IEC PAS 62840-3

Edition 1.0 2021-09

PUBLICLY AVAILABLE SPECIFICATION

PRE-STANDARD

Electric vehicle battery swap system –
Part 3: Particular safety and interoperability requirements for battery swap systems operating with removable RESS/battery systems

IEC PAS 62840-3:2021-09(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 43.120

ISBN 978-2-8322-1031-6

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTRIC VEHICLE BATTERY SWAP SYSTEM –

Part 3: Particular safety and interoperability requirements for battery swap systems operating with removable RESS/battery systems

FOREWORD

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IEC PAS 62840-3 has been processed by IEC technical committee 69: Electrical power/energy transfer systems for electrically propelled road vehicles industrial trucks.

The text of this PAS is based on the following document:

This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document

Draft PAS	Report on voting
69/749/DPAS	69/772/RVDPAS

Following publication of this PAS, which is a pre-standard publication, the technical committee or subcommittee concerned may transform it into an International Standard.

This PAS shall remain valid for an initial maximum period of 2 years starting from the publication date. The validity may be extended for a single period up to a maximum of 2 years, at the end of which it shall be published as another type of normative document, or shall be withdrawn.

In this document, the following print types are used:

– requirements: in roman type;
– *test specifications: in italic type*;
– notes: in small roman type.

A list of all parts in the IEC 62840 series, published under the general title *Electric vehicle battery swap system,* can be found on the IEC website.

INTRODUCTION

The IEC 62840 series is published in separate parts according to the following structure:

IEC TS 62840-1: Electric vehicle battery swap system – Part 1: General and guidance

IEC 62840-2: Electric vehicle battery swap system – Part 2: Safety requirements

IEC PAS 62840-3: Electric vehicle battery swap system – Part 3: Particular safety and interoperability requirements for battery swap systems operating with removable RESS/battery systems

This document derives from IEC 61851-3 (all parts) and was established by IEC TC 69 WG10 as a referencing document to IEC TS 61851-3-1.

NOTE In this document, EV supply equipment configuration type F according to IEC TS 61851-3-1 for removable battery systems is named "battery swap station".

After moving of the document to IEC TC 69 WG13, IEC TC 69 decided to publish the document as PAS based on IEC TS 61851-3-3 as an intermediate specification, which responds to particular market needs according to 2.4.8 of ISO/IEC Directives, Part 1:2020, published prior to the development of a full International Standard.

For this reason, this document is to be used in conjunction with IEC 61851-3 (all parts).

By the upcoming revision of IEC 62840 (all parts), this document will be fully integrated into the IEC 62840 series.

ELECTRIC VEHICLE BATTERY SWAP SYSTEM –

Part 3: Particular safety and interoperability requirements for battery swap systems operating with removable RESS/battery systems

1 Scope

This document applies to battery swap systems for removable RESS of electric road vehicle when connected to the supply network, with a rated supply voltage up to 480 V AC or up to 400 V DC, for battery systems with a rated voltage up to 120 V DC.

NOTE 1 In the following countries, the acceptable nominal supply voltage is up to 600 V AC: CA, US.

This document applies to battery swap systems for removable RESS/EV where the removable RESS/EV is stored for the purpose of transfer power between the battery swap station and removable RESS/EV.

Requirements for bidirectional energy transfer DC to AC are under consideration and are not part of this document.

This document applies to:

– battery swap systems supplied from on-site storage systems (for example buffer batteries etc);
– manual, mechanically assisted and automatic systems;
– battery swap systems intended to supply removable battery systems having communication allowing to identify the battery system characteristics;
– battery swap systems intended to be installed at an altitude of up to 2 000 m.

The aspects covered in this document include:

– requirements for power transfer between the battery systems;
– additional requirements for communication;
– the connection to supply network.

Additional requirements may apply to special locations.

This document does not apply to:

– safety requirements for mechanical equipment covered by ISO 10218 (all parts);
– locking compartments systems providing AC socket-outlets for the use of manufacturer specific voltage converter units and manufacturer specific battery systems;
– safety aspects related to maintenance;
– electrical devices and components which are covered by their specific product standards;
– trolley buses, rail vehicles;
– any on-board equipment which is covered by ISO;
– EMC requirements for on-board equipment while connected to the supply, which are covered by IEC 61851-21-1.

Requirements for battery swap systems using protective measures as covered by 410 of IEC 60364-4-41:2005 other than double or reinforced insulation are under consideration.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038, *IEC standard voltages*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

IEC TS 61851-3-1:—, *Electric vehicles conductive power supply system – Part 3-1: Particular requirements for EV supply equipment where protection relies on double or reinforced insulation – AC and DC conductive power supply systems*[1]

IEC TS 61851-3-2: —, *Electric vehicles conductive power supply system – Part 3-2 Particular requirements for EV supply equipment where protection relies on double or reinforced insulation – Portable and mobile DRI EV supply equipment*[2]

IEC TS 61851-3-4: —, *Electric vehicles conductive power supply system – Part 3-4 Particular requirements for EV supply equipment where protection relies on double or reinforced insulation – General definitions and requirements for CANopen communication*[3]

IEC TS 61851-3-5: —, *Electric vehicles conductive power supply system – Part 3-5 Particular requirements for EV supply equipment where protection relies on double or reinforced insulation – Pre-defined communication parameters and general application objects*[4]

IEC TS 61851-3-6: —, *Electric vehicles conductive power supply system – Part 3-6: Particular requirements for EV supply equipment where protection relies on double or reinforced insulation – Voltage converter unit communication*[5]

IEC TS 61851-3-7: —, *Electric vehicles conductive power supply system – Part 3-7: Particular requirements for EV supply equipment where protection relies on double or reinforced insulation – Battery system communication*[6]

IEC TS 62196-4:—, *Plugs, socket-outlets, vehicle connectors and vehicles inlet – Conductive charging of electric vehicles – Part 4: Dimensional compatibility and interchangeability requirements for DC pin and contact-tube accessories for class II or class III applications*[7]

IEC TS 62840-1:2016, *Electric vehicle battery swap system – Part 1: General and guidance*

IEC 62840-2:2016, *Electric vehicle battery swap system – Part 2: Safety requirements*

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[1] Under preparation. Stage at the time of publication: IEC ADTS 61851-3-1:2021.

[2] Under preparation. Stage at the time of publication: IEC ADTS 61851-3-2:2021.

