LS - VBCC Protocol Suite

LOCK SMART - VEHICLE BATTERY CHARGER CLOUD PROTOCOL SUITE
DRAFT VERSION 2.4.3
23RD JULY 2018

An Industry group involved in three-wheeler Manufacturing (e-auto and e-rickshaw manufacturing) got-together in February 2017 with CBEEV, IIT Madras and Prof. Ashok Jhunjhunwala, then the Principal Advisor to Minister of Power and New and Renewable Energy to figure out the business model of electric autos and electric -rickshaw (with Li Ion batteries) using battery swapping. The group made Prof. Jhunjhunwala the Group-Convener. The group worked on specifications for the vehicle, batteries, chargers and communication protocols to be used for this. The members of the group are as follows

Members:

1. Dr. Ashok Jhunjhunwala
2. Dr. Prabhjot Kaur, CBEEV, IIT Madras.
3. Mr. Zafar Equbal, Goenka Electric Motor Vehicles Pvt. Ltd.
4. Mrs. Sulajja Firodia, Kinetic Green Energy & Power Solutions Limited
5. Mr. Sohinder Gill, Hero Electric
6. Mr. Ayush Lohia, Lohia Auto Industries
7. Mr. Amol Chavan, Mahindra Electric
8. Mr. S. Venkateswarlu, Lucas TVS Limited
9. Mr. Puneet Jain, Grinntech Motors & Services Pvt. Ltd.
10. Mr. Chinam Patro, Bajaj Auto Ltd.
11. Mr. Anant Misra, Greenfuel Energy Solutions Pvt. Ltd.
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13. Mr. Apoorv Shaligram, Ather Energy Pvt. Ltd.
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Revision History	Issued on	Release Notes
Draft V1.0	1st Jul 2017	
Draft V2.3.3.	19th Aug 2017	
Draft V2.3.4.	15th Sep 2017	
Draft V2.4	30th Sep 2017	
Draft V2.4.1	21st Nov 2017	1.Updated explanation in required places and the flow 2.Correction of typo/errors 3.Included parameter for continuous storage of battery's ambient temperature every 15 mins 4.Charging protocol a. Changes in the message code for SAE J compliance b. Included new data types for battery. 5.Driving Protocol a. Included Vehicle start message b. Included messages for storing Open command data from vehicle to BMS 6.Included BLE specification 7.Included OMS-Bulk charging protocol.
Draft V2.4.2	28th Feb 2018	Major changes are as below

Protocol	#	Changes
Charging Protocol	**1**	One-time data request value corrected from 0xAA to timestamp
	2	Addition of parameters: battery measured current and battery measured voltage during charging stage and consumed energy retrieval in battery one-time data
	3	Charging Protocol includes BIN authorization with OMS before proceeding with charging. This is explicitly mentioned

			4	Lock-smart mode parameter included in the battery log list (It is already included in the expected messages but was missing in the overall listing of battery log parameters)
		Driving Protocol	**5**	BMR Message description changed to add more clarity.
			6	VPV PGN number with missing one zero is corrected.
			7	In Section 4.5.1.2/ 3-byte count for VCA message corrected to 3 bytes.
			8	Inclusion of battery temperature as a parameter to VCU during driving stage
			9	Vehicle controller current from VCU to BMS added as a new parameter
			10	BMS message for Master BMS to Slave BMS communication included
		OMS Protocol	**11**	Addition of 'ConnectorId' parameter in SetAdminConnectorState message and ChargerParamConfiguration message
			12	Data type for few parameters included in 8.6
			13	Current charging stage enumeration included
			14	JSON for BT8, BT9 and BT10 included
			15	Changes for configuring periodicity of data log retrieval (also updated in Charging Protocol)
			16	Effective resistance of power path threshold value setting
			17	UFD included in Battery charging one-time data
		Driving & Charging Protocol	**18**	Units for current and voltages made common across protocols
			19	The reset of state machine and start from beginning of protocol after each suspension included
			20	Changes for LS batteries authorization in Driving and Charging protocol
			21	Firmware version as a part of protocol during handshake stage

Draft V2.4.3	23rd Jul 2018	Major changes are as below	
		Charging Protocol	CCOD message byte size changed to 4
			Included timestamp in VT size
			UFD from 8 byte to 16 byte
			Example values in BT, VT and CT types for each parameter
			SoC, Charger output current, Battery demand voltage, Measured battery current, Last calibrated timestamp, charging cycle number during last calibration, adaptive charging overridden count included in charging data log
			CT4, CT5,CT6 and CT7 included for SoC. included in charging log
			3.5.4.1.2. balancing current status to be changed; 1- balancing and 0- unbalanced
			SoH included in charging data log , BCOD packet and memory calculation
			New Section on granularity of data retrieval mode of driving and charging
			Included suspension reason for pack and cell over voltage and under voltage
			BPT message for min. and max. temperature update to charger included during charging
			VT9 type for vehicle controller voltage logging included
		Driving	VCA message SPN size updated to 3 bytes
			VRA message PGN corrected to 001D00H from 000F00H
			Battery capacity included in BPE message during parameter configuration stage - For DTE calculation
			Vehicle speed units changed to m/sec from km/sec
			3seconds waiting time included between receiving two BMR
			Battery suspension reason included for indicating discharge lock state and out of geo-fence
		OMS	BMSChargingPeriodicTimeDataUpdate JSON to include SoCatsuspension parameter
			1. Session ID correction in data type 2.Included data types
			3.STOP transaction response included with SoC including the CC or CV state and these values to be NULL for stages before charging stage
			4.BIN included along with charging stage notification

			5.New Charger initiated messages : BatteryTemperatureUpdate and ConditionalRetrievalMode
			6.SoH included in charging data log, BCOD packet and memory calculation
		BLE	Added istrackingenabled parameter in EV-Charged Battery VIN Association characteristics
			Characteristics for Temperature of battery through BLE added
			Data type & size included for all parameters
		TM	Messages included to aid optional tracking of vehicles and batteries in protocols
		Generic	The document renamed to LS VBCC Protocol Suite 2.4.3
			Provision of Adaptive Charging, Conditional retrieval of all data during driving/charging protocol and recalibration of battery SoC/SoH.

Description	Date	Revision
LS – VBCC Protocol Suite	23rd Jul - 2018	2.4.3

Contents

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1. Scope

This standard specifies various communication protocols involved in the battery swapping architecture. Fig 1 shows the Battery Swapping Architecture and the various entities involved.

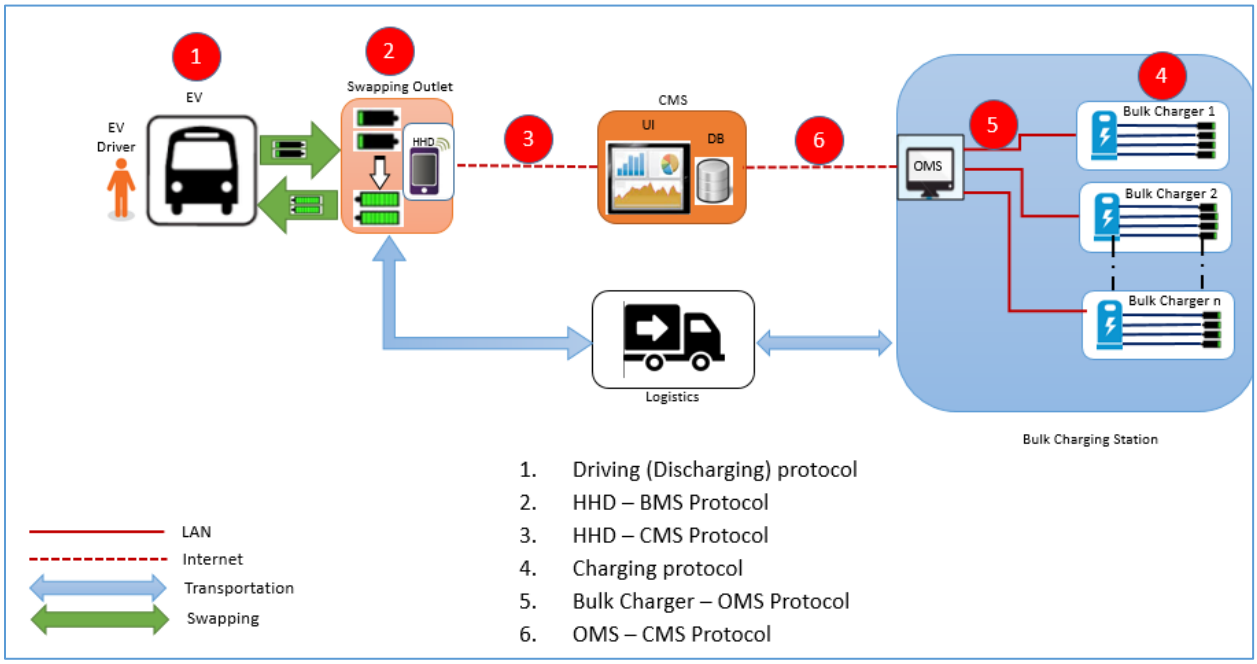


Fig 1: Battery Swapping Architecture

This document provides the draft specifications of the communication detailing of the following protocols:

1. Communication protocol between BMS and Bulk Charger – Charging Protocol
2. Communication protocol between BMS and the Electric Vehicle – Driving Protocol
3. Communication protocol between BMS and HHD
4. Communication protocol between HHD and CMS
5. Communication protocol between Bulk charger and OMS

2. Entities Involved

- EV: Assumed to be E-Rickshaw, E-auto or E-bus.
- EV Driver: Person who drives EV
- Battery Management System (BMS) and Battery modules
  - Discharged/Charged batteries received from /placed in Vehicle
- Swapping Outlet (SO): A small shop where battery swapping is done. Can be same as charging station.
- Hand-held device (HHD) in swapping outlets
  - A device to identify and assign batteries at swapping outlets
  - Used for calculating energy consumption units and billing
- Central Management System(CMS)
  - A cloud server to collect data, check & authorize operations from various entities

- Bulk Charging Station(BCS)
  - A Central station to where all the discharged batteries from various swapping outlets are brought for charging and charged batteries will be distributed
  - There could be multiple Bulk chargers per BCS and the charging function is done by Bulk Charger(BC)
- Operational Management System(OMS)
  - OMS - a local server to collect, check and authorize operations from all the bulk chargers in the bulk charging station
  - One OMS will be available per bulk charging station
  - OMS perform battery pairing. Battery pairing is required at the swapping outlet to help the operator in assigning charged batteries to the vehicle.

2.1. Entity Identifiers

2.1.1. Vehicle Identification Number – VIN (Existing Definition/

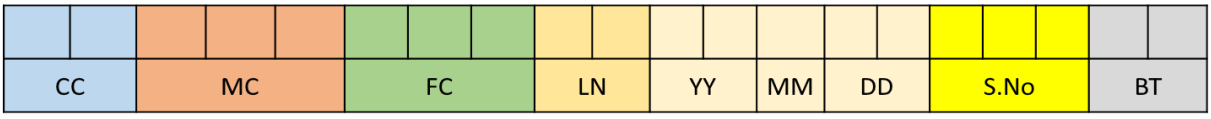
- VIN - 17-digit code and does not include alphabets I, O, Q to avoid confusion with numerals 1 and 0

Standard	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ISO 3779	World manufacturer identifier			VDS						VIS							

- WMI - World Manufacturer Identifier [Digits 1-3]
  - Assigned by SAE (Society of Automotive Engineers) in US to countries and manufacturers
  - First two digit indicates country code: India country code: MA- ME
  - Third digit indicates manufacturer E.g. J- Ford India, L – Hyundai, 1 – Mahindra etc. E.g. WMI – MAL: India Hyundai, MB1: India Ashok Leyland etc.
- VDS - Vehicle Descriptor Section [Digits 4-9]
  - Carries manufacturer specific information like engine type, vehicle model, body type, transmission etc.
  - Besides letter I, O, Q not being used in VIN, letters U and Z are not used in VDS
  - Used according to local regulations to identify vehicle type and each manufacturer has unique system for using this field to identify the vehicle
- VIS - Vehicle Identifier Section [Digits 10-17]
  - Digit 10 – Model year of the vehicle
  - Digit 11 – Plant code of the manufacturer
  - Digit 12-17 – 6-digit Serial number of the vehicle

2.1.2. Battery Identification Number – BIN (Proposed)

- BIN Components – 20 Digits

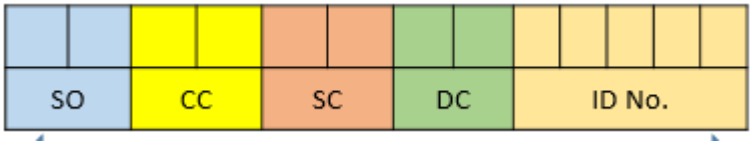


#	Components	Abbreviation	Description	Reference	Digits
1	Country code	CC	To identify the country	ISD country codes can be used Ref: https://countrycode.org/	2
2	Manufacturer Code	MC	To identify the manufacturer	To be assigned by some regulatory authority to identify different manufacturers. E.g. EXI – Exide, AMR-Amara raja	3
3	Factory code of the manufacturer	FC	To identify the factory code where the battery manufacturing is done	This could be manufacturer specific data to identify the factory	3
4	Line Number in the factory	LN	To identify the line number in the factory	This could be manufacturer specific data to identify the factory	2
5	Production Date	YYMMDD	Year, Month and date of production	Year: Offset to be 2017. E.g. 1 indicates 2017, 2 indicates 2018 and so on up to 99 Month: A-Jan, B-Feb, C-Mar…. J-Nov, K-Dec Date: 01, 02, 03… 30, 31.	2+1+2=5
6	Serial Number	S.No	Serial number of the battery	Three-digit serial number of the battery ranging from 1 to 4095(0X01H to 0xFFFH)	3
7	Battery Type	BT	Battery chemistry type	01H: lead acid battery;02H: nickel hydrogen battery; 03H: lithium iron phosphate battery; 04H: lithium manganite battery; 05H: cobalt based lithium battery; 06H: ternary material battery; 07H: polymer lithium-ion battery;08H: lithium ion battery; 09H: NMC (Lithium	2

				Nickel Manganese Cobalt Oxide)0AH: NCA (Lithium Nickel Cobalt Aluminum Oxide)0BH: Lithium titanate oxide (LTO)0CH: Lithium Nickel cobalt manganese FFH: other batteries	

2.1.3. Swapping Outlet Identifier – SOID (Proposed)

- SOID Components – 13 Digits

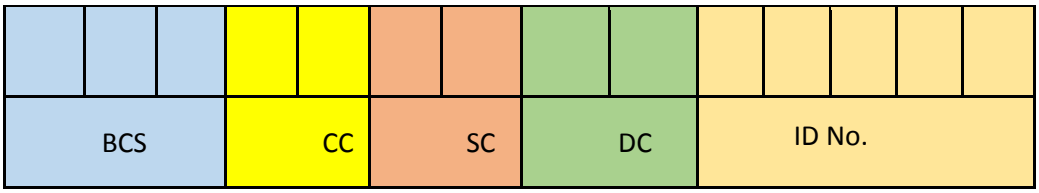


#	Components	Abbreviation	Description	Reference	Digits/ Bytes
1	Entity Name: Swapping Outlet	SO	To identify the entity name in the infrastructure	Taken from the first letters from each word of entity name	2
2	Country Code	CC	To identify the country	ISD country codes can be used Ref: https://countrycode.org/	2
3	State code	SC	To identify the state in which the SO is present. State codes used in vehicle number plate can be taken as reference. CMS will have list of state code. This would be captured during registration of SO with CMS and generated based on user's selection of location	Ref:https://en.wikipedia.org/wiki/Vehicle_registration_plates_of_India#Current_codes	2
4	District Code	DC	To identify the district of respective state in which the SO is present.	Ref: https://en.wikipedia	2

			CMS will have list of state-wise district code. This would be captured during registration of SO with CMS and generated based on user's selection of location	.org/wiki/List_of_districts_in_India	
5	ID Number	ID No.	5-digit number to identify the SO	Auto-generated 5-digit ID from CMS upon successful registration	5

2.1.4. Bulk Charging Station Identifier – BCSID (Proposed)

- BCSID – 14 Digits

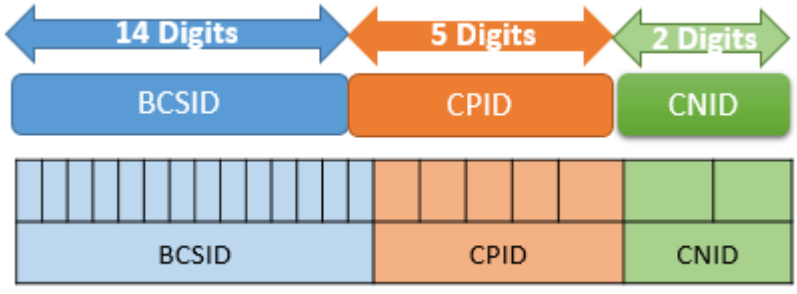


#	Components	Abbreviation	Description	Reference	Digits /Bytes
1	Entity Name: Bulk Charging Station	BCS	To identify the entity name in the infrastructure	Taken from the first letters from each word of entity name	3
2	Country Code	CC	To identify the country	ISD country codes can be used. Ref: https://countrycode.org/	2
3	State code	SC	To identify the state in which the BCS is present. State codes used in vehicle number plate can be taken as reference. CMS will have list of state code. This	Ref:https://en.wikipedia.org/wiki/Vehicle_registration_plates_of_India#Current_codes	2

			would be captured during registration of SO with CMS and generated based on user's selection of location		
4	District Code	DC	To identify the district of respective state in which the BCS is present. CMS will have list of state-wise district code. This would be captured during registration of SO with CMS and generated based on user's selection of location	Ref:https://en.wikipedia.org/wiki/List_of_districts_in_India	2
5	ID Number	ID No.	5-digit number to identify the BCS	Auto-generated 5-digit ID from CMS upon successful registration	5

2.1.5. Bulk Charger and Slot Identifiers – Proposed

Bulk Charger and slot identifier – 21 digits



- Each Bulk Charging Station (BCS) is assumed to have multiple chargers with 15/30/60 charging channels.
- Each charger would be referred as Charge Point(CP) and identified using CPID: CP followed by three-digit number

E.g. CP001, CP002 ……CP00N

- Each slot/charger channel would be referred as Connector (CN) and identified using CNID by two-digit number.

  E.g. 0x01, 0x02, 0x03……

3. Charging Protocol

The Communication protocol between BMS and Bulk Charger will be referred as charging protocol.

- The charging function is done by bulk charger
- The communication network between bulk charger and battery adopts CAN 2.0B communication protocol
- During charging, the charger and BMS monitors parameters such as Voltage, current and temperature.
- The battery log data captured during driving is transferred to OMS through Bulk charger as a part of this protocol.
- Charging Protocol Version: 0.9.0

3.1. Physical Layer

Physical Layer conforming to this standard shall refer to ISO 11898-1:2003 and SAE J1939-14: 201612. The communication between charger and BMS in this standard shall use the CAN interface. The communication rate between charger and BMS would be 500 Kbit/s.

3.2. Data Link Layer

3.2.1. Frame Format

Equipment complying with this standard shall use 29-bit identifier of CAN extended frame, and the corresponding definition of each specific bit allocation shall meet the requirements as given in SAE J1939-21:2006.

3.2.2. Protocol Data Unit (PDU)

Each CAN data frame contains a single protocol data unit (PDU). The protocol data unit is composed of seven parts which respectively are priority, reserved bit, data page, PDU format, specific PDU, source address and data field.

3.2.3. PDU Format (PF)

In this standard, the PDU1 format defined in SAE J1939-21:2006 is used.

3.2.4. Parameter group number (PGN)

The second byte of PGN is PDU format (PF) value, and both high byte and low byte are 00H.

3.2.5. Functions of transport protocol

The transport of 9~1785-byte data between BMS and charger shall use the transport protocol function. The specific connection initialization, data transport and connection closing shall comply with the provisions on message transport as given in 5.4.7 and 5.10 of SAE J1939-21:2006. As for the multi-frame message, the message period refers to the transport period for the whole data package.

3.2.6. Address allocation

Network address is used to guarantee the uniqueness of message identifier and to indicate the message source. The Charger address is fixed as 128(Dec) or 80H and battery address is assigned by the charger as a part of the protocol.

3.3. Application Layer

- The application layer is defined as set of parameters and parameter groups.
- Parameter group is numbered by PGN, and each node identifies the content of data packet according to PGN.
- Data are transported in the form of periodical transport and event-driven mode.
- In case that multiple PGN data need to be transmitted to realize one function, it requires receiving multiple PGN messages of this definition to judge the successful transmission of this function.
- The message options may be either mandatory or optional. If all the contents in the same frame of message are optional, such message may not be transported; if some contents in the same frame of message are optional, all the optional bits are transported in the format as specified in this standard or filled with 1; the invalid bit or field not specified in this standard is filled with 1.
- The length of message and content and format of mandatory item shall be transported as detailed in subsequent chapters.

3.4. Overall Charging Procedure

The Communication protocol between a Bulk Charger (BC) and Battery Management System (BMS) comprises of following stages, after the establishment of physical connection: Auto-address assignment Stage, Handshake Stage, Battery Authenticity Check Stage, Driving log Transfer Stage, Parameter Configuration Stage, Charging Stage, Charging log transfer stage and End-of-charging stage.

In each stage, if the charger or BMS does not receive message from the other party or does not receive correct message within the stipulated time limit, the waiting entity will timeout (timeout means failure to receive a complete data package or correct data package within specified time); unless otherwise specified, the timeout is all 5s. After timeout BMS or charger will send suspending message.

The figure below presents the overall charging process.

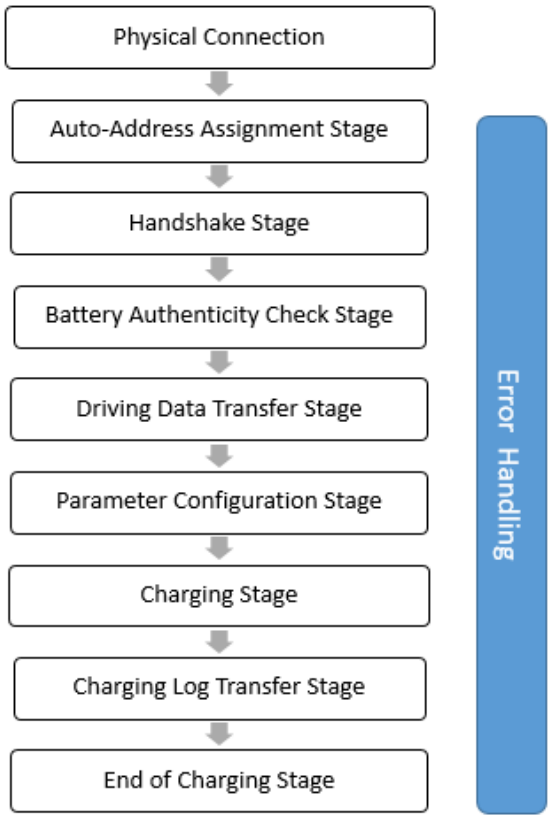


Fig: Overall Charging Process

3.5. Charging Protocol Stages

The bulk charger will be capable of charging 15/30/60 batteries simultaneously. Bulk charger will assign address automatically to each BMS as it gets plugged-in. For all the parameters, the order of SPNs in the CAN communication is as per the order specified in the table itself. For any suspension during the protocol flow, the state machine will reset and start from the beginning of the protocol

3.5.1. Auto address assignment stage

The BMS address will not be hard coded in them, instead when modules are connected to bulk charger (BC), BC will assign address to each module. BC should reserve the address in the range of 0x95 -0x185 for BMS addressing. BC's source address (SA) is defined as 128 (80H). By default, BMS should have default address as 254(0xFE) i.e. Null address.

- **Message1: Request for address claim from BMS**

BMS will send a request for address claim by generating a random number (RN1- say 2E2614D0) of 4 bytes in the data field. Bytes 1 to 4 will be used for this. Unused bytes in the data field will be filled with 0x00.

SA	DA	DATA Byte:01-04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08

FE (Null Address)	80 (BC Address)	2E2614D0	00	00	00	00

- **Message2: Broadcast response for address claim from BC**

BC broadcasts to CAN bus with the same random number (RN1- 2E2614D0) and allotted address (say 0x95). The allotted address will be available in the 5th byte of data field.

SA	DA	DATA Byte:01-04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
80 (VCU Address)	FF (Broadcast Address)	2E2614D0	95	00	00	00

- **Message3: BMS confirmation request for allotted address from BMS**

BMS requests BC to confirm the usage of the allotted address by generating and sending another random number (RN2 – say 33AB7F30) and allotted address (0x95) to BC.

SA	DA	DATA Byte:01-04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
FE (Null Address)	80 (BC Address)	33AB7F30	95	00	00	00

- **Message4: VCU confirmation response for allotted address from BC**

BC broadcasts to CAN bus with the random number (RN2), allotted address (0x95) and address status (0xAA: Success; 0xFF: Failure). The address status will be available in the 6th byte of data field. If the status from BC is a failure i.e. the address being allotted to some other BMS, then BMS has to repeat and start from Message1.

SA	DA	DATA Byte:01-04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
80 (BC Address)	FF (Broadcast Address)	33AB7F30	95	AA	00	00

- **Message 5: BMS confirmation on allotted address**

BMS confirms to BC on the allotted address by sending the random number 2, allotted address and the confirmation status (0xAA: Success; 0XFF: Failure)

SA	DA	DATA Byte:01-04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
FE (Null Address)	80 (BC Address)	33AB7F30	95	AA	00	00

The failure status would occur, if BMS is unable to assign the allotted address for some reasons. In this case, the BMS must repeat and start from Message1 to get an address assigned.

When BC sees a success status, it ensures that this address is not given to any other BMS.

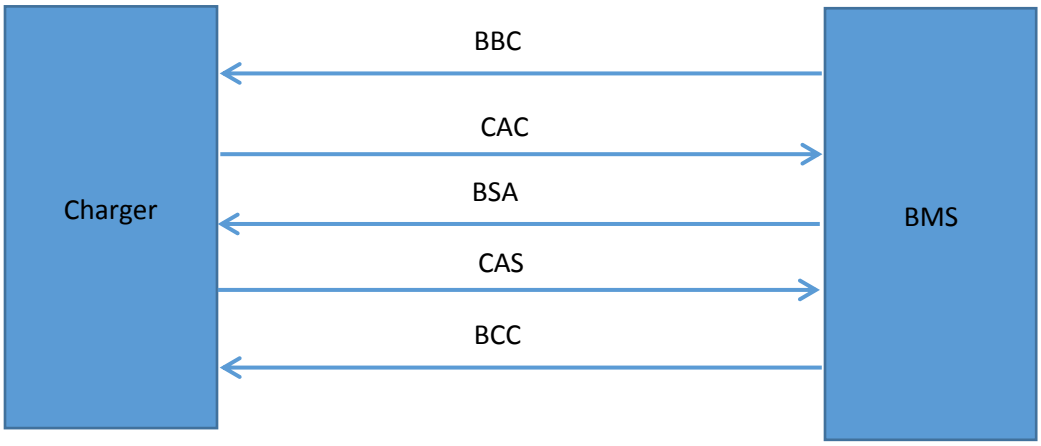
The address assignment for other BMS will happen in parallel in the same manner. The following use case is defined to elaborate on address assigning procedure under few conditions:

Case 1: Bulk Charger (BC) receiving the same random number from two BMS (Message1)

- BC will broadcast RN1+allotted address as defined in Message2.
- Both the BMS will receive this response and will send a confirmation request for allotted address with random number 2(RN2).
- BC will receive the message and by looking at the allotted address being common in the packets, it will send (Message4 with AA in byte 06) success to first BMS and failure(Message4 with 00 in byte 06) to other BMS.
- BMS receiving success status will continue with Message5 onwards and BMS receiving failure status will start from Message1

  Probability of occurrence of random number 2 being same for two BMS is very less and assumed to not occur. Refer Annexure C for auto address assignment flow

3.5.1.1. Message Flow



3.5.1.2. Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
BBC	Battery address claim request message	BMS To Charger	001000H	4	4	250

CAC	Charger broadcasts response for address claim message	Charger to BMS	002600H	4	5	250
BSA	BMS confirmation address request Message	BMS to Charger	002700H	4	5	250
CAS	Charger confirmation address response	Charger to BMS	002800H	4	6	250
BCC	BMS confirmation response on allotted address	BMS to Charger	001100H	4	6	250

3.5.1.3. Parameters

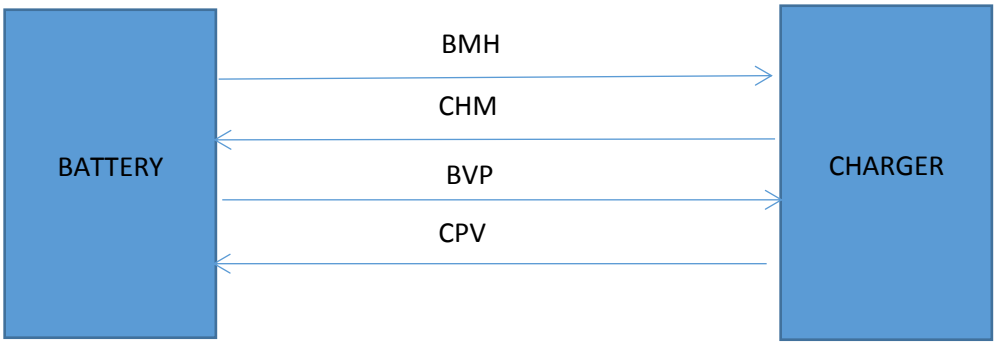
Message Code	Parameter Name	Description	SPN in (Dec)	Size in Bytes	Delivery Option
BBC	Random Number 1	Random number 1 generated by BMS. Till Charger confirms or rejects or time out, this random number 1 to be re-used.	346	4	Mandatory
CAC	Random Number 1	Random number received in BBC	289	4	Mandatory
	Allotted address	Address allotted by charger	290	1	Mandatory
BSA	Random Number 2	Random number 2 generated by BMS. Till charger confirms or rejects or time out, this random number 1 to be re-used.	291	4	Mandatory
	Allotted address	Allotted address in CAC	292	1	Mandatory
CAS	Random number 2	Random number 2 received in BSA message	347	4	Mandatory
	Allotted address	Allotted address by charger in CAC message	348	1	Mandatory
	Allotted status Success=0xAA; Failure=0xFF	Allotted address status. Charger confirming the address status as success or failure	349	1	Mandatory

BCC	Random Number 2	Random number 2 generated in BSA message	350	4	Mandatory
	Allotted address	Allotted address in CAC messages	351	1	Mandatory
	Acceptance status Success=0xAA; Failure=0xFF;	BMS acceptance status for allotted address	352	1	Mandatory

3.5.2. Handshake stage

In this stage, both charger and BMS communicates the charging protocol version between them. Annexure A1 provides details on the protocol version matching.

3.5.2.1. Message Flow



3.5.2.2. Messages

Message Code	Message Description	Source – Destination	PGN (HEX)	Priority	Data Length in Bytes	Message Period (ms)
BMH	Battery module Handshake Message	BMS to Charger	002900H	6	49	250
CHM	Charger Handshake Message	Charger to BMS	002A00H	6	7	250
BVP	Battery Protocol Version Confirmation Message	BMS to Charger	002B00H	6	3	250
CPV	Charger Protocol Version Acknowledgment Message	Charger to BMS	002C00H	6	1	250

3.5.2.3. Parameters

Message Code	Parameter Name	Description	SPN (Dec)	Size in Bytes	Delivery Option
BMH	BIN	Unique battery identification number. Before continuing with the charging, charger must authorize battery by sending BIN number to OMS server. Refer Section 8.5.2.3 for the relevant message.	293	20	Mandatory
	BMS communication protocol version	Communication protocol version number of BMS	294	3	Mandatory
	BMS Firmware version	Firmware version of BMS	2565	3	Mandatory
	UFD (Unique ID for drive)	Unique ID for drive assigned during battery issue in the swapping outlet	2566	16	Mandatory
	Time in seconds from last Calibration	Time elapsed since battery was last calibrated	2563	4	Mandatory
	No. of cycles after last Calibration	Number of elapsed cycles after calibration was last performed	2564	2	Mandatory
	Calibration due indication	Battery indicating the requirement of calibration with value 0xAAH	2598	1	Mandatory
CHM	Bulk Charger communication protocol version	Communication protocol version number of charger	295	3	Mandatory
	Charger firmware version	Firmware version of charger	2567	3	Mandatory
	Calibration acceptance	Charger providing the acceptance (0xAAH)/ rejection (0xFFH) based on the response from "IsBatteryAllowedToCharge: message. Refer Section 8.5.2.3	2597	1	Mandatory
BVP	Confirmed version of BMS communication protocol	Based on charger's protocol version, BMS will confirm the version number	296	3	Mandatory

CPV	Protocol version acknowledgement	Acknowledgement on protocol version from BMS. Success:0xAA; Failure:0XFF	297	1	Mandatory

3.5.3. Battery authenticity check stage

Authenticity check is done in two stages:

Stage 1 – Authenticity check initiated by Charger

In this stage, a random number (RN1) is generated by charger and sent to BMS. BMS runs an algorithm and sends the result to charger (Result). Charger runs the same algorithm and based on the result, it authenticates the battery.

For internal testing purpose, Result = RN1 / 2 could be assumed with some random number as RN1.

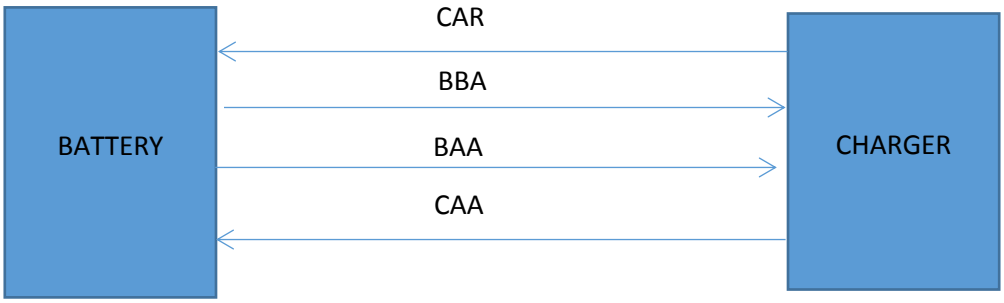
Stage2: Authenticity check initiated by Battery

In this stage, a random number (RN2) is generated by BMS and sent to charger. Charger runs an algorithm and sends the result to BMS (Result). BMS runs the same algorithm and based on the result, it authenticates the Charger.

For internal testing purpose, Result = RN2 / 2 could be assumed with some random number as RN2.

The proprietary algorithm will be provided by Energy Business company for both the stages: Authentication from Charger as well as from Battery as binaries. The BMS and Charger OEMs would have to develop their firmware using the same.

3.5.3.1. Message Flow



3.5.3.2. Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
CAR	Charger authenticity Request Message initiated by charger	Charger to BMS	002D00H	6	4	250

BBA	BMS authenticity Response Message for request initiated by charger	BMS to Charger	002E00H	6	4	250
BAA	BMS authenticity request message initiated by battery	BMS to Charger	001F00H	6	4	250
CAA	Charger authenticity response message for request initiated by battery	Charger to BMS	001E00H	6	4	250

3.5.3.3. Parameters

Message Code	Parameter Name	Description	SPN (DEC)	Size in Bytes	Delivery Option
CAR	Charger Random Number for Authentication	Authenticity request initiated by Charger	298	4	Mandatory
BBA	BMS Response for Given Random Number	Battery authenticity response	299	4	Mandatory
BAA	Battery random number for authentication	Authenticity request initiated by battery	2568	4	Mandatory
CAA	Charger response for given random number	Authenticity response by charger for battery initiated request	2569	4	Mandatory

3.5.4. Driving log transfer stage

3.5.4.1. Driving Data Log

This section describes the parameters logged in battery during driving. These data are transferred from BMS to charger during driving data transfer stage using defined packet formats. The charger should ensure "store and forward mechanism" is implemented in such a way that any driving data(and charging data) retrieved from BMS over CAN is safely delivered to the OMS. When all data is transferred for a given type or if there is no data available for transfer, BMS should respond with a packet with all '0's to indicate

this. After this stage and during charging, if there is a suspension due to some reason, the driving data log transfer will not repeat. The BMS to respond with all '0's if the data transfer has already been done.

These packets are formed by grouping various parameters. The charger will interpret the data based on the defined packet formats. Following groups of data are logged

- Battery related log
- Vehicle related log

There could be either one or multiple batteries (e.g. 2 to 3 batteries for 3W) in each vehicle and one among these batteries will act as Master BMS to provide required parameters to VCU. The assignment of Master BMS will be handled by VCU during the address assignment stage. Each BMS will have the mode as Master (0x01) or Slave(0x00) based on the assignment from VCU.

3.5.4.1.1. Driving Log Parameters

The parameters are logged either one-time at each ignition of the vehicle or periodically during running of the vehicle along with the timestamp.

- One-time parameters: All the one-time parameters are combined to form a packet. This single packet of defined size would be transferred from BMS to charger on one-time data request during driving data log transfer stage. This data is stored for every start of the vehicle.
- Periodic parameters: All periodic parameters are defined with granularities based on the data type they carry. They are combined to form a packet along with the timestamp for each record. These periodic data would be transferred from BMS to charger on periodic data request during driving data log transfer stage. The data are split up into multiple types and transferred based on the request type initiated by the charger. The timestamp for periodic data size would be 4 bytes and the format is defined in Section: 5.4.
- Additional Parameters: In addition to the above defined data, protocol allows extension to log additional battery related data. Additional data logging can be made for periodic or event based parameters. In case of event based parameters, the granularity should be '0'.
- The data logging is retrieved by defined packet structure and methods. This retrieval logic is detailed in Section 5.

3.5.4.1.2. Battery Data Log Parameters

Battery Data Log in each battery module						
#	**Parameter Name**	**Description**	**Size in Bytes**	**Parameter type**	**Logging Granularity**	**Log Size**
1	Battery Mode: Master(0x01) /Slave(0x00)	Mode showing whether battery was master /slave during driving. This parameter will help charger to retrieve additional vehicle data from BMS. BMS must keep this parameter set even if it had earlier been a Master and had	1	One-time	Vehicle Ignition	1

		become slave upon a failure				
2	Driving Protocol Version	Driving Protocol Version	3	One-time	Vehicle Ignition	3
3	BIN	BIN number	20	One-time	Vehicle Ignition	20
4	VIN	VIN Number	17	One-time	Vehicle Ignition	17
5	Available energy	Available energy (w-hr.) in battery at start of vehicle	2	One-time	Vehicle Ignition	2
6	Number of cells	Number of cells in battery	1	One-time	Vehicle Ignition	1
7	Number of temp. sensors	Number of temperature sensors in battery	1	One-time	Vehicle Ignition	1
8	BMS Firmware Version	Firmware version of BMS	3	One-time	Vehicle Ignition	3
9	Consumed energy	Consumed energy in w-hr	2	One-time	Vehicle Ignition	2
10	Lock-Smart Mode	Lock-smart mode: Drive mode 0x01/Charge mode 0x00	1	Periodic	15 mins	1
11	Available energy in w-Hr	Available energy in battery run in w-Hr	2	Periodic	1 Sec	2
12	Maximum current that battery can provide in Deci Amperes	Maxi. Current battery can provide at the instant of logging	2	Event based (log only when there is a change)	0	2
13	Battery instantaneous voltage in Deci volt	Battery instantaneous voltage	2	Periodic	1 Sec	2
14	Battery instantaneous current in Deci ampere	Battery instantaneous current	2	Periodic	1 Sec	2
15	Individual cell voltage in centi volt	Individual cell voltage and will be based on number of cells	2	Periodic	1 Sec	2* no. of cells

16	Individual Sensor temperature	Individual temperature of temp. sensors in 0.1°C. and will be based on sensors count	2	Periodic	1 Sec	2* no. of temperature sensors
17	Balancing cell status	If cell is balanced '1' have to be stored and '0' if cell is not balanced. Cell 0 status is stored in LSB and Cell 32 status is stored in MSB	4	Event based (Logged only when any one of the cell is in balancing state	0	4
18	Suspending /Alert reasons	Whenever / BMS suspends or sends alerts	Based on the reason	Additional data - Event-based	0	Based on the reason
19	Battery Ambient temperature	Battery ambient temperature in 0.1°C.	2	Periodic	15 mins.	2

3.5.4.1.3. Battery Data Storage format in BMS

- Battery one-time data storage format in BMS

Parameter Name	Timestamp	Battery Mode: Master/ Slave	Driving Protocol Version	BIN	VIN	No. of cells	No. of temp. sensors	Available energy	BMS Firmware Version	Consumed Energy
Size	4	1	3	20	17	1	1	2	3	2

- Battery periodic data storage format in BMS

BMS will have multiple sets of records for storing various parameters. These records are defined based on the granularity of the parameter.

Record 1:

Parameter Name	Time Stamp	Available Energy	Battery instantaneous voltage	Battery instantaneous current	Cell number 1	Cell Voltage 1	Cell number 2	Cell voltage 2
Size (Bytes	4	2	2	2	1	2	1	2

Record 1 table continued …

Cell number n	Cell Voltage n	Temp. Sensor Number 1	Temp. Sensor Value 1	Temp. Sensor 2	Temp. Sensor Value 2	Temp. sensor number n	Temp. Sensor value n
1	2	1	2	1	2	1	2

Record 2:

Parameter Name	Timestamp	Suspending reason + Data
Size (Bytes)	4	Based on the reason

Record 3:

Parameter Name	Timestamp	Lock-smart mode Drive mode:0x01 /charge mode :0x00	Battery ambient temperature
Size (Bytes)	4	1	2

Record 4:

Parameter Name	Timestamp	Maximum current that battery can provide
Size (Bytes)	4	2

Record 5:

Parameter Name	Timestamp	Balancing current status
Size (Bytes)	4	4

3.5.4.1.4. Vehicle Data Log

Vehicle Data Log in Master Battery Module						
#	**Parameter Name**	**Description**	**Size**	**Parameter type**	**Granularity**	**Log Size**
1	VIN - Vehicle Identification Number	VIN Number	17	Vehicle Ignition	Once	17
2	Effective resistance of power path	The voltage across the cable connecting battery and the vehicle controller in milli-ohm	2	Vehicle Ignition	Once	2
3	Odometer reading	Odometer reading in KM at the start of vehicle	4	Vehicle Ignition	Once	4

4	VCU Firmware Version	Firmware version of VCU	3	Vehicle Ignition	Once	3
5	Vehicle speed	Vehicle speed in mph during driving	2	Periodic	1 Sec	2
6	Odometer reading	Odometer reading	4	Periodic	1 Sec	4
7	Vehicle controller current	Vehicle controller current	2	Periodic	1 Sec	2
8	Vehicle controller voltage	Vehicle controller voltage	2	Periodic	1 Sec	2
9	OC1	Open Command 1	2	Additional data - Periodic	15 Sec	2
10	OC2	Open Command 2	2	Additional data - Periodic	15 Sec	2
11	OC3	Open Command 3	2	Additional data - Periodic	60 Sec	2
12	OC4	Open Command 4	2	Additional data - Periodic	60 Sec	2
13	Suspending/ Alert reasons	Vehicle suspending/alert reasons	Based on the reason	Event	0	Based on the reason

3.5.4.1.5. Vehicle Data Storage format in BMS

- Vehicle one-time data storage format in BMS

Parameter Name	Timestamp	VIN - Vehicle Identification Number	Effective resistance of power path	Odometer reading	VCU Firmware Version
Size	4	17	2	4	3

- Vehicle periodic data storage format in BMS

BMS will have the following set of records for storing various parameters at various granularity levels.

Record 1:

Parameter Name	Timestamp	Vehicle Speed	Odometer Reading	Vehicle controller Current	Vehicle controