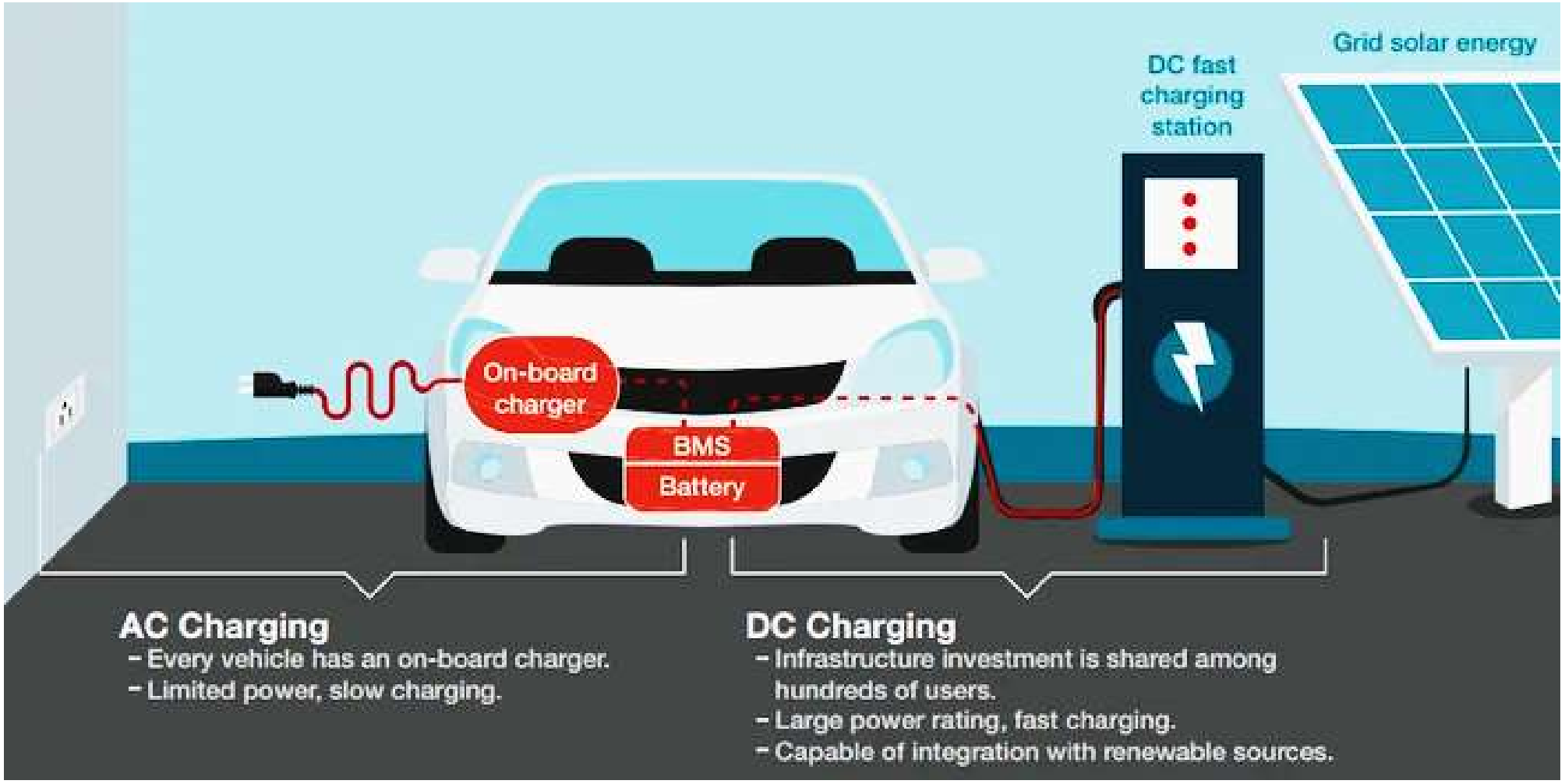
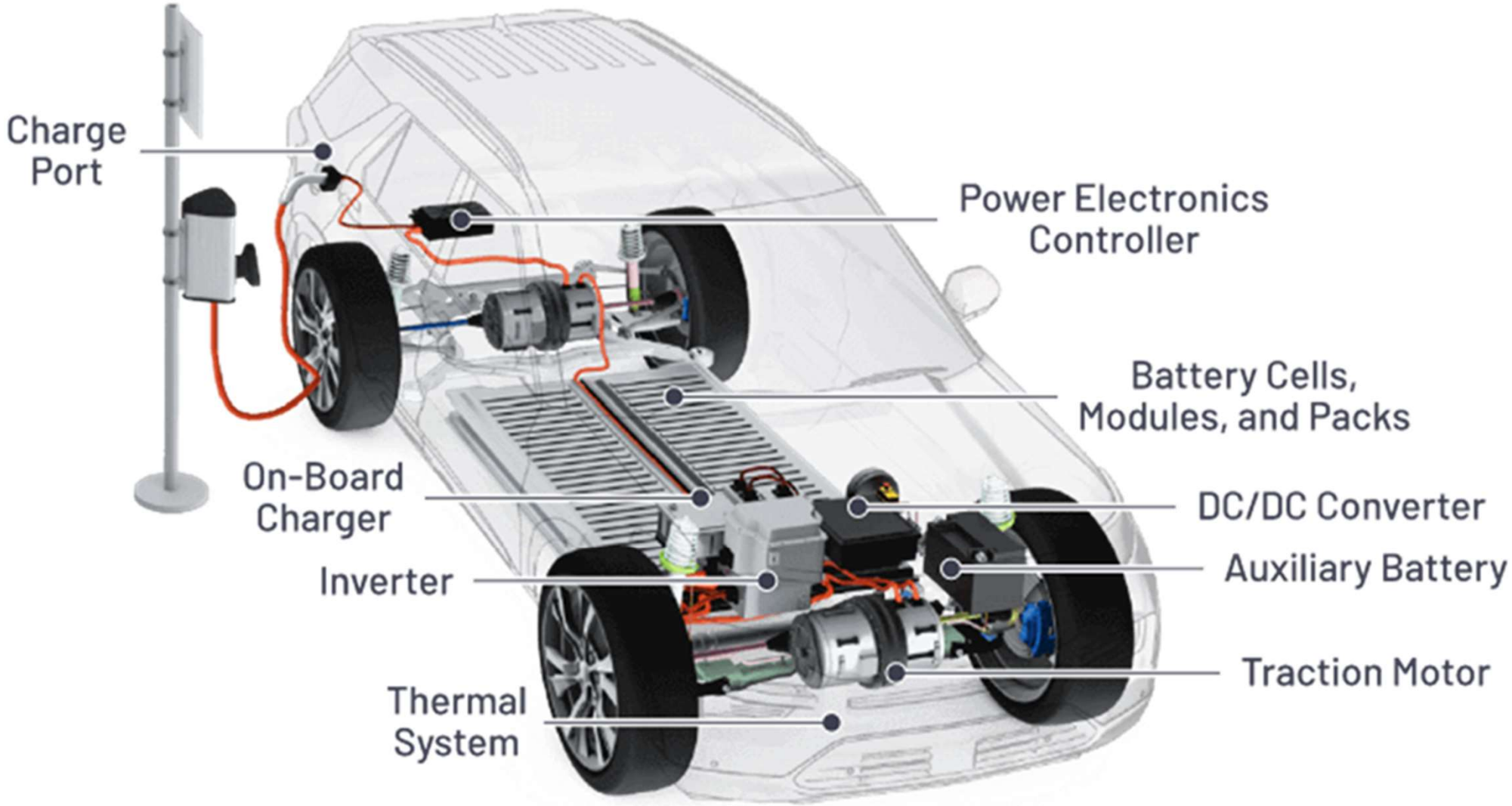
REESS(Rechargeable Energy Storage System) of EV



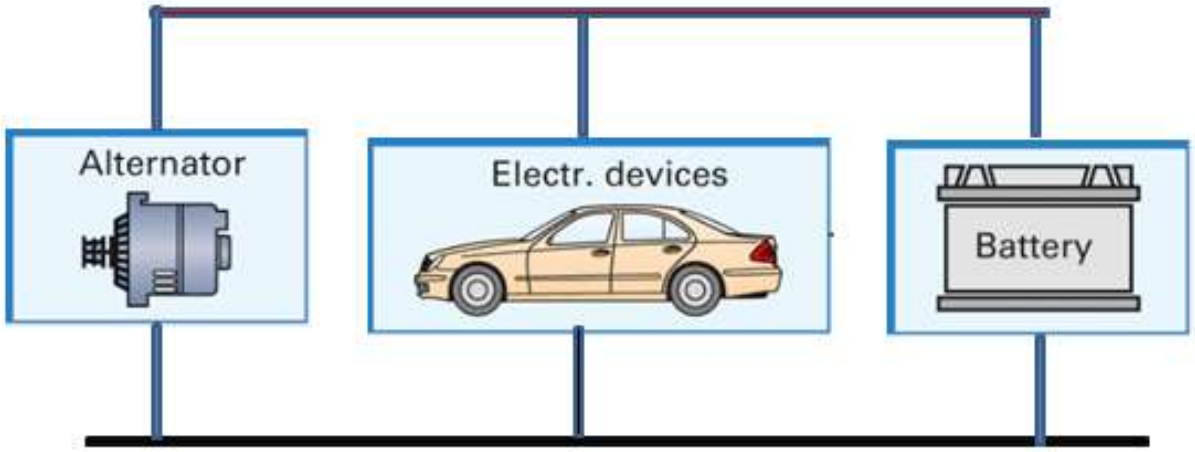
U Aung Kyaw Lin
B.E (Aeronautical)
National Chief Assessor
National Skill standards Authority

Main Components of EV Drive

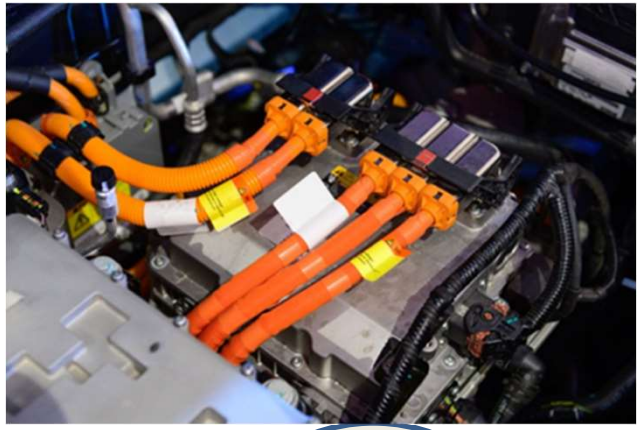


High Voltage Pack *20 ‘C to 40’C* *Power electric and electronic device* *65’C to 85’C*

EV Car Electrical System (low voltage and High Voltage)

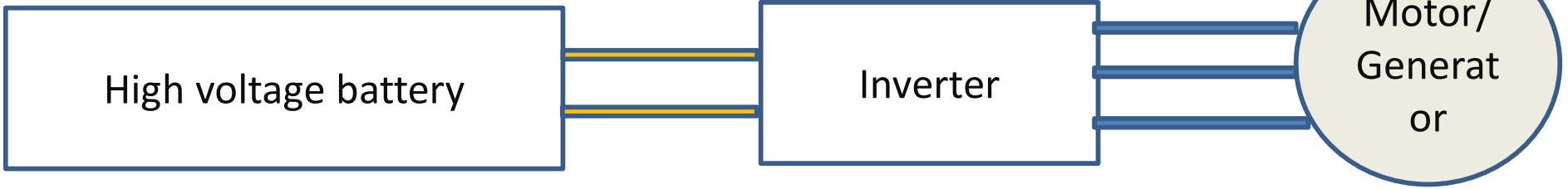


Vehicle body (chassis ground)

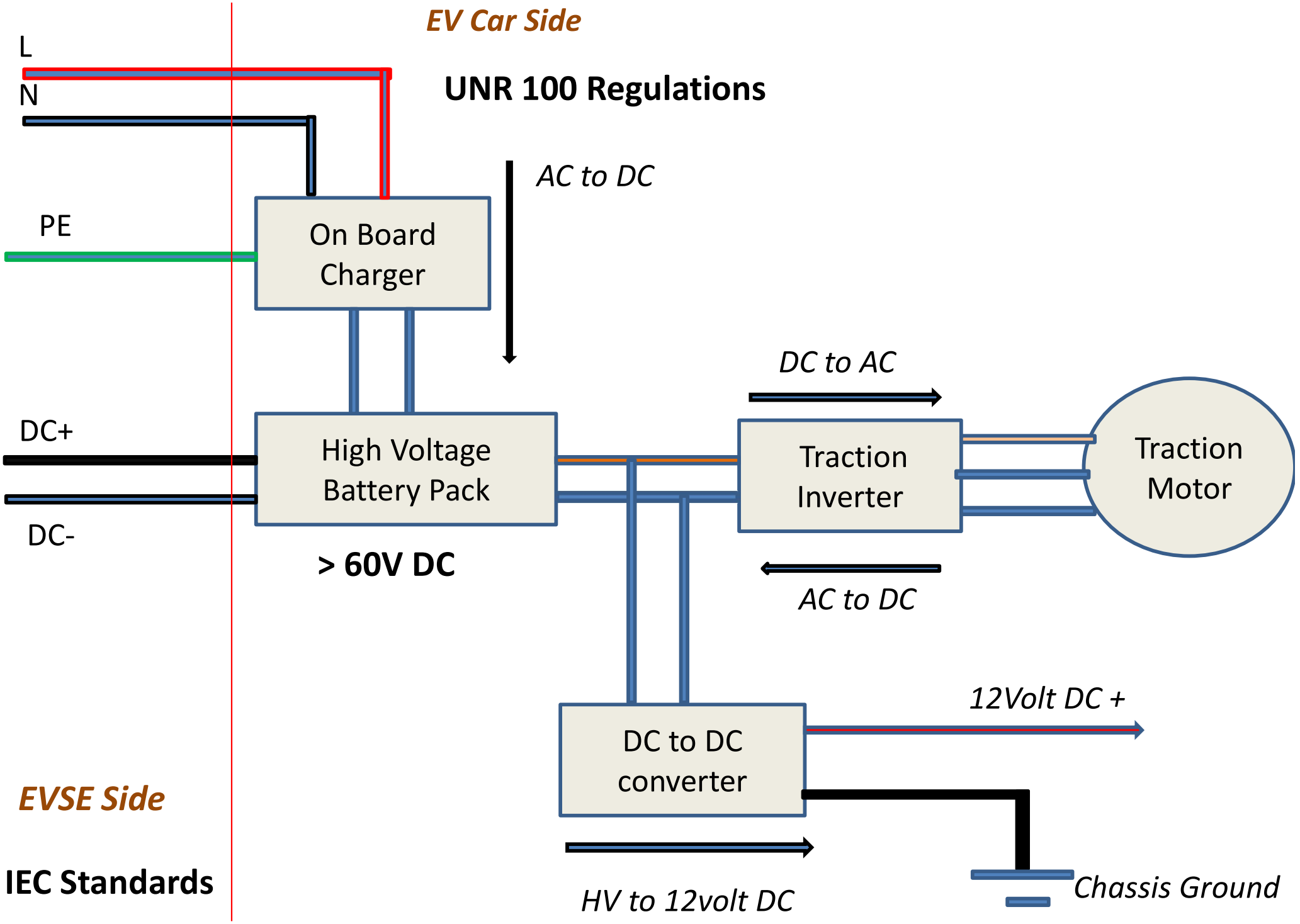


+

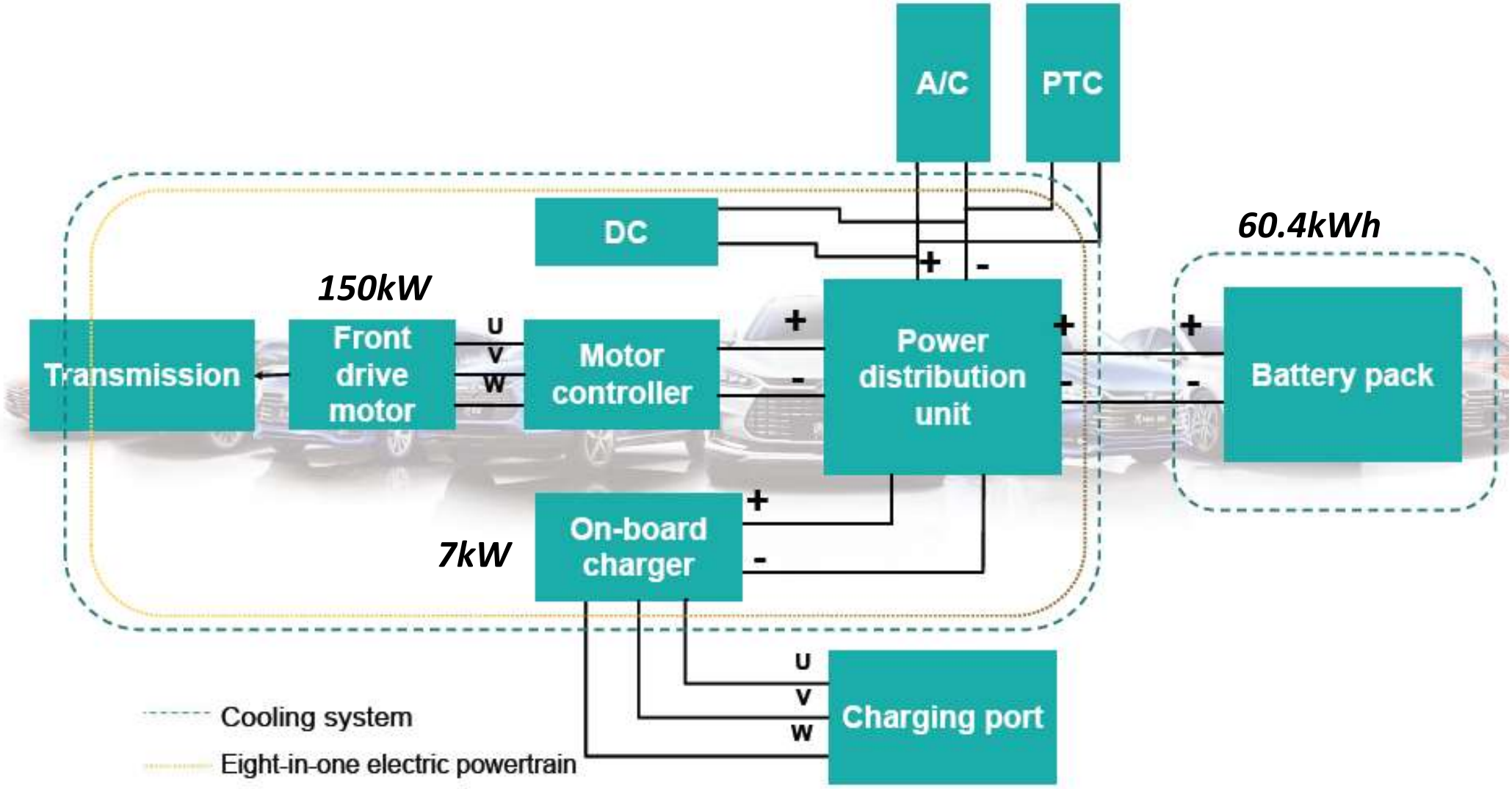
HV > 60V DC & > 30V AC



Vehicle body (chassis ground)