[3] Under preparation. Stage at the time of publication: IEC RPUB 61851-3-4:2021.

[4] Under preparation. Stage at the time of publication: IEC RPUB 61851-3-5:2021.

[5] Under preparation. Stage at the time of publication: IEC RPUB 61851-3-6:2021.

[6] Under preparation. Stage at the time of publication: IEC RPUB 61851-3-7:2021.

[7] Under preparation. Stage at the time of publication: IEC BPUB TS 62196-4:2021.

IEC TS 63066:2017, *Low-voltage docking connectors for removable energy storage units*

ISO 10218-1:2011, *Robots and robotic devices – Safety requirements for industrial robots – Part 1: Robots*

ISO 10218-2:2011, *Robots and robotic devices – Safety requirements for industrial robots – Part 2: Robot systems and integration*

ISO 19353:2019, *Safety of machinery – Fire prevention and fire protection*

EN 14470 (all parts), *Fire safety storage cabinets*

EN 50604-1:2016, *Secondary lithium batteries for light EV (electric vehicle) applications – Part 1: General safety requirements and test methods*
EN 50604-1:2016/AMD1:2021

3 Terms and definitions

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
battery swap system
battery swap station and supporting systems

[SOURCE: IEC TS 62840-1:2016, 3.2]

3.2
battery swap station
BSS
facility that provides a removable battery swap service for EVs and client

Note 1 to entry: In the context of this document, BSS is representing the DRI EV supply equipment type F according to IEC TS 61851-3-1.

[SOURCE: IEC TS 62840-1:2016, 3.4 modified – Addition of Note 1]

3.3
supporting system
system which serves the battery swap station

[SOURCE: IEC TS 62840-1:2016, 3.3]

3.4
battery pack
energy storage device that includes cells or cell assemblies normally connected with cell electronics, power supply circuits and overcurrent shut-off device, including electrical interconnections, interfaces for external systems

Note 1 to entry: See Clause A.2 of ISO 12405-4:2018 for further explanations.

Note 2 to entry: Examples of external systems are cooling, voltage class B, auxiliary voltage class A and communication

[SOURCE: ISO 12405-4:2018, 3.2]

3.5
battery swap equipment
swap equipment
equipment used for mounting/unmounting removable battery system to/from EVs

Note 1 to entry: The battery transferring function may be integrated in the battery swap equipment

[SOURCE: IEC TS 62840-1:2016, 3.13, modified – SBS is replaced by removable battery system.]

3.6
handling system
equipment that provides the function of moving, positioning or otherwise manipulating removable battery systems

Note 1 to entry: Handling system could be a part of BSS or external to the BSS.

3.7
battery control unit
BCU
electronic device that controls, manages, detects or calculates electric and thermal functions of the battery system and that provides communication between the battery system and other vehicle controllers

Note 1 to entry: See also Annex A for further explanation.

[SOURCE: ISO 12405-4:2018, 3.1]

3.8
battery management system
BMS
local energy management system (EMS unit) for the battery system, protecting the battery system from damage, monitoring and increasing the lifetime, and maintaining the functional state

Note 1 to entry: BMS and BCU (according to ISO 12405 all parts) do not have the same functions.

[SOURCE: IEC TS 61851-3-4, 3.7]

3.9
removable battery system
removable RESS
RBS
battery system/RESS that can be moved/removed from an EV by hand (portable RESS) or with the assistance of an installation/device (mobile RESS)

3.10
RESS coupler
means enabling the connection of RESS to an EV or a DRI EV supply equipment

3.11
double or reinforced insulated EV supply equipment
DRI EV supply equipment
EV supply equipment in which protection against electric shock relies on double insulation or reinforced insulation, there being no provision for protective earthing or reliance upon installation conditions

[SOURCE: IEC TS 61851-3-1:—, 3.1.1]

3.12
EV supply system
complete system including the DRI EV supply equipment and the EV/RESS functions that are required to transfer power between the fixed installation or supply network and the EV/RESS

[SOURCE: IEC TS 61851-3-1:—, 3.1.2]

3.13
charging
all functions necessary to condition voltage and/or current provided by the AC or DC supply network to assure the supply of electric energy to the RESS

[SOURCE: IEC 61851-1:2017, 3.1.8]

3.14
voltage converter
set of equipment to convert one type of electric current to another type different in nature, voltage and/or frequency

[SOURCE: IEC 60050-811:2017, 811-19-01, modified – The word "voltage" has been added to the term, and the words "static or rotating" has been deleted from the definition.]

3.15
voltage converter unit
VCU
voltage converter with local EMS and communication interface

[SOURCE: IEC TS 61851-3-1:—, 3.1.8]

3.16
DC power circuit
circuit for DC conductive power transfer

[SOURCE: IEC TS 61851-3-1:—, 3.1.11]

3.17
gateway
functional unit that connects two networks with different network architectures and protocols

[SOURCE: IEC 60050-732:1998, 732-01-17, modified – The words "computer networks" has been replaced by "networks" in the definition, and Note 1 and 2 have been deleted.]

3.18
energy management system
EMS
system consisting of active and passive devices for controlling the power transfer

[SOURCE: IEC TS 61851-3-1:—, 3.3.3]

3.19
active device
device connected to DC power circuit, AUX circuit and CAN circuit

[SOURCE: IEC TS 61851-3-1:—, 3.3.4]

3.20
passive device
device connected to AUX circuit and CAN circuit

[SOURCE: IEC TS 61851-3-1:—, 3.3.5]

3.21
energy management system controller
EMSC
device or virtual device that manages the communication as well as the energy exchange

[SOURCE: IEC TS 61851-3-4:—, 3.9]

4 Abbreviated terms

BCU	battery control unit
BMS	battery management system
BSS	battery swap station
EMSC	energy management system controller
EMS	energy management system
HMI	human machine interface
SOC	state of charge
SOH	state of health
VCU	voltage converter unit

5 General requirements

The battery swap system for removable battery systems described in this document allows simultaneous connection of removable battery systems to the BSS independent of their state of charge (SOC), state of health (SOH), chemistry and performance.

EV supply system configuration type F according to 6.7 of IEC TS 61851-3-1:— is considered to be stationary equipment according to a) of 6.6 of IEC TS 61851-3-1:— (see also 7.2.1).

The BSS shall be rated for one or a range of standard nominal voltages as given in IEC 60038.

NOTE 1 In the following countries, standard nominal voltages are given in CAN3-C235-83: CA.

For extreme environment or other special service conditions, see IEC 61439-7:2018.

Unless otherwise specified, the tests shall be carried out in a draught-free location and at an ambient temperature of 20°C ± 5°C.

For robots and robotic devices and their integration into the BSS, a hazard identification and risk assessment shall be provided according to Clause 4 of ISO 10218-1:2011 or ISO 10218-2:2011 and under consideration of Annex A and Annex F of ISO 10218-1:2011 or Annex A and Annex G of ISO 10218-2:2011 depending on the application.

NOTE 2 For BSS with more than one robot systems implemented in the same application, ISO 10218-2 is applicable.

Additional attention regarding hazards of fire shall be given by the risk assessment considering ISO 19353:2019.

All tests indicated in this document are type tests unless otherwise mentioned.

Unless otherwise specified, all tests shall be carried out in the order of the clauses and subclauses in this document.

6 Classification

Clause 6 of IEC TS 61851-3-1:— is applicable except as follows.

Additional paragraph:

6.8 Automation level

Automation levels of the BSS are classified as follows:

– full automatic;
– semi-automatic;
– manual.

7 Requirements for battery swap system

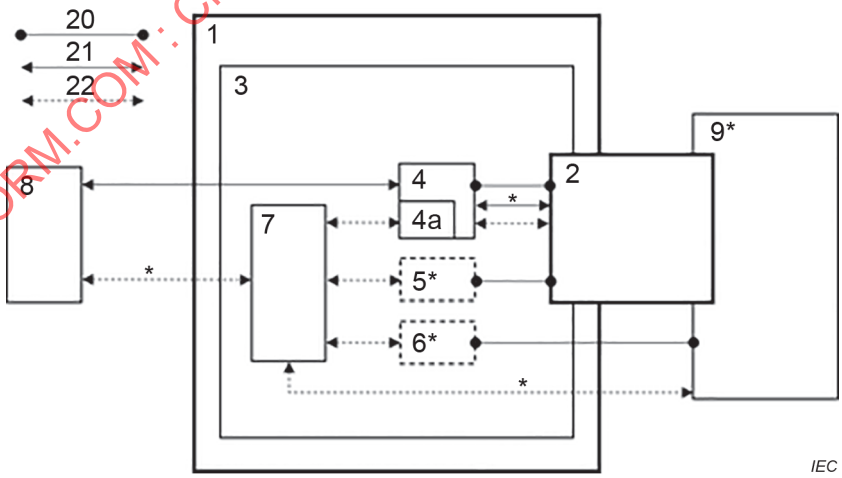
7.1 General

A battery swap system as covered by IEC 62840 (all parts) consists of:

– battery swap station (BSS), 7.2;
– supporting systems (optional), 7.3;
– removable battery systems, 7.4;
– power supply system (optional), 7.5.

Figure 1 shows the composition of the battery swap system as defined in this document and the relationships between the various systems.

NOTE Figure 1 in this document is different from Figure 1 of IEC TS 62840-1:2016.



Key	
1	battery swap system
2	removable battery system (7.4)
3	battery swap station (7.2)
4	storage system (7.2.4)
4a	charging system included in storage system (7.2.5)

5	handling system (7.2.3)
6	lane system (7.2.2)
7	EMSC
8	supply network
9	electric vehicle
20	mechanical connection
21	electrical connection
22	communication
*	optional

Figure 1 – Composition of the battery swap system

A battery swap system according to the use-case description of Annex A may provide the following functions (see also Table 1):

– battery system mounting and unmounting from/to the vehicle;
– transfer of the removable battery system within the BSS;
– storage of the removable battery system in the BSS;
– power transfer between removable battery system and supply network; and
– other functions.

Examples of use cases for battery swapping are indicated in Annex A. Battery swap systems that correspond to the identified use cases will be composed of different components with different levels of automation, storage and handling systems. For details, see also Table 1.

Table 1 – Sub-systems mandatory for use-cases

Sub-system	Storage system		Handling system		Lane system
Function	**Storage**	**Power transfer**	**Mounting/ unmounting**	**Transfer**	**-**
Use case	**-**	**-**	**-**	**-**	**-**
Convenience store device (attended)	M	M	n.a.	n.a.	n.a.
Unattended locking compartment DC	M	M	n.a.	n.a.	n.a.
Battery exchange box	M	M	n.a.	n.a.	O
Automatic battery exchange box	M	M	M	M	M
Automatic vehicle storage system	M	M	M	M	M
M: mandatory O: optional n.a.: not applicable NOTE Unattended locking compartment only concerns DC power transfer.					

7.2 Battery swap station (BSS)

7.2.1 General

EV supply equipment configuration Type F according to IEC TS 61851-3-1 for removable battery systems is named in this document "battery swap station".

A battery swaps station as covered by IEC 62840 (all parts) consists of:

– lane system, 7.2.2;
– battery handling system, 7.2.3;
– storage system, 7.2.4;
– charging system, 7.2.5;
– supervisory and control system, 7.2.6.

A BSS shall be in accordance with 7.1.1, 7.2 and 7.3 of IEC TS 61851-3-1:—, if applicable.

NOTE 1 Exceptions regarding latching of the accessories according to 7.3.1 of IEC TS 61851-3-1:— are given in 7.2.4.

NOTE 2 For compatibility check, see 7.3.1 of IEC TS 61851-3-1:—.

Compliance shall be tested by measurement according to 7.1.1, 7.2 and of 7.3 of IEC TS 61851-3-1:—.

Annex B shows examples of BSS wiring for removable battery systems.

Annex C shows examples of BSS for stackable removable battery systems.

7.2.2 Lane systems

Lane systems (if any) are used to transfer and/or position the EV to the designated location to get ready for removable battery system handling. Lane systems are described in IEC 62840 (all parts).

The lane system (if any) shall comply with 5.2 of IEC 62840-2:2016.

Compliance is checked according to 5.2 of IEC 62840-2:2016.

7.2.3 Handling system

The handling system (if any) is generally composed of a number of mechanical, electro-mechanical and electric subassemblies that provide the transportation, mounting, unmounting and swapping of removable battery system. Such handling system may be internal to the enclosure of the BSS external to the enclosure or both.

Semi-automatic or automatic BSS use handling systems to move or position removable battery systems within or to the BSS. For further information, see also IEC TS 62840-1:2016.

The handling system consists of:

– swap equipment; and
– transferring equipment.

The swapping shall only be initiated when confirmation is obtained that the removable battery system (and the EV, if applicable) is ready for swapping.

NOTE 1 Object 6002h (status word) according to IEC TS 61851-3-7:— can be used to provide the status of the removable battery system to the EV and the BSS.

Compliance is tested by inspection of communication protocol.

The handling system shall ensure that the removable battery system is correctly placed and latched or unlatched, if applicable, at each phase of the transport or movement. This includes placement in the EV or in the storage system.

NOTE 2 Object 6002h (status word) according to IEC TS 61851-3-7:— can be used to provide the status of the removable battery system to the EV and the BSS.

Compliance is tested by inspection of communication protocol.

A handling system shall have, according to 5.3 of IEC 62840-2:2016, the function of detecting presence of objects on the passage of the movement of the removable battery system that will hinder the operation (e.g., another removable battery system). In addition, 5.10 of ISO 10218-2:2011 shall be taken into consideration by establishing the risk assessment as mentioned in Clause 5.

NOTE 3 This function avoids that a battery system will be loaded into a compartment, which is already occupied by another removable battery system.

Compliance is checked by inspection.

Handling systems shall have an emergency procedure according to 5.3 of IEC 62840-2:2016 when the removable battery system to be removed from EV or storage rack is suffering from a malfunction (for example, a contact welding malfunction, contact deformation, etc.)

Compliance is tested by applying the maximum withdrawal force as described in the relevant document of the used accessory to the parts of the accessory located on the removable battery system.

The operator may control the handling system remotely through the human machine interface (HMI) (see also 7.2.6).

NOTE 4 HMI is specified in Part 9 of CiA 454-9.

Handling system can be subject to national standards or regulations.

7.2.4 Requirements for storage system

The storage system is used to store the removable battery system safely and supports the control of the status (monitoring) of the removable battery system (see PDO mapping entries given in Table B.1 of IEC TS 61851-3-5:—) during:

– power transfer between removable battery system and BSS according to IEC TS 61851-3 (all parts);
– storage (without power transfer).

The storage system consists of at least of the following elements:

– storage compartments or locking compartments following EN 14470 (all parts) consisting of:
  - RESS connector connected to a power supply/VCU (for additional information, see Annex B);
  - communication provided by virtual EMSC according to Annex B of IEC TS 61851-3-4:—;
  - communication provided by VCU according to Clause 5 of IEC TS 61851-3-6:—;
  - sensors (if required);
  - thermal management system (optional).

The storage system may provide storage compartments, which do not provide power transfer between removable battery system and BSS.

Each removable battery system shall be connected to the EMS according to IEC TS 61851-3-4:— as long it is stored in the storage system to control the status of the removable battery system.

Compliance is tested by inspection.

Each storage compartment shall be provided with an independent temperature sensor.

If temperature inside of the storage compartment is above 60 °C, power transfer from/to the battery system shall be interrupted. An alarm (optical alarm up to reset and acoustical alarm for 120 s) shall be initiated. Automatic reset of the system shall be prohibited.

Compliance is tested by inspection and the following test.

- *Charging of a load from the RESS connector. The load may be inside or outside the compartment.*
- *The compartment temperature is increased by an artificial heat source.*
- *Current flow to the RESS connector shall be interrupted (independently of the battery electronics) and the alarm activated when the temperature exceeds 60°C.*
- *The compartment temperature shall be decreased below 40 °C.*
- *The current shall not be automatically reconnected within 2 h after the transition below 40 °C.*

The maximum fire load of each storage compartment shall be limited up to maximum capacity (at 1 °C) of 6 kWh of the removable battery system or the combination of removable battery systems by compatibility check.

Compliance is tested by performing compatibility check according to 8.2.3.4 of IEC TS 61851-3-4:— by simulation of the connection of a non-conform removable battery system. See also 7.4.1.

Protection against fire shall be provided by at least T15 according to EN 14470 (all parts) between storage compartments.

Compliance is checked by inspection.

Protection against fire can be subject to national standards or regulations.

Ventilation shall be provided by construction or thermal management system according to manufacturer's description.

Ventilation can be subject to national standards or regulations.

Latching of the accessories as mandatory function for power transfer according to 7.3.1 of IEC TS 61851-3-1:— can also be provided by locking of the storage compartment (for example door, lid) before start of the power transfer and unlocking storage compartment after stop of the power transfer.

Power contacts of accessories (for example RESS coupler) of storage compartment shall only be live if:

- door of storage compartment is locked;
- compatibility check according to 8.2.3.4 of IEC TS 61851-3-4:— is successfully completed.

Immediately after the following events, all active devices shall be disconnected from the DC power circuit within 100 ms:

- door of storage compartment is unlocked;
- communication is lost (detected by a missing heartbeat according to 5.1.7 and 5.1.8 of IEC TS 61851-3-5:—)

– request to power off the device (according to 9.2.2 of IEC TS 61851-3-4:—).

Compliance is checked by inspection and, if necessary, by a test on the sample wired as in normal use and an externally generated test sequence that simulates the fault conditions.

7.2.5 Charging system

In this document, the requirements for charging system are integrated into the requirements for storage system completely. Subclause 4.2.5 of IEC TS 62840-1:2016 and Subclause 5.5 of IEC 62840-2:2016 are not applicable.

7.2.6 Supervisory and control system

Supervisory and control system shall be implemented according to the operating principles as covered by Clause 8 of IEC TS 61851-3-4:— and Clause 5 of IEC TS 61851-3-6:—.

NOTE For communication, see Clause 8.

A number of battery system objects are defined in IEC TS 61851-3-5:— and IEC TS 61851-3-7:—. In addition to the mandatory objects indicated in these documents, the following objects are also generally required for the operation of a battery swap system:

– 6.2 of IEC TS 61851-3-5:—:
  - device actual external voltage (Object 6039h, 6.2.22);
– 6.5 of IEC TS 61851-3-7: —:
  - battery system status (Object 6101h, 6.5.2);
  - battery system rated Ah capacity (Object 6103h, 6.5.3);
  - battery system manufacturer (Object 6109h, 6.5.8);
  - battery system maximum charge start temperature (Object 6120h, 6.5.11);
  - battery system minimum charge start temperature (Object 6121h, 6.5.12);
  - battery system maximum discharge temperature (Object 6122h, 6.5.13);
  - battery system minimum discharge temperature (Object 6123h, 6.5.14);
  - battery system maximum temperature for storage (Object 6124h, 6.5.15);
  - battery system minimum temperature for storage (Object 6125h, 6.5.16).

The operator may require further objects defined in IEC TS 61851-3-5:— and IEC TS 61851-3-7:—.

Application objects relevant for fleet management are defined in Clause 7 of IEC TS 61851-3-5:—.

7.3 Supporting systems (optional)

Supporting systems as described in 5.8 of IEC 62840-2:2016 are not used in this document.

7.4 Removable battery systems

7.4.1 General

Battery systems which are not conform with EN 50604-1:2016 and EN 50604-1:2016/AMD1:2021 shall not pass compatibility check.

Compliance is tested by performing compatibility check according to 8.2.3.4 of IEC TS 61851-3-4:— by simulation of the connection of a non-conform removable battery system.

Battery systems with a maximum capacity not in accordance with 7.2.4 shall not pass compatibility check.

Compliance is tested by performing compatibility check according to 8.2.3.4 of IEC TS 61851-3-4:— by simulation of the connection of a non-conform removable battery system.

Monitoring (control of the status) of the removable battery system is covered by 7.2.4.

NOTE Removable battery system recommends by sending PDOs (see PDO mapping entries given in Table B.1 of IEC TS 61851-3-5:—) optimal conditions for removable battery system (for example, to provide maintenance).

7.4.2 Interoperability requirements

Interoperability requirements for BSS and their implications on removable battery systems are shown in Table 2.

Table 2 – Interoperability requirements

	Interoperability requirements for BSS	Implications on removable battery systems
a	Minimum size of dimensions of storage compartment	Maximum size of battery system housing
b	Position of RESS connector	Position of the RESS inlet
c	Type of RESS connector	Type of the RESS inlet
d	Communication according to IEC TS 61851-3 (all parts)	Communication according to IEC TS 61851-3 (all parts)
e	Direction of handling	Direction of handling
f	Protection against fire, see 7.2.4	Maximum capacity (fire load)
NOTE 1 Dimensions and positions depending on the removable battery system are under consideration. NOTE 2 RESS coupler(s) are under consideration. NOTE 3 Communication according to other systems is under consideration.		

Compliance is checked by following the relevant use case according to Annex A with the intended removable battery system(s).

BSS manufacturer shall provide for test 3 BSS and 3 removable battery systems from different manufacturers, if available.

7.5 Power supply system (optional)

Power supply systems as described in 5.9 of IEC 62840-2:2016 are not used in this document.

7.6 Interfaces

The storage system shall be fitted with a DC RESS connector (accessory) tested according to IEC TS 62196-4 or IEC TS 63066.

7.7 Zones of accessibility

The battery swap system according to 4.7 of IEC TS 62840-1:2016 is divided into 4 separate zones with different accessibility patterns.

Subclause 4.7 of IEC TS 62840-1:2016 is applicable also for this document; in addition, 5.10 of ISO 10218-2:2011 needs to be taken into consideration by establishing the risk assessment as mentioned in Clause 5.

Compliance is checked by inspection.

8 Communications

Clause 8 of IEC TS 61851-3-1:— is applicable.

9 Protection against electric shock

Clause 9 of IEC TS 61851-3-1:— is applicable.

10 Specific requirements for accessories

Clause 10 of IEC TS 61851-3-1:— is applicable.

11 Cable assembly requirements

Clause 11 of IEC TS 61851-3-1:— is only applicable for non-stationary equipment.

EXAMPLE 1 Portable and mobile equipment.

EXAMPLE 2 Convenience store device according to A.2.2 can be considered similar to EV supply system configuration type D with multiple battery system connection.

12 DRI EV supply equipment constructional requirements and tests

Clause 12 of IEC TS 61851-3-1:— is applicable except as follows.

12.3 IP degrees

Replacement:

The minimum IP degrees of accessories according to IEC TS 62196-4 shall be:

– indoor use:
  - battery system connector/inlet when not mated: IP21;
  - battery system connector/inlet mated: IP44.
– outdoor use:
  - battery system connector/inlet when not mated: IP24;
  - battery system connector/inlet mated: IP44.

Compliance is checked by test in accordance with IEC 60529.

Battery swap system may be subject to national standards or regulations, for example, EN 14470 (all parts).

13 Overload and short-circuit protection

Clause 13 of IEC TS 61851-3-1:— is applicable.

14 Emergency switching or disconnect (optional)

Clause 14 of IEC TS 61851-3-1:— is applicable.

15 Marking and instructions

Clause 15 of IEC TS 61851-3-1:— is applicable except as follows.

15.1 Installation manual

Addition:

The manual shall indicate the type of battery system that can be accepted for swapping.

15.2 User manual (instructions) for DRI EV supply equipment

Addition:

Information to the user shall state the type of battery system that can be accepted for swapping.

Annex A
(informative)

Use cases

A.1 General

This annex treats the various use cases for battery swap systems as they apply to removable battery systems according to EN 50604-1:2016 and EN 50640-1:2016/AMD1:2021.

An overview of the use cases is given by the following list:

– convenience store solution (attended) (see A.2.1);
– unattended locking compartment (see A.2.2);
– battery exchange box (see A.2.3);
– automatic battery exchange box (see A.2.4);
– automatic vehicle storage system (see A.2.5).

Additional optional functions of BSS:

– communication between EV/vehicle user and BSS over the cloud;
– POI data availability for navigation system in the cloud (pre-condition);
– availability information in the cloud (pre-condition);
– updated availability information in the cloud (post-condition).

A.2 Use case description

A.2.1 Convenience store device (attended)

Use case convenience store device (attended) see Table A.1.

Table A.1 – UC convenience store device (attended)

UC topics	Details	Remarks
Description	Convenience store solution consists of: – storage system. The storage system can be realized, for example, by: – one or more VCUs according to IEC TS 61851-3-2 providing a vehicle connector according to IEC TS 62196-4 sheet 4-II and each connected by standard plug to one AC standard socket-outlet placed, for example, on a case board; – a multiple battery system recharger connected to AC or DC supply network consisting of: – one or more VCUs according to IEC TS 61851-3-2; – one or more RESS inlets according to 7.6. – a storage rack connected to AC or DC supply network, providing one or more compartments consisting of: – a VCU according to IEC TS 61851-3-2; and – a RESS inlet according to 7.6.	– The storage system in this UC does not follow strictly the description of 7.2.4 because of the very specific situation. – Manufacturer specific battery systems with manufacturer device can be used. – Bi-directional power transfer DC to AC is not foreseen in this UC. – Security unit will only be needed if latching is provided.

UC topics	Details	Remarks
Actors	Consists of: – vehicle user; – "EVSE" operator.	– "EVSE" operator is in this use case the convenience store owner or attendant.
Preconditions	Are: – recognition of BSS service/convenience store and type of battery system; – vehicle user has parked his EV; – vehicle user is going to swap the empty battery system for a full battery system by a convenience store.	– Lane system is not needed, sufficient parking space should be available; – Handling system is not needed because swapping is done manually.
Postconditions	Are: – swapping procedure of the battery systems has been completed safely; – vehicle user drives away with its EV; – empty battery system is recharged in the storage system; – battery system shall be monitored during and after the recharging process.	
Normal Flow	Are: – the empty battery system will be removed unmounted by the vehicle user/EVSE operator from the vehicle by hand; – the empty battery system will be placed into the storage system by an EVSE operator by hand; – the full battery system will be taken out of the storage system by an EVSE operator by hand; – the vehicle user pays fees to the EVSE operator; – the full battery system will be mounted to the vehicle by vehicle user/EVSE operator by hand.	

Figure B.2 and Figure B.3 give an example of a battery exchange box that could be used by an convenience store where the operator swaps the battery on behalf of the client.

A.2.2 Unattended locking compartment

A.2.2.1 Unattended locking compartment DC

Use case unattended locking compartment see Table A.2.

Table A.2 – UC unattended locking compartment DC

UC topics	Details	Remarks
Description	Unattended locking compartment consists of: – storage system. The storage system can be realized, for example, by: – an equipment locker with one or more locking compartments. For DC, each compartment shall be supplied by a VCU according to IEC TS 61851-3-2 and with one or both of the following solutions: – vehicle connector according to IEC TS 62196-4 sheet 4-II; – RESS connector according to 7.6. Access by, for example: – key or key with deposit; – card reader; – HMI; – mobile phone.	– Storage rack (equipment locker with one or more locking compartments) according to 7.2.4. – Manufacturer specific battery systems with manufacturer device can be used.
Actors	Consists of: – vehicle user; – “EVSE” operator.	– “EVSE” operator is in this UC the provider of the service, and not present at the location.
Preconditions	Are: – recognition of BSS service/unattended locking compartment and type of battery system; – vehicle user has parked his EV; – vehicle user is going to charge the empty battery system by an unattended locking compartment.	– Lane system is not needed, sufficient parking space should be available. – Handling system is not needed because swapping is done manually.
Postconditions	Are: – charging procedure of the battery systems has been completed safely; – vehicle user drives away with its EV.	
Normal flow	Are: – the empty battery system will be unmounted by the vehicle user from the vehicle by hand; – identification/authentication of vehicle user vs. the EVSE operator, if needed; – the empty battery system will be placed into the storage system (locking compartment) by vehicle user by hand; and if needed connected to the EV supply equipment (or standard socket-outlet); – empty battery system is recharged in the storage system; – battery system is monitored by EMSC during and after the recharging process. – the full battery system will be taken out of the storage system by a vehicle user by hand; – the full battery system will be mounted to the vehicle by vehicle user by hand.	– Identification/authentication may include payment. – Payment depends on the access method.

Figure B.2 and Figure B.3 give an example of a battery exchange box that can be used as a basis for an unattended locking compartment. Further access control is necessary.

A.2.2.2 Unattended locking compartment AC

This use case is not covered by this document.

The safety requirements of this document demand full control of the status of the battery system during power transfer and/or storage.

High attention needs to be given to the risk assessment as described in Clause 5 for implementation of this use case considering the major requirements of this document. Use case unattended locking compartment see Table A.3.

Table A.3 – UC unattended locking compartment AC

UC topics	Details	Remarks
Description	Unattended locking compartment consists of: – storage system. The storage system can be realized, for example, by: – an equipment locker with one or more locking compartments.. For AC, independent standard socket-outlet for vehicle users with their own VCU (optional); Access by, for example: – key or key with deposit; – card reader; – HMI; – mobile phone.	– Storage rack (equipment locker with one or more locking compartments) according to 7.2.4. – Manufacturer specific battery systems with manufacturer device can be used.

UC topics	Details	Remarks
Actors	Consists of: – vehicle user; – "EVSE" operator.	– "EVSE" operator is in this UC the provider of the service, and not present at the location.
Preconditions	Are: – recognition of BSS service/unattended locking compartment and type of battery system; – vehicle user has parked his EV; – vehicle user is going to charge the empty battery system by an unattended locking compartment.	– Lane system is not needed, sufficient parking space should be available. – Handling system is not needed because swapping is done manually.
Post conditions	Are: – charging procedure of the battery systems has been completed safely; – vehicle user drives away with its EV.	
Normal flow	Are: – the empty battery system will be unmounted by the vehicle user from the vehicle by hand; – identification/authentication of vehicle user vs. the EVSE operator, if needed; – the empty battery system will be placed into the storage system (locking compartment) by vehicle user by hand; and if needed connected to the EV supply equipment (or standard socket-outlet); – empty battery system is recharged in the storage system; – battery system shall be monitored during and after the recharging process. – the full battery system will be taken out of the storage system by a vehicle user by hand; – the full battery system will be mounted to the vehicle by vehicle user by hand.	– Identification/authentication may include payment. – Payment depends on the access method.

A.2.3 Battery exchange box

Use case battery exchange box see Table A.4.

Table A.4 – UC battery exchange box

UC topics	Details	Remarks
Description	Battery exchange box consists of: – storage system; – handling system (optional); – lane system (optional).. The storage system can be realized, for example, by: a) an equipment locker with one or more locking compartments, each compartment shall be supplied by a VCU according to IEC TS 61851-3-2 and provide a RESS inlet according to 7.6; b) a storage rack (covered by a housing), providing one or more compartments with individual access, each compartment shall be supplied by a VCU according to IEC TS 61851-3-2 and provide a RESS inlet according to 7.6. c) a storage rack (covered by a housing) with handling system, providing several compartments with single access or input and output access, each compartment shall be supplied by a VCU according to IEC TS 61851-3-2 and provide a RESS inlet according to 7.6. The handling system according to 7.2.3 can be realized for example, by: – a robotic according to ISO 10218:2011 inside of the battery exchange box. Access by, for example: – card reader; – HMI; – mobile phone.	– Storage rack (equipment locker with one or more locking compartments) according to 7.2.4. – Manufacturer specific battery systems with manufacturer device can be used. – For c), the handling system transports the battery system from input window to storage rack and from storage rack to window output. – Input window and output window can be the same/single access.
Actors	Consists of: – vehicle user; – “EVSE” operator.	– “EVSE” operator is in this use case the convenience store owner or attendant.
Preconditions	Are: – recognition of BSS service/ battery exchange box and type of battery system; – vehicle user has parked his EV; – vehicle user is going to charge the empty battery system by a battery exchange box.	– Lane system may be needed for structuring access, robotic not needed, only signalling/marking. – Sufficient parking space should be available.
Postconditions	Are: – vehicle user drives away with its EV; – empty battery system is recharged in the storage system; – battery system is monitored during and after the recharging process.	– Battery systems in the battery exchange box can be used for grid stabilization.

UC topics	Details	Remarks
Normal flow with handling system	Are: – access over lane system (optional); – vehicle user is parking his EV; – identification/authentication of vehicle user vs. the EVSE operator; – vehicle use follows the instruction of battery exchange box; – the empty battery system will be unmounted by the vehicle user from the vehicle by hand; – the empty battery system will be placed into the battery input window of the battery exchange box by the vehicle user by hand; – after closing the door, the handling system transports the empty battery system to storage system; – the empty battery system will be placed into the storage system by handling system; – a full battery system will be taken out of the storage system by handling system; – the handling system transports the full battery system to the output window; – after opening the door, the full battery system will be taken out of the output window by vehicle user; – the full battery system will be mounted to the vehicle by vehicle user by hand; – leaving over lane system (optional).	– Payment depends on the access method. – Identification/authentication may include payment.
Normal flow without handling system	Are: – access over lane system (optional); – identification/authentication of vehicle user vs. the EVSE operator; – vehicle use follows the instruction of battery exchange box; – the empty battery system will be unmounted by the vehicle user from the vehicle by hand; – a full battery system will be taken out of the storage system by vehicle user by hand; – the empty battery system will be placed into the storage system by the vehicle user by hand; – the full battery system will be mounted to the vehicle by vehicle user by hand; – leaving over lane system (optional).	– Identification/authentication may include payment. – Payment depends on the access method. – Taking out of the full battery system and placing into the empty battery system can be vice versa.

Figure B.2 and Figure B.3 give an example of a battery exchange box.

A.2.4 Automatic battery exchange box

Use case automatic battery exchange box see Table A.5.

Table A.5 – UC automatic battery exchange box

UC topics	Details	Remarks
Description	Automatic battery exchange box consists of: – storage system – handling system; – lane system. The storage system can be realized, for example, by: – a storage rack according to 7.2.4. The handling system according to 7.2.3 can be realized, for example, by: – a robotic according to ISO 10218-1:2011 inside of the automatic battery exchange box. The lane system is realized according to IEC 62840 (all parts). Access by, for example – card reader; – HMI; – mobile phone.	– Manufacturer device shall not be used within a battery exchange box .
Actors	Consists of: – vehicle user; – “EVSE” operator.	
Preconditions	Are: – recognition of BSS service/automatic battery exchange box and type of battery system.	
Postconditions	Are: – vehicle user follows UC according to Clause A.1 of IEC TS 62840-1:2016; – vehicle user drives away with its EV; – empty battery system is recharged in the storage system; – battery system is monitored during and after the recharging process.	– Battery systems in the automatic battery exchange box can be used for grid stabilization. – Full battery systems may be transported by handling system to a part of the storage system which provides only monitoring but no power transfer.
Normal Flow	Are: – identification/authentication of vehicle user vs. the EVSE operator; – access over lane system according to UC Clause A.1 of IEC TS 62840-1:2016; – battery swap system follows UC according to Clause A.2 of IEC TS 62840-1:2016; – leaving over lane system according to UC Clause A.1 of IEC TS 62840-1:2016.	– Payment depends on the access method. – Identification/authentication may include payment. – Communication between EV and BSS over NFC according to Annex F of IEC 61851-3-4:—, alternatively Bluetooth or WiFi.

A.2.5 Automatic vehicle storage system

Use case automatic vehicle storage systems see Table A.6.

Table A.6 – UC automatic vehicle storage system

UC topics	Details	Remarks:
Description	Automatic vehicle storage system consists of: – storage system (for the vehicle); – handling system (for the vehicle); – lane system The storage system can be realized, for example, by: – a storage rack according to 7.2.4. The handling system according to 7.2.3 can be realized, for example, by: – a robotic according to ISO 10218-1:2011 inside of the automatic vehicle storage system. The lane system is realized according to IEC 62840 (all parts). Access by, for example: – card reader; – HMI; – mobile phone.	
Actors	Consists of: – vehicle user; – "EVSE" operator.	
Preconditions	Are: – recognition of BSS service/ automatic vehicle storage system.	
Postconditions (locking for owned vehicle)	Are: – vehicle user follows UC according to Clause A.1 of IEC TS 62840-1:2016; – vehicle user drives away with its EV.	– EVs with full battery systems may be transported by handling system to a part of the storage system which provides only monitoring but no power transfer
Postconditions (locking for rented vehicle)	Are: – vehicle user follows UC according to Clause A.1 of IEC TS 62840-1:2016; – vehicle user drives away with EV. – EV with empty battery system is recharged in the storage system; – battery system shall be monitored during and after the recharging process.	– Battery systems in the automatic vehicle exchange box can be used for grid stabilization. – EVs with full battery systems may be transported by handling system to a part of the storage system which provides only monitoring but no power transfer.
Normal flow (locking for owned vehicle)	Are: – identification/authentication of vehicle user vs. the EVSE operator; – access over lane system according to UC Clause A.1 of IEC TS 62840-1:2016; – battery swap system follows UC according to Clause A.2 of IEC TS 62840-1:2016; – empty battery system is recharged in the storage system; – battery system shall be monitored during and after the recharging process; – leaving over lane system according to UC Clause A.1 of IEC TS 62840-1:2016.	– payment depends on the access method. – identification/authentication may include payment. – (battery systems in the automatic vehicle exchange box can be used for grid stabilization)

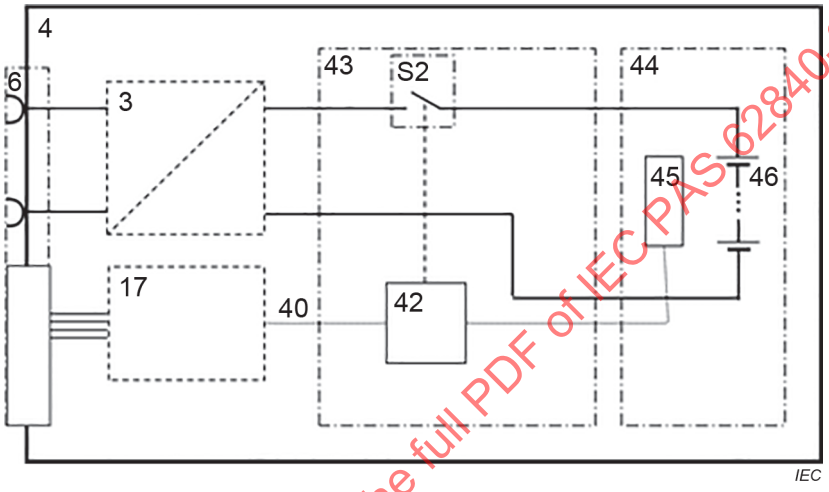
UC topics	Details	Remarks:
Normal flow (locking for rented vehicle	Are: – identification/authentication of vehicle user vs. the EVSE operator; – access over lane system according to UC Clause A.1 of IEC TS 62840-1:2016; – battery swap system follows UC according to Clause A.2 of IEC TS 62840-1; – leaving over lane system according to UC Clause A.1 of IEC TS 62840-1:2016.	– Payment depends on the access method. – Identification/authentication may include payment.

Annex B
(informative)

Examples of BSS wirings for removable battery systems

B.1 General

This annex shows examples of BSS wirings for removable battery systems. Figure B.1 shows an informative example of a removable battery system wiring according to EN 50604-1:2016 and EN 50604-1:2016/AMD1:2021. This figure is given to contribute to the understanding of use cases given in Annex A.



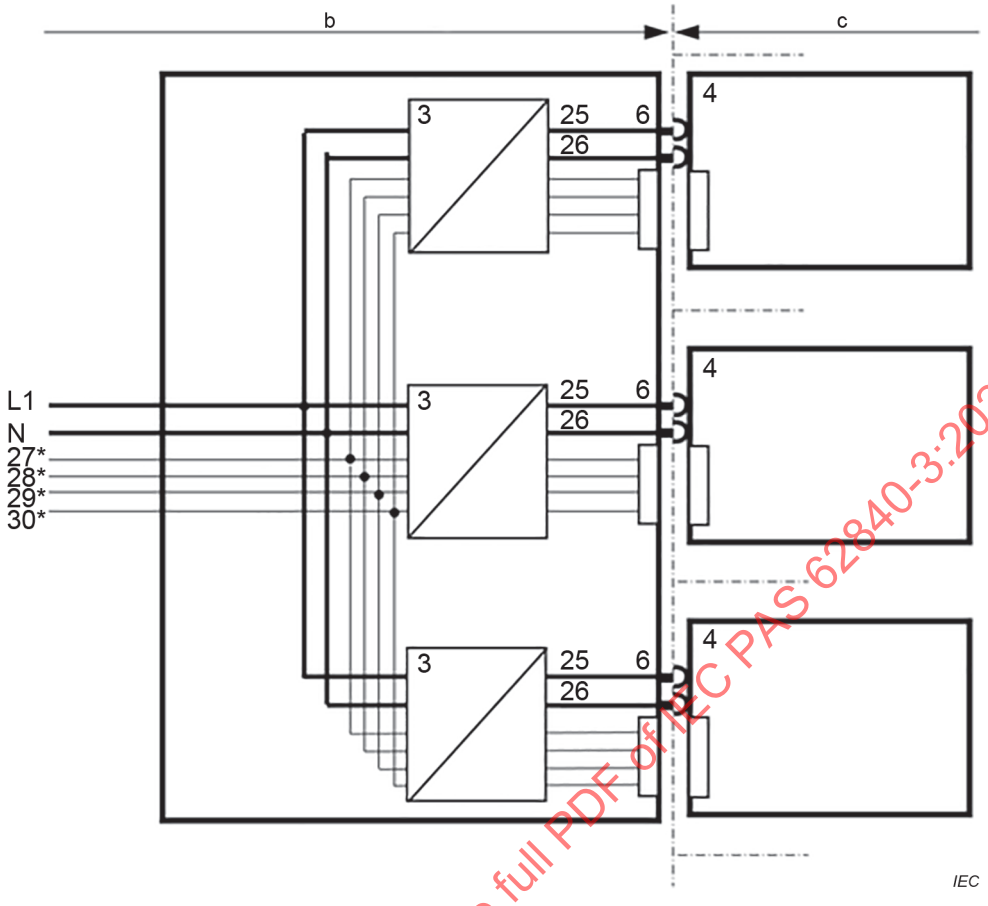
Key

3	built-in VCU (DC/DC) (optional)	43	battery management system
4	removable battery system	44	battery pack
6	RESS coupler (connector)	45	sensing and balancing electronics
17	gateway (optional)	46	cells
40	manufacturer specific circuit	S2	switch
42	protection device(s)		

Figure B.1 – Example of a removable battery system wiring (for information)

B.2 Example of a BSS wiring providing independent VCU for each battery system

The example shown in Figure B.2 uses one VCU per battery system. This allows for completely independent power transfer and isolation of the battery systems.



Key

b	fixed installation
c	portable or mobile equipment
3	built-in or fixed VCU
4	removable battery system
6	DC RESS coupler
17	gateway
25	DC +60 V
26	DC 0 V
27	AUX +12 V
28	AUX 0 V
29	CAN Hi
30	CAN Lo
48	End Cap
49	Battery Swap Station (BSS)
L1	AC supply voltage (L2, L3)
N	neutral line
S11-S13	switch

Figure B.2 – Example of a BSS wiring providing independent VCU for each battery system