Second Life EV Batteries

Lesson 3: Second-Life Battery management, maintenance and safety

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In this video you will learn:

- SLB specification
  - SLB monitoring, control and communications architecture
    - SLB safety functionalities
      - Guidance on SLB maintenance and usability

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Item	Specification
Second-life battery origin	Example: Electric vehicle
Battery chemistry	Example: NMC, LFP…
System scalability	Example: N battery modules/ racks in series and/or parallel
Nominal energy	Example: 40 kWh
Nominal power	Example: 20 kW
Nominal capacity	Example: 200 Ah
Nominal voltage	Example: 200 V
Operating DC voltage range	Example: 160-240 V
Maximum current	Example: 300 A
Roundtrip efficiency	Example: 96 %
Response time	Example: 0.5-1.2 s
Maximum depth of discharge (DoD)	Example: 80 %
Cycle life (80% DoD, 25ºC)	Example: 2.500 cycles
Calendar life (50% SOC, 25ºC)	Example: 5 years
Dimensions	Example: 1.900×760×420 mm
Weight	Example: 540 kg
Operating temperature range	Example: 10-45 ºC
Maximum relative humidity	Example: 95 %
IP protection degree	Example: IP 54
Fire detection	Example: Smoke and heat sensor and sprinkled water fire suppression system
Protections	Example: Overcurrent, isolation monitoring, overvoltage, overtemperature
Cooling system type	Example: Forced air cooling
Control & monitoring	Example: HMI with local and remote access,
Communications	Example: TCP/IP, Modbus, CAN bus, RS-485
System warranty	Example: 2.000 cycles or 10% SOH by 3 years
Standards and regulations	Example: EMC: IEC 61000-2, IEC 61000-6 Safety: UN 38.3, IEC 62619 CE marking

SLB specification

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· Electrical specifications for adequate grid and/or renewable energy system coupling.

· Environmental parameters to be checked.

· Protection systems for enhanced safety.

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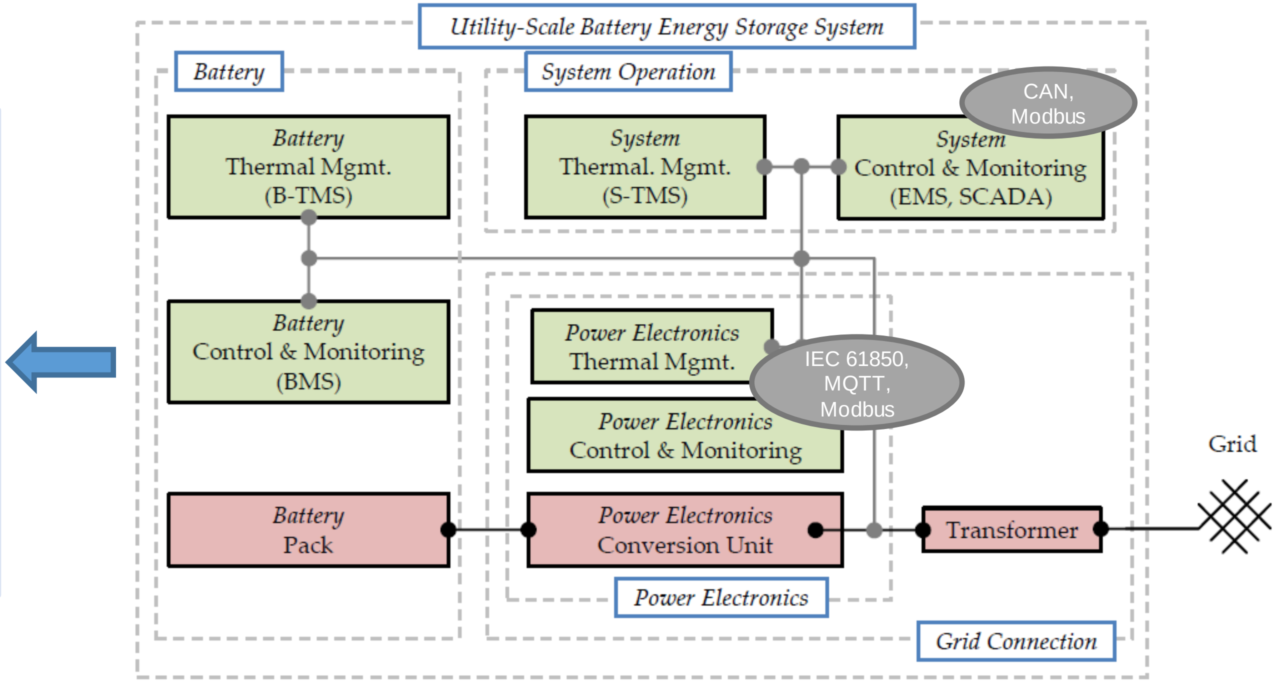
· System warranty is crucial to ensure extended second-life.

· Standard compliance ensures product quality.

SLB monitoring, control and communications architecture

Goal: maintaining system efficiency and safety at every time.

- **Cell level:** ideally, single cell voltage and temperature.
- **Module level:** voltage, current, min and max cell voltages for SOH and SOC estimation.
- **Pack level:** voltage and current.



Functional monitoring and control systems and interaction with ESS elements (Hesse et al., 2017).

SLB safety functionalities

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Thermal safety

Layer 1 (preventive system):

· Based on status monitoring and BMS-TMS interaction.

· The TMS dissipates heat using different fluids and a set of logics that manipulate temperature setpoints and/or fluid flow rates.

· Two main categories: air cooling (HVAC) and liquid cooling (hydraulic circuit).

Layer 2 (corrective system):

· Based on a fire supression system, different sensors that detect heat and/or fog, alarm devices that extinguish the fire event.

· The sensors are also connected to the BMS.

· Fire suppression systems are based on water or other chemicals.

SLB safety functionalities

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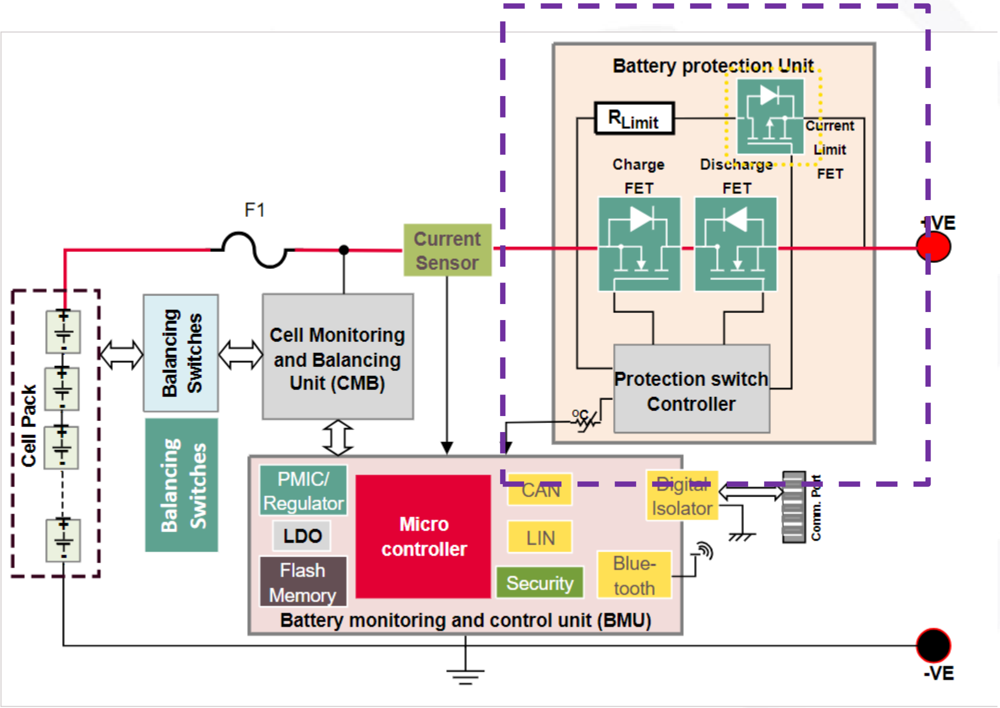
Electrical safety

· Different **electrical hazardous events** need to be avoided: overcurrent, overcharge, overdischarge or reverse polarity, among others.
· For that, **electrical protections** like fuses, disconnection switches, isolation meters are installed.
· These are usually **centralized in the Battery Protection Unit (BPU).**



Simplified BPU layout (Infineon, 2019).

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Guidance on SLB maintenance and usability (I)

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Battery maintenance is a key performance in order to preserve a minimal loss of energy yield while avoiding premature degradation or damage.

Three main **maintenance types** (Arrinda et al., 2021):

- **Corrective maintenance:** based on periodical system element repairs are done when significant damage is caused to the battery. *The simplest*.
- **Preventive maintenance:** it consists of diagnosing the actual state of the battery and acting once some damage thresholds are overcome (but not critical).
  The most common nowadays.
- **Predictive maintenance:** it consists of predicting failure before any real damage is inflicted by using recorded data that are recurrently analyzed using aging models and prognosis algorithms. *The optimal.*

Guidance on SLB maintenance and usability (II)

Good practices for SLB maintenance:

- Module accessibility.
- Advanced monitoring functionality implementation.
- Consider the environmental characteristics of the deployment site. In particular, regarding dust, vegetation, humidity, corrosion, temperature and solar exposure.
- Check battery datasheet and select the location to the environmental features.
- Limit the accessibility to the battery (theft, vandalism or children).
- Avoid exposing battery to excessive shock or vibration.

Guidance on SLB maintenance and usability (III)

Good practices for SLB usability:

- Modularity by design allows for easy system upgrading.
- High environmental degrees preferred.
- Avoid battery overheating due to solar exposure and, if posible, include a thermal management system.
- Avoid deep and fast cycling to extend battery lifetime.
- Easy installation is preferred for non-technical users.
- Incorporated inverter solutions ease compatibility issues in terms of electrical and communications coupling.

Additional References

- Hesse, H.C., Schimpe, M., Kucevic, D., Jossen, A., 2017. Lithium-Ion Battery Storage for the Grid—A Review of Stationary Battery Storage System Design Tailored for Applications in Modern Power Grids. Energies 10, 2107. https://doi.org/10.3390/en10122107
- https://www.infineon.com/cms/en/applications/solutions/battery-management-system/industrial-and-consumer-bms/battery-protection/
- Arrinda, M., Sánchez, D., Oyarbide, M., Macicior, H., Zubiria, A., 2022. Development of the State of Warranty (SOW) for Electric Vehicles. World Electr. Veh. J. 13, 135. https://doi.org/10.3390/wevj13080135

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