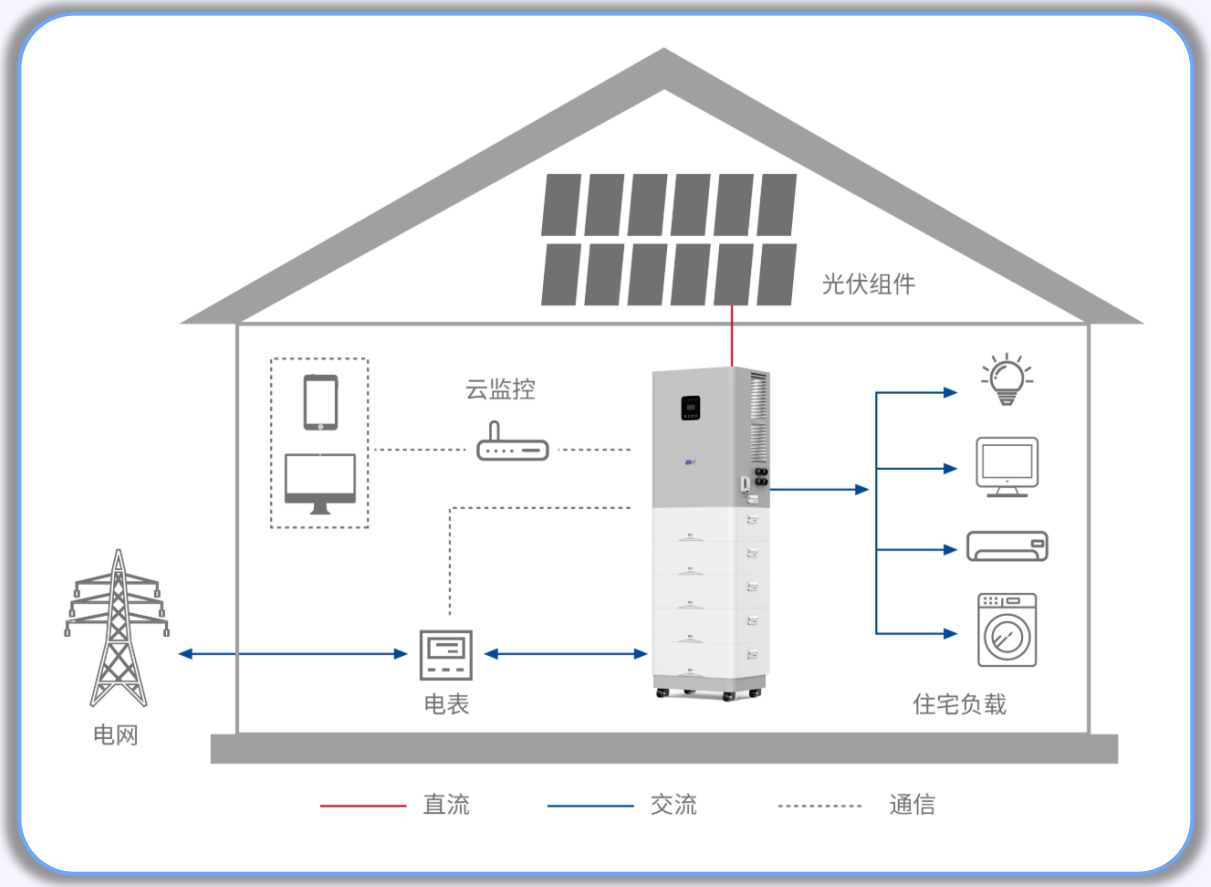
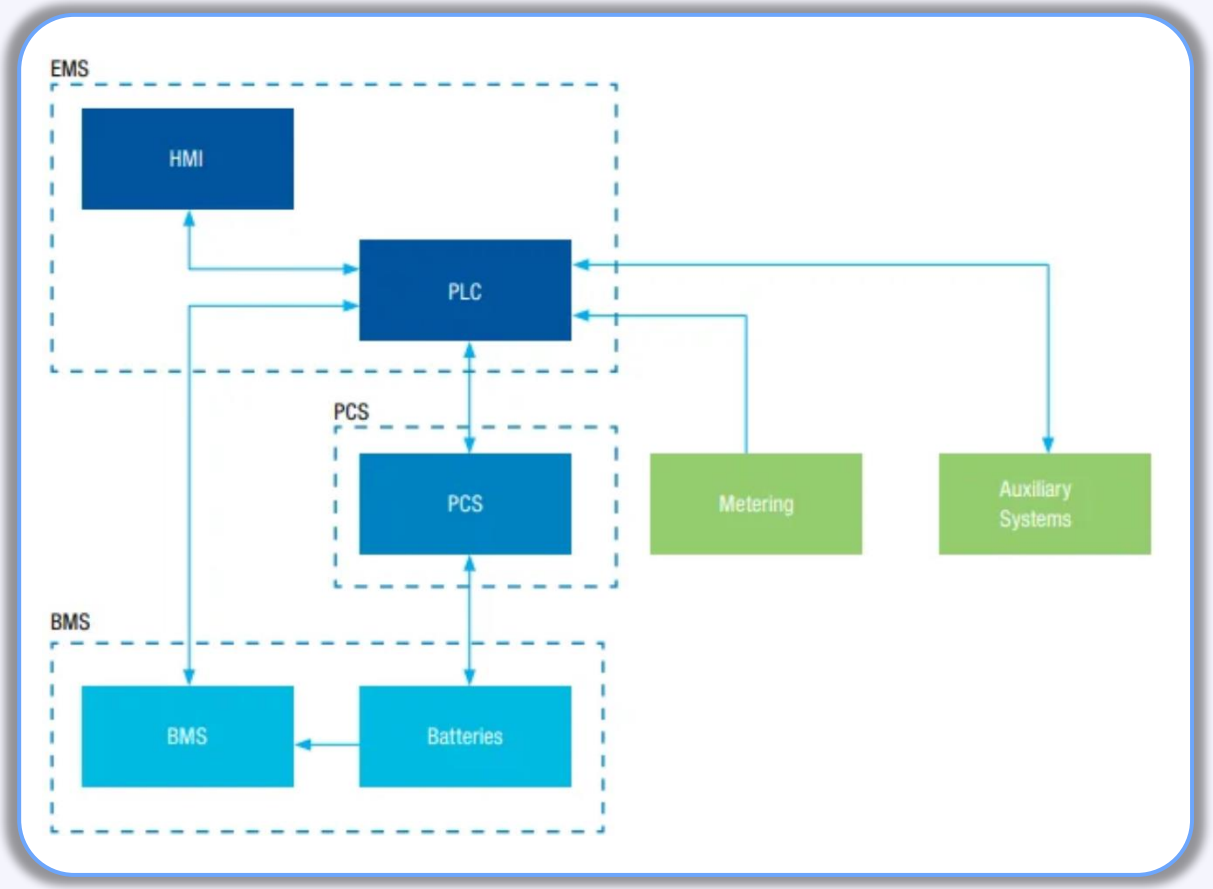
Agenda

- Home energy storage and BBU system Overview
- Common active balancing schemes and MPS active balancing products introduction
- MPS Solutions by Sockets

Home energy storage and BBU Overview

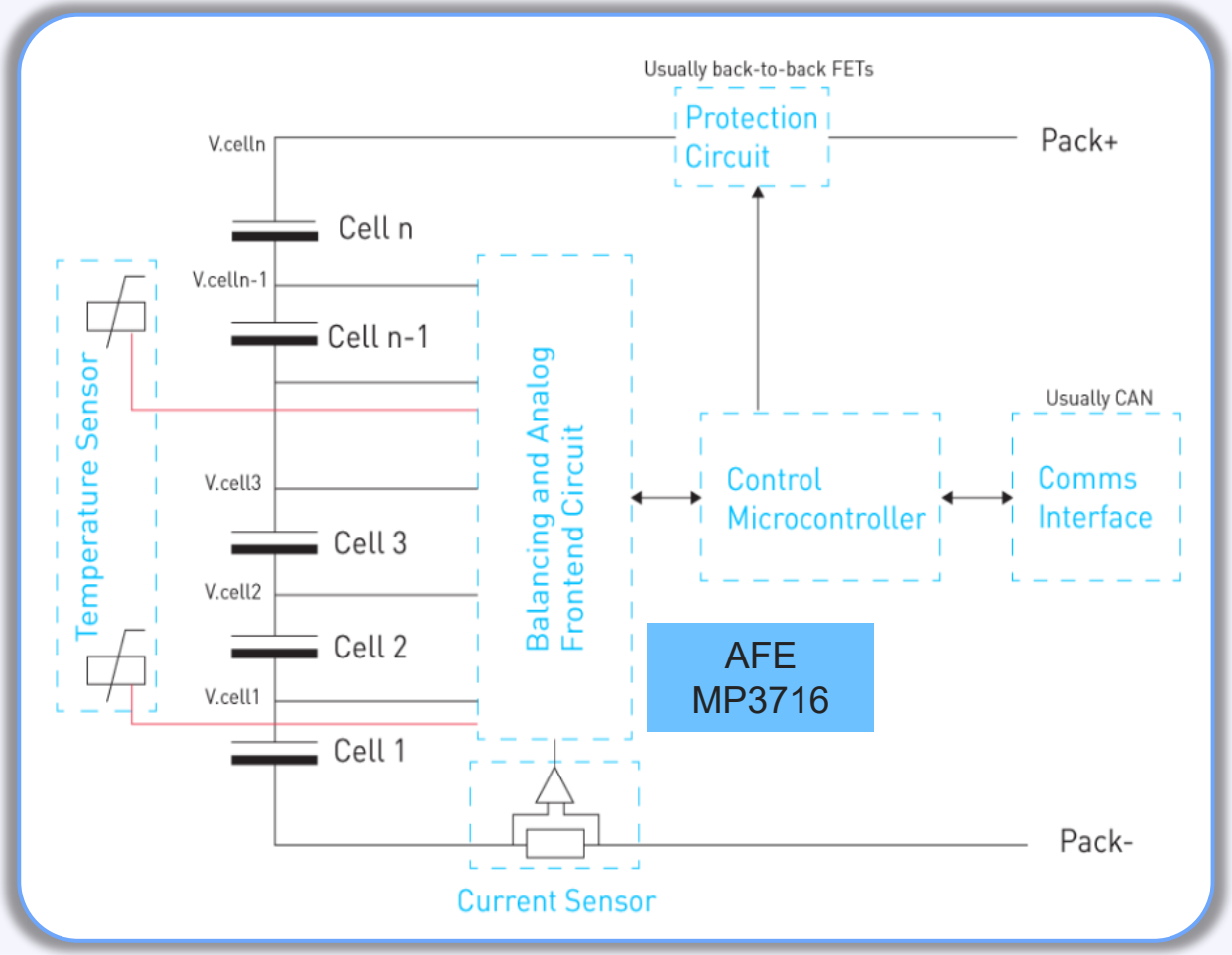
Home energy storage





The home energy storage system is an integrated unit of battery and inverter, aiming to provide users with an intelligent and convenient all-in-one home energy storage solution, perfectly combining the energy storage battery system, photovoltaic power generation system and mains power.

BMS Board

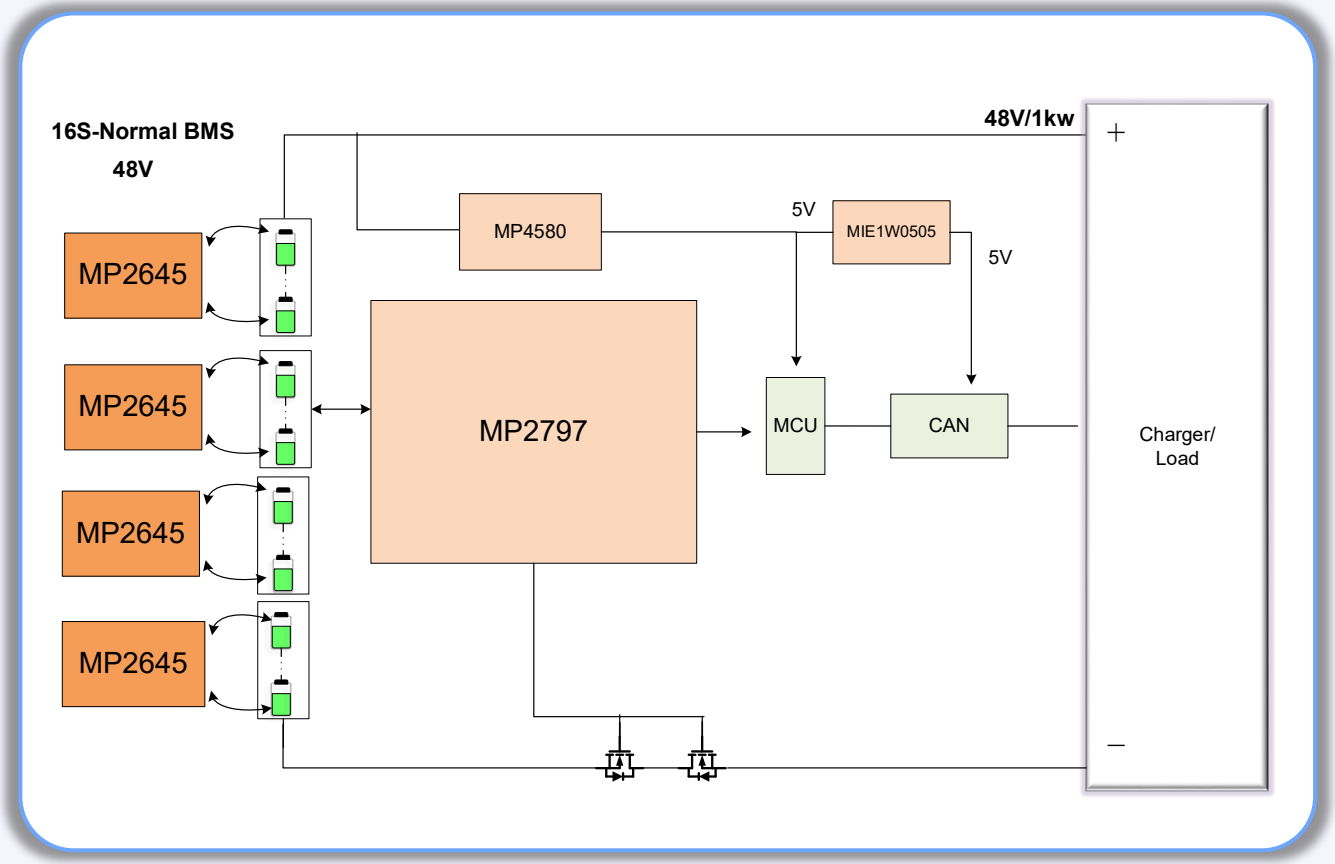


Several linked components, each with a distinct function make up a typical BMS. The principal elements consist of:

- Sensors
- Control Module
- Protection Circuitry
- Balancing Circuitry
- Communication Interfaces

Home energy storage

BMS Board

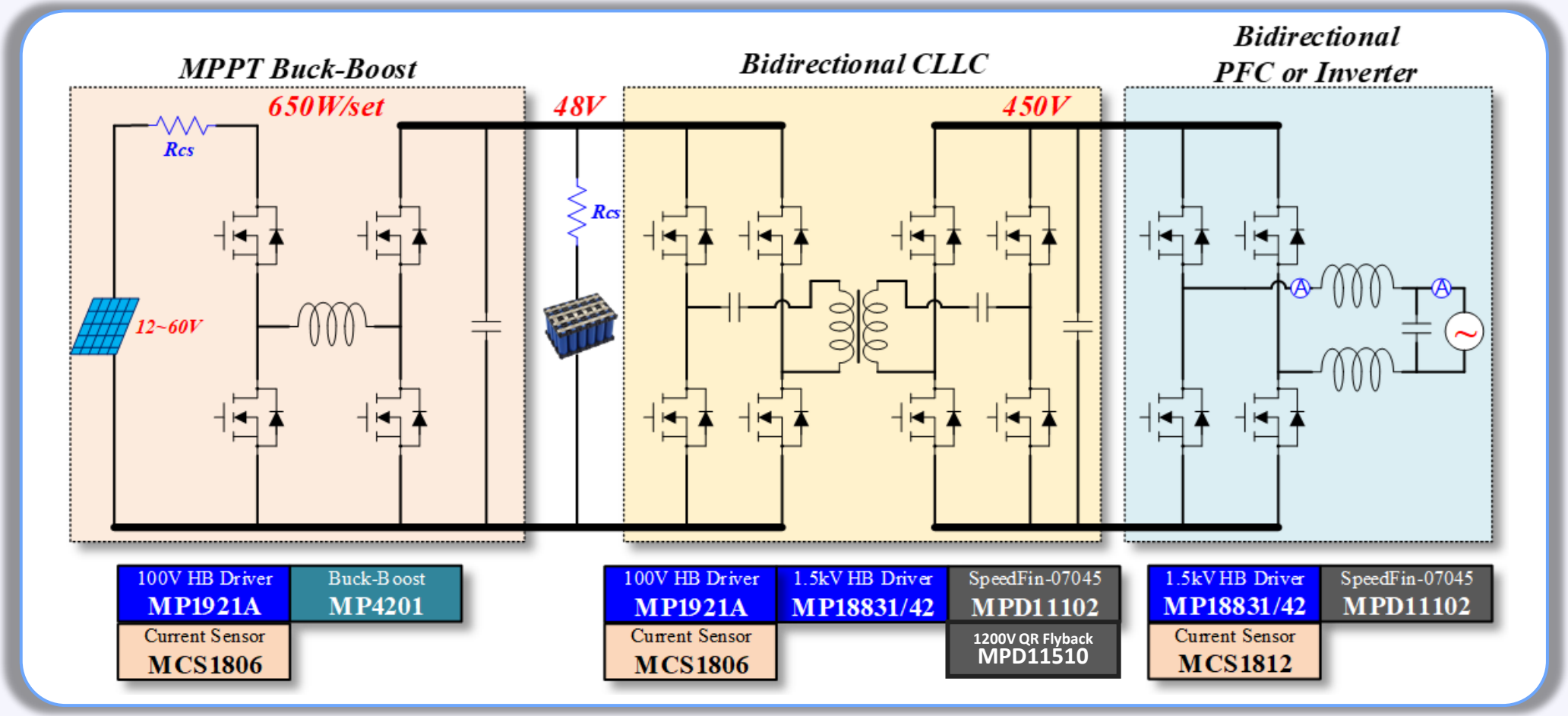


MPS offers a complete solution for BMS boards:

- Sensors/Control Module/Protection Circuitry: MP279X/MP371X
- Balancing Circuitry: MP2645A
- Communication Interfaces: MP27922

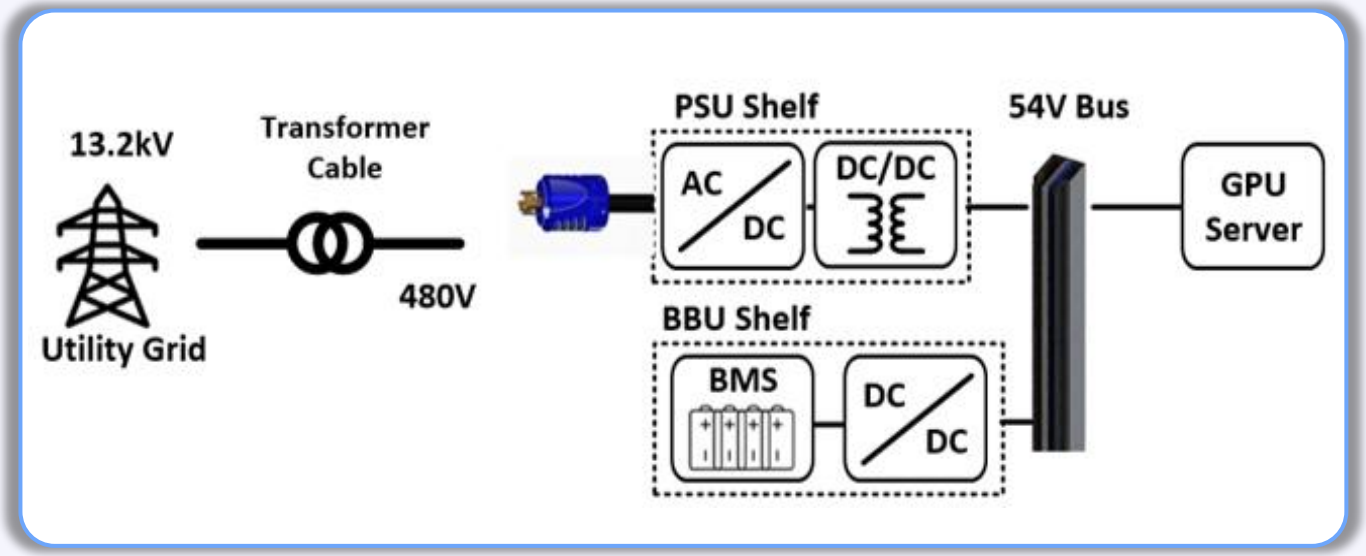
Home energy storage

PCS Board

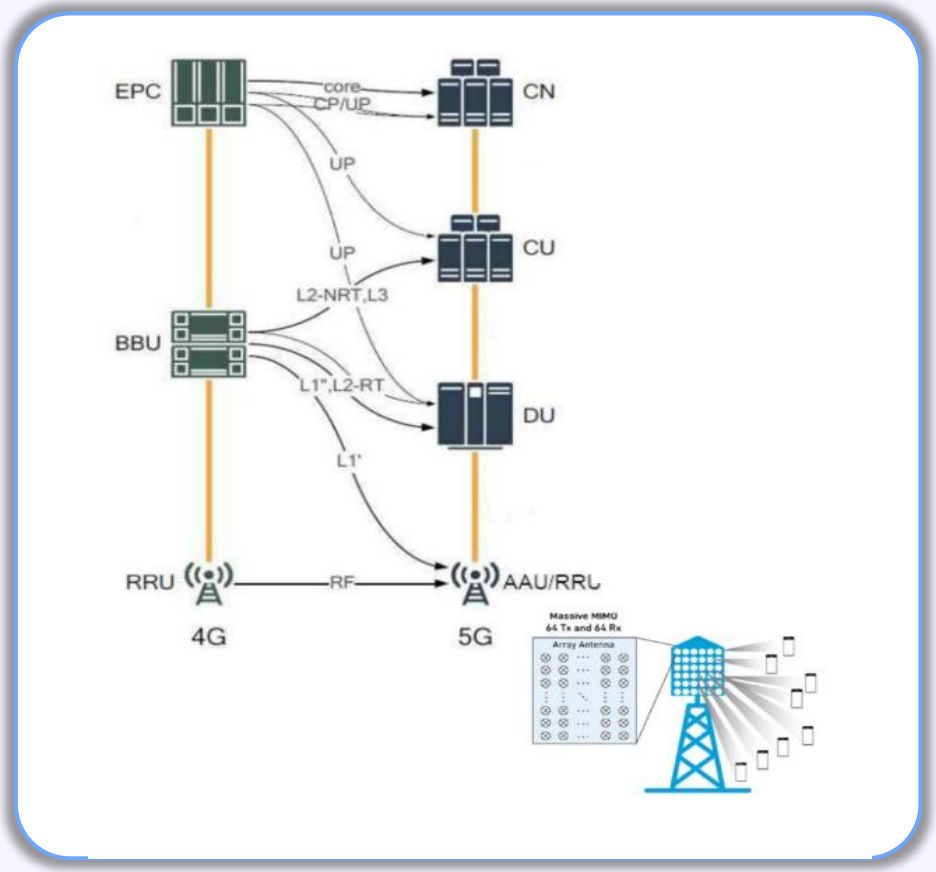


The PCS (Power Converter System) is the interface between the DC link of the batteries and the AC Busbar of the inverter. In addition, the PCS monitors electrical variables, alarms of interest and is fully integrated with the operation, control and energy management (EMS) system.

Battery Backup Unit for data center

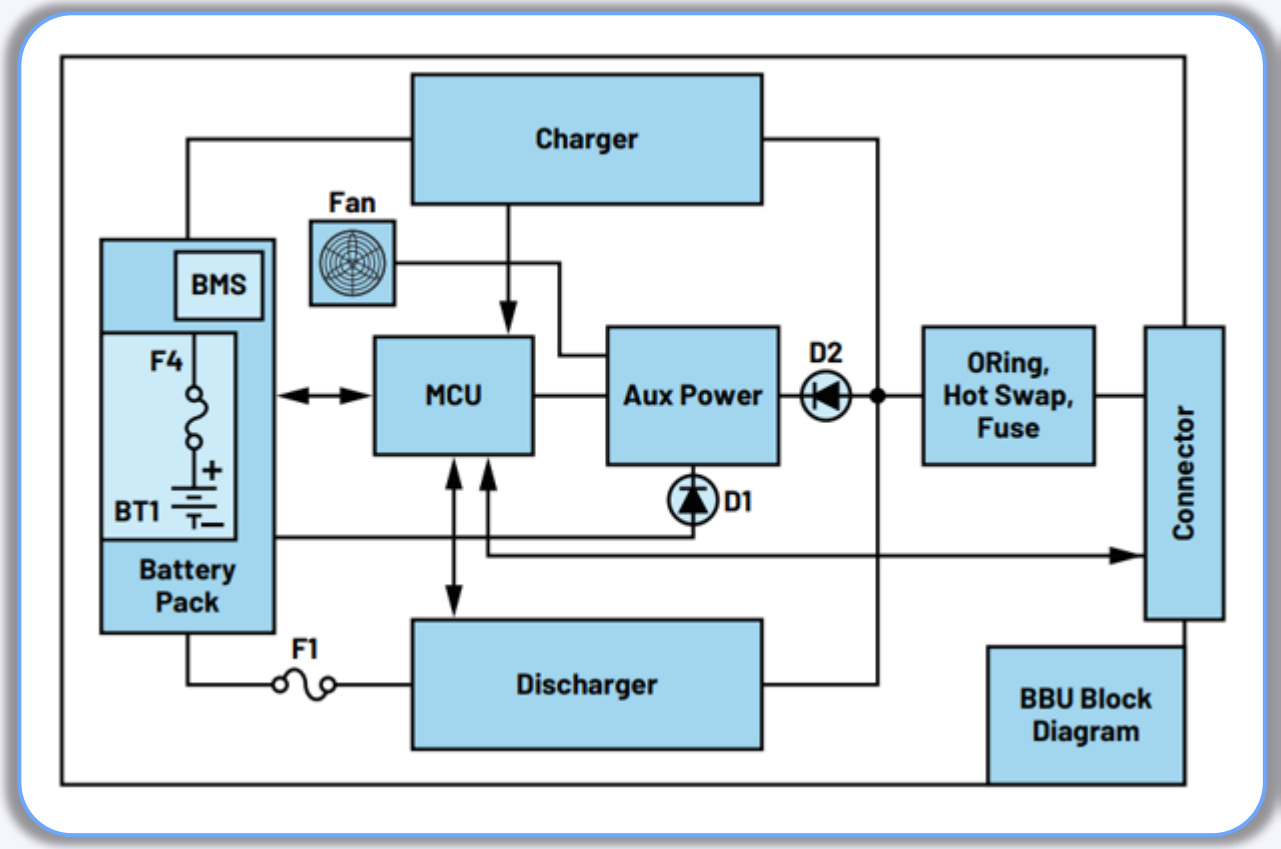


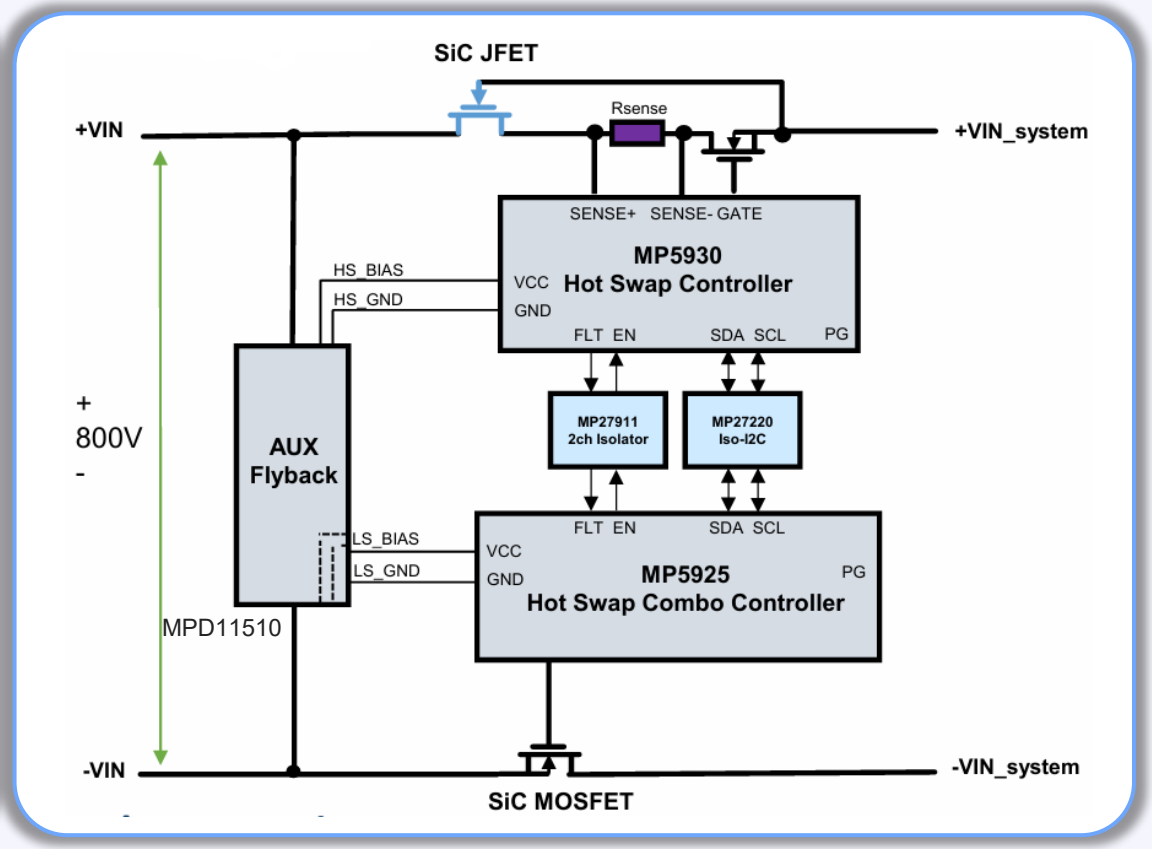
Building Baseband Unit



BBU (Baseband unit) is an integral part of wireless communication systems, particularly cellular networks. It processes baseband signals, which are the original frequencies of transmissions before modulation.

BBU



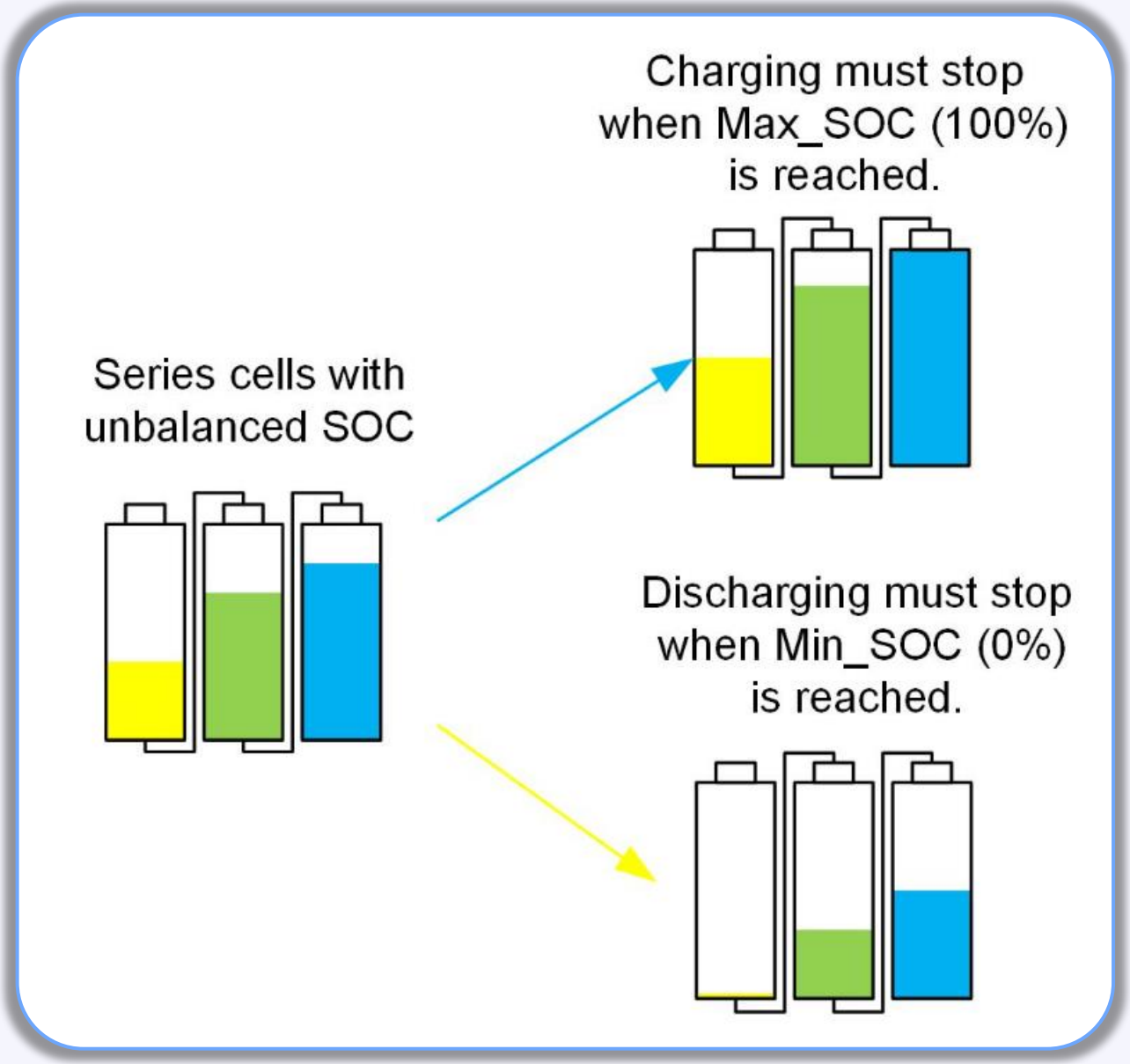


BBU performs multiple vital functions:

- Signal Processing
- Communication
- Control Functions

Active-balance Solution

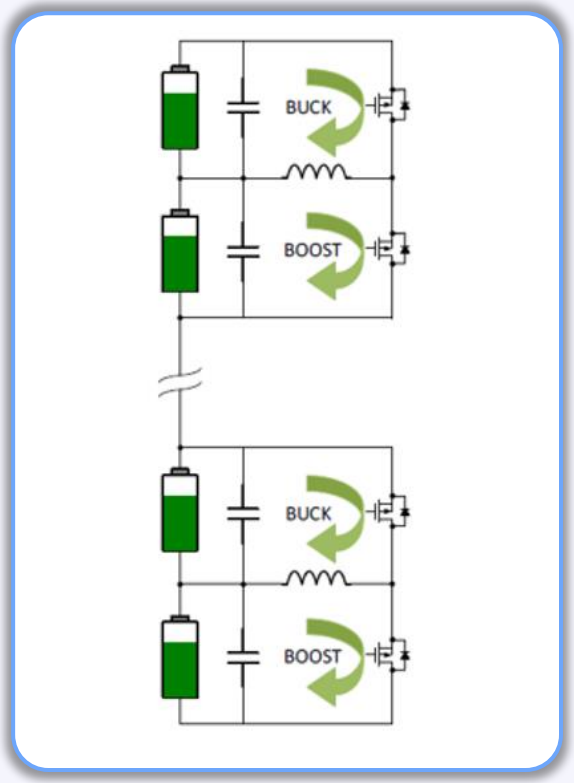
Balancer significance



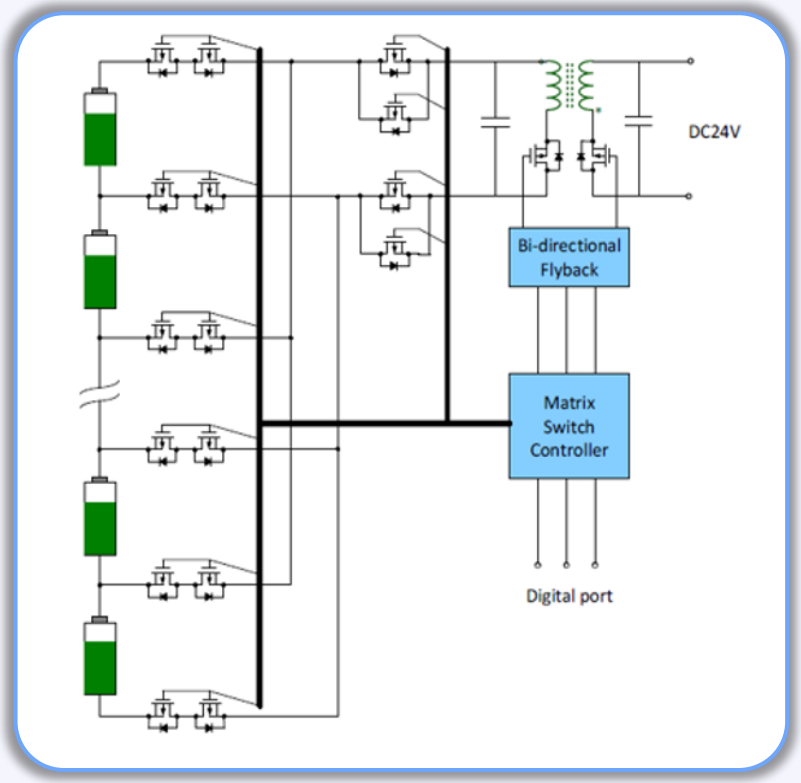
Note: The remaining capacity available in a battery cell is generally expressed as a percentage (0% = empty; 100% =full).

Typical Balancer

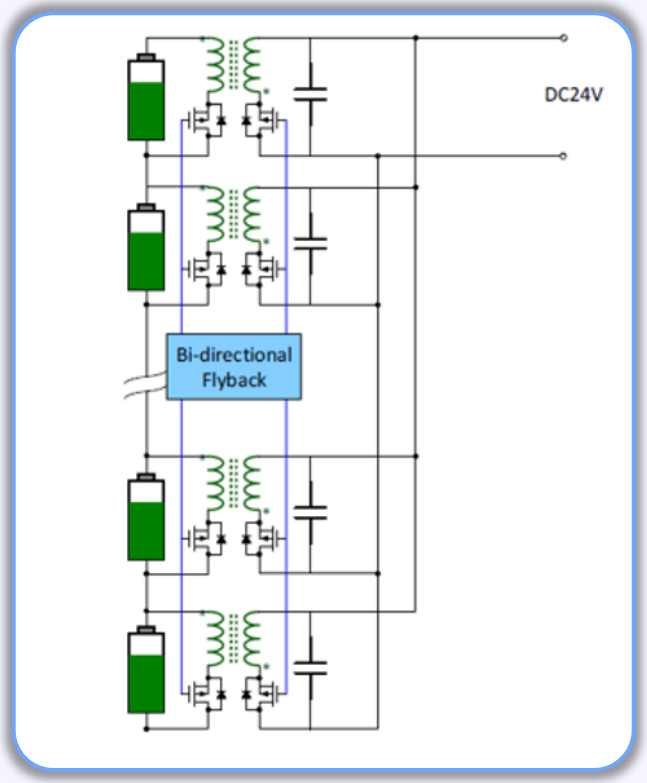
Buck-Boost



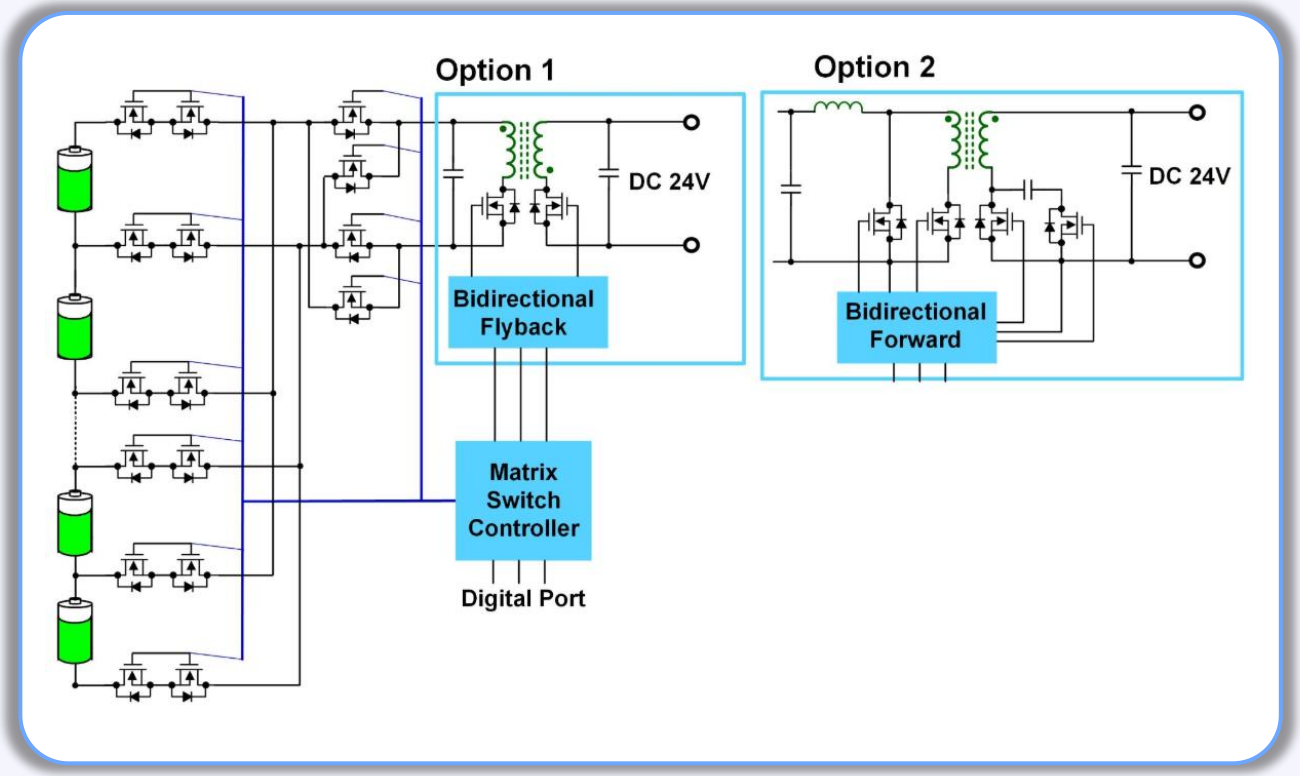
Matrix Switch



Bi-directional Flyback

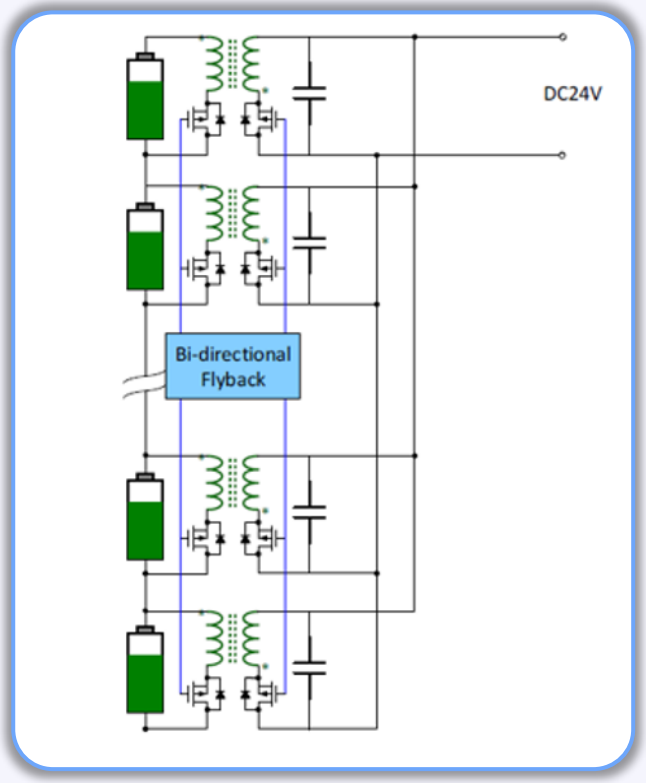


Matrix Switch



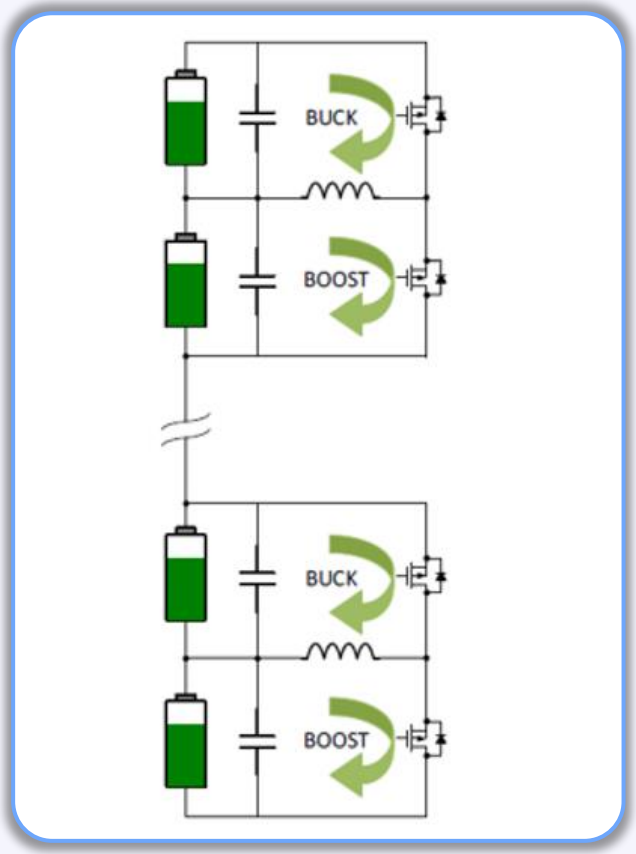
The switch matrix plus transformer method uses a switch array to connect transformers to each cell, thereby reducing the number of transformers to one. There are two types of switches in the switch matrix: cell switches and polarity switches.

Bi-directional Flyback



Each battery cell in the battery pack requires a bidirectional flyback converter, including a flyback transformer. Transformer-based active balancing methods typically require many transformers, which leads to battery pack solutions with high string counts being bulky and costly.

Buck-Boost



Compared with the first two types of active balancers, the dual-channel buck-boost active balancer follows a simple process

- In the buck balancing mode, the active balancer transfers energy from the upper battery (CU) to the lower battery (CL).
- In the boost balancing mode, the active balancer transfers energy from CL to CU.

Among the three types of active balancers, the bidirectional step-up and step-up active balancer is the simplest and most reliable.

Typical Balancer

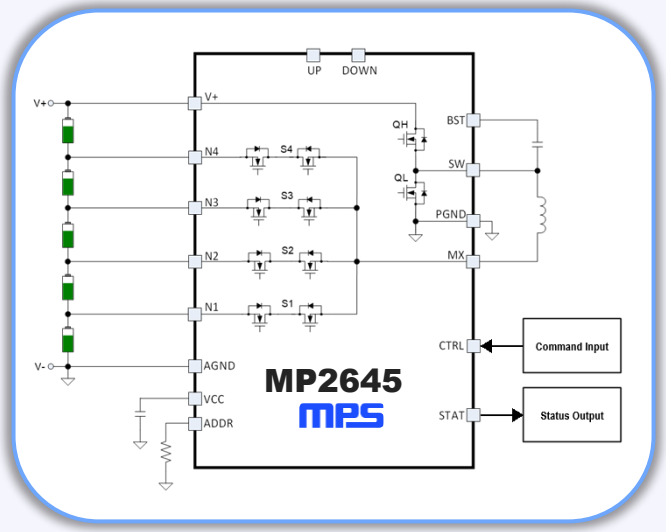
	优势	劣势
双向反激式	•均衡效率更高 •可同时均衡多个通道	•变压器复杂，价格昂贵 •占地面积大 •可靠性低 •变压器采购困难
矩阵开关	•均衡效率较高	•由于 MOSFET 数量较多而成本昂贵，例如2x(N+1)+4个（其中 N 为电芯数量）电路复杂 •一次只能均衡一个通道
升降压	•高可靠性 •低成本，单电感 •操作简单 •可同时均衡多个通道	•均衡效率较低（精心设计平衡策略可提高平衡效率）

MP2645A: 2 to 5-Cell Buck-boost Active Balancer

In Production

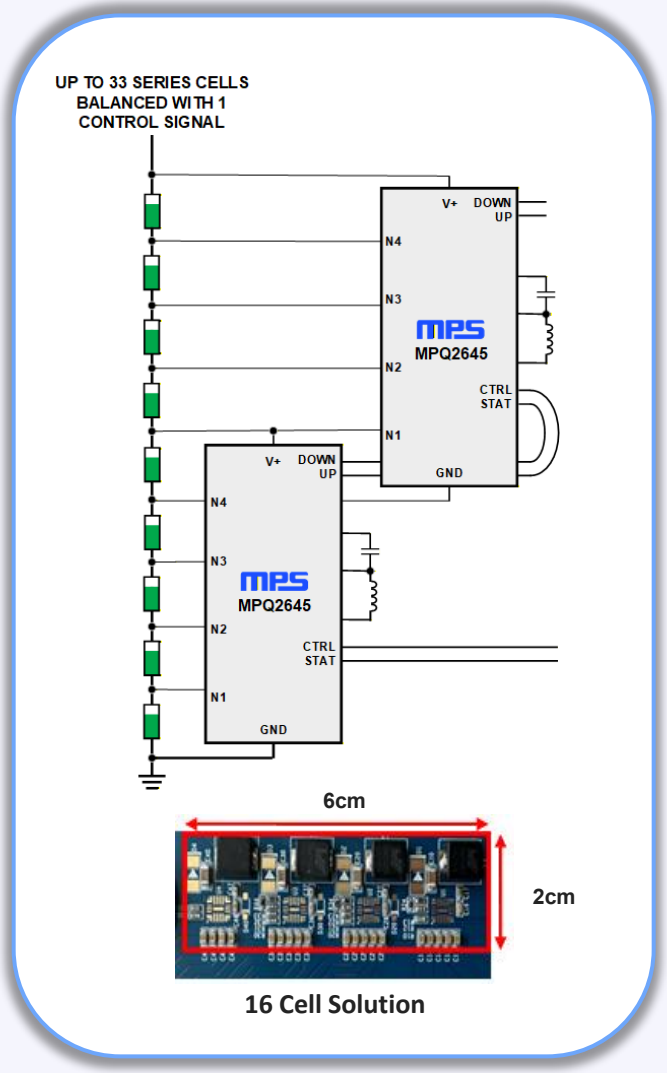
Overview

- Novel 5 Cell Balancer
- Stack Voltage: 40V
- Transfer Efficiency: > 92% (@2A balancing current)
- Shut Down Current: < 2.5uA
- Balancing Current up to 3.75A
- Daisy-chain Interface for up to 8 Devices
  - Supports 33s (8 MP2645 w/ 1-cell interleaving)
  - Simple Serial Interface for Control (Up)
  - Simple Status Signal for Monitoring (Down)
- AEC-Q100

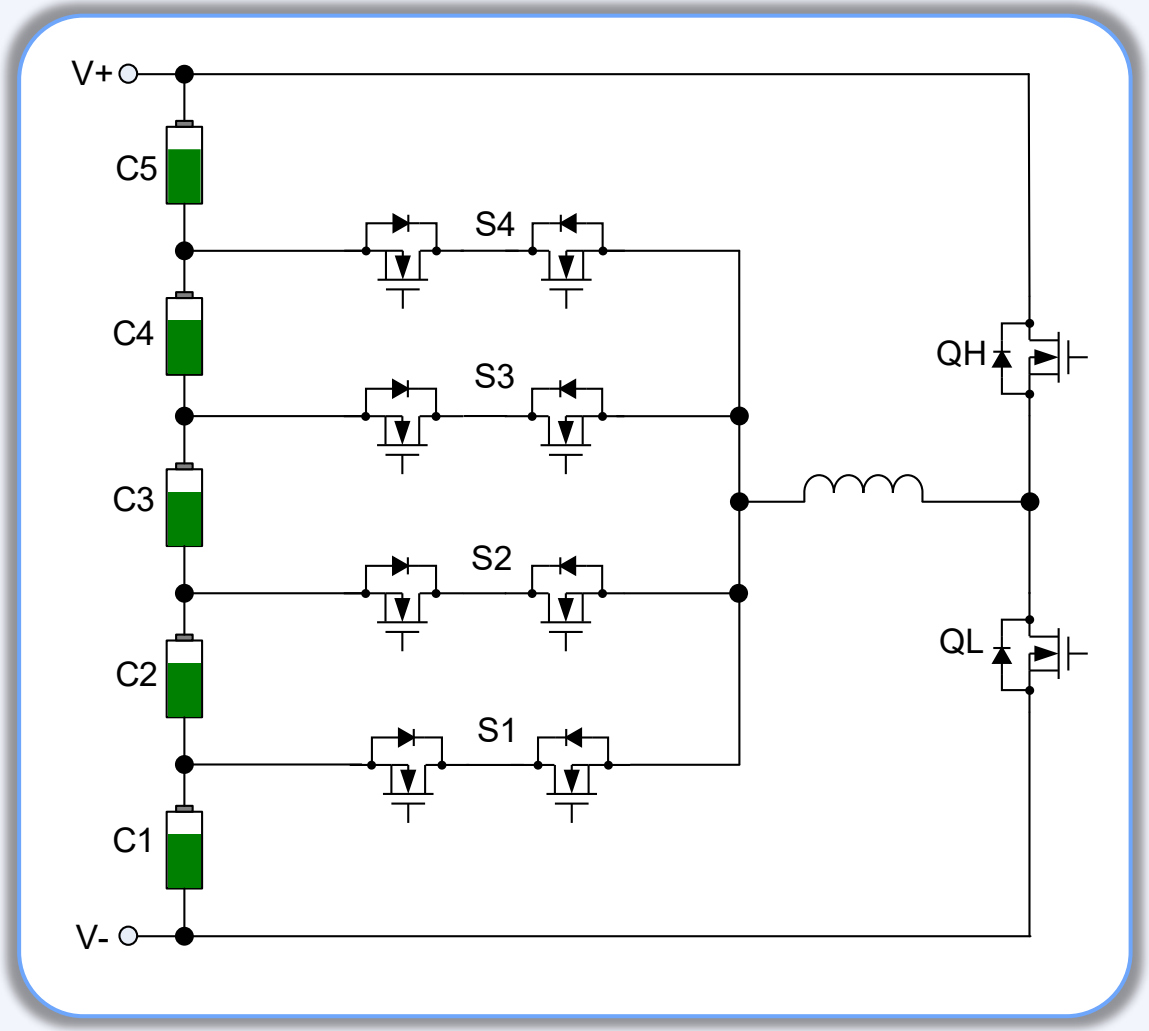


Low-cost, Simple, Small Footprint

- One Serial Control Line & One Serial Status Line
- Single Inductor per MP2645
- 4mm x 4mm QFN Package
- Low-cost Total Solution



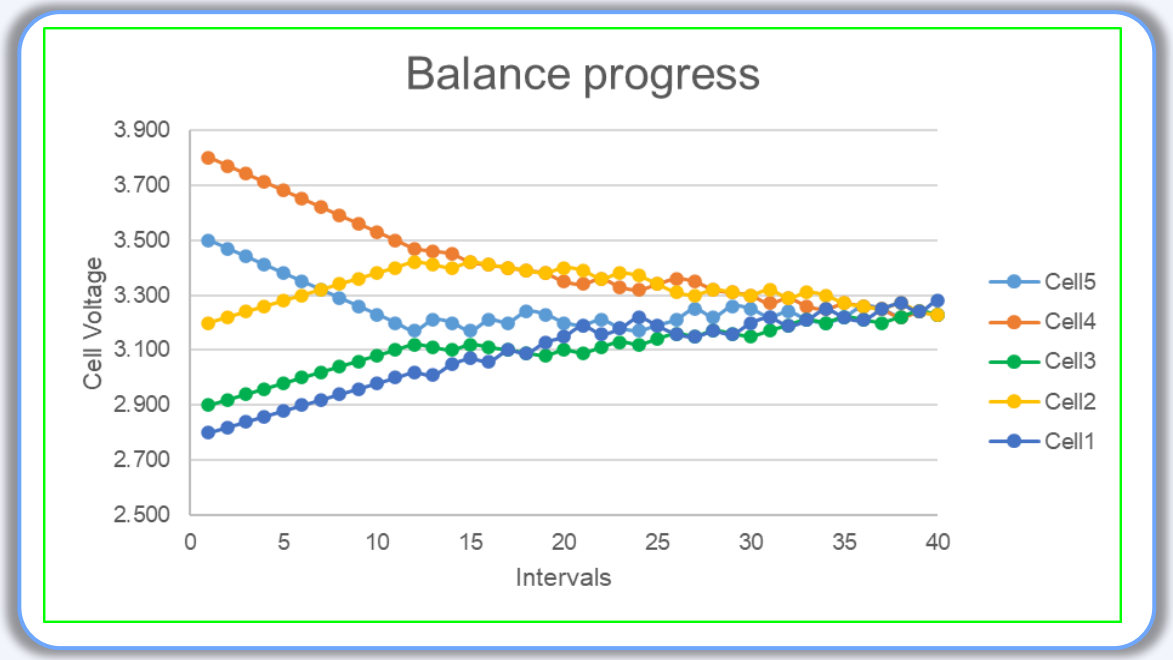
Topology overview



QH and QL are switching FETs, they build up a bridge, it can buck or boost.

S1-S4 are fully on/off switches, they tie the inductor to the middle of battery cells.

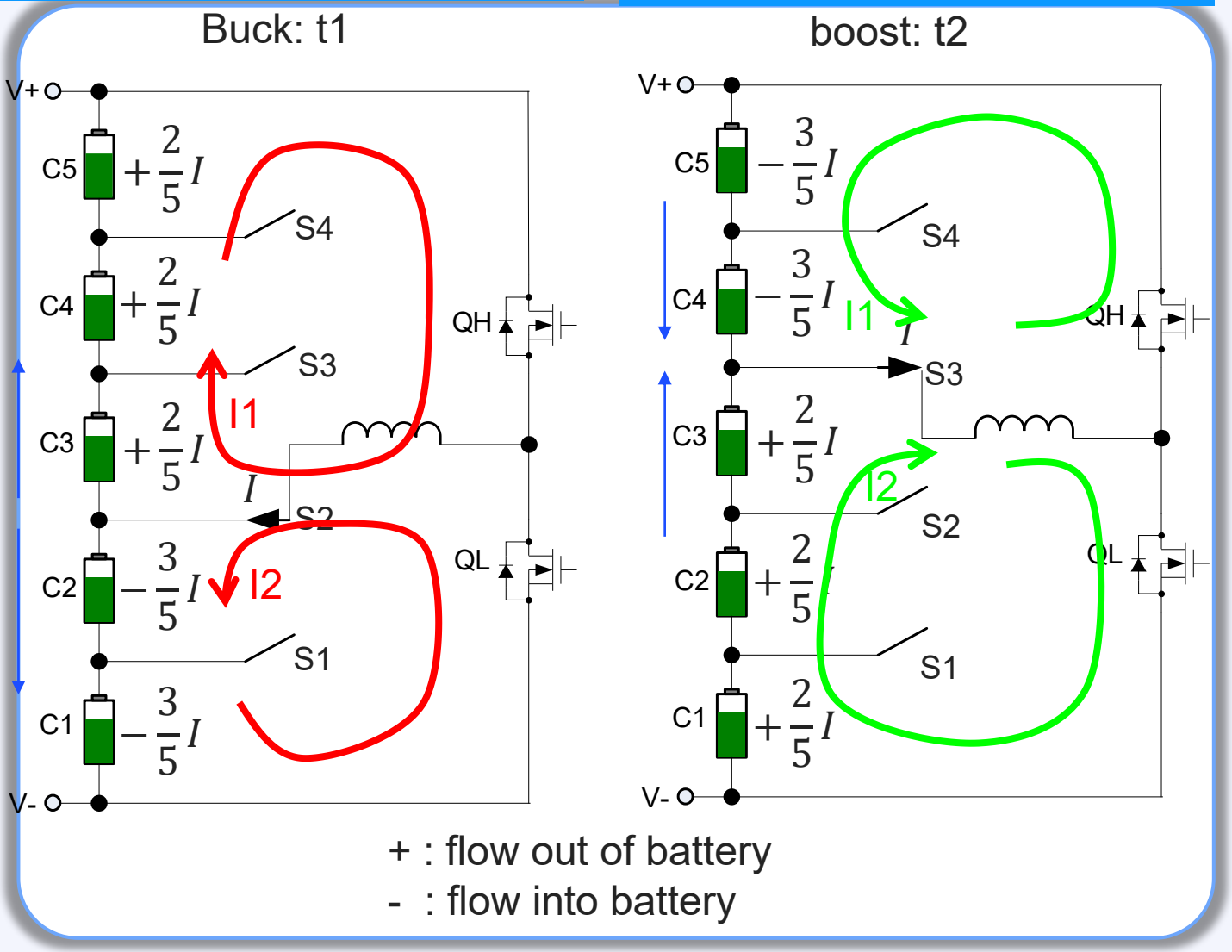
Inductor current is regulated, so as the balance current.



Example: discharge C3

P=(V3+V4+V5)*I1=(V1+V2)*I2

P=(V4+V5)*I1=(V1+V2+V3)*I2



If we find C3 is the highest cell, we turn on:

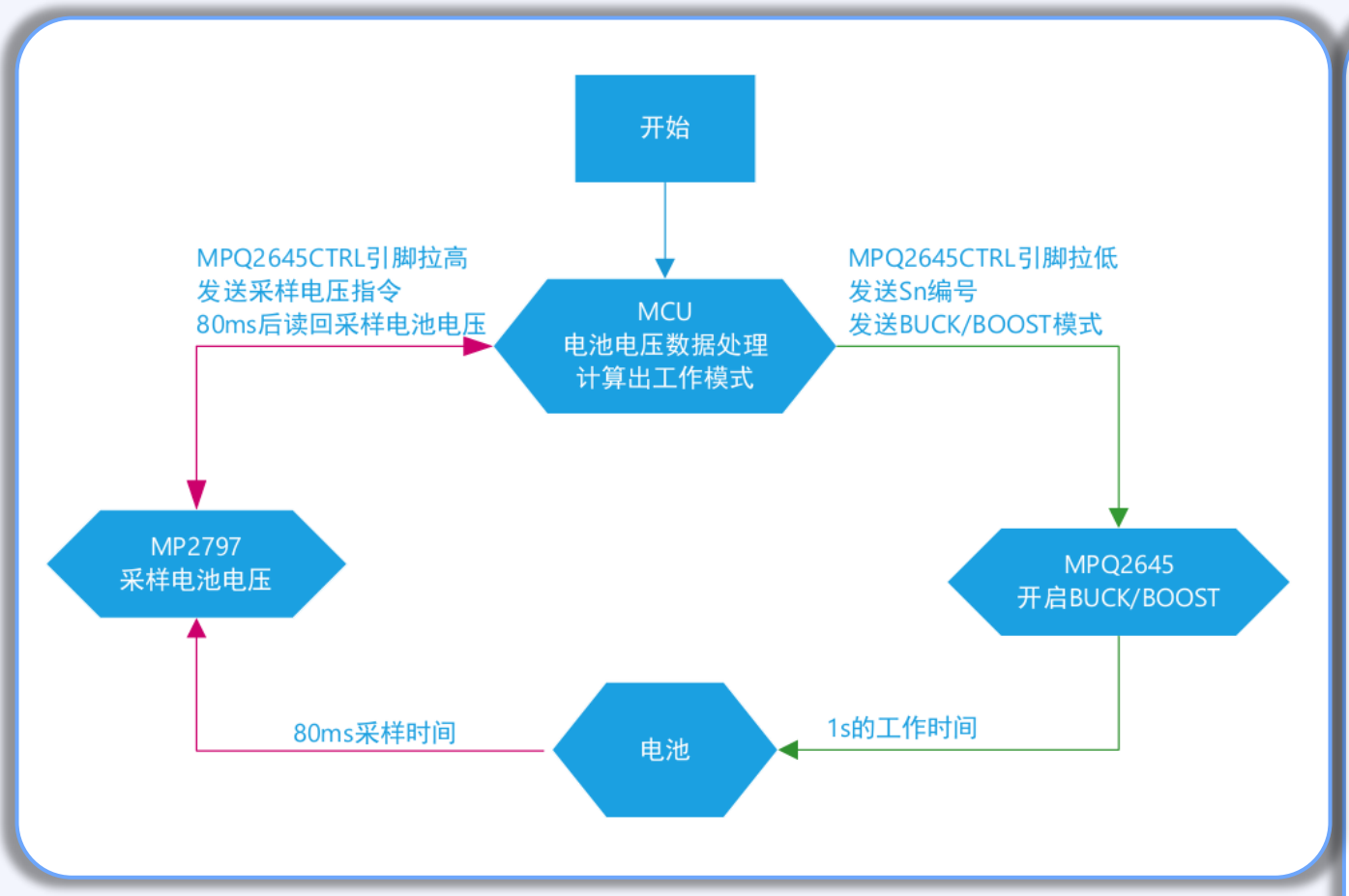
- buck+S2 for t1
- Boost+S3 for t2

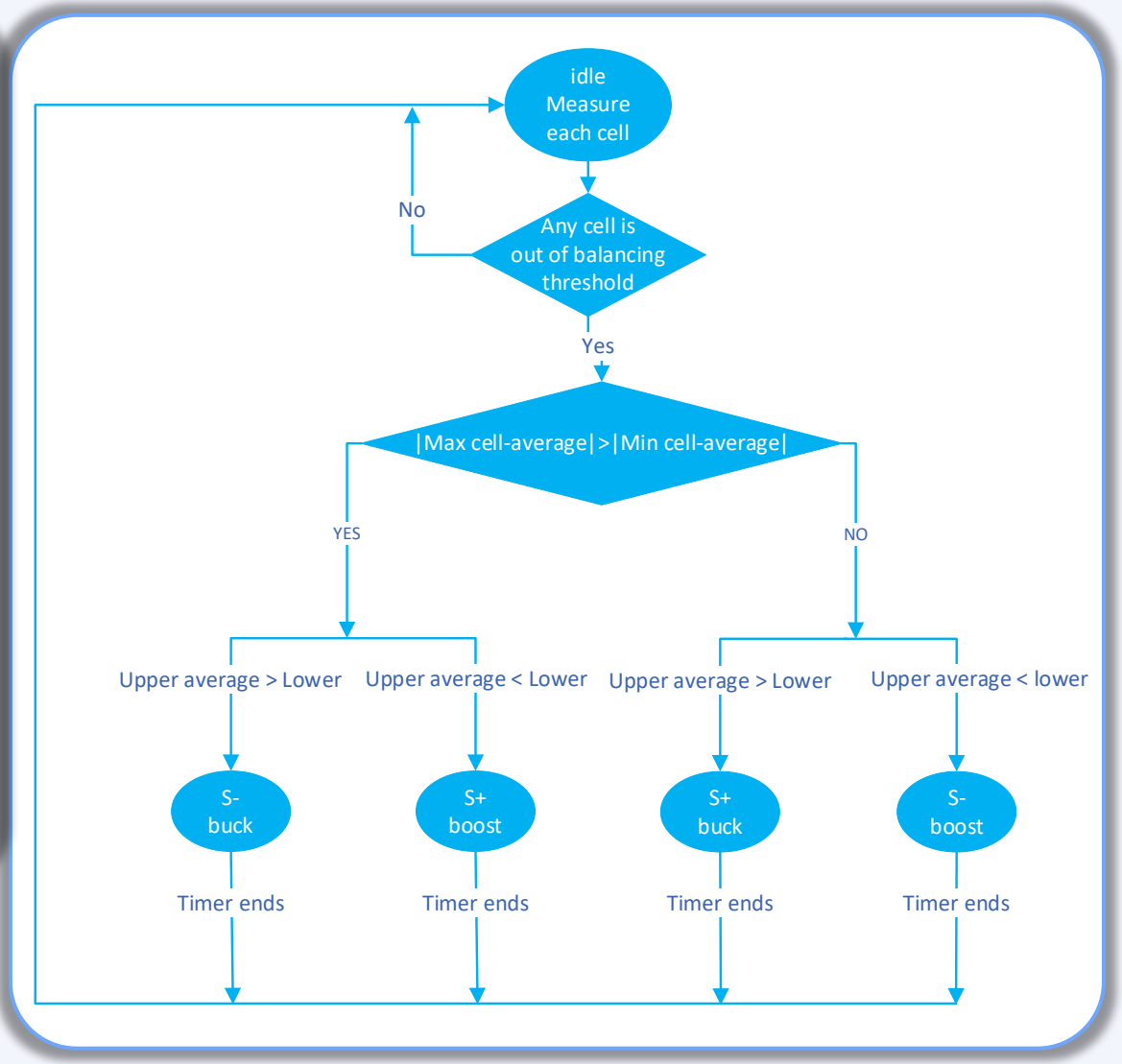
We can observe that for both t1 and t2, C3 is discharged.

C4/C5 is charged or discharged?

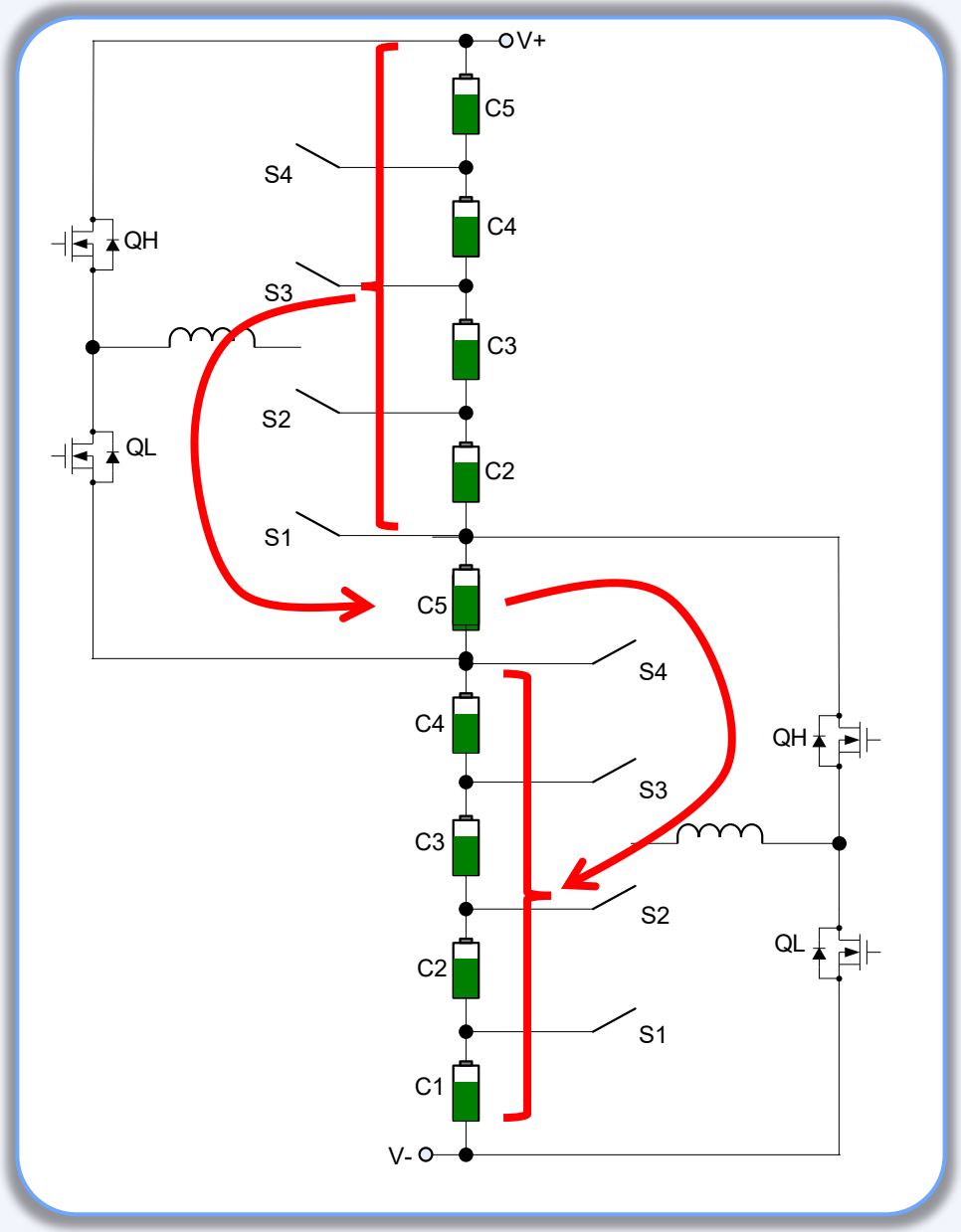
- It is purely depending on t1:t2.
- We know every cell's charge, so MCU can decide where the C3's energy goes.
- Eg. If C4/C5 average charge is higher than C1/C2, we deliver more energy to C1/C2.

Balance algorism





Stack operation



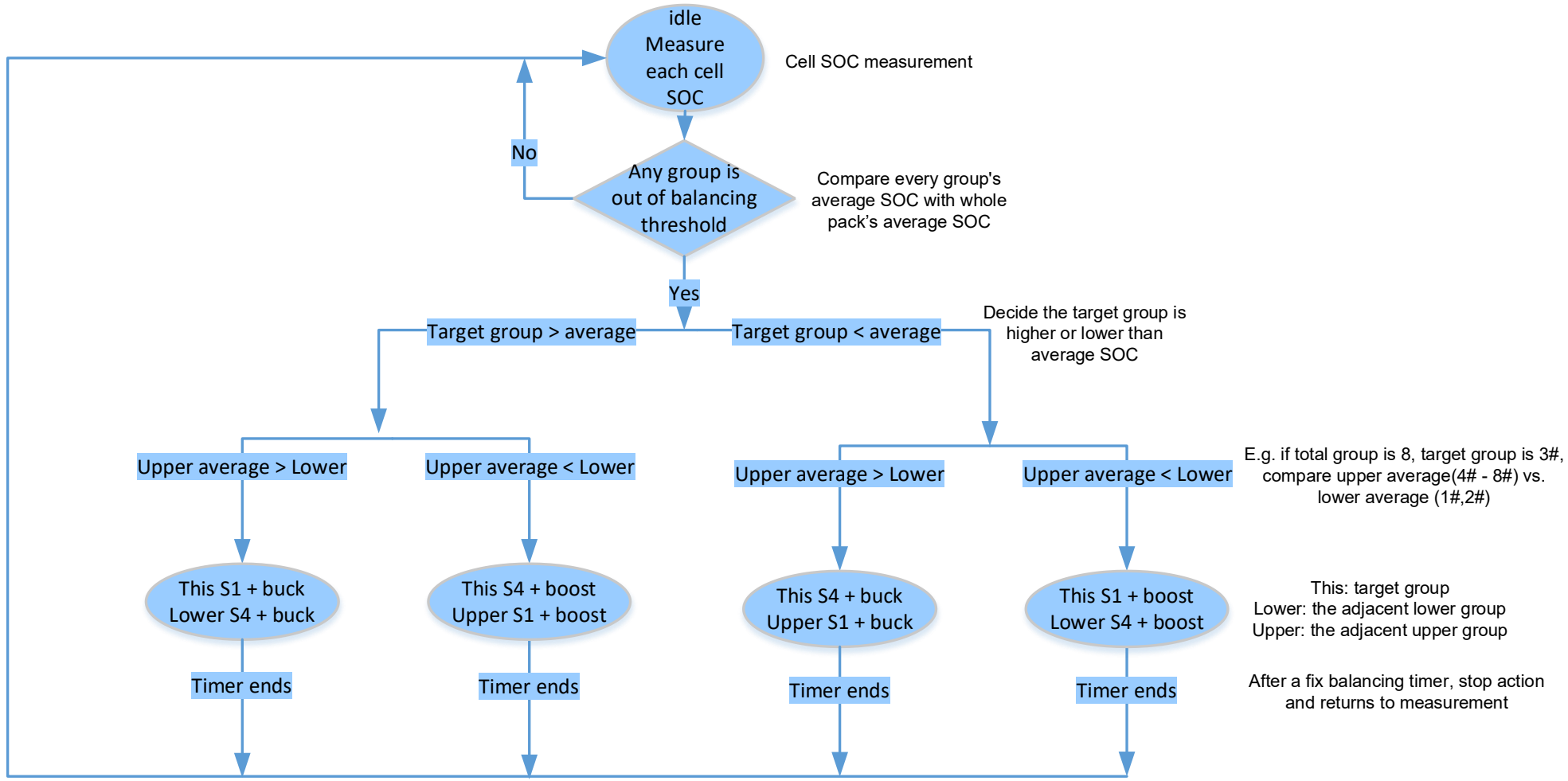
If upper 5 cell's average charge is higher than lower 5 cell's average charge:

- Upper: turn on buck+S1
- Lower: turn on buck+S4

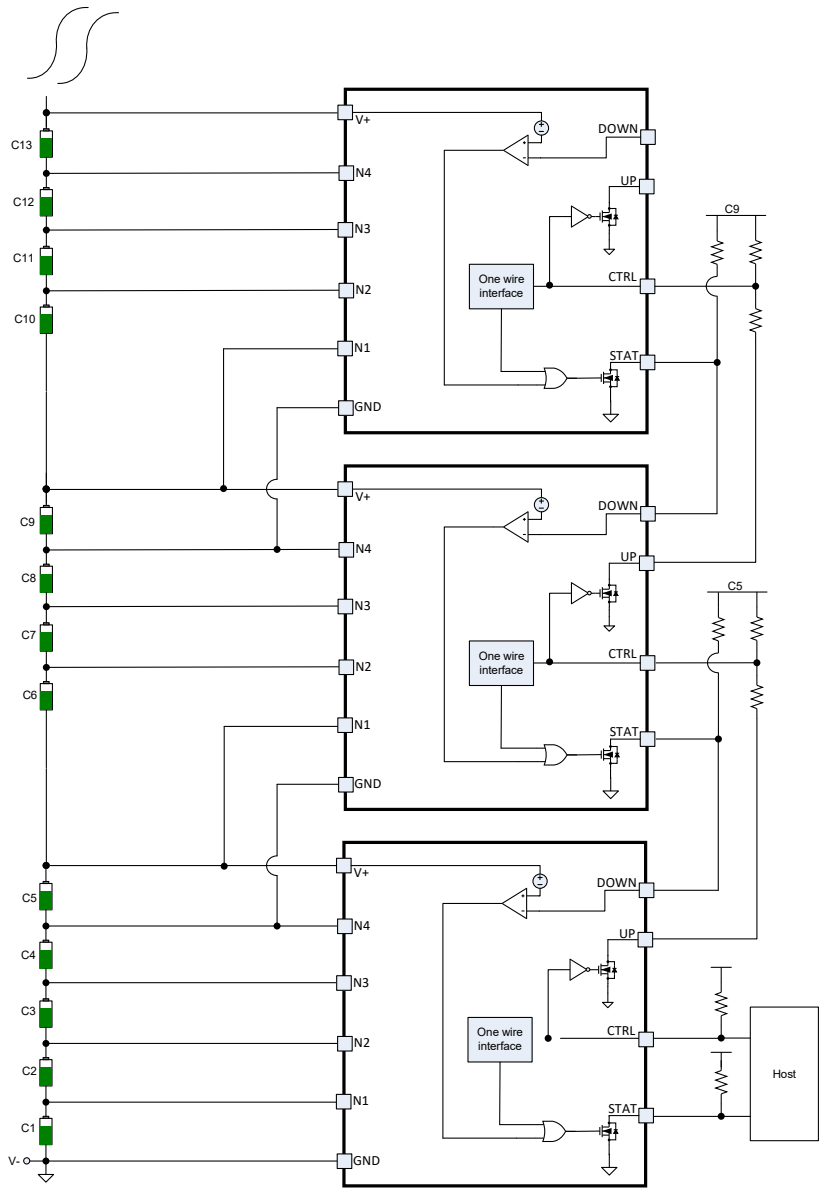
If upper 5 cell's average is lower than lower's

- Upper: turn on boost+S1
- Lower: turn on boost+S4

Balance algorism – between group



Two-wire pass-through communication



CTRL: command input

STAT: status report

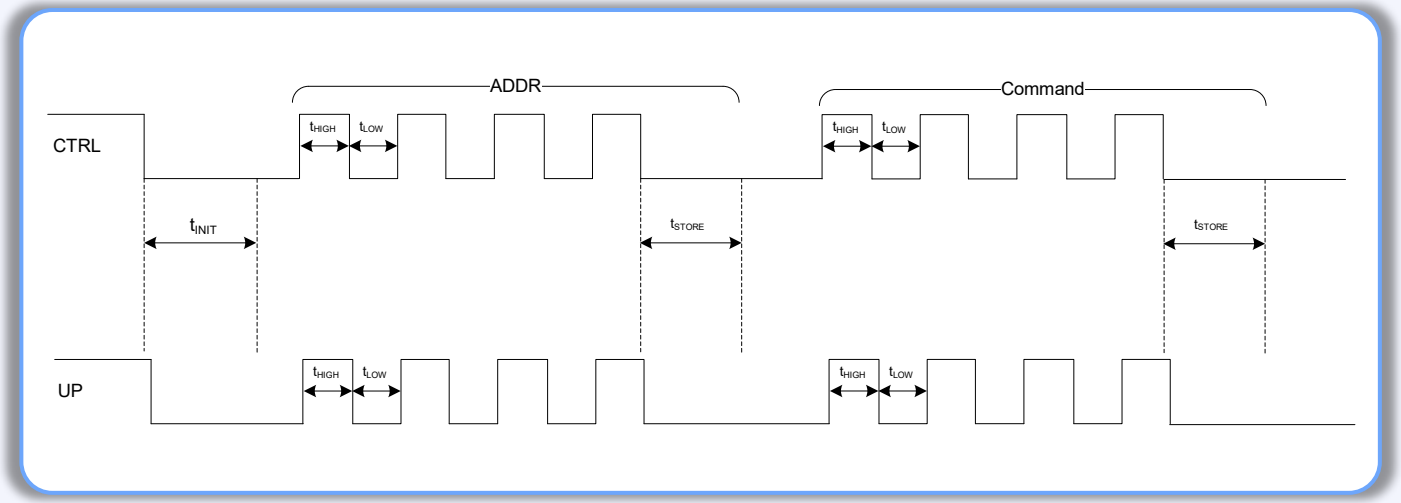
UP: command passing to upper device

DOWN: status passing to lower device

8 addresses support up to 8 stacked devices (33 cells)

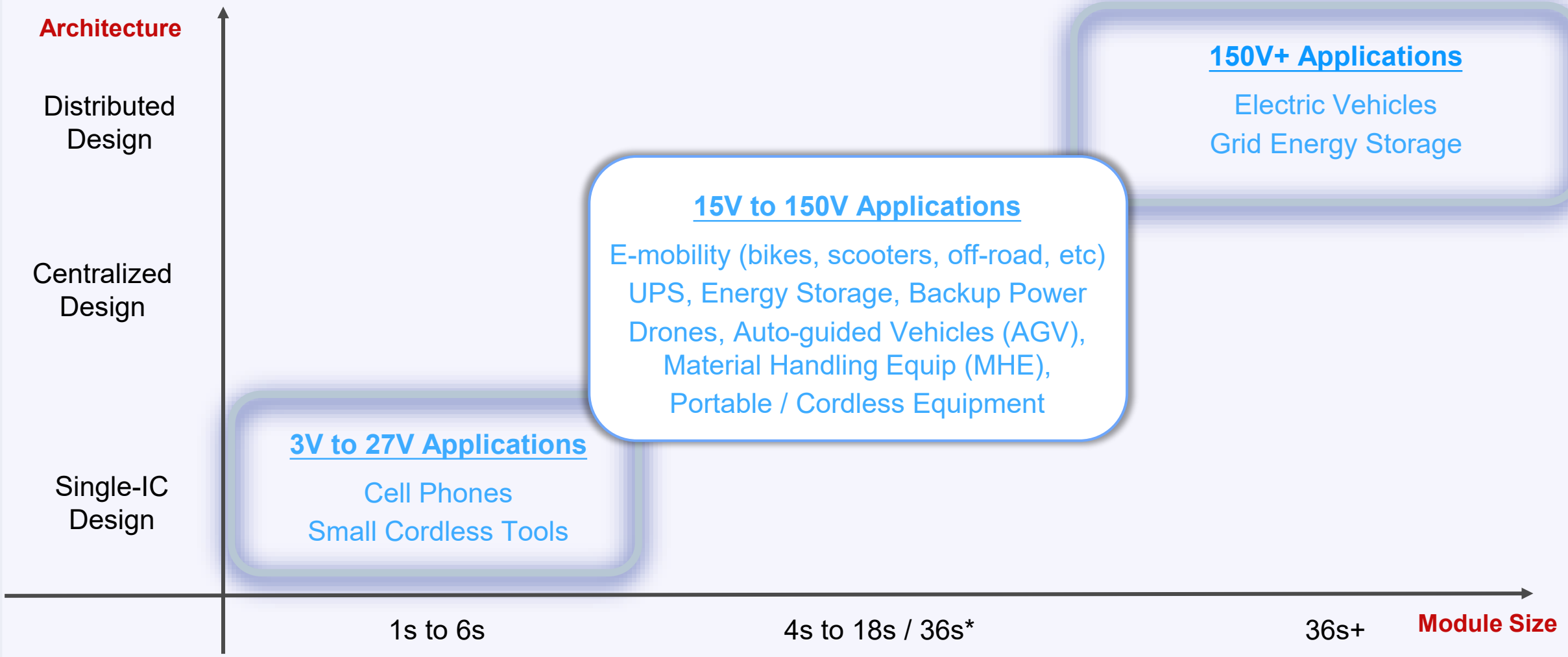
2 IOs from MCU controls up to 33 cells.

MPS patented communication structure



MPS BMS Intro & Roadmap

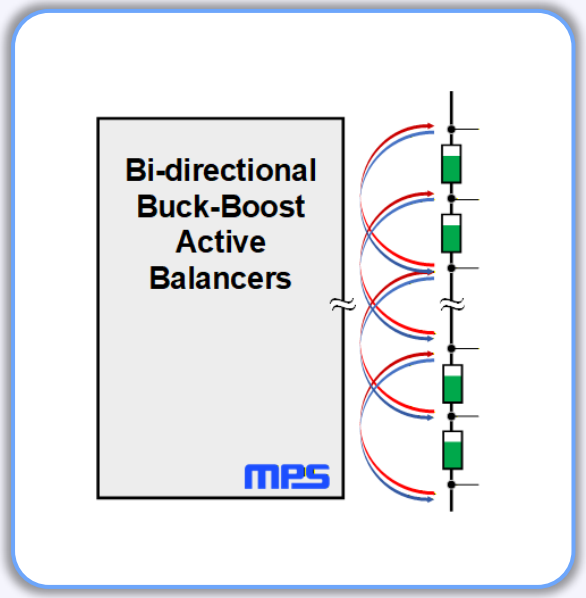
Target Applications



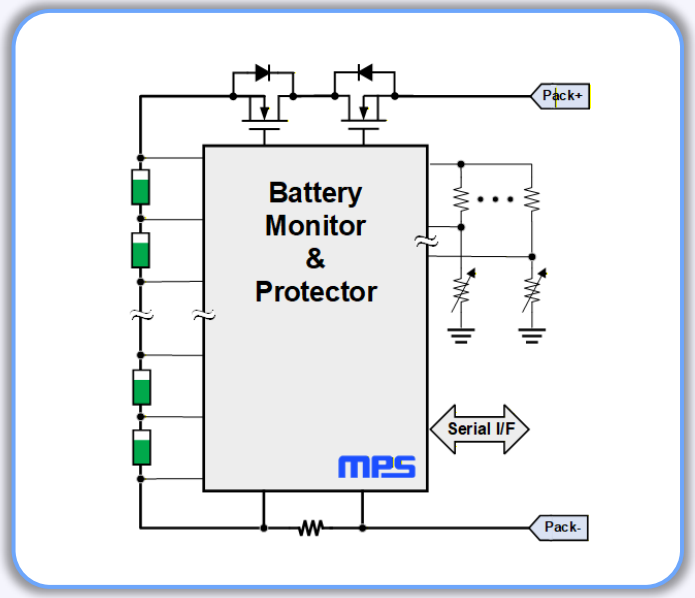
* > 18s supported by using 2x stacked MPS Battery Monitors

Battery Management ICs

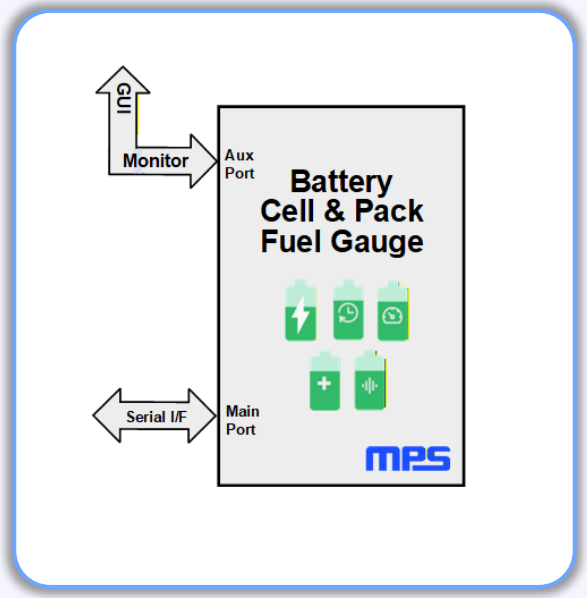
High Current Active Balancers



Battery Monitor & Protectors



Cell & Pack Fuel Gauges



Battery Management ICs

Battery Monitor & Protector

MP2797 FAMILY 7s to 16s

HS FET Drivers
Current Sense
Coulomb Counter
Soft-start

MP3716 FAMILY 3s to 18s

High Accuracy, Adv Soft-start, Energy Storage Option, Stand-Alone Option, Low Voltage w/ Fuel Gauge Option

MP37xx FAMILY 4s to 24s

High & Std Accuracy
Fuse Control
Adv Soft-start
Low-side Option
Stand-Alone Option

Fuel Gauge

MPF4279x FAMILY 2s to 16s

Standard Fuel Gauge
Li-Ion / Li-Po / LFP
Cell Impedance, Thermal

MPF427xx 2s to 18s

Controller Fuel Gauge
Direct MP279x/371x Ctrl
LFP, LiPo, Li-Ion Support

MPF427xx 2s to 24s

Direct I/F MP3717/8
LiFePO4, LiPo, Li-Ion
Complete Feature Set

MPF427xx Up to 112s

Standard Fuel Gauge
Li-Ion / Li-Po / LFP
Complete Feature Set

Active Balancer

MP2640/1 2s

Bi-directional Buck-Boost
Supports all Pack Sizes

MP2642/3 2s

Optimized 1A / 2A Net Xfr
Supports all Pack Sizes

MP2645 2s to 5s

Daisy-chain for HV String
Ultra Low Cost, Industrial

MPQ264x 2s to 5s

AEC-Q100 Version for Automotive

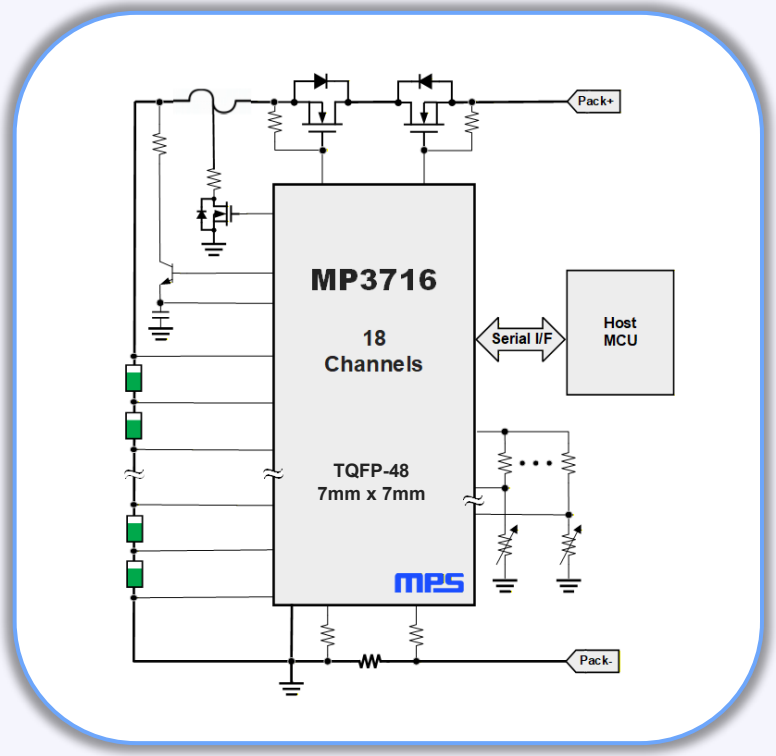
Timeline

MP3712/3/4/6: 3 to 18-Cell Battery Monitor & Protectors

In Production

Overview

- Voltage Measurements for 3 to 8/10/16 Cells (0 to 5V Range)
  - A-grade: ±3mV (25°C) / ±4mV (-20 to 65°C) / ±5mV (-40 to 105°C)
  - B-grade: ±5mV (25°C) / ±7.5mV (-20 to 65°C) / ±12.5mV (-40 to 105°C)
- Current Measurements
  - Synchronized Current Snapshot w/ Each Cell Voltage
  - Accuracy: ±0.6% (-40° to 85°C, 100mV Sense Range)
  - Includes Coulomb Counting Function
- Integrated, Independently Controlled High Side N-FET drivers
  - Power-control Soft-start (Protects FET during Start-up, Eliminates Pre-charge)
- Supports Charging with <1V/cell
- Internal Passive Balancing up to 58mA per Cell
  - Supports External FET or NPN for Higher Current
- Integrated LDO for Regulated 3.3V Output
- Shutdown Current <2.5uA
- Temp Monitors: 4 Dedicated NTC Inputs + IC Die + 3 GPIO
- 3 GPIO (Configurable as NTC Inputs) + 1 GPIO HV (or Fuse)
- Configurable Fuse control for Secondary fault protection
- I2C or SPI communication with CRC
- MTP Memory to program project dependent critical parameters



Safety Features

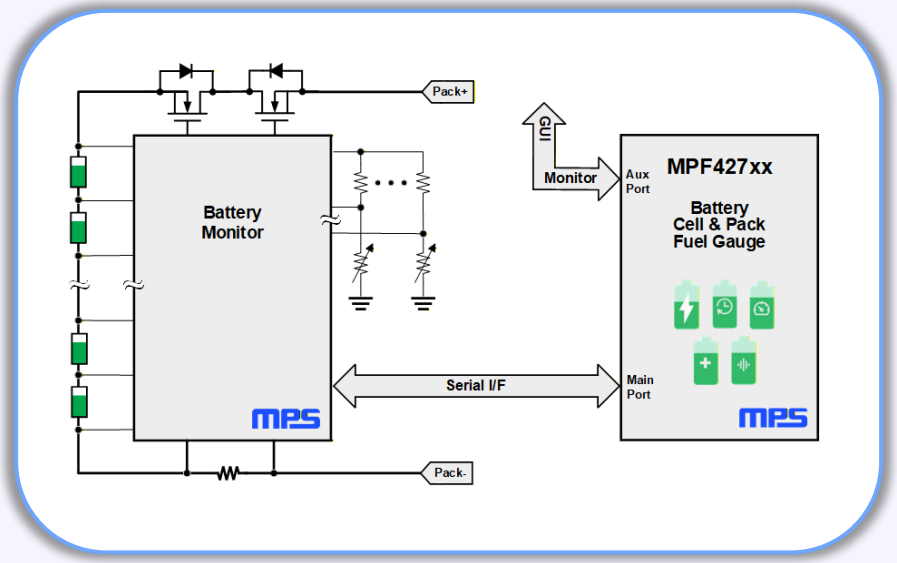
- Cell-level Faults: OV, UV, Dead Cell, Imbalance, Open-wire
- Pack-level Faults: OV, UV, Over-current, Short-circuit
- Fuse Driver for Severe Under-voltage & Over-voltage Conditions
- DSG / CHG FET Controlled Separately Under Fault Conditions
- Communication Watchdog Timer
- ADC Self-test
- Random Cell Connection Tolerant

MPF427xx: Battery Cell & Pack Fuel Gauges

In Production

Overview

- Provides Fuel Gauge Estimates for MPS Battery Monitors
  - MPF42790: Directly Interfaces to MP279x Family (3s to 16s)
  - MPF42781: Directly Interfaces to MP371x Family (3s to 18s)
  - Supports NMC/NCA (±2% Accuracy) and LFP (±5% Accuracy)
- Provides Critical Battery Information
  - Pack and Cell State-of-Charge (SoC)
  - Pack and Cell State-of-Health (SoH)
  - Remaining Run Time and Charge Time
  - Instantaneous Available Power
  - Real-time Cell Resistance
- Adaptive Learning
  - Refines Initial Charge Settings
  - Refines Initial Discharge Settings
  - Updates Cell SoH to Track Degradation
  - Updates Cell ESR to Track Degradation
- Direct MPS Active Balance Control using SOC, Energy, or Voltage
- Lifetime Logging of Key Parameters
- 2.5V Minimum Supply Volage
- 6µA Shutdown Current
- Dual I2C Communication Interfaces (up to 400kHz)



2 Architectures Available

- Controller Fuel Gauge
  - Streamlined Solution - Local MCU Not Required
  - Specifically Designed for MPS Battery Monitors
  - Configures, Controls and Accesses Battery Monitor Measurements
  - Provides a Single System-level Interface
- Standard Fuel Gauge
  - Local MCU Interfaces to Battery Monitor, Fuel Gauge & System
  - Agnostic Design - Supports Any Battery Monitor

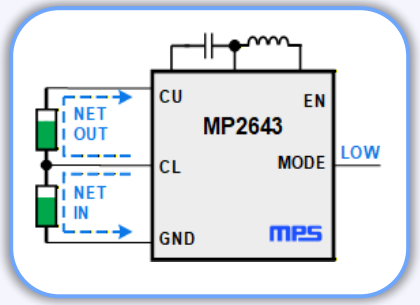
MP2643: 2-Cell Buck-boost Active Balancer

In Production

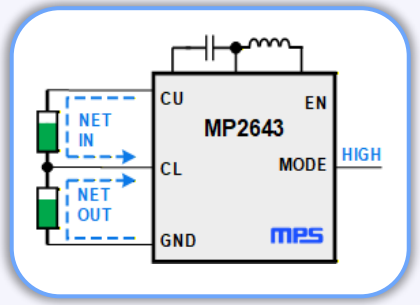
Overview

- Integrated High Current FETs
- Cell Voltage Range: 2.4V to 4.35V
- Programmable Cell-to-cell Balancing Current
  - MP2642: 1 Amp Max Net Transfer
  - MP2643: 2 Amp Max Net Transfer
- Integrated Protection Features
  - Thermal Shutdown
  - Battery Reverse Leakage Blocking
  - Low Voltage Protection in Boost-Balance Mode
- Directly Powered from the Battery Cells
- Interleavable for Transfer Across Many Cells
- >92.8% Charge Transfer Efficiency @3.3V
- QFN-26 (4mmx4mm) Package

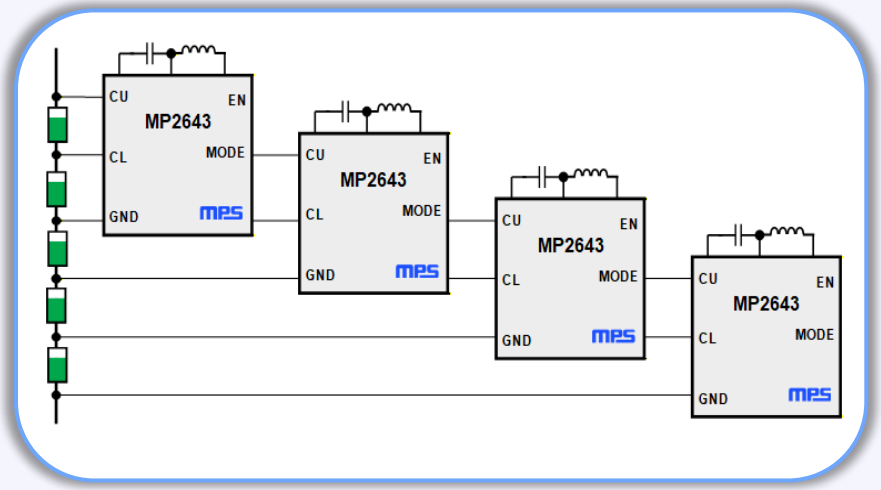
Buck Operation



Boost Operation



Interleaving for any Size Stack



Advantages of Active Balancing

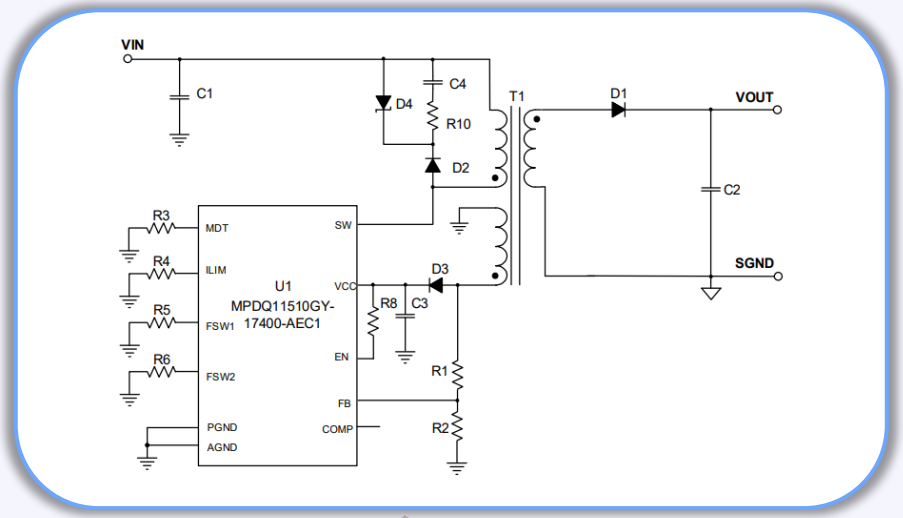
- Faster Balancing (Enables Short Cycle Operation)
- Lower Cost Thermal Design (Reduced Thermal Load)
- Improved Energy Efficiency (Redistributes vs Dissipates)
- Increased System Runtime when used During Discharge)

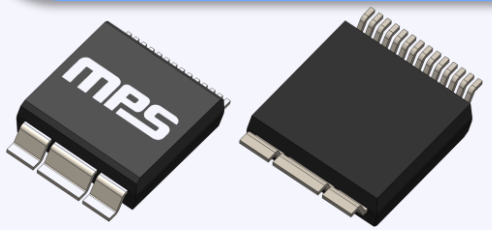
MPDQ11510-AEC1: 1200V Flyback w/ Integrated SiC

Key Features

- 20V-1200V Wide Input Range
- Built-in HV startup (5mA startup circuit)
- Integrated 1700V/400mohm SiC Device
- Quasi-resonant with Low EMI
- Support PSR and SSR Feedback
- Low Shutdown Leakage with SiC Clamp
- Programmable Peak Current Limit
- Up to 140kHz Programmable Frequency
  - 50Hz/2.5kHz Minimum Frequency Options
- EMI Reduction with Frequency Dithering
- Operating Temp Range: -40°C to 150°C
  - 120℃ Junction Temperature Warn Signal
  - 170℃ Over-Temperature Protection
- SOIC-28 WB (7.5mm creepage)
- AEC-Q100 Grade

Application Circuit





7.5mm creepage

Applications

- EV Traction Inverter
- Aux Backup Power Supply

Thank you!