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LIBERTY NEWS

this issue

LIBERTY
LIGHTWEIGHT BATTERY SYSTEM
FOR EXTENDED RANGE AT IMPROVED SAFETY

Lightweight Battery System for Extended Range at Improved Safety

About

The LIBERTY project consortium is developing automotive batteries for the future.

Our work started in January with the kick-off of this promising and challenging EU research project.

The LIBERTY project will develop a battery that provides a vehicle with a range of up to 500 km, with ultra-fast charging capability, coupled with an expected lifespan similar to that of a combustion engine-powered vehicle.

The project has a budget of ~11 million euros over 3 ½ years and is a strategic project for the electromobility sector funded by the European Commission's Horizon 2020 programme and the participating industry.

LIBERTY Project – an insight in the technical work

Requirements. design criteria of the battery system and test plan

Led by MERCEDES-BENZ AG

The main objective of this work package is to define requirements which ensure that the project goals for the battery system are met. In a multi-partner and multi-disciplinary project, it is important to keep record of the requirements and boundary conditions to facilitate a seamless integration of all the different components. Therefore, this work package also serves as a platform for discussion and exchange between different stakeholders and also to maintain the focus on the defined targets during the whole development process.

What we have achieved

Higher-level design guidelines were developed in order to achieve the partly competing technical goals in the project (e.g. energy density versus safety). For this purpose, the dependencies of the individual properties were worked out. The system requirements were collected, evaluated and consolidated. As a result, the E/E architecture was defined and the requirements for the corresponding components were allocated.

The test plan was defined with respect to the requirements, this to achieve full test coverage and validation of the requirements.

What comes next

In the next step, based on the developments in the other work packages, the requirements will be reviewed and, if necessary, sharpened or supplemented.

Battery system conceptual design

Led by Brussels Research and Innovation Center for Green Technologies

This work package is looking forward to providing a battery system design to meet the following objectives:

- Decreasing the vehicle weight by 20 %, optimal TCO and meeting the crashworthiness requirements.
- Having the fast-charging ability of up to 350 kW while increasing the system voltage from 400 to 800 Volts.
- Considering the safety aspects to limit the potential thermal runaway considering the high insulation.

What we have achieved

Based on the needs of the project considering safety, fast charging, voltage and durability aspects the cell chemistry is selected. In the second phase, different battery system configurations were analysed considering space design and requirements from WP1. Based on the available space, a feasibility study for the battery pack design was provided considering weight reduction, optimal TCO and eco-design requirements. In these scenarios, various space designs with different components such as a thermal fuse, cooling plates, busbars, cell spacers and cell holders were considered. A first CAD design of cell to pack approach was developed including designed cost-effective cell spacers and cell holders to facilitate the assembly and dismantling process.

Maybe you have met us @ ECOMONDO

The Green Technology Expo, 8 November, Rimini, Italy

Our project coordinator Egoitz Martinez-Laserna presented LIBERTY innovations towards electric vehicle sustainability and 2nd life at the CINE EU Stand.

LIBERTY @ H2020 Batteries Projects clustering event 17-18 November 2021, remotely

Our project coordinator Egoitz Martinez-Laserna will be the leader of the Battery Management System Discussion Group, partners from Fraunhofer and Flanders Make will give support.

Battery Innovation Days 23-25 November 2021 @ our own virtual booth!

Our project coordinator Egoitz Martinez-Laserna took the opportunity and shared and discussed our vision of upgrading EV battery performance, safety and lifetime from a lifecycle and sustainability point of view.

Finally, based on the comprehensive previous steps involving the partners, the battery system simulation platform focusing on the cell configuration, safety, durability, fault detection and data availability for the second life of the battery was developed. Figure 1 shows the steps of WP2:

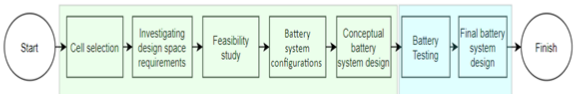

Figure 1: Steps of WP Battery system design

What comes next

In the next steps, the battery cell characterisation will be performed based on their electrical, thermal, mechanical, and thermal runaway parameters. Then, the final optimal battery system design will be provided based on the developments in other WPs in the project.