EV Car Side
L
N
UNR 100 Regulations
AC to DC
PE
On Board Charger
DC to AC
DC+
High Voltage Battery Pack
Traction Inverter
Traction Motor
DC-
> 60V DC
AC to DC
12Volt DC +
DC to DC converter
EVSE Side
IEC Standards
HV to 12volt DC
Chassis Ground

BYD ATTO3


A/C
PTC
DC
60.4kWh
150kW
Transmission
Front drive motor
U
V
W
Motor controller
+
-
Power distribution unit
+
-
+
-
Battery pack
7kW
On-board charger
+
-
U
V
W
Charging port
Cooling system
Eight-in-one electric powertrain

REESS includes

battery cells and module

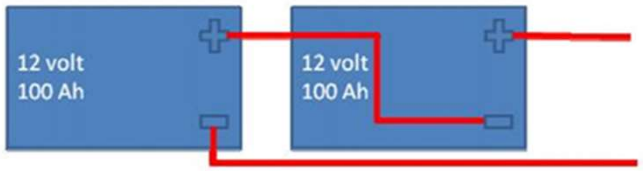
thermal management

safety contactors

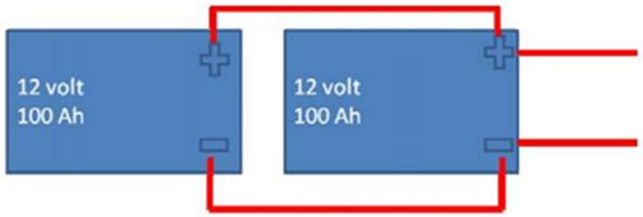
Battery Management System(ECU) and sensors

Cell balancing

Series Connection



Parallel Connection



Cell Type		Laminate Type
Cathode Active Material		LMO with LNO
Anode Active Material		Graphite
Capacity (0.3C)		32.5 Ah
Nominal Voltage		3.75 V
Exterior Dimensions	Length	290mm
	Width	216mm
	Weight	787 g
Energy Density		317Wh/L 157Wh/kg

Battery A:
12V
100Ah

Battery B:
24V
50Ah

Battery C:
48V
50Ah

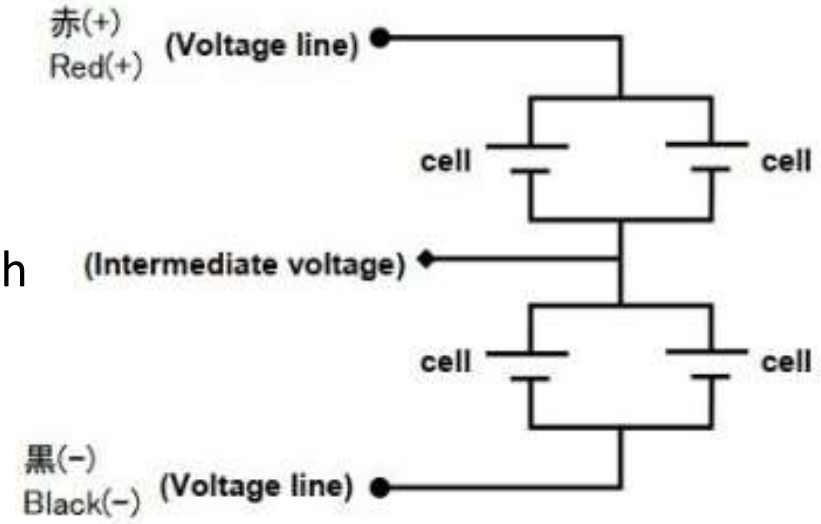
EV Battery kWh

Nissan Leaf Gen1 24kWh

Nissan leaf Gen 2 30kWh

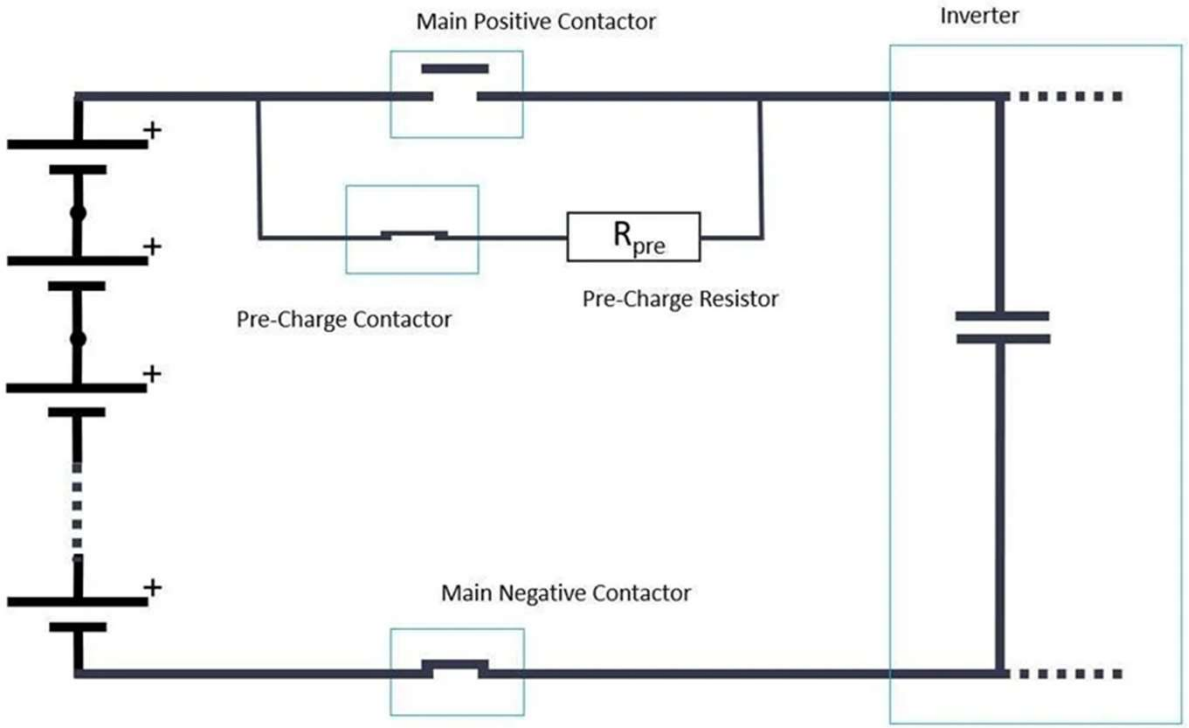
Nissan Leaf Gen3 40kWh

7.5 Volt 65Ah



BYD D1

BYD Seagull



IG Sw on/off

Insulation fault

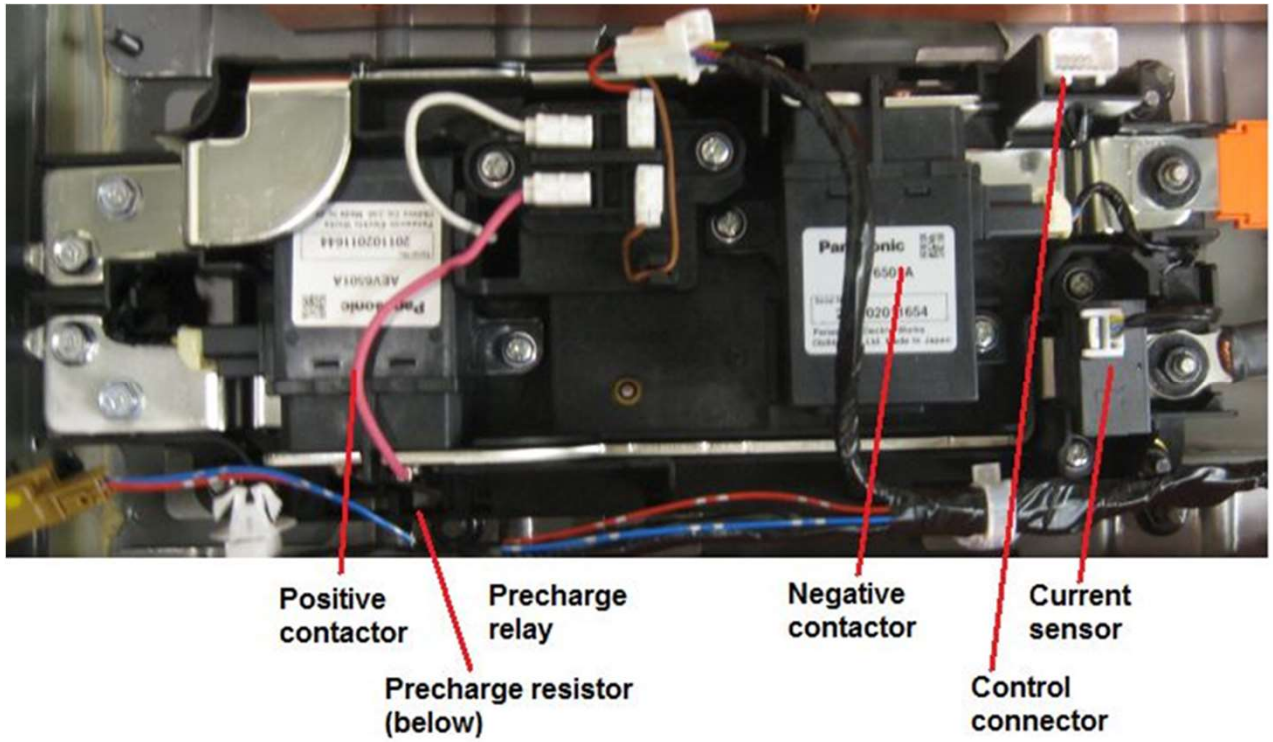
Accident

Sintering

Severe overvoltage

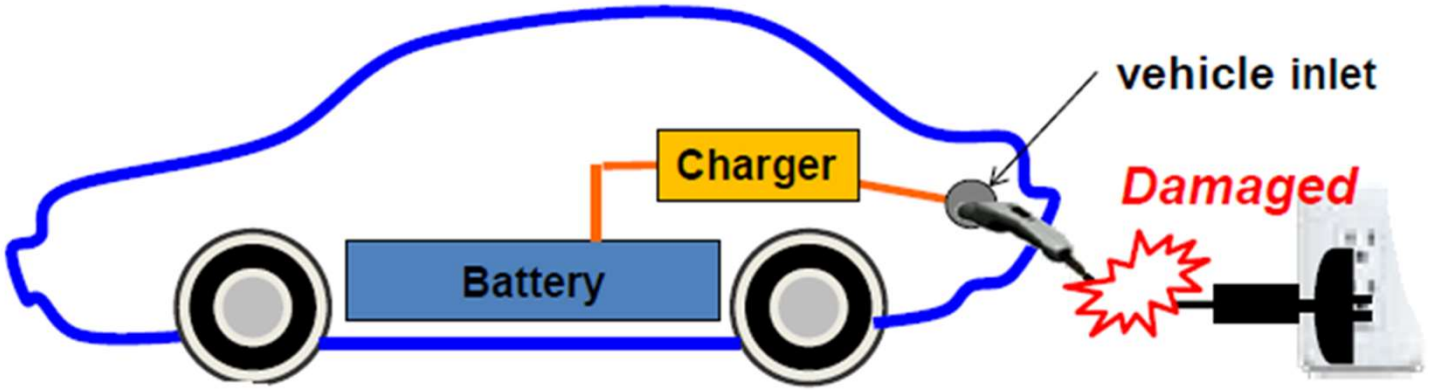
Severe under voltage

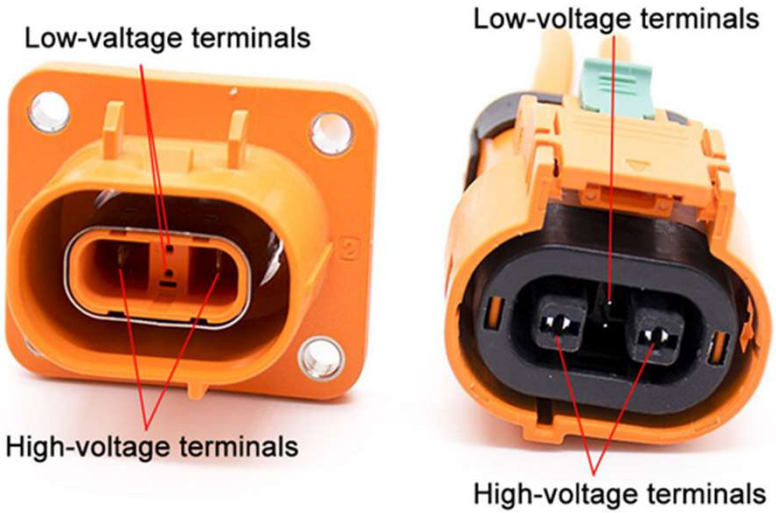
HV interlock

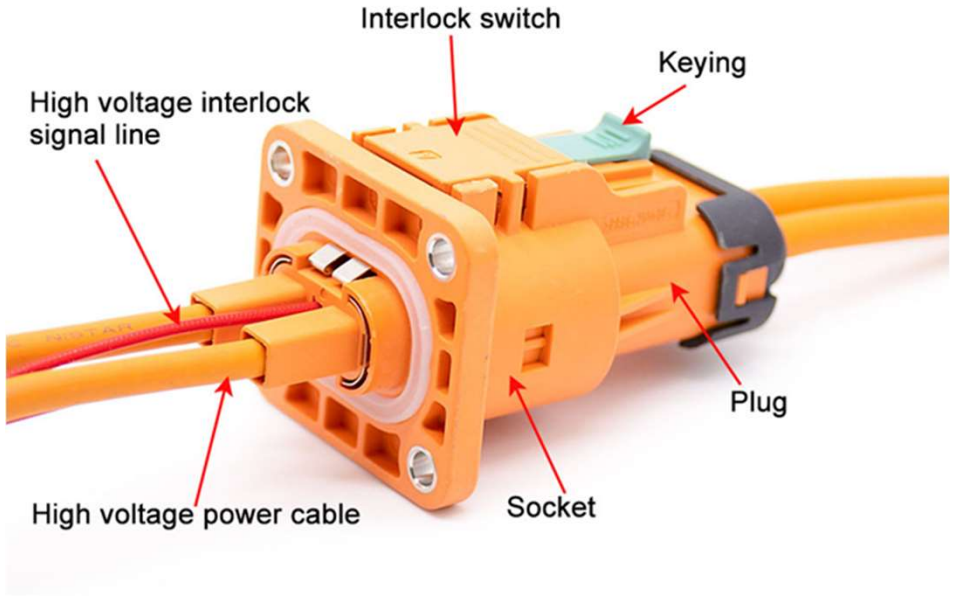


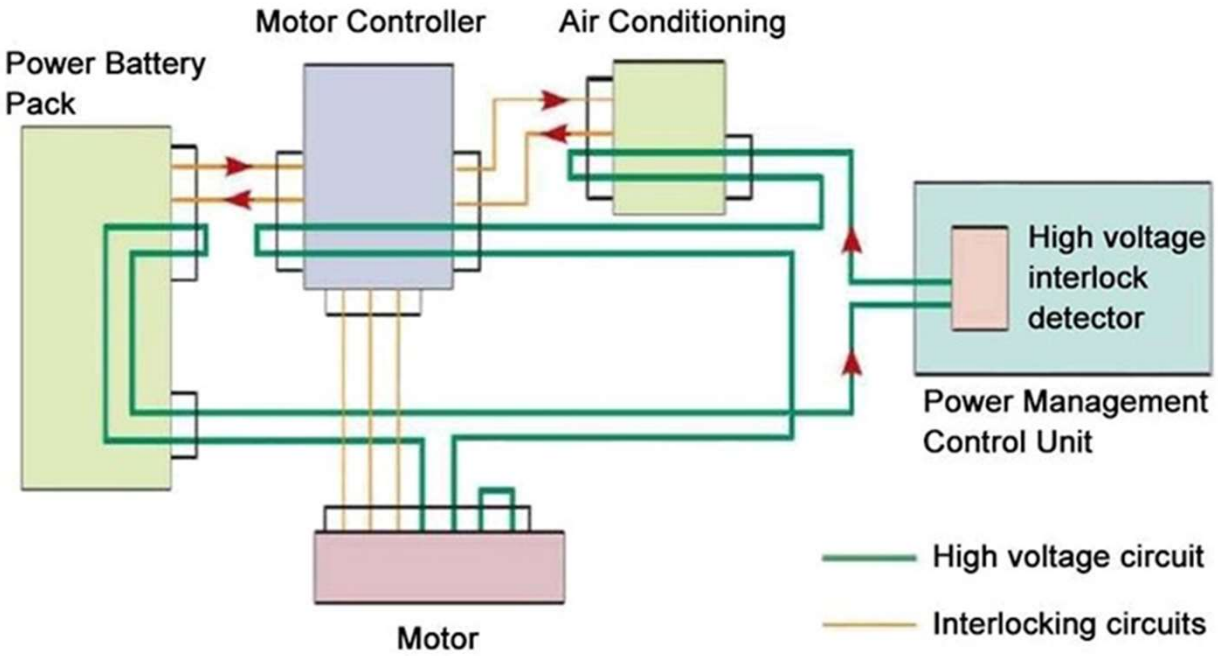
EV Car Dash Indicator

Prevention of vehicle movement during charging

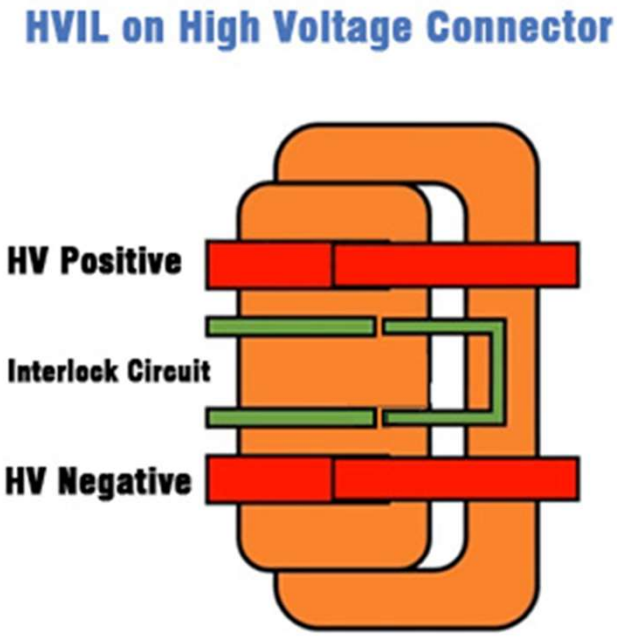




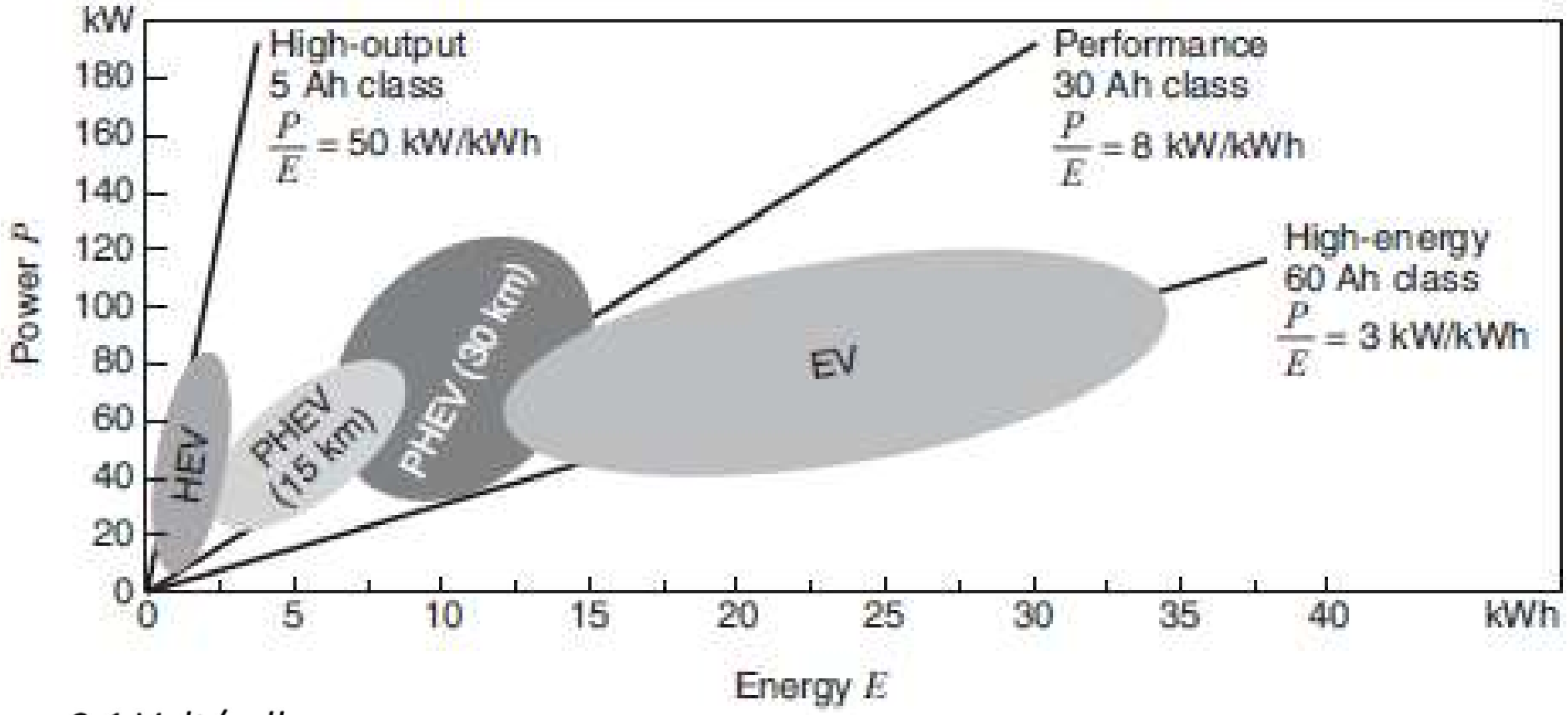




High-voltage interlocking system in new energy vehicles



HEV Hybrid electric vehicle,
PHEV Plug-in hybrid electric vehicle,
EV Electric vehicle.

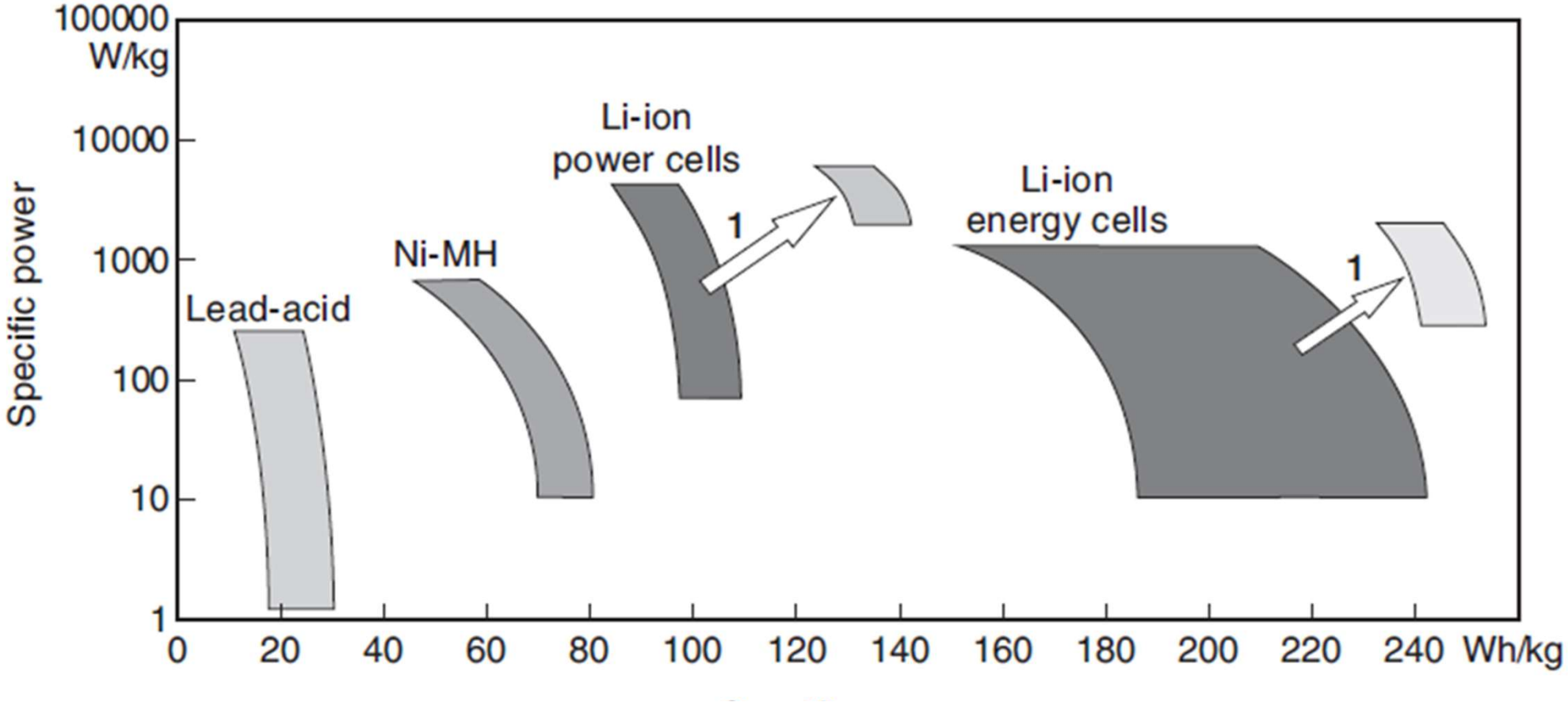


2.1 Volt/cell

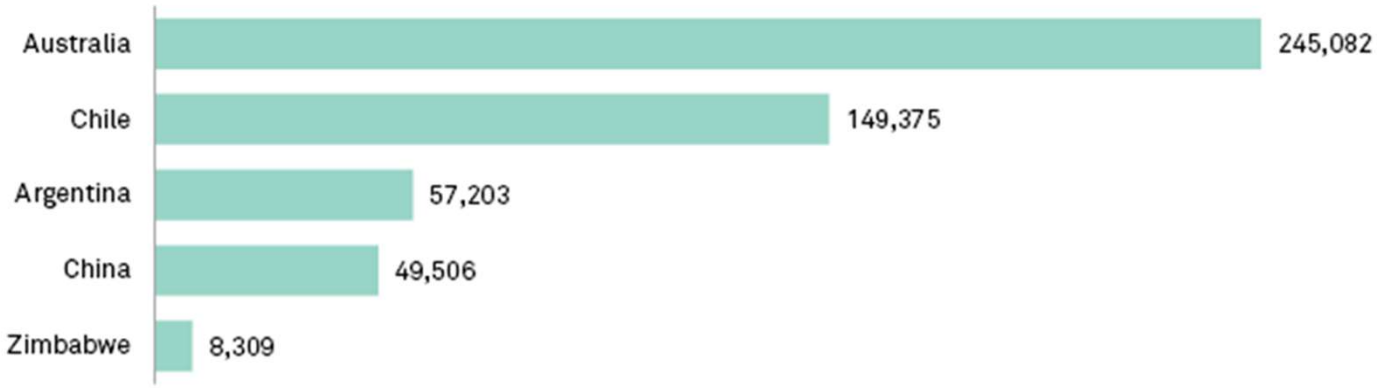
1.2volt/cell

3.2 to 3.6 volt/cell

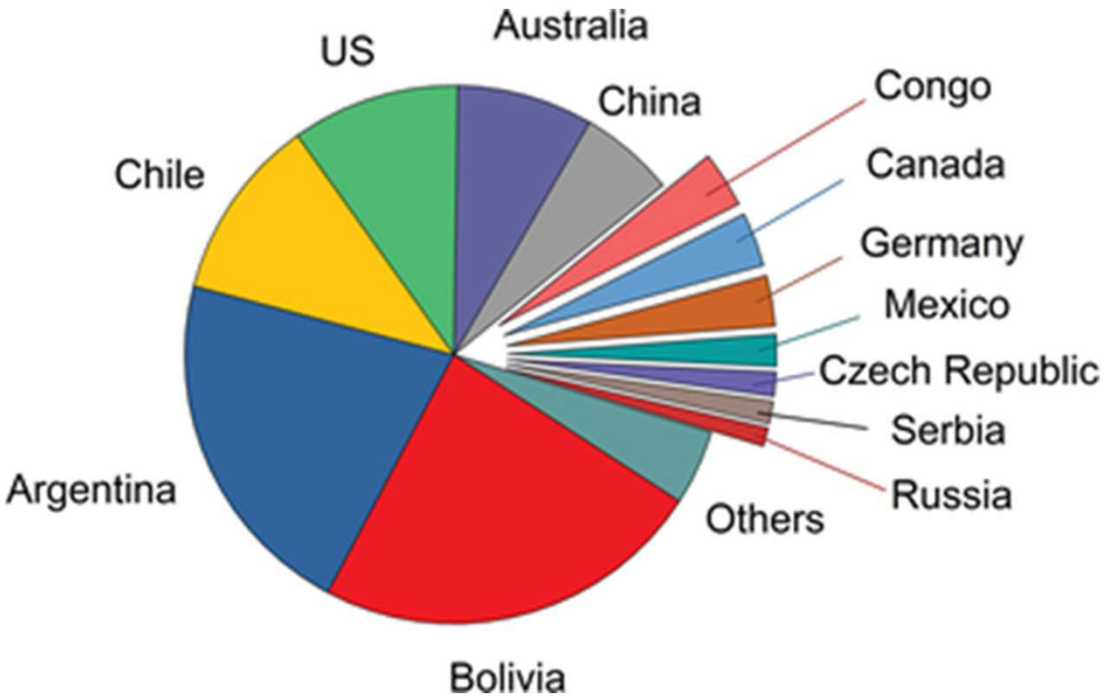
EV Battery


100000
W/kg
10000
1000
100
10
1
Specific power
Lead-acid
Ni-MH
Li-ion
power cells
1
Li-ion
energy cells
1
0
20
40
60
80
100
120
140
160
180
200
220
240
Wh/kg

Major countries by lithium production, 2021 (tonnes)

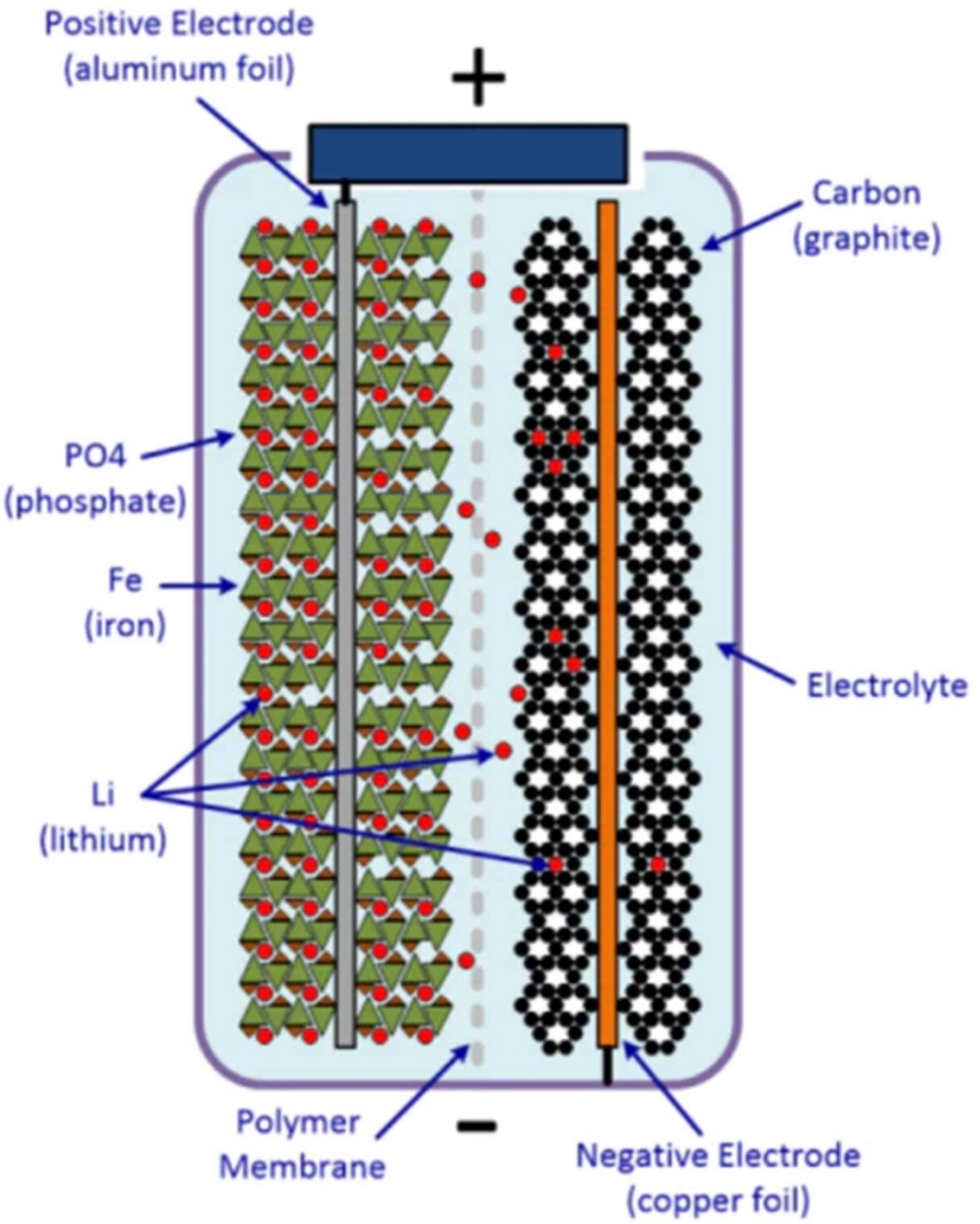


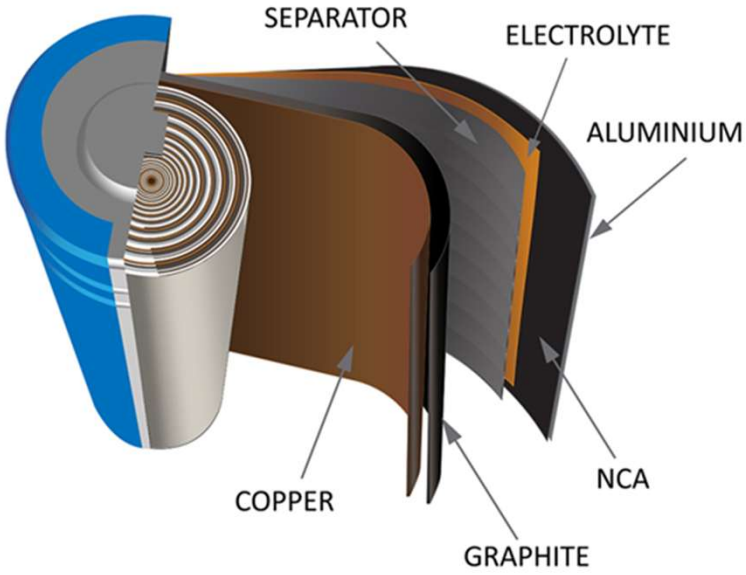
Data compiled June 3, 2022.
Includes standardized production estimates based on lithium mining properties located in the corresponding countries.
Production data for Bolivia is not available.
Source: S&P Global Market Intelligence

