

Battery Management System (BMS)

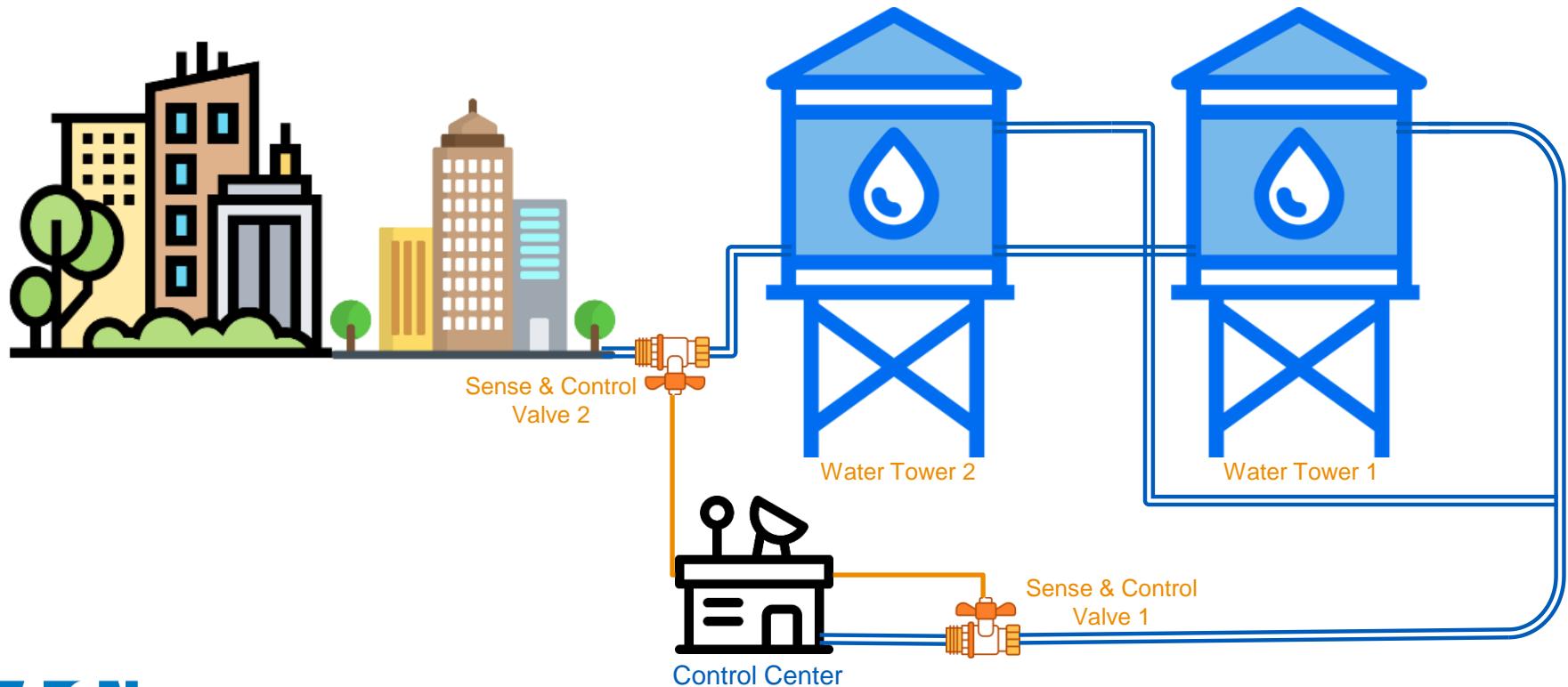
Mohammad Mohiuddin - FAE

May 2nd, 2022

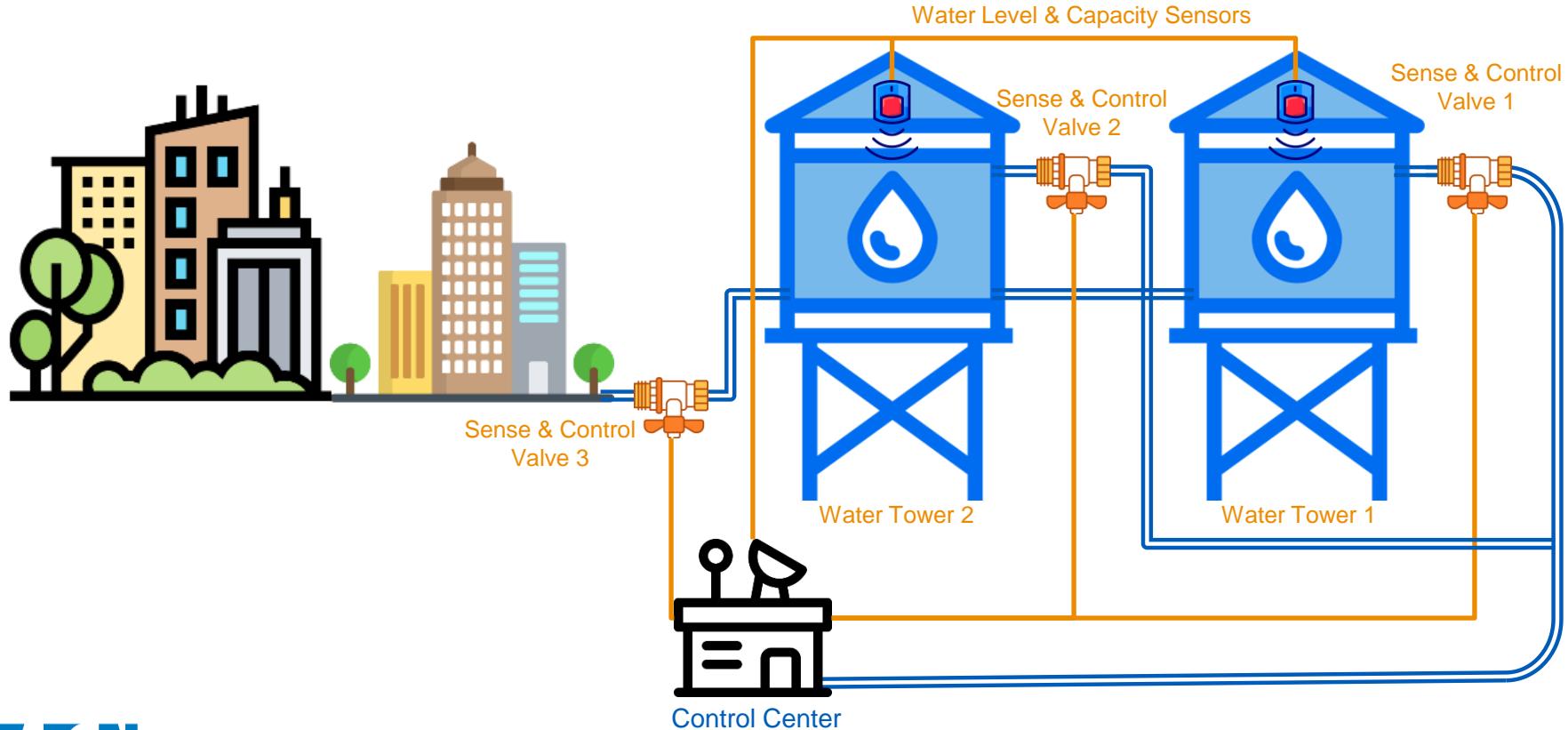
Agenda

- What is BMS
- Why use BMS
- Building Blocks of BMS
- Battery States
- BMS Monitoring
- BMS Topologies
- Eaton Resources

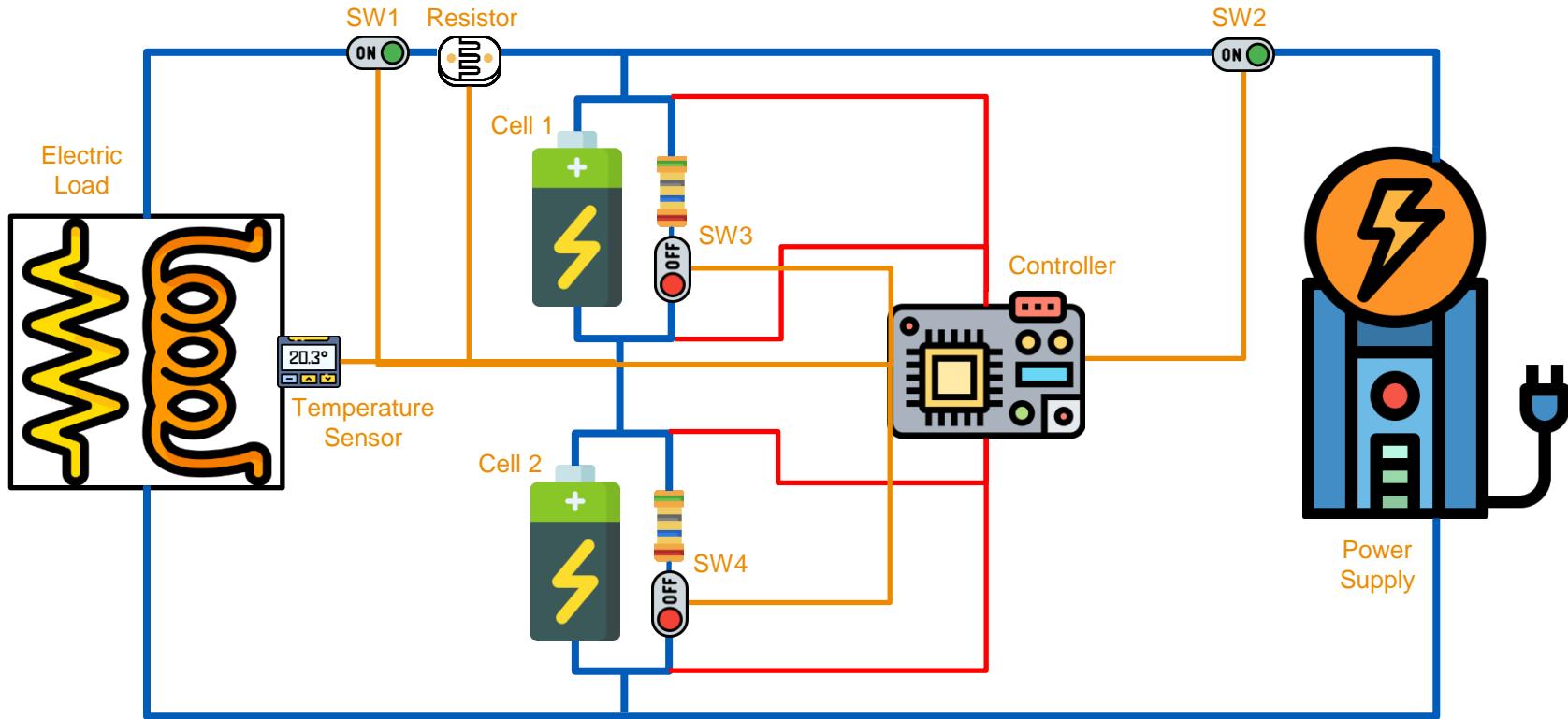
Waterflow & Control Analogues to BMS



Waterflow & Control Analogues to BMS



What is BMS

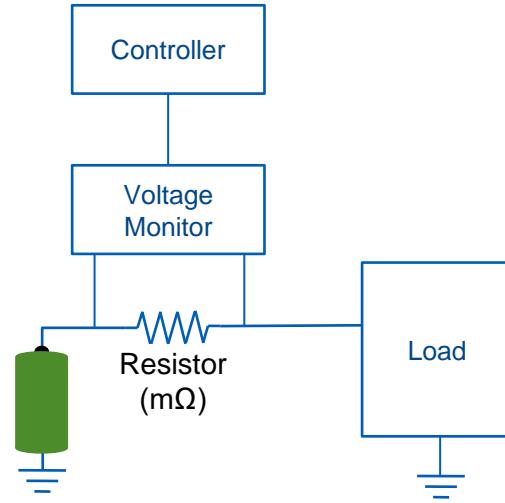


What is BMS Cont'd

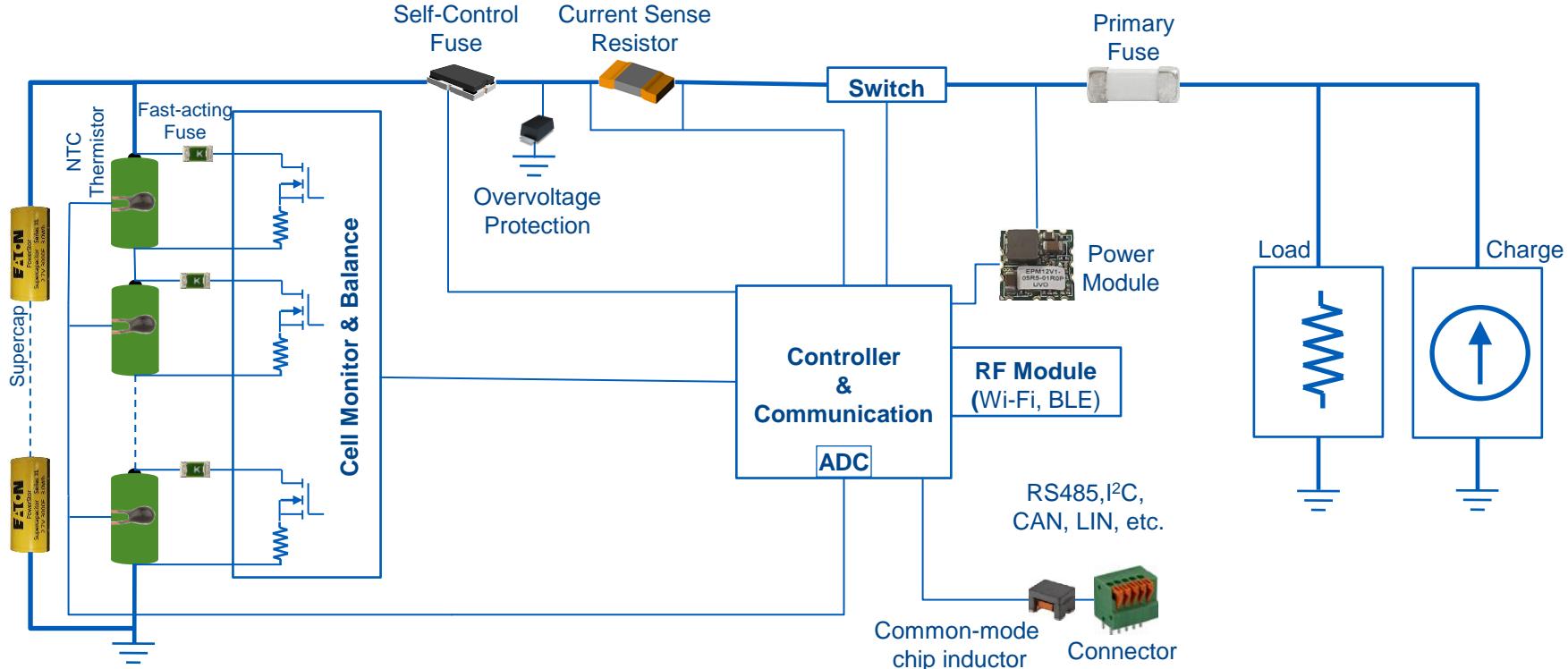
- Monitors individual cells and reacts.
 - Balances voltage and regulates the current flow.
- Monitors system voltage, current, temperature (other environmental conditions) and reacts
 - If thermal runaway is detected, positive-disconnect the battery from load and source.
 - If upper or lower voltage, current, or temperature limit is exceeded, temporarily disconnects the load or source.
- Estimates State of Health (SoH), State of charge (SoC), State of Energy (SoE), and State of Power (SoP)
 - Will explore these topics later.

What is BMS Cont'd – A Primitive BMS

- A precision resistor is placed in series with the load.
- The resistor is sized to handle the load current.
- Any given time, Controller knows the current flow rate
$$I = V_{(\text{across } R)} \div R$$
- *Power consumption of the system is*
$$P = V_{(\text{Battery})} \times I_{(\text{Calculated})}$$
- Disadvantage: Temperature change and drift in component value will sway the result.

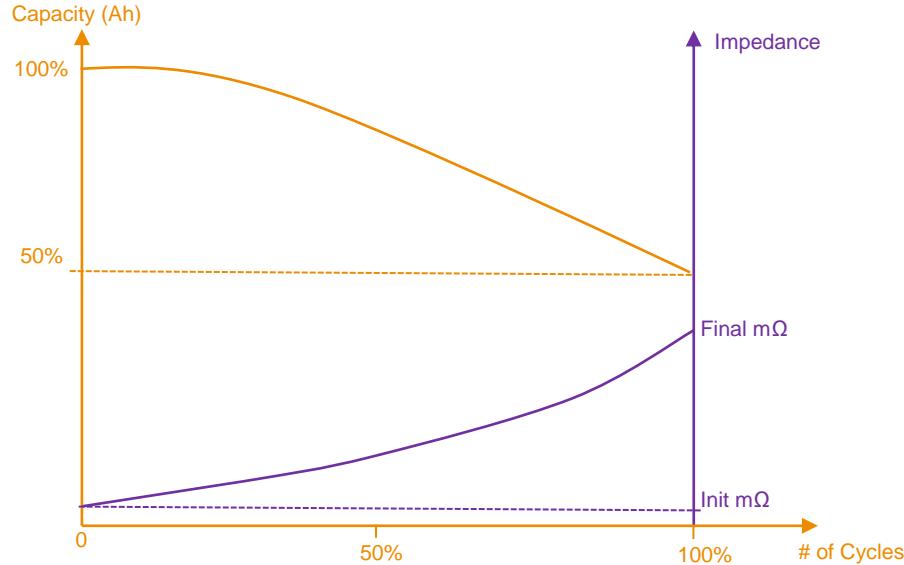


Building Blocks of BMS

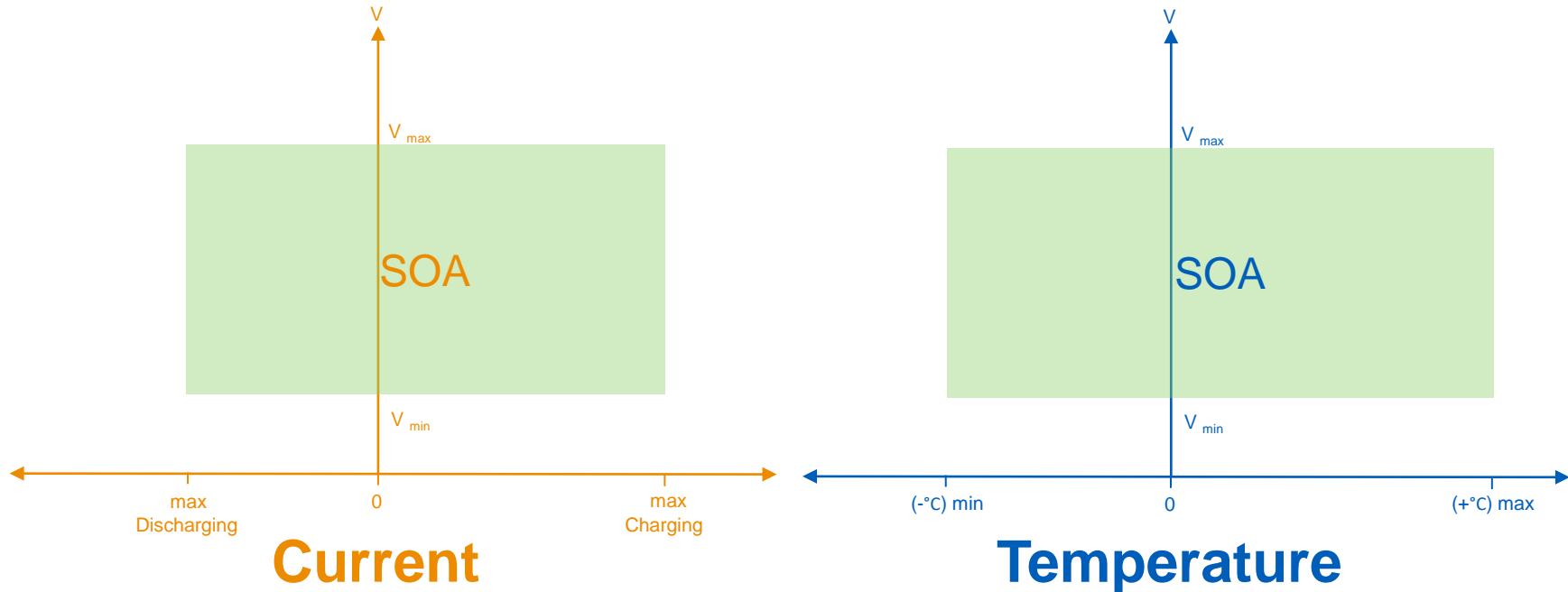


Battery States

- State of Health (SoH)
The capacity (%Ah) of the battery due to aging – number of cycles, temperature changes, and time.
- State of Charge (SoC) is the existing capacity (%Ah) due to use.
 - A method to estimate charge is Coulomb Counting
$$\text{SoC}_{\text{Prsnt}} = \text{SoC}_{\text{Init}} - \text{Capcty}_{\text{Utlzd}}$$
 where $\text{Capcty}_{\text{Utlzd}} = \frac{I \times \Delta t}{\text{Init Ah}} \times 100$
- State of Energy (SoE)
The energy remains in the battery vs the maximum energy a battery can store
$$\Delta E = P \times t$$
 while $P = V \times I$ therefore $\Delta E = V \times I \times \Delta t$
$$E_{\text{Present}} = E_{\text{Max}} - \Delta E$$
 OR $\text{SoE} = \frac{\Delta E}{E_{\text{max}}} \times 100$
- State of Power (SoP)
$$P = V \times I$$
 where V is present voltage, and I is the current stated in the datasheet OR $\text{SoP} = \frac{P_{\text{max now}}}{P_{\text{nominal}}} \times 100$
- A cycle of a battery is one full charge (max V) and full discharge (min V).
- As number of cycles increase, the capacity decreases, and the internal impedance of the battery (ESR, equivalent series resistance) increases.



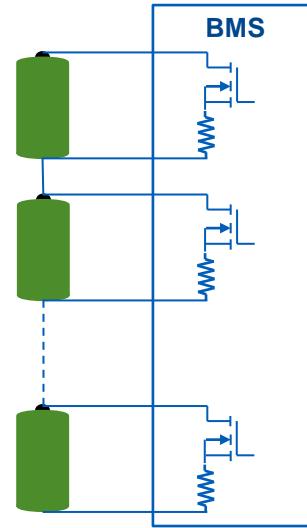
BMS Monitoring



SOA = Safe Operating Area

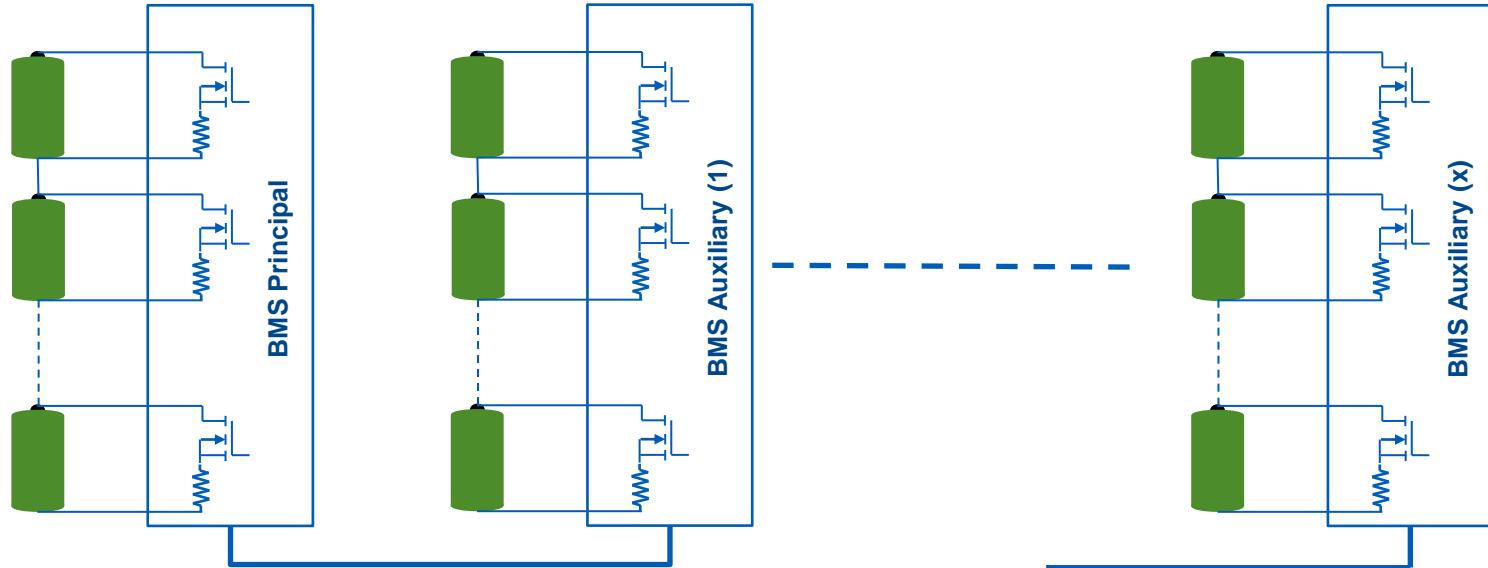
BMS Topologies – Single BMS

- Limited number of batteries
- Controls all batteries directly
- Balances and controls each battery and optimize performance
- When number of cells are matched with available ports of the design
- Suitable for power tools, small UPS, laptops.



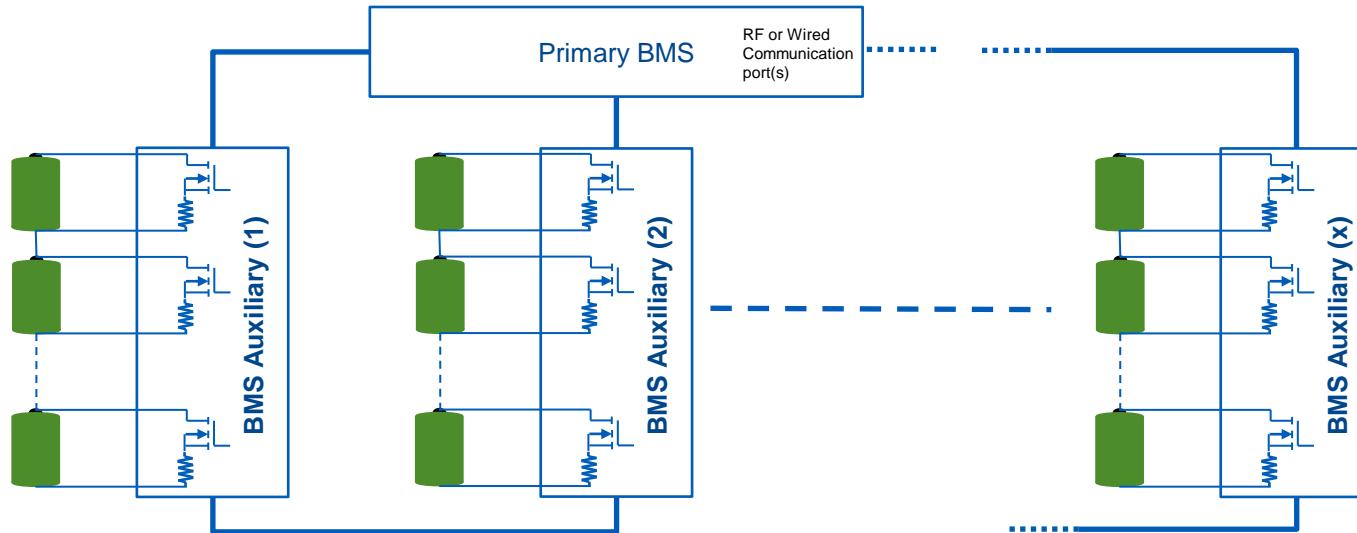
BMS Topologies – Multiple BMS

- More than one BMS.
- Each BMS controls multiple batteries – suitable for larger number of batteries.
- Each BMS communicates its status to principal BMS.
- Principal relays the information to the central computer.
- Suitable for large UPS, e-bike, portable power station



BMS Topologies – Multiple BMS with Dedicated Principal

- Multiple BMS with one dedicated BMS
- Each BMS controls multiple batteries
- All BMS communicate to Principal which in turn relays the information to Central Computer
- Suitable for EV, solar energy backup, data center



Application Notes

Fuse Technology

PPTC Application Note

Selecting Fuseholders

Selecting Terminal Blocks

Tools & Resources



[Parametric Search](#)

Drill down into the Eaton Electronics product database to find the right part for your application



[IC Matching](#)

Find the Eaton Electronics parts called out on IC manufacturers' demo and evaluation boards.



[Cross Reference](#)

Find a cross to a competitor's product or to an alternate Eaton Electronics part number.



[Supercapacitor Calculator](#)

Determine your calculated requirements and design capability.



[Terminal Block Selector](#)

Find the right terminal block for any application.



[Automotive Electronics Solutions](#)

Find electronics components for automotive solutions.

www.eaton.com/electronics

ELXTechSupport@Eaton.com



Powering Business Worldwide

Eaton NTC Products

NRGB



Features:

- Operating temperature: -40~300°C
- Single ended, glass sealed construction
- Highly heat resistant with high sensitivity
- Mainly used in above 200°C applications

NDBG



Features:

- Operating temperature: -40~250°C
- Glass sealed construction
- Axial leaded, "diode" footprint
- Mainly used in 100~200°C applications

NRBE



Features:

- Operating temperature: -40~125°C
- Epoxy coated/resin sealed construction
- Broad application range
- Mainly used in below 100°C applications

NRLx



Features:

- Working temperature: -40~125°C
- Single ended, epoxy coated construction
- Insulated wire offered in 3 gages
- Mainly used in below 100°C applications

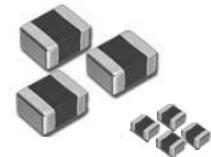
NRMx



Features:

- Working temperature: -40~125°C
- Single ended, epoxy coated construction
- Enameled wire insulation with color option
- Mainly used in below 100°C applications

NTxx



Features:

- Working temperature: -40~125°C
- 0402, 0603, 0805 sizes
- Mainly used in below 100°C applications

Self-control Fuse

Product Description

Triggerable fuse that provides overcurrent and overcharge (overvoltage) protection

Features & Benefits

- Three terminal surface mount circuit protection device in compact and low height footprint
- 12 to 45 amp nominal current ratings
- Different variations and footprints to match with multiple cells in battery packs

Applications

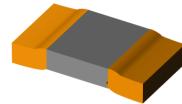
- Industrial & Consumer: Power Tools, Cordless Tools, Vacuum Cleaners
- Computing & Consumer: Notebooks, Smart phones, Tablets, PCs
- Energy: High power battery systems,
- Transportation: e-bikes, battery powered AGVs

Current Sense Resistor Technologies



Technology Comparison

Characteristics	Film	Metal Foil	Metal Plate	Shunt
Resistor Range (mΩ)	$10 < R \leq 910$	$1 \leq R \leq 40$	$0.5 \leq R \leq 20$	$0.1 \leq R \leq 5$
Temperate Coefficient (PPM)	± 100	± 50	± 50	± 50
Power (W)	Low	Mid	High	Highest
Inductance (nH)	Low	Low	Low	Low
Conductor Content	Low	Mid	High	High



Overcurrent Products

Trusted Bussmann name in circuit protection for over 100 years with superior reliability that meets modern safety standards throughout the world

Overcurrent Protection

Ferrule/Cartridge & Axial Leaded Fuses



Fuse Clips & Holders

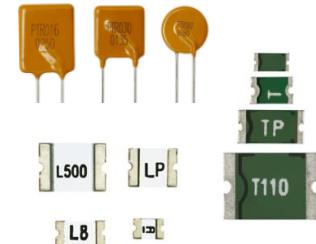
Radial Fuses



Surface Mount Fuses



PPTC Resettable Fuses



Overvoltage Products

Low capacitance ESD protection to protect against fast voltage transients

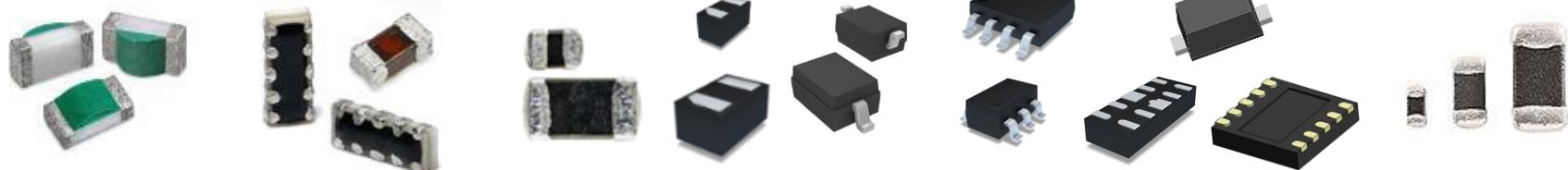
Circuit Protection

ESD Suppressors

Ultra-Low Capacitance PolySurg

TVS Diodes – Discrete & Arrays

Multilayer
Varistors



Terminal Block Products

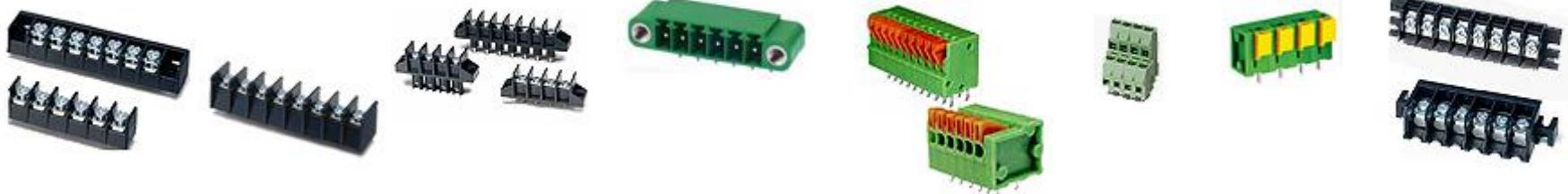
North American & European-style terminal blocks and edge connectors in a wide variety of configurations

Terminal Blocks

Single Row Terminal Blocks
Barrier Strips

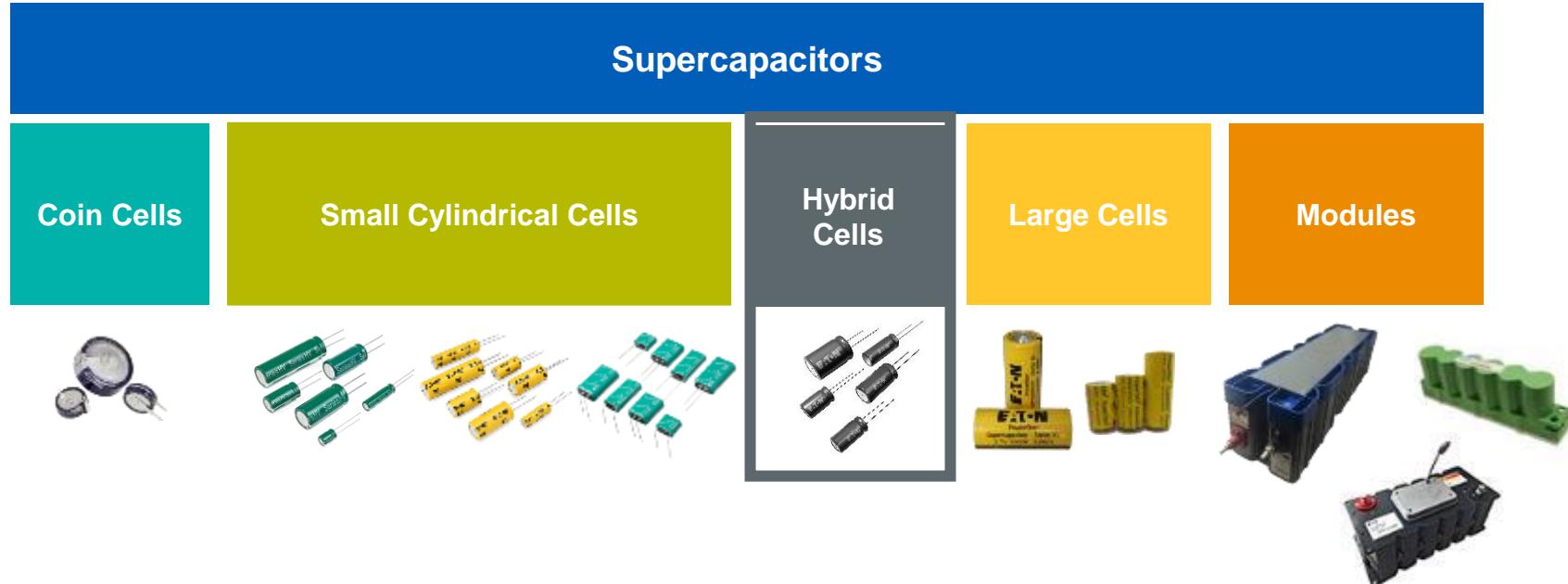
EuroMag Blocks and Plugs
IEC style

Edge
Connector



Supercapacitor Products

Broad product offering – 0.1 F to 3400 F cells – for long life, reliable energy storage with leading power and efficiency



Eaton Magnetics for Power & RF Applications

Trusted brand in power magnetics and filtering products for DC-DC conversion and EMC filtering in high frequency RF circuits.

Magnetics Portfolio

Power Inductors

High Current

Transformers

RF/EMC Filtering

Power Modules

Toroid

Unshielded

Semi-Shielded

Shielded

Pressed

Ferrite

Coupled

Custom

Standard

Common Mode

Chip Bead

DC/DC Converter



Eaton Power Module (EPM)



EPM78Vx
6 SKU

Product Description

Non-Isolated DC-DC Converter, 1A

Features & Benefits

- Switching vs Linear Regulator
- LM78 Compatible 3-SIP Package
- Input voltages: 4.75 V to 32 Vdc
- 6 SKU's representing 6 output voltages
- Efficiency up to 96%
- -40°C to +90 °C Operating Temperature
- Continuous short circuit protection
- Meets EN62368 safety standard



EPM12V1
1 SKU

Product Description

Non-Isolated DC-DC Converter, 1A

Features & Benefits

- Non-isolated DC-DC converter
- 3-14 Vdc input voltage range
- Efficiency up to 89.5%
- Operating temperature from -40 to +82 °C
- Short circuit protection
- Remote ON/OFF function
- Programmable output voltage (0.9-5.5 Vdc)
- EN62368 safety standard



EPM12V2
2 SKU

Product Description

Non-Isolated DC-DC Converter, 12A

Features & Benefits

- Non-isolated DC-DC converter
- 3-14.4 Vdc input voltage range
- Efficiency up to 91%
- Operating temperature -40 to +90 °C
- Short circuit protection
- Remote ON/OFF
- Programmable output voltage (0.6 -5.5 Vdc)
- EN62368 safety standard



Isolated DC-DC Converter

Eaton Isolated EPM series are specially designed in SIP package which are for applications where an isolated voltage conversion is required in a Power and Distributed power supply system.