Battery system hardware component development

Led by Valeo Systemes Thermiques SAS

The main objective of this work package is the development and production of the hardware components for the battery system. The components are designed to fulfil all the requirements and provide specific advantages in relation to current state-of-the-art of battery packs. In this sense, the components include a lightweight battery casing, an optimised thermal management system including safety function, the high-voltage electrical subsystem and a solid-state battery switch to ensure reliability of the whole battery pack. All the components take into account range increase, fast charging, safety and recyclability for the development.

What we have achieved

The activity in this work package started in month 4. From that time, the highest effort from the different partners involved has been centered in interaction analysis between components. Integration of all these components is a key issue to achieve a cell-to-pack battery system design with the highest energy density. Fast charging conditions impose a challenge for thermal conditioning of the cells. In this project, a direct liquid cooling method is proposed where the cells are partially immersed in dielectric fluid. This system must ensure compatibility with the lightweight housing produced with innovative materials and with a safety system that is located in group of cells to prevent fire propagation. Moreover, the high voltage used for the battery, up to 800 V, implies a specific design for the electrical subsystem. A pressure sensor will also be installed in the battery pack and the battery main switch will be produced according to a revised concept. All the components must be packaged efficiently, with the specific physical means for cell supporting. The activities done so far has enabled to settle the basis for co-design activities to ensure the proper integration.

What comes next

The next milestone is to freeze the design to start production of the different demonstrators. For that, co-design activities will be running in the following months. There will also be intermediate actions for validation of the concepts used in the different components. The design freeze of validated concepts will lead to production and further integration in the battery pack.

Battery management system and state estimator development

Lead by Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V.

The main objective of this work package is the development of a flexible battery management system (BMS) with the focus on the realization of the overall project targets (range improvement, short charging time). In addition, novel AI-based state estimators (State-of-Health, State-of-Safety, State-of-Charge, State-of-Function) will be developed.

The BMS implementation and testing will first be performed in a lab environment before all components will be validated in the full-electric demonstrator vehicle.

The following activities are covered within this work package:

- The definition of the Battery Management System (BMS), where the high-level requirements are brought to component level for electronics, functionality and interfaces
- The development of improved battery state estimators
  - Improved state of safety estimation algorithms
  - Improved battery state estimators, based on adaptive and predictive techniques, such as neural networks and artificial intelligence
- The development of the Battery Management System (BMS) hardware (HW) and software (SW)
  - Data logging and mining to support HW and SW BMS improvements
  - BMS software capabilities for remote maintenance and troubleshooting
  - BMS master hardware development for multi-domain applications
  - BMS slave development incl. definition of components for measurements (e.g., cell voltage, cell temperature)
- The assembly and testing of all BMS-related components

What we have achieved

The overall system requirements from WP1 have been analysed in WP4 and a comprehensive subset of relevant requirements has been identified. The definition of the Battery Management System (BMS) has been worked out for electronics, functions and interfaces between the BMS and other components in the vehicle.

The BMS-Master will be based on a Texas Instruments TMS570-family microcontroller, which is a safety controller in the automotive domain as well as in aviation applications. Various communication interfaces and components (e.g. non-volatile data storage) are added, meant to be used during BMS and state estimation algorithm execution. For a better overview, Figure 2 shows a block diagram of the BMS-Master. The BMS software architecture is focused on diagnostics and safety as depicted in Figure 3.

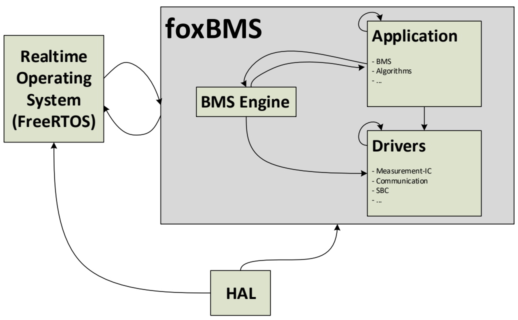

Figure 3: foxBMS 2 – Software architecture

A hardware abstraction layer (HAL) provides various interfaces to directly access the hardware and its peripherals. The HAL is a third-party product (provided by the manufacturer of the MCU) and is therefore not part of the actual foxBMS software.

The open-source real-time operating system FreeRTOS is the centrepiece of the software architecture. Its reliable kernel is ideally suited to ensure the compliance of all soft and hard real-time requirements of a battery-management system. Like the HAL, the FreeRTOS is a third-party product and therefore not part of the actual foxBMS software.

The foxBMS software itself is grouped into three different layers:

- A dedicated driver layer using the HAL interface providing different communication interfaces.
- Diagnostic functions, error handling and system monitoring are the most important tasks of the BMS Engine.
- The actual BMS implementation including the monitoring of the safety parameters and the state estimation

What comes next

In the next project months, the overall BMS definition will be broken down to the single hardware and software components, such as the BMS-Master and the BMS-Slaves.

The actual development of first hardware prototypes will start. Concurrently, the various state estimators and other algorithms will be developed and configured based on the output of the battery cell characterisation tests.

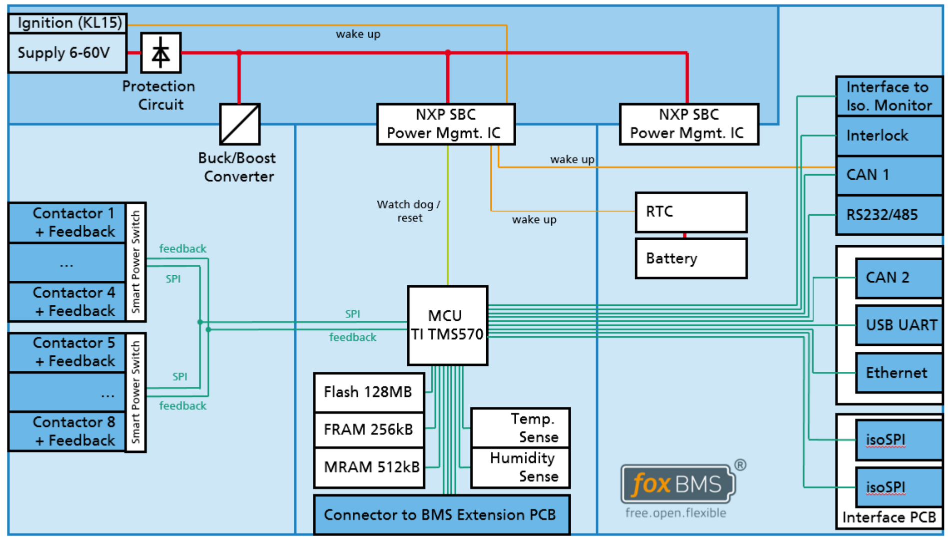

Figure 2: Block diagram of the BMS Master

Development of advanced test procedures for safety and performance

Led by VIRTUAL VEHICLE Research GmbH

The main objective of this work package is the development of advanced testing procedures for battery systems. This includes the following disciplines:

- Performance testing (life, electrical-thermal) under severe operating conditions (load cycles, climate conditions) taking high power fast charging and cost effectiveness into account
- Battery safety testing (crashworthiness, thermal runaway and functional safety) beyond standard operating conditions

This should result into a joint proposal for advanced test procedures in collaboration with other projects from this call. The proposal could be the future basis for new testing regulations and standards in these fields.

What we have achieved

To support the accelerated life testing, a cell model is already available. It will be extended up to battery system level and will be updated with the planned aging tests. The physical thermal runaway simulator will be improved in the fields of alternative heater materials, mechanic and electrical design and integrability (e.g.: power cables and sensors).

A common stack design – including cooling, (active) safety spacers and casing – for thermal and thermal runaway testing will be developed. This leads to a simplification of the transferability of results between the disciplines and enables the reuse of cell stacks. Namely, non-destructive thermal tested cell stacks can be reused for destructive thermal runaway testing. Cells and stack components can be spared to realize a sustainable use of resources.

Concerning functional safety test procedures on BMS level related requirements and test plans are currently reviewed and analysed.

What comes next

- Cell characterisation tests on aging will be started on cell level.
- The common stack design will be finalized.
- Thermal runaway tests on cell level as a basis for the physical thermal runaway simulator will be performed.
- BMS safety test procedures will be classified according to HW and SW.

Integration, testing and concept validation on cell, cell stack, battery system and EV level

Led by Flanders Make

The objective of this WP is the integration, testing and validation of the developed battery system. This contains the validation of the performance and safety requirements, validation of the developed test procedures and the demonstration.

This WP contains several challenges such as the assembly of the battery system, the testing activities on cell and battery system level and the seamless integration in the electric vehicle. Since the results from this WP serve as input for other WPs and tasks, it is thereby critical that these results are obtained on time.

How to find out more about LIBERTY project:

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What we have achieved

The main activities since the start of this WP are the practical alignment between the testing partners (e.g. datalogging) and the cell preparation (e.g. connection of the cells to the test equipment). Both activities ensure that the test execution will be coherent between all partners and that the results are reusable in other tasks in an easy manner.

What comes next

The next steps in this WP are the characterisation and ageing tests of the cells. The objective of the characterisation tests is to evaluate the electrical and thermal behavior of the cells, together with the cell properties (for example the electrical performance at different temperatures, internal resistance…). This information will be used among others for the BMS software development and for optimising the simulation model of the battery system.

The ageing tests on the other hand will be performed to evaluate the lifetime expectation of the battery system under the load conditions expected in the target EV.

Overall techno-economic assessment, recycling and LCA

Led by Accurec Recycling GmbH

The objective of this work package is to estimate the environmental impact of the LIBERTY battery pack. From the design of battery pack to selection of materials then to the end-of-life treatment. The carbon footprint in each life cycle step is evaluated. Additionally, a new recycling process will be designed, including a semi-automated dismantling process and lithium recovery. In the end, the total cost of ownership of the LIBERTY battery pack will be evaluated.

What we have achieved

Mondragon University (MON) is currently building the life-cycle-assessment model and collect state-of-the-art data from partners and literatures. MON has defined potential circular design criteria for the LIBERTY pack development by relying on the information gathered through a questionnaire filled by the project partners based on their expertise and involvement in the development of the different battery components. MON has built and shared a preliminary life cycle inventory datasheet to start gathering data for the LCIA of the LIBERTY battery pack. Currently, MON is building a preliminary LCA of different benchmark batteries.

Accurec is analyzing the state-of-the-art battery dismantling and recycling technology. Several battery packs in Accurec's production were dismantled manually. The working efforts, safety risks as well as dismantled components in each dismantling step were investigated. The possible improvements of the battery pack design for recycling were discussed.

What comes next

MON will, based on the preliminary results from the benchmark batteries and the LIBERTY battery pack concept, identify environmental hotspots and propose alternatives to the partners for the circular and environmentally sustainable battery design. This will be a useful exercise for the upcoming LCI data collection processes to perform the comprehensive LCA of the LIBERTY battery. Then, Accurec will recommend battery disassembly and recycling to the partner in the design of the battery pack. Different aspects of the battery pack during recycling will be discussed. For example, the state of charge control of the battery pack, the sealing technology, insulation technology at different level, battery management system control. In the end, how to improve these aspects during the design of the battery pack will be discussed with other partners.

PROJECT FACTS

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Start: 01 January 2021

Duration: 42 Months

Total investment: 10.8 M€

Participating organisations: 16

Number of countries: 7

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