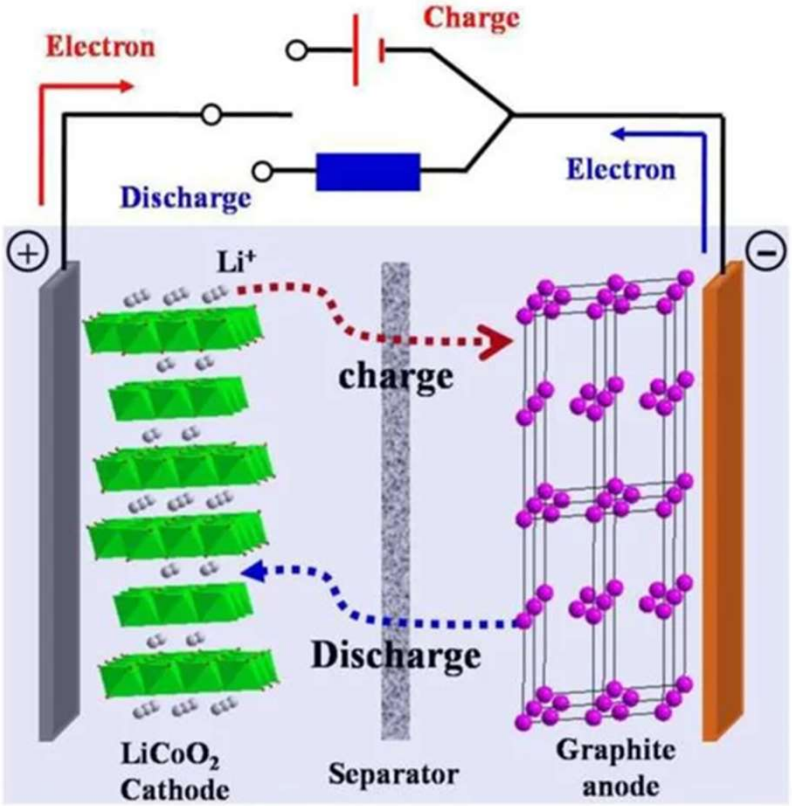


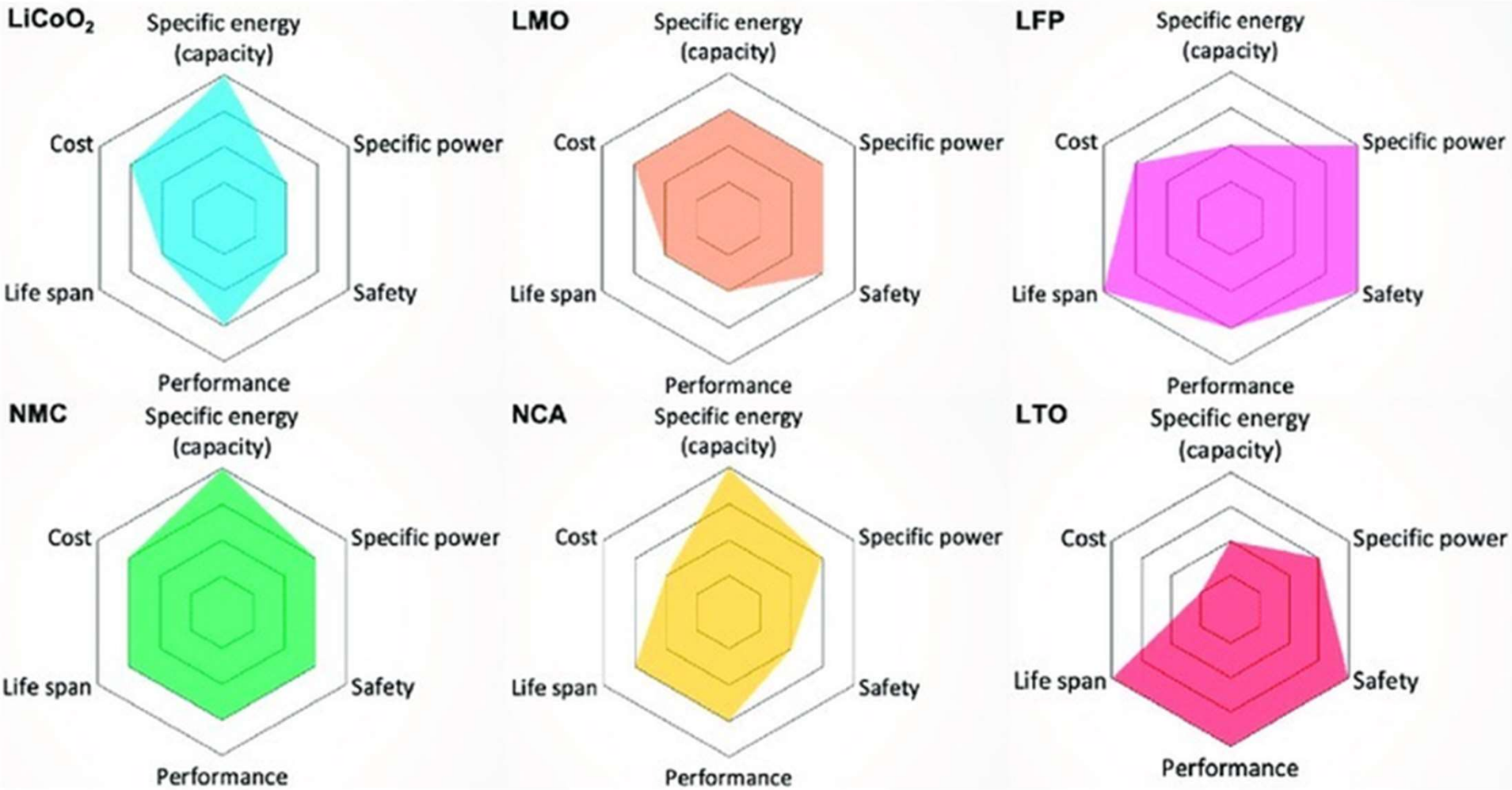
Cathode capacity and voltage

Anode charge / discharge rate







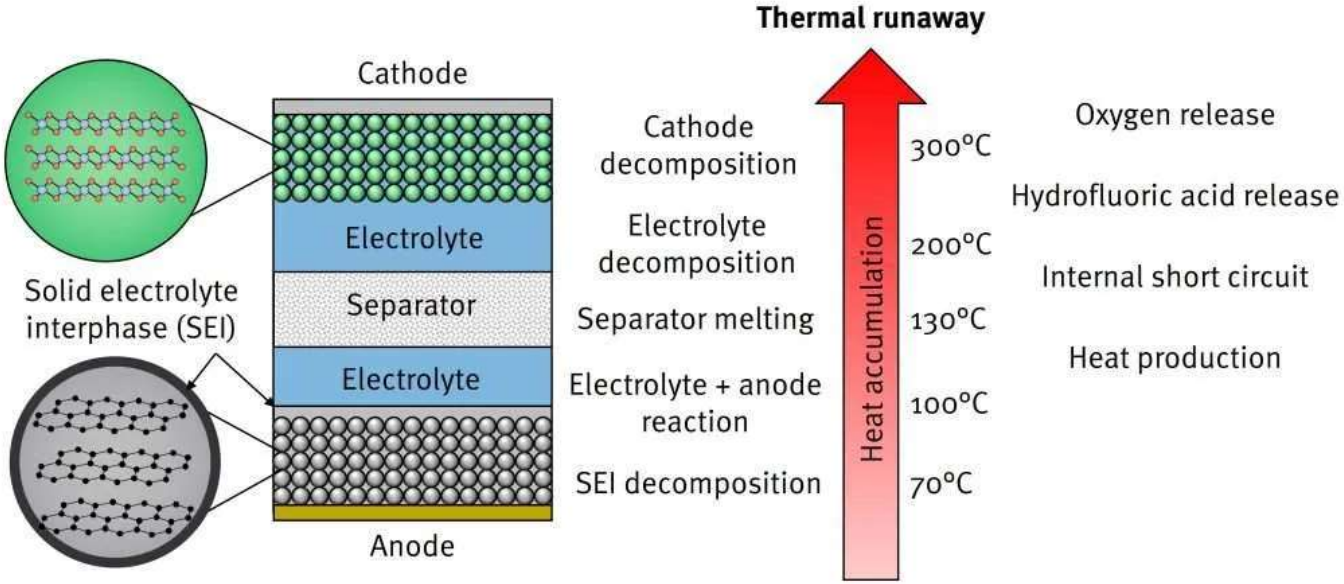


LCO for mobile phone, laptop, camera(high cost of cobalt)

LMO for portable power tool, medical equipment(short life span)

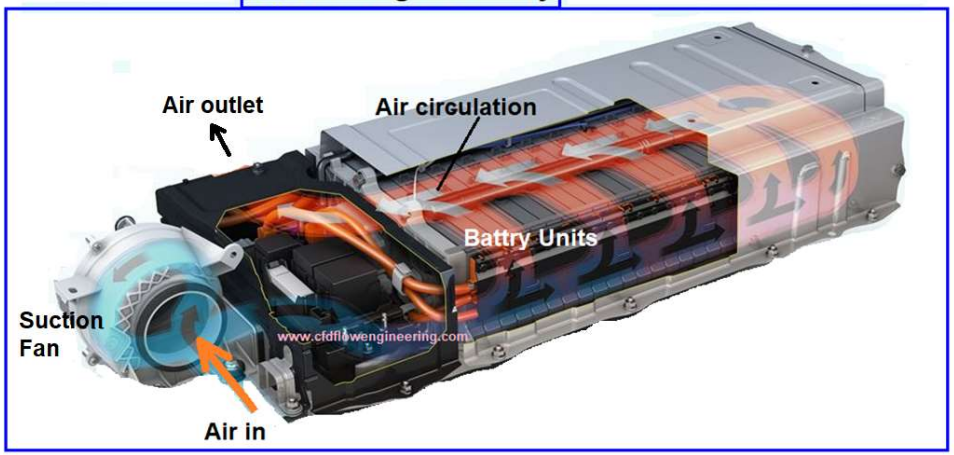
LTO for telecommunication, uninterrupted power supply, charging station

Thermal management of REESS

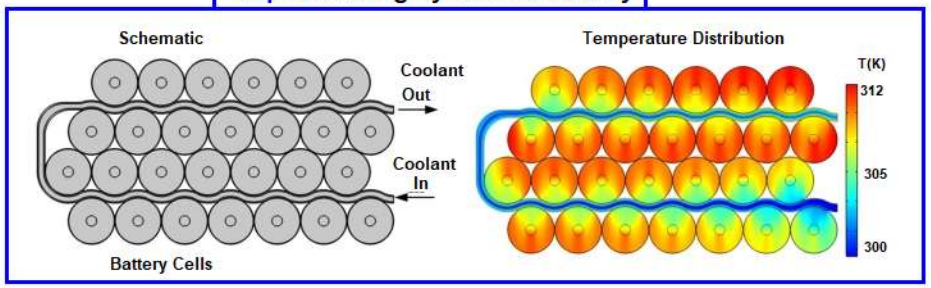


Common battery electrolyte components = Salt + solvent
Salt = Lithium Hexafluorophosphate ($LiPF_6$)
Solvent = Ethylene Carbonate (EC), Dimethyl Carbonate (DMC)

Air Cooling of Battery



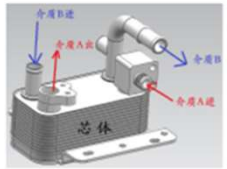
Liquid Cooling System for Battery

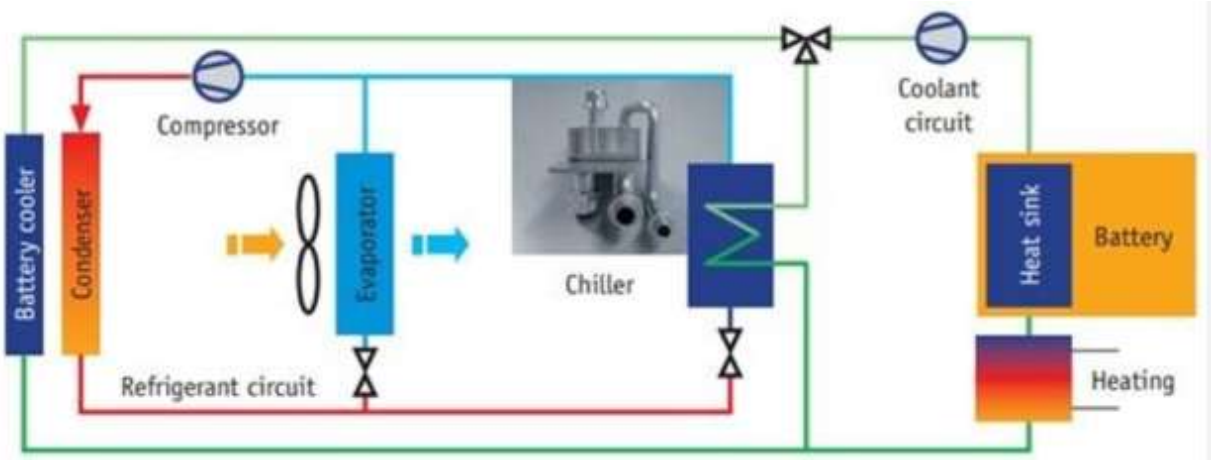


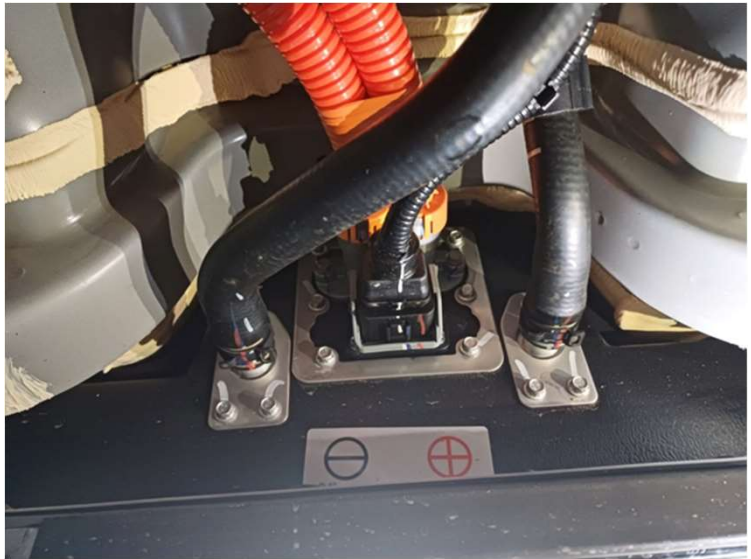
Heating (0~7KW) ---Battery cooling (1~5KW)

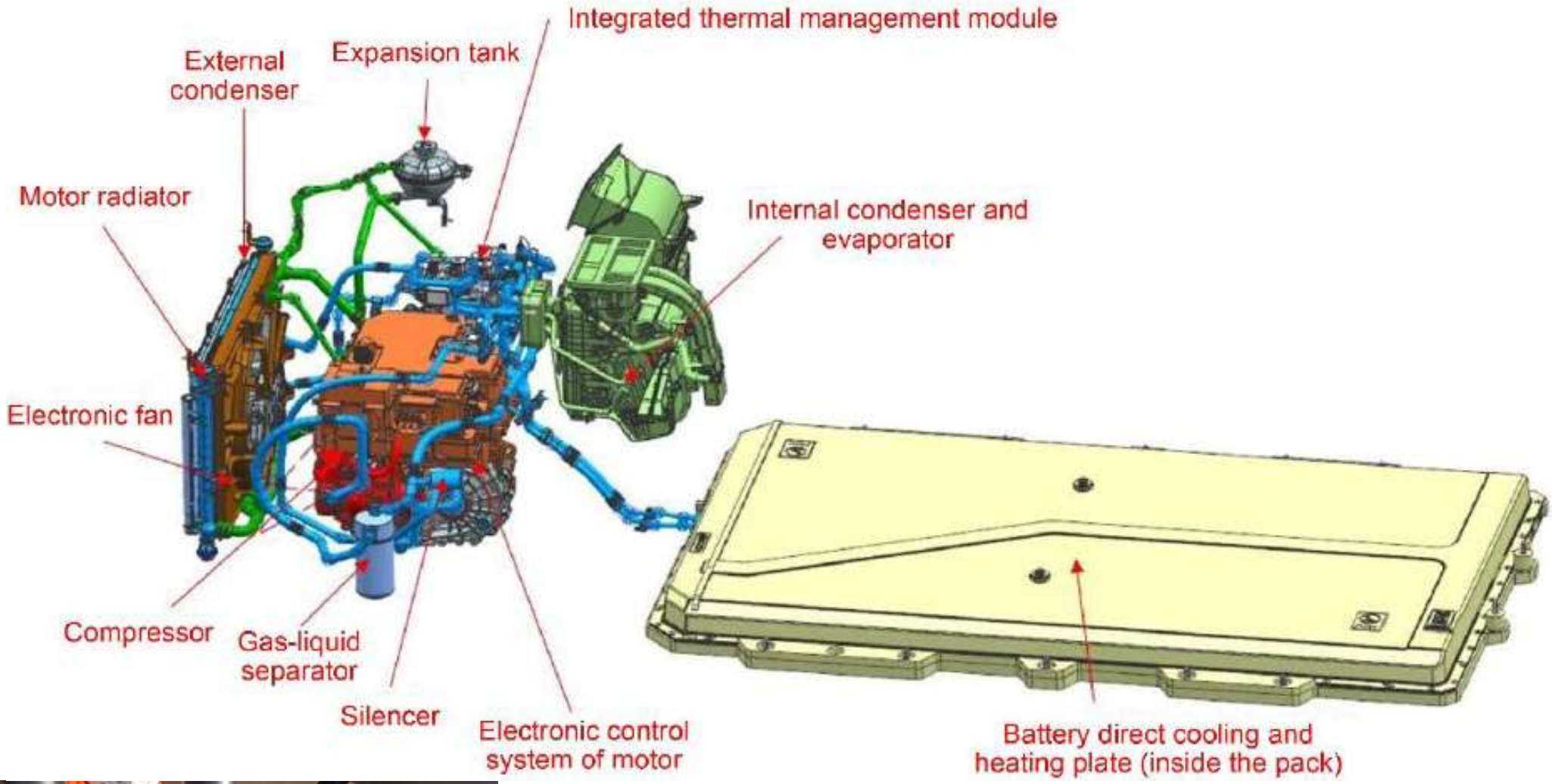
need to be heated

need to be cooled

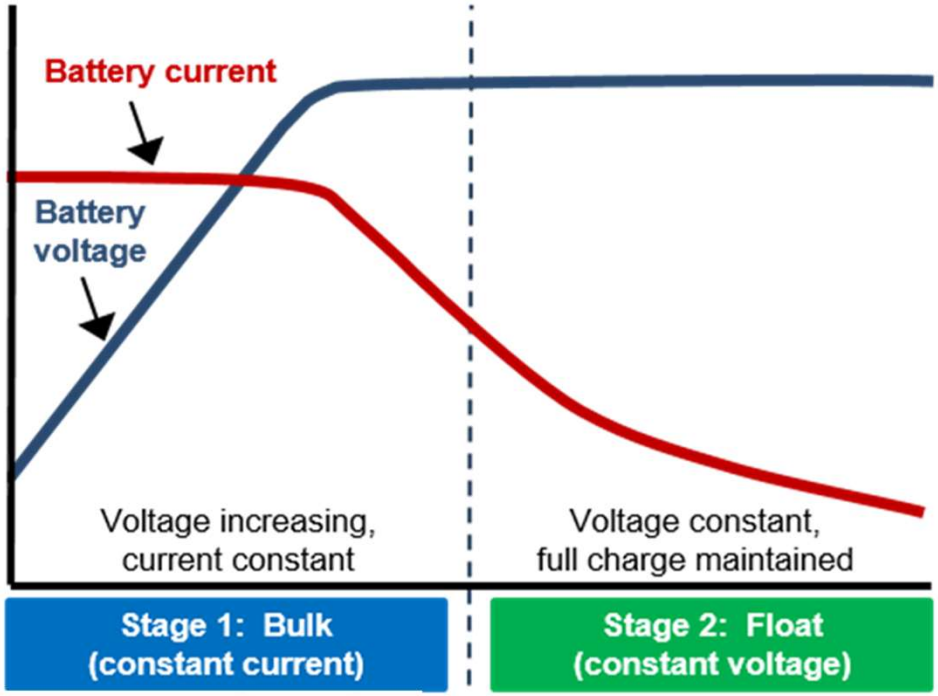






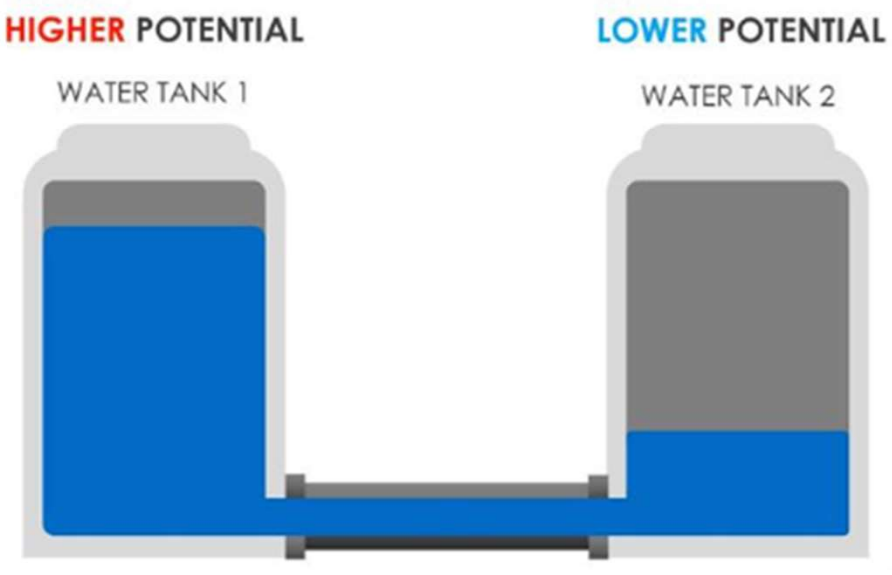

Integrated thermal management module
External condenser
Expansion tank
Motor radiator
Internal condenser and evaporator
Electronic fan
Compressor
Gas-liquid separator
Silencer
Electronic control system of motor
Battery direct cooling and heating plate (inside the pack)

Battery Charging



Limitations of DC fast charging

- Higher losses in charger and battery (I^2R)
- Battery
  - Only 70-80% SOC can be charged with fast charging
  - Shorter battery lifetime based on C-rate
- Cable
  - Limited maximum current for cable that can be easily lifted
  - Thermal management



C/10	C/5	C/4	C/3	C/2	1C	2C	3C	4C
10 hours	5 hours	4 hours	3 hours	2 hours	1 hour	30 minutes	20 minutes	15 minutes

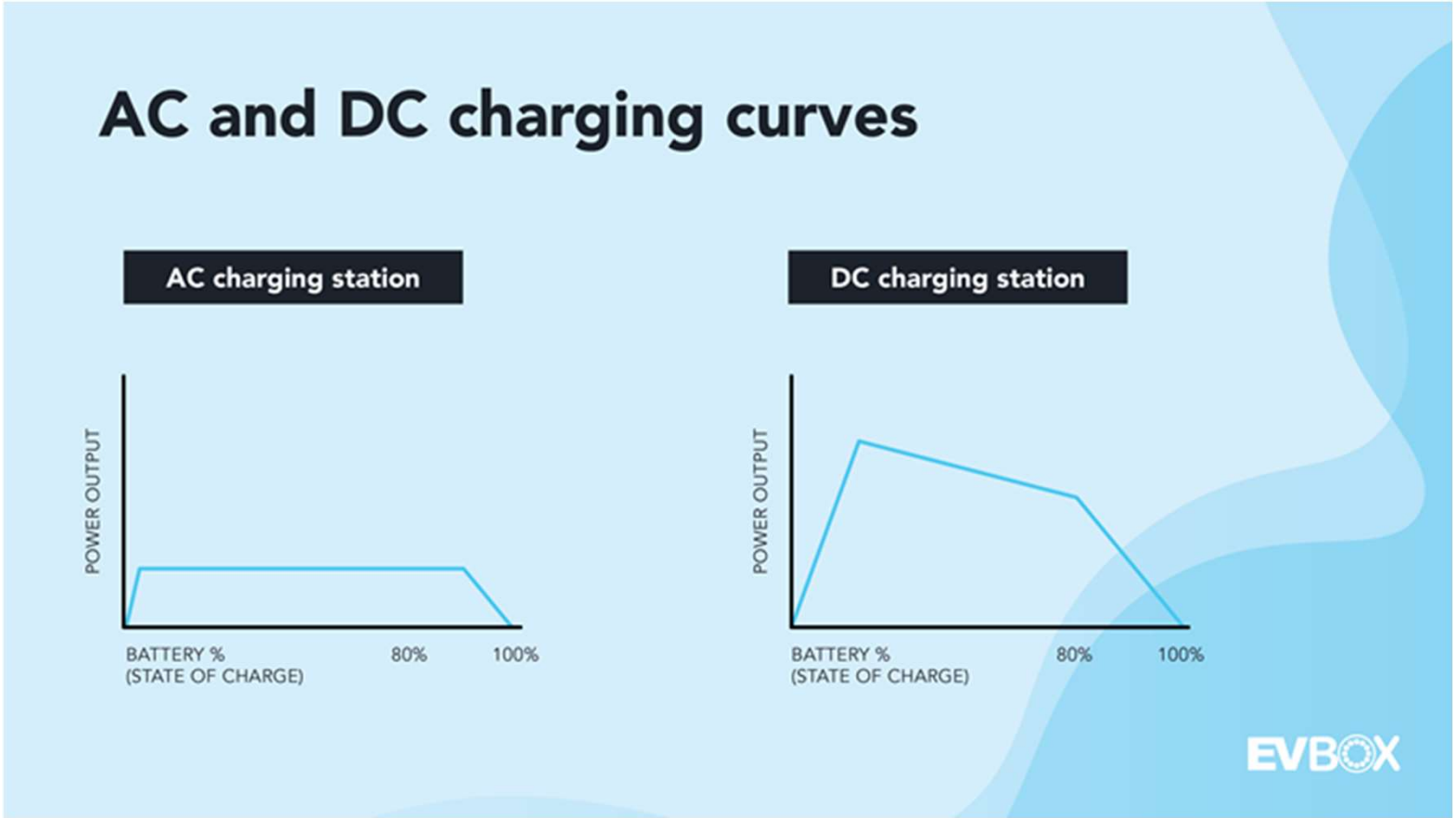
SLOW CHARGE

FAST CHARGE

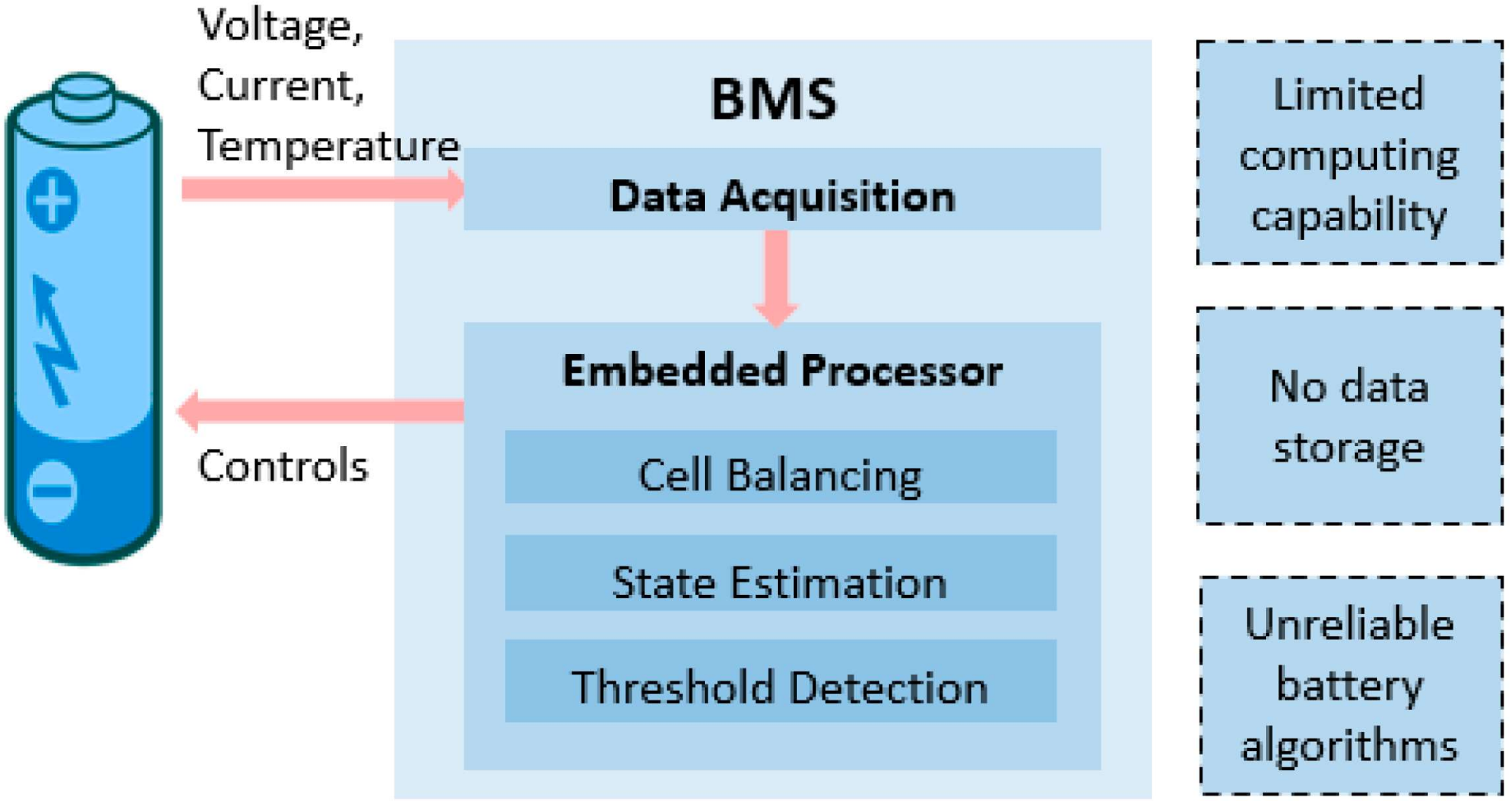
STEADY DRIVING

FAST ACCELERATION

AC and DC charging curves



Battery management System



- **End of Charge Voltage**
- When the rechargeable battery is fully charged, the battery voltage will not rise if the battery continue to be charged. The voltage at this time is called the end of charge voltage .
- If you continue to charge after reaching the cut-off voltage, it is overcharging, which generally ***damages the performance and life of the battery.***

- **End of Discharge Voltage**
- The end of discharge voltage refers to the minimum voltage allowed when the battery is discharged.
- If the battery continues to discharge the voltage is lower than the end of discharge voltage, the voltage both ends of the battery will drop rapidly, forming a deep discharge ***causing the negative electrode carbon to release lithium ions*** excessively, causing it sheet structure to collapse.

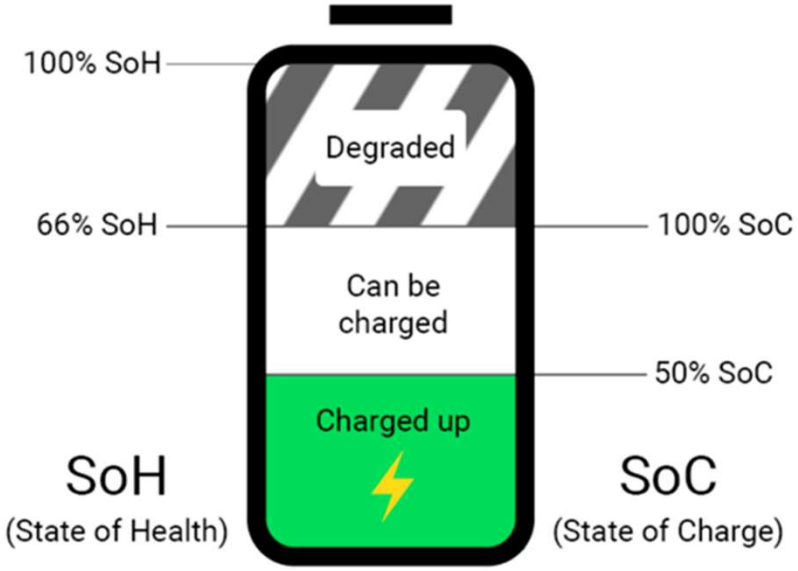
Battery Type	Rated Voltage	Single Charge Cut Off Voltage	Single Discharge Cut Off voltage
Ternary	3.7V	4.1-4.2V	2.7-2.8V
Lithium Iron Phosphate	3.2V	3.6-3.65V	2.4-2.5V
Lithium Titanate	2.3V	2.7-2.8V	1.6-1.7V

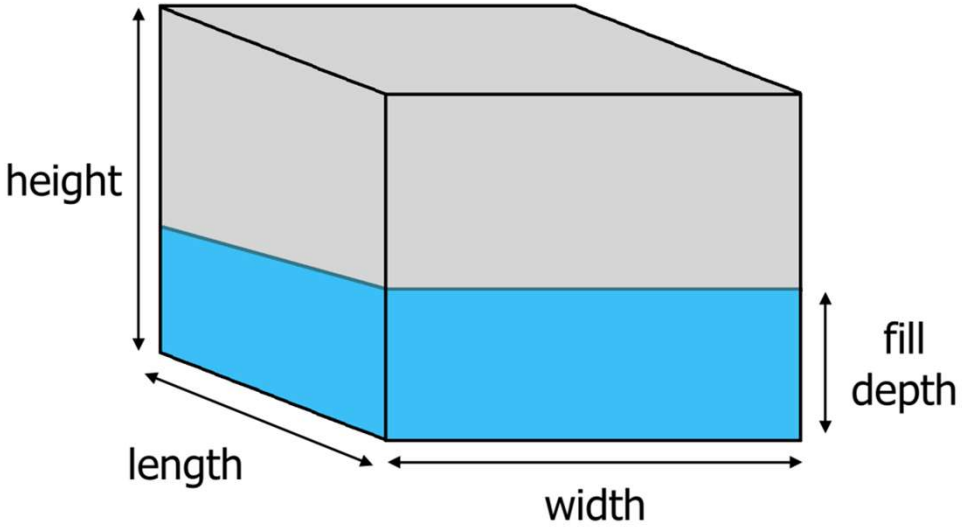
Lithium Iron Phosphate Cell (Voltage difference < 50mVolt)

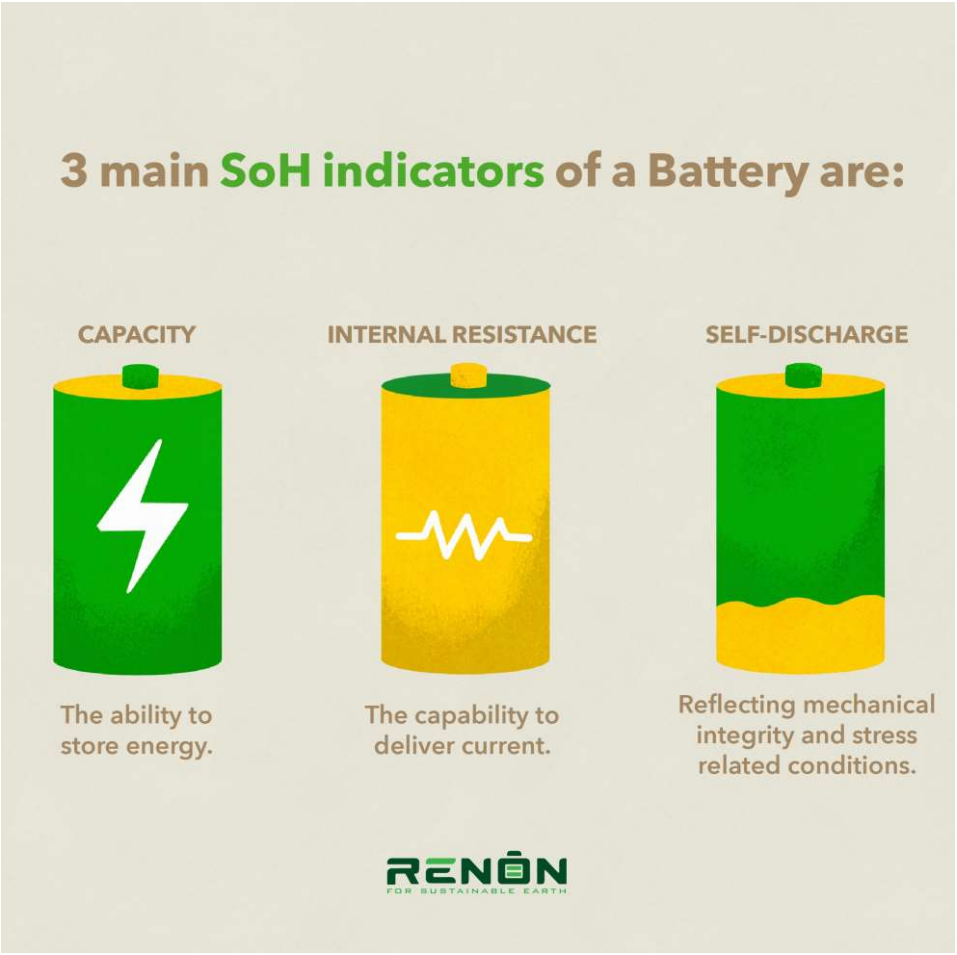
SOC	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Voltage	2.893	3.211	3.247	3.278	3.293	3.295	3.298	3.334	3.335	3.336	3.441

Ternary Cell / Nickel Cobalt Lithium Manganese Oxide (Voltage Difference< 200mVolt)

SOC	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Voltage	3.391	3.487	3.588	3.603	3.632	3.674	3.768	3.867	3.974	4.092	4.229



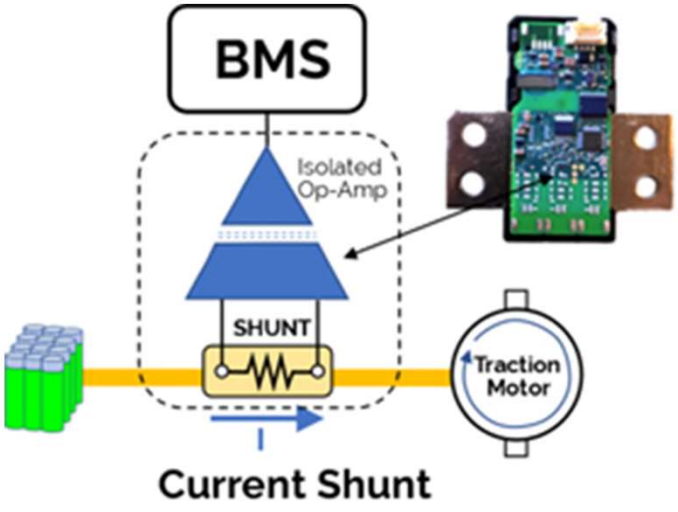




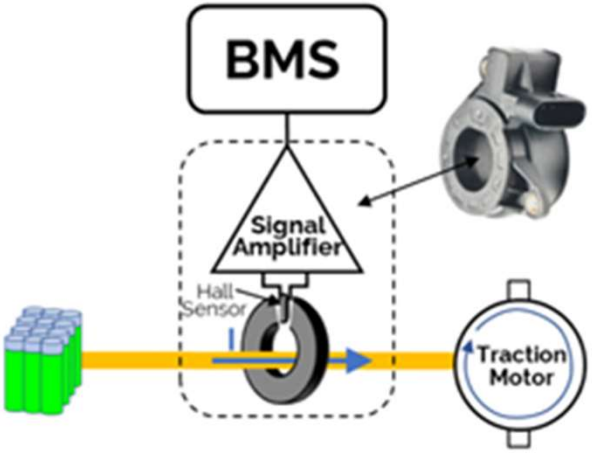
Indication of State of Charge of Battery is ***Voltage***

Indication of SOH (state of health) is ***temperature rise during charge and discharge***

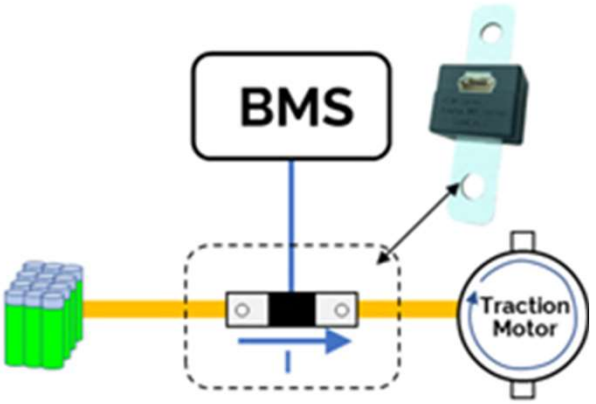
Current Measurement



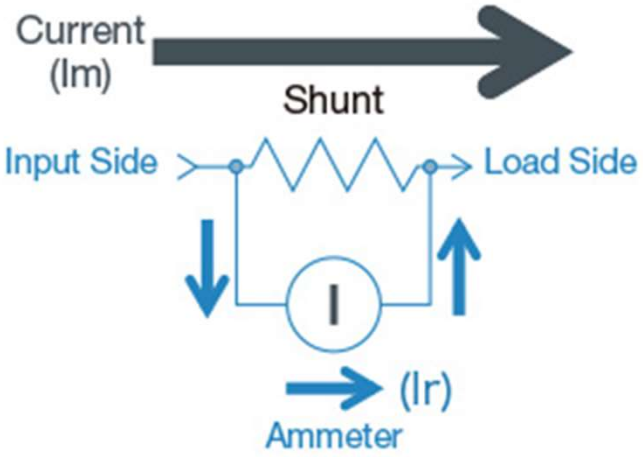
Current Shunt

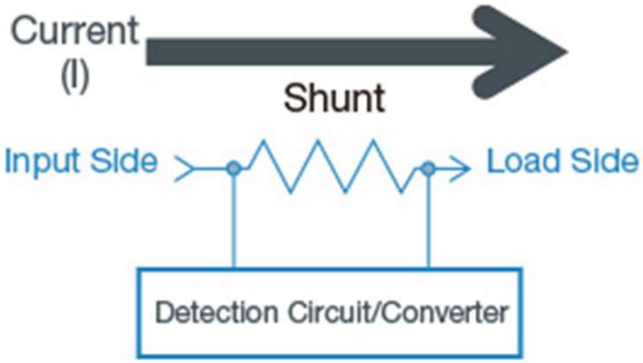


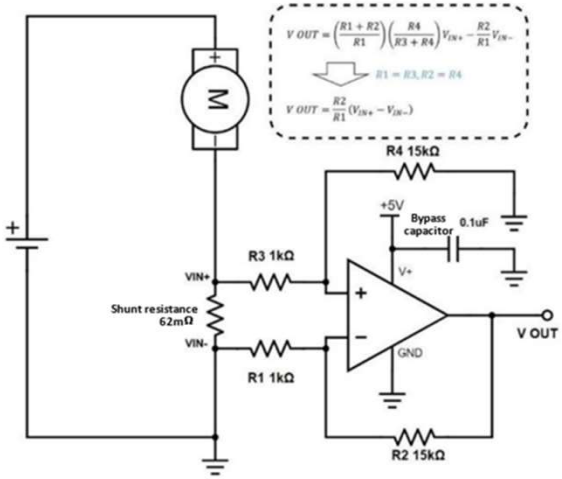
Hall Sensor



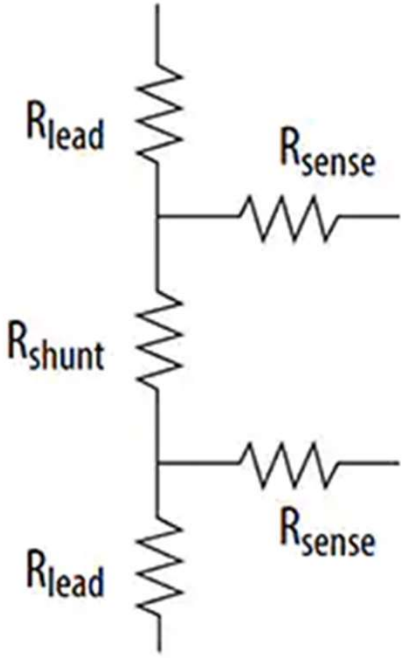
Magneto-Resistance

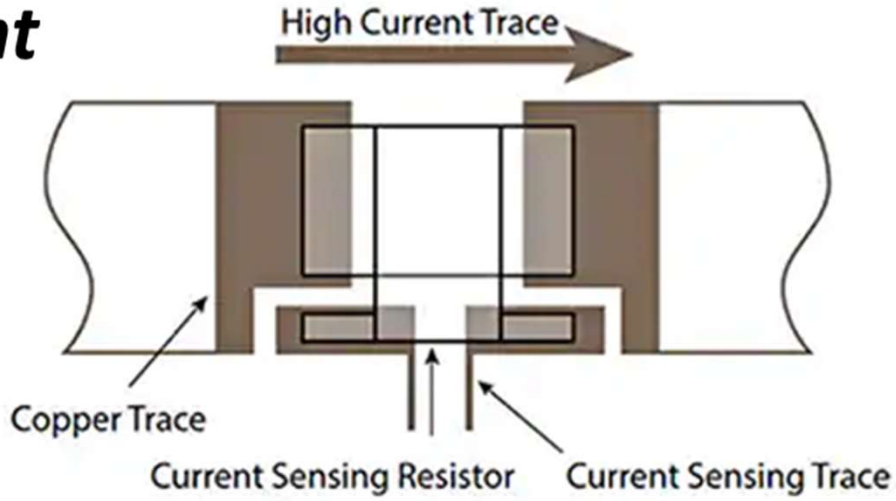


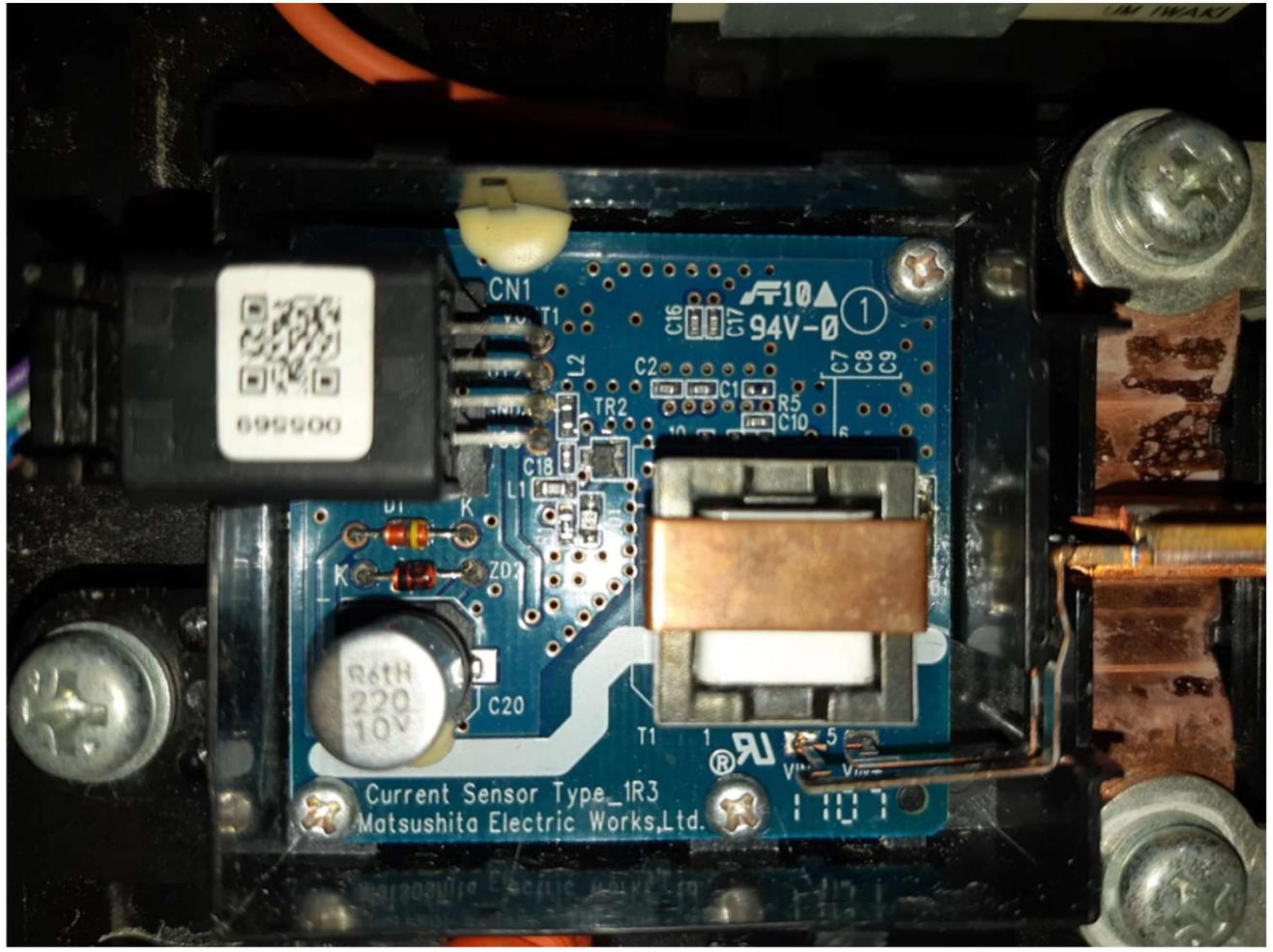




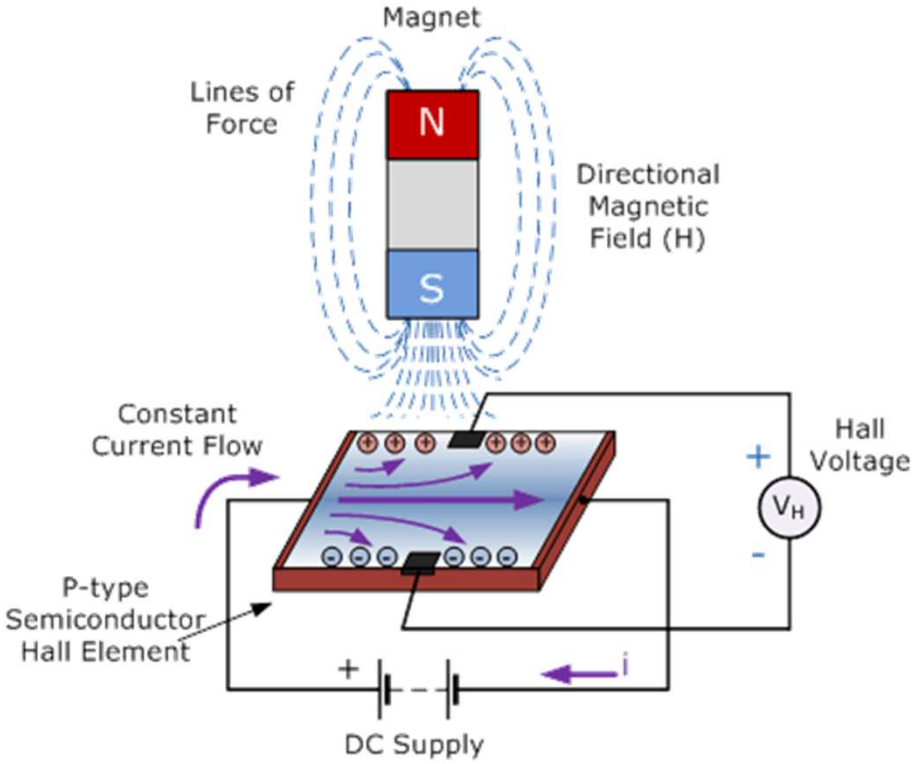
Current Measurement







Current measurement by Hall Effect (AC/DC)



$$V_H = R_H\left(\frac{I}{t} \times B\right)$$

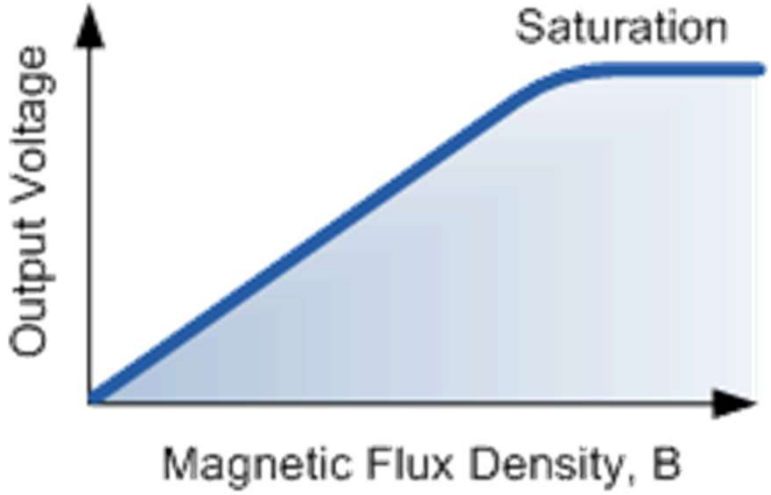
V_H is the Hall Voltage in volts

R_H is the Hall Effect co-efficient

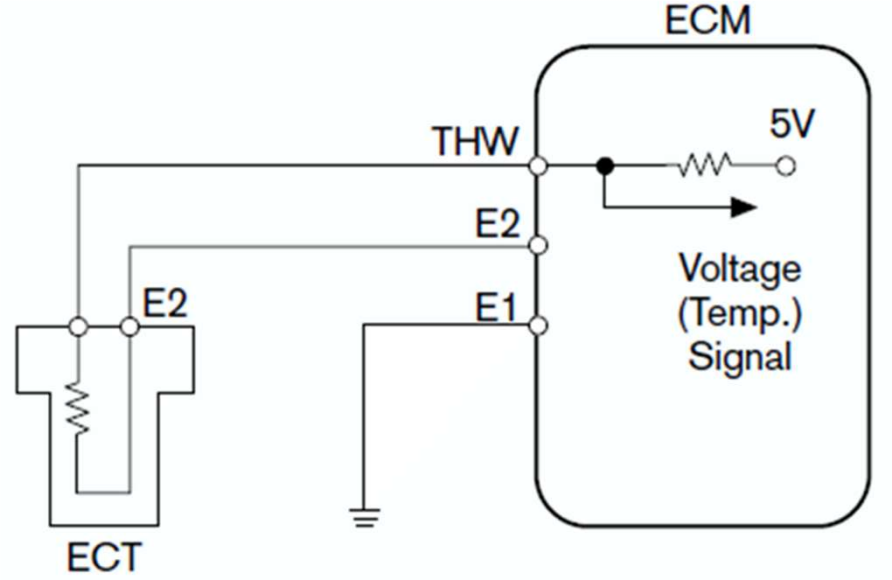
I is the current flow through the sensor in amps

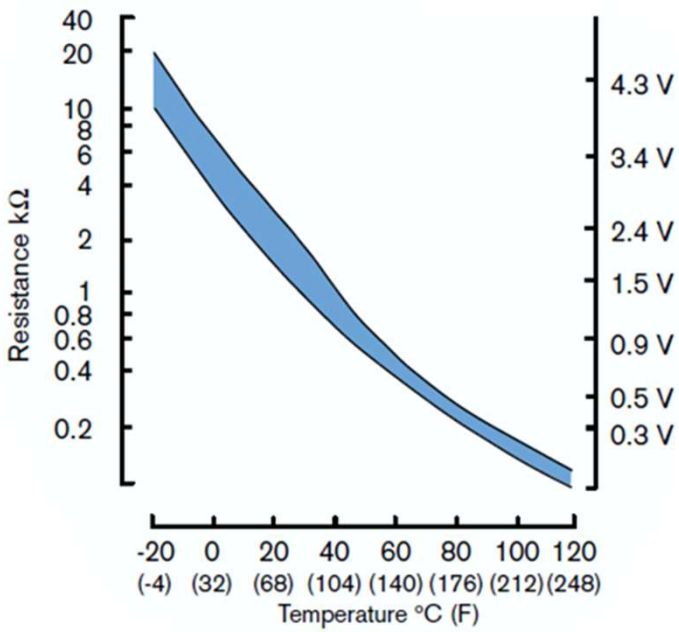
t is the thickness of the sensor in mm

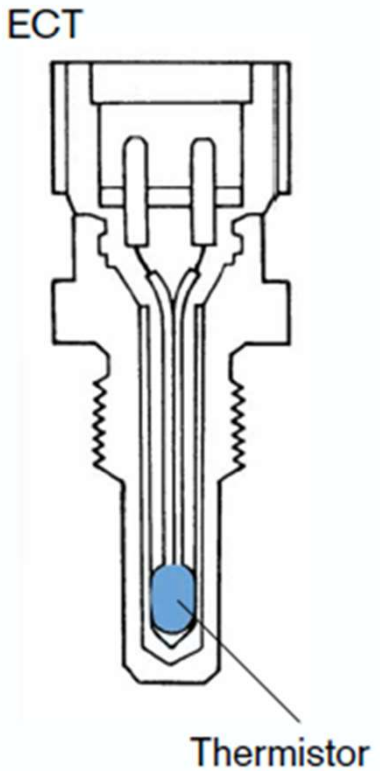
B is the Magnetic Flux density in Teslas

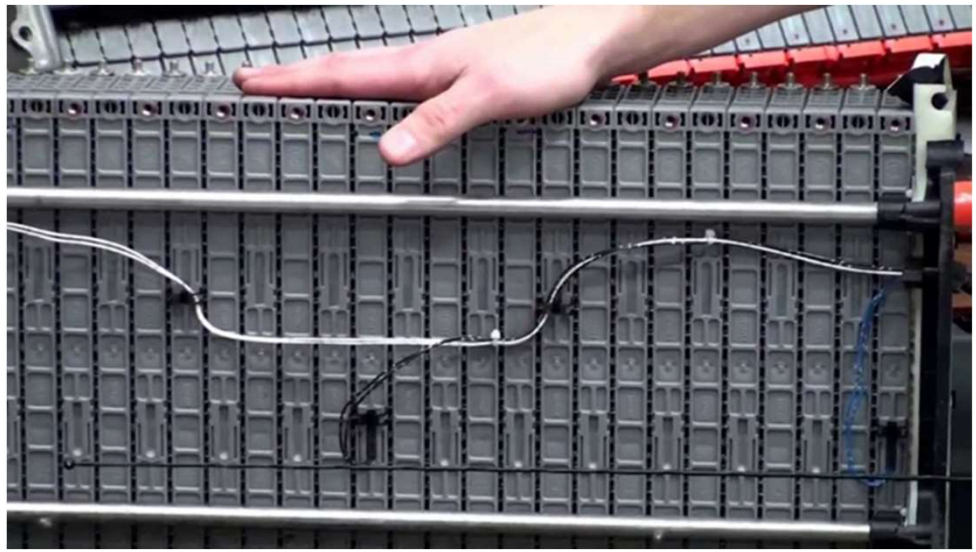


Temperature Sensor

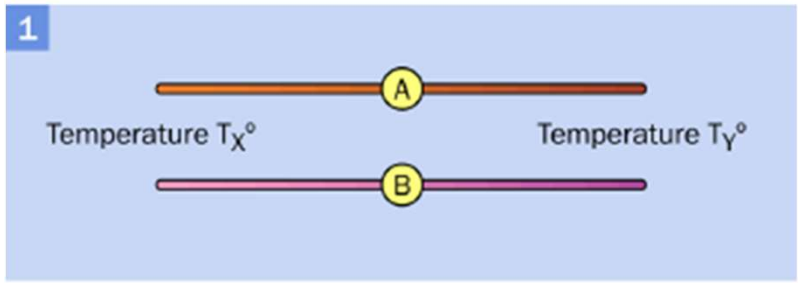


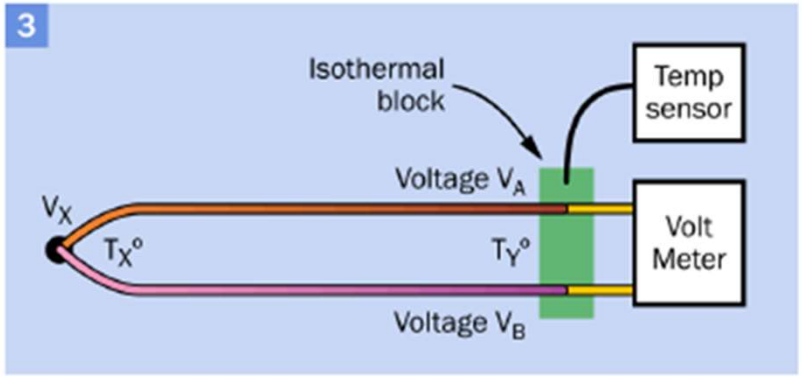


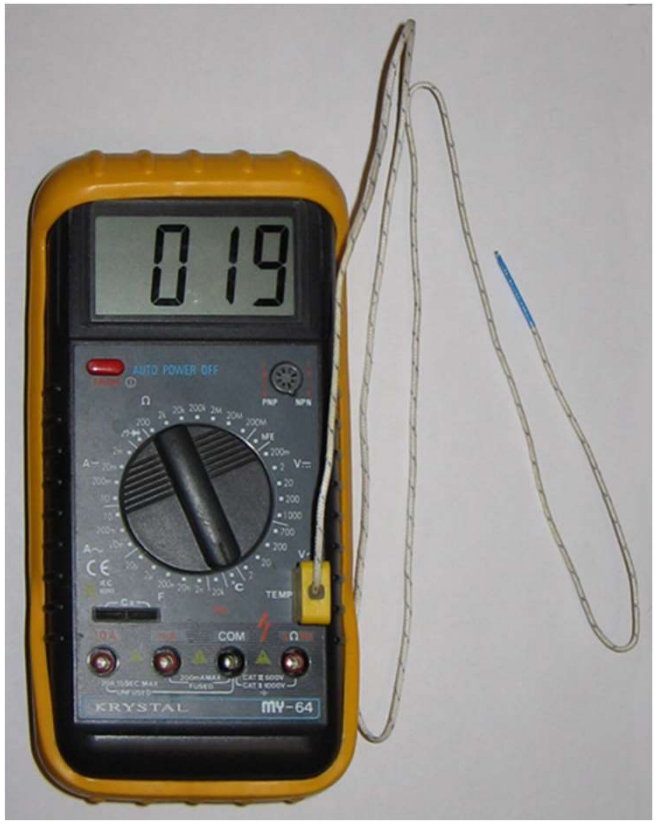




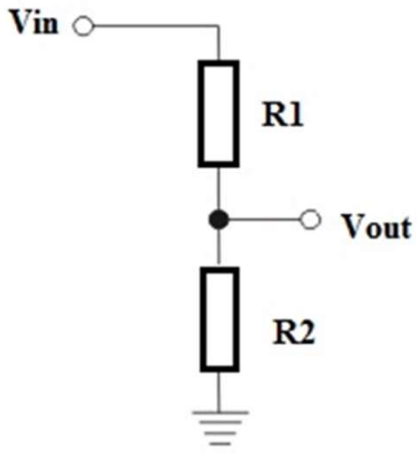
Temp Reading by Thermocouple Method



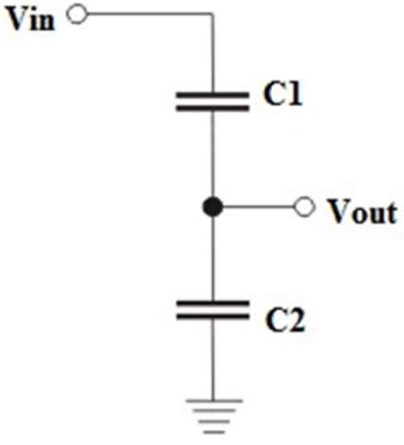




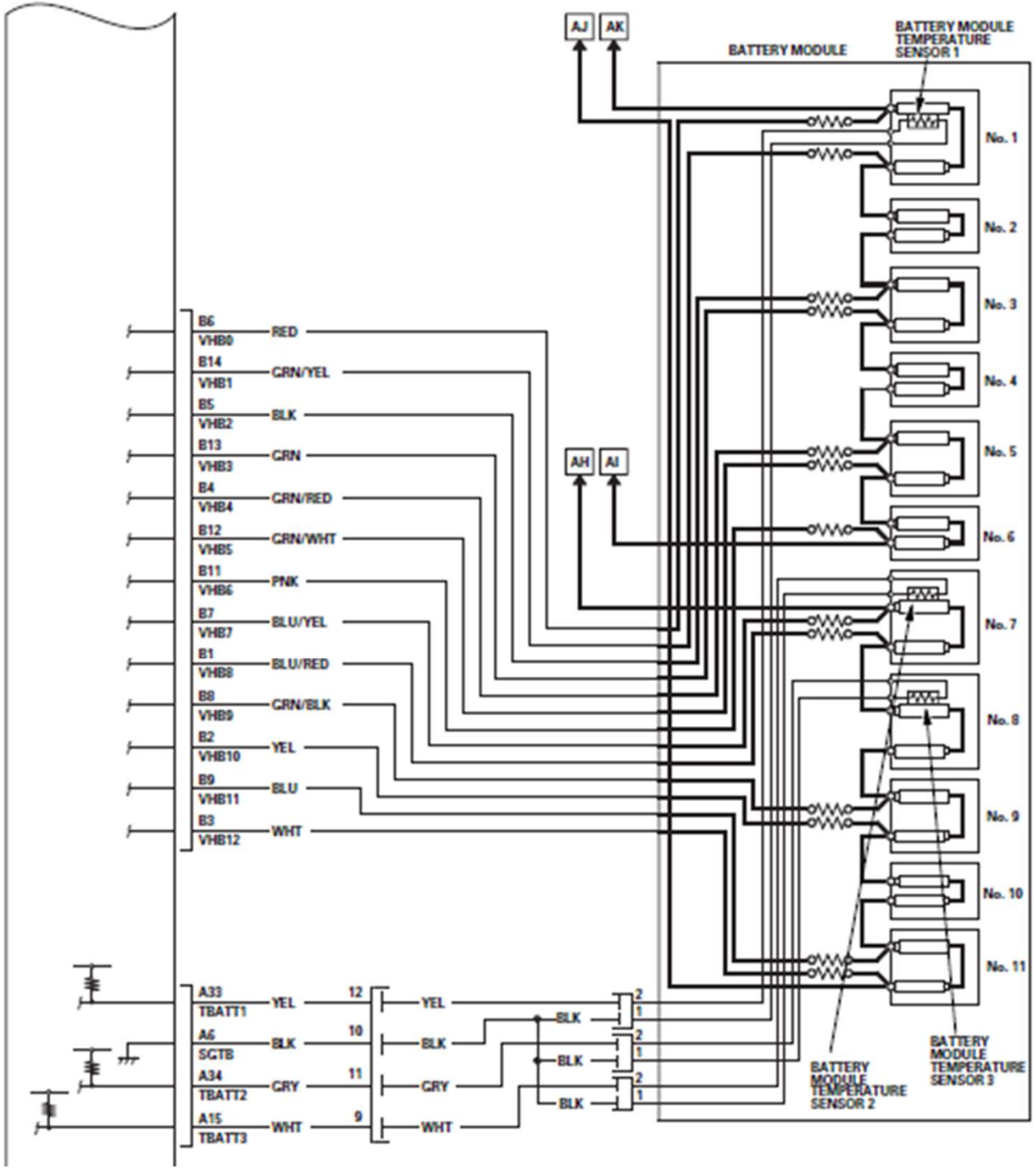
Voltage Measurement of Battery Modules

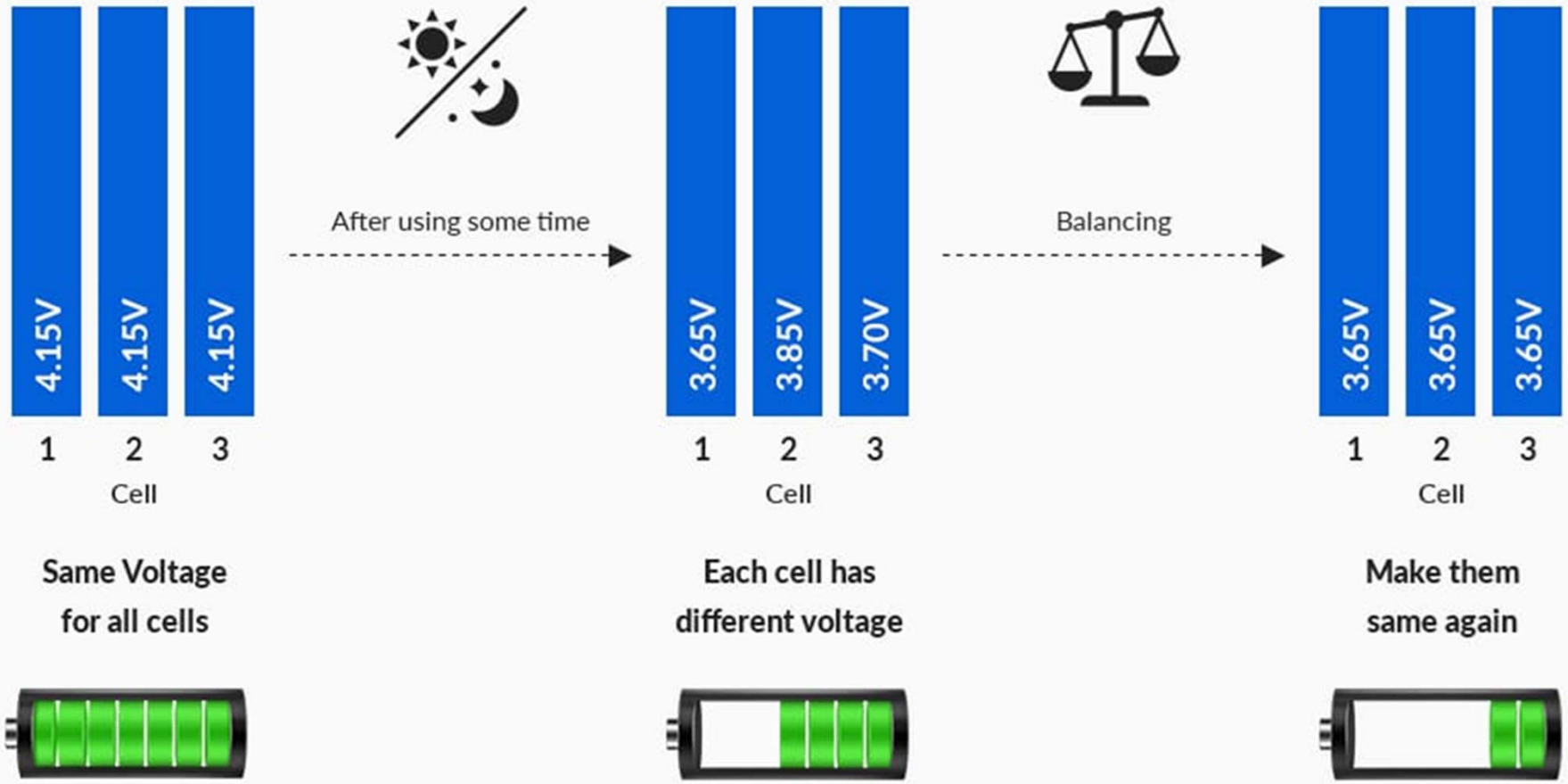


V out = V in × R2/(R1+R2)

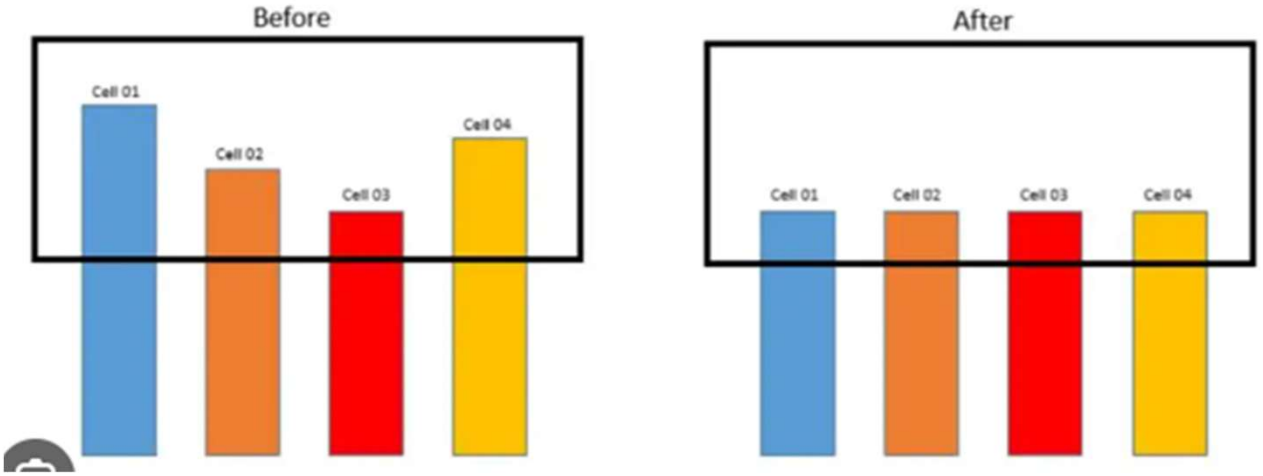


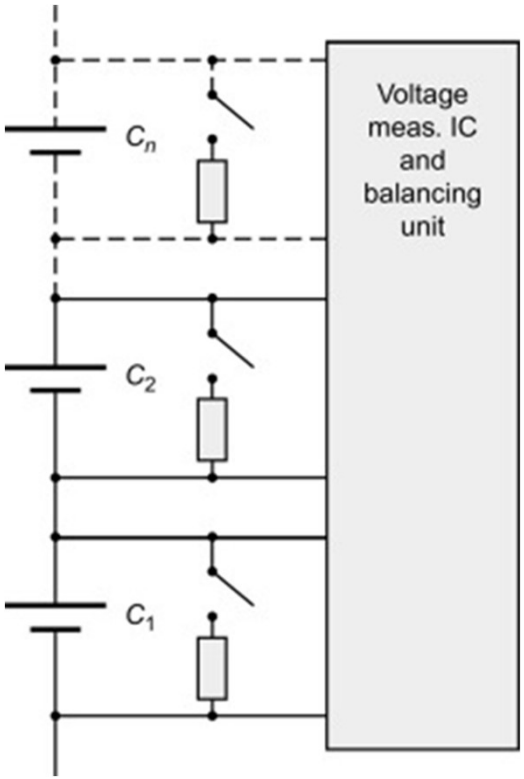
V out = V in × Xc 2/ (Xc1+ Xc2)

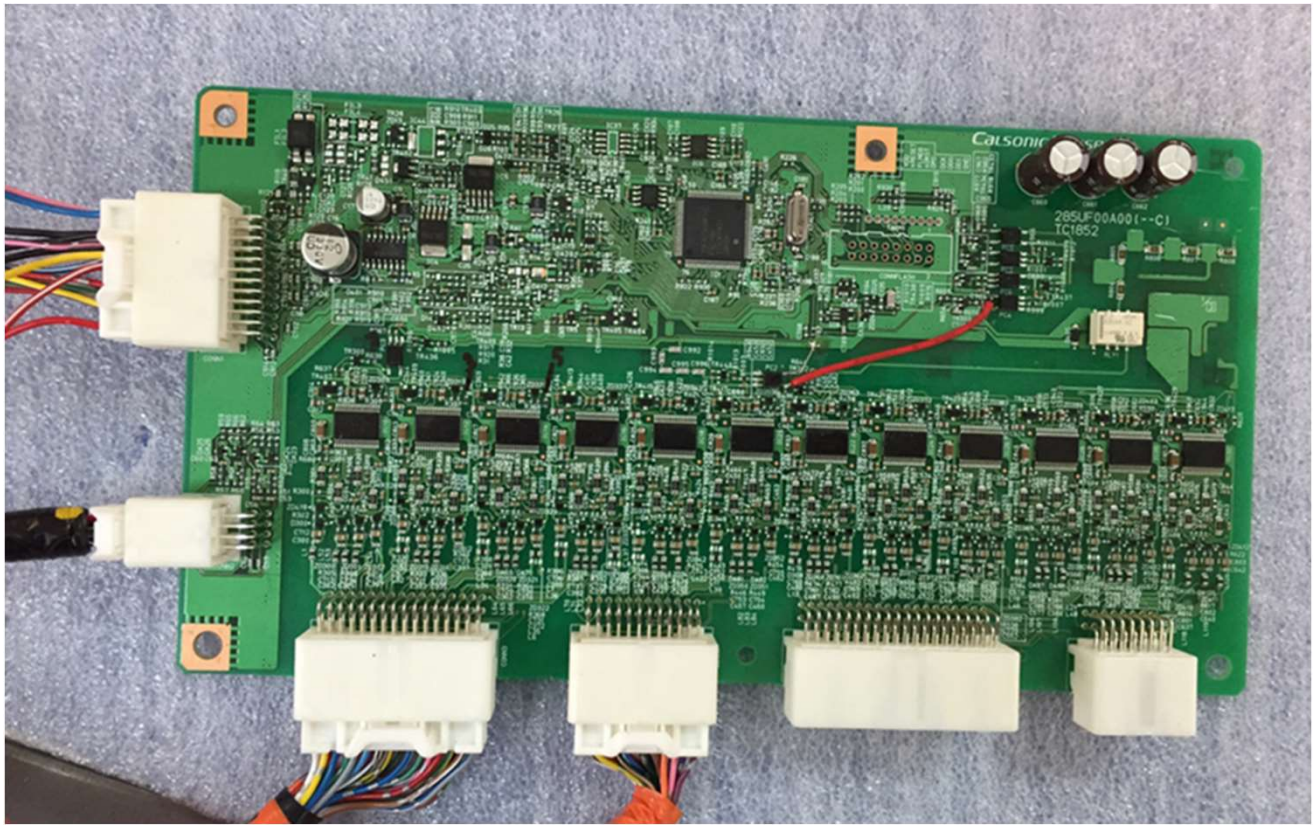


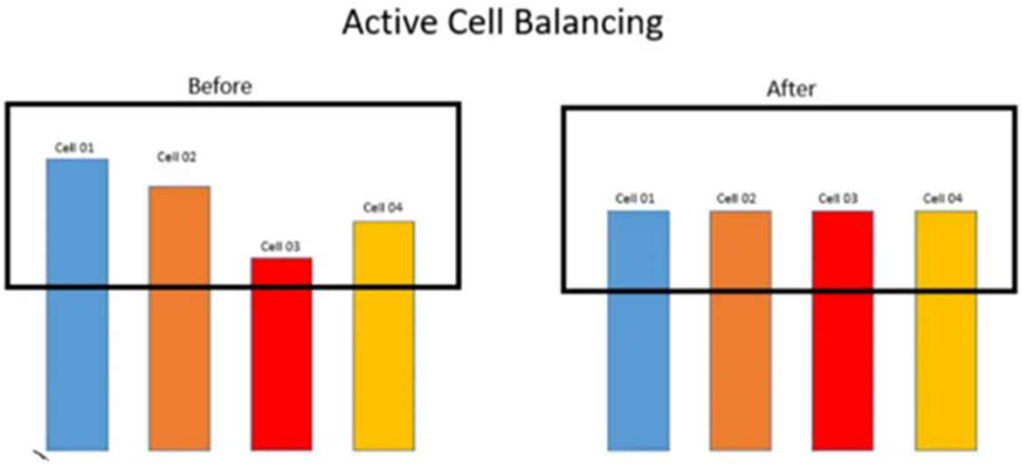

4.15V
4.15V
4.15V
1
2
3
Cell
Same Voltage
for all cells
After using some time
3.65V
3.85V
3.70V
1
2
3
Cell
Each cell has
different voltage
Balancing
3.65V
3.65V
3.65V
1
2
3
Cell
Make them
same again

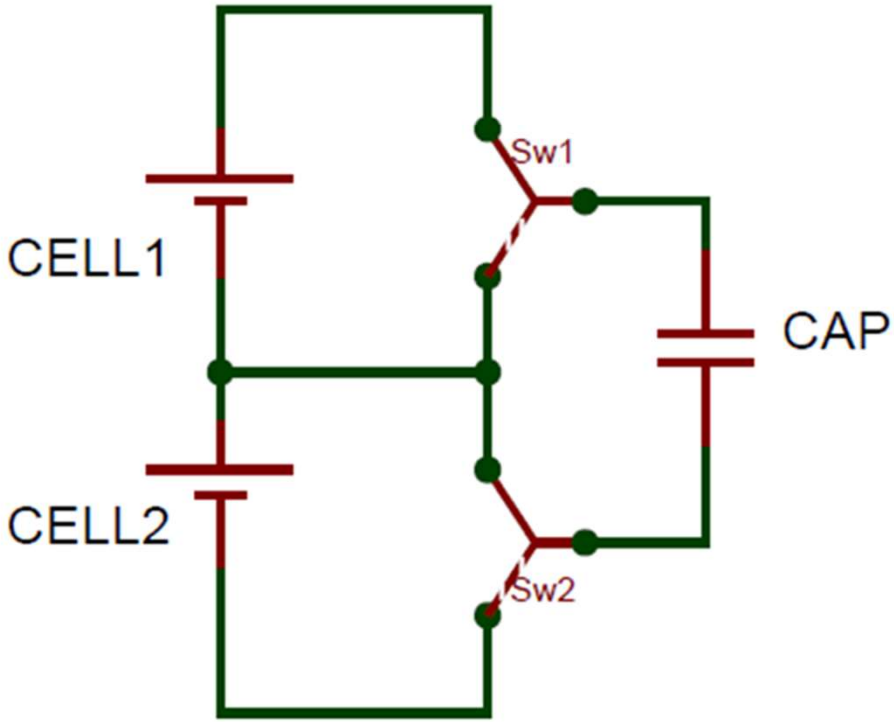
Passive Cell Balancing



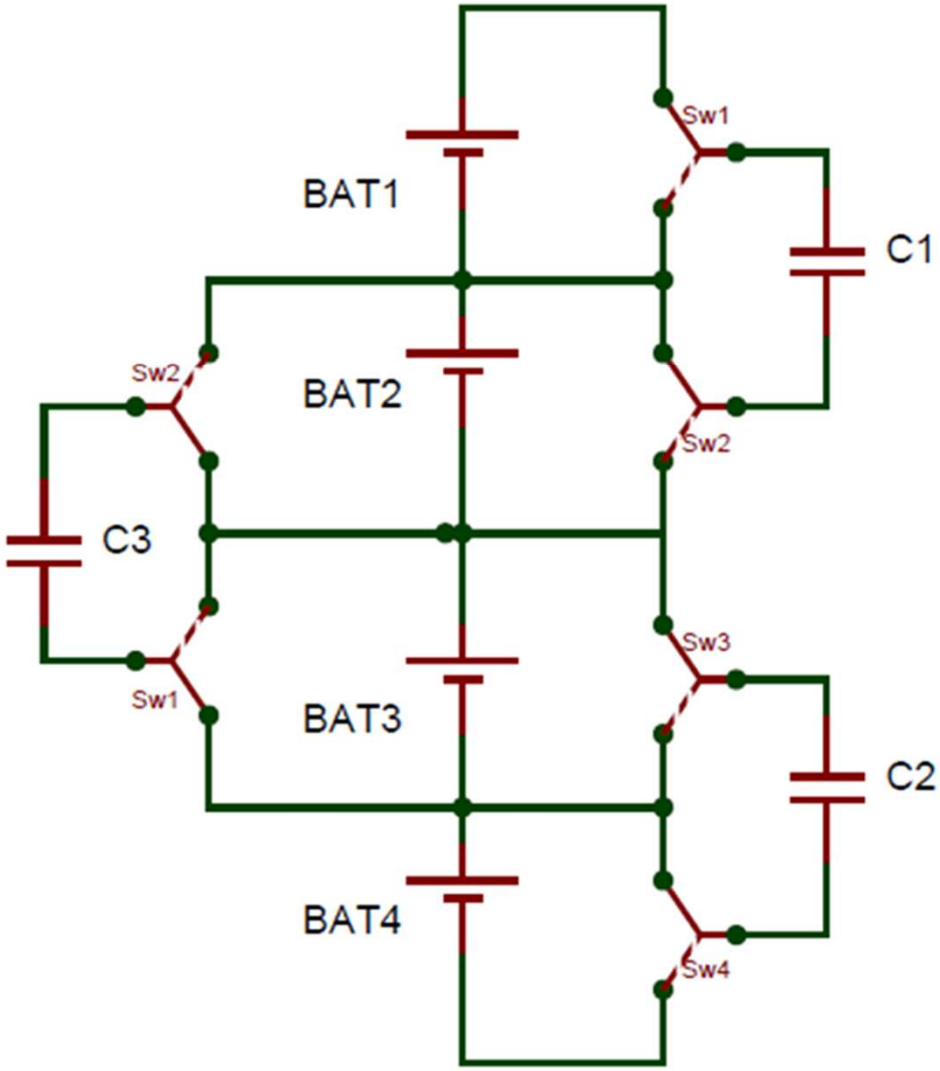








Charge Shuttles - flying capacitor illustration



Charge Shuttles - flying capacitor illustration

In case of fire , use large amount of water (about 100,000 lits)

Used on gaseous fire,
wood, paper, textile fire
flammable liquid
live electrical equipment

Used for flammable liquid and live electrical equipment

Not Used for wood, paper and textile fire and flammable metal fire

ABC Powder Type

Recommended Fire Extinguisher for EV/HEV

CO2 Type

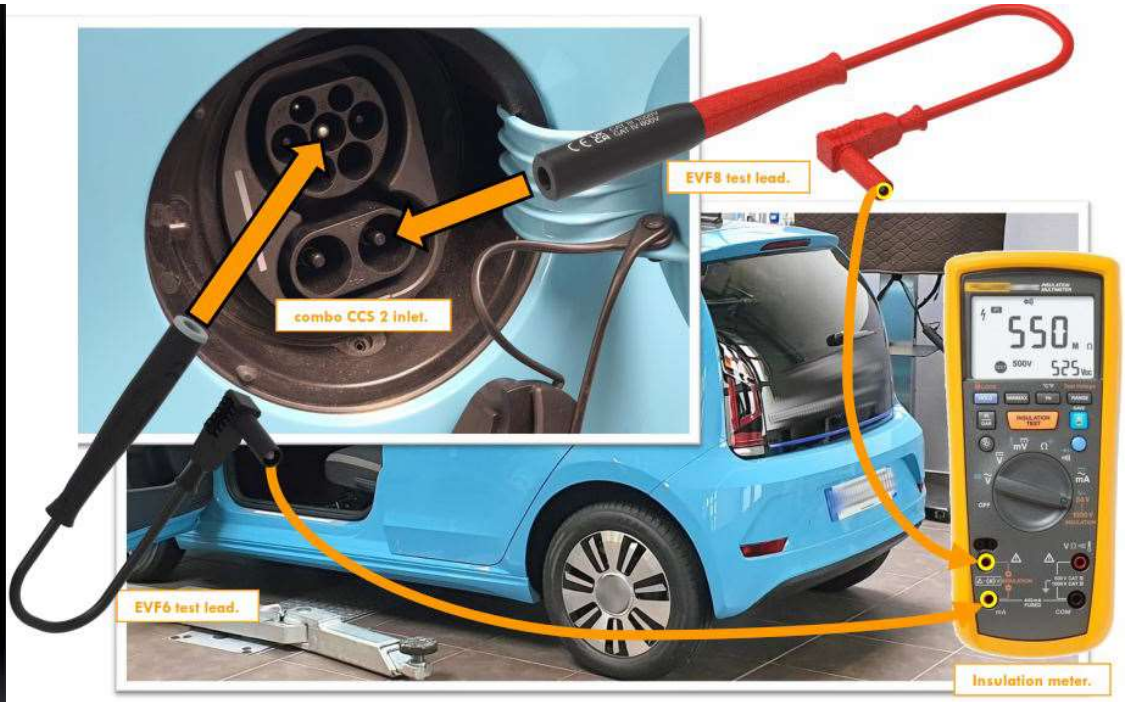

HIOKI
LOCK
EARTH
600V
LINE
MEASURE
PASS COMP
>4000 MΩ
IR 4056 INSULATION TESTER
125V 250V 500V 1000V
50V
V
OFF
Ω
200mA CONTINUITY
HIOKI
LIGHT
0Ω ADJ
COMP
500V/1000V RELEASE


ELECTRICAL SAFETY
TRAINING


DANGER/POISON
DANGER/POISON


LOCK
ACC
ON
START


The best of safety and comfort
for electrical operations


EVF8 test lead.
combo CCS 2 inlet.
EVF6 test lead.
550
525
Insulation meter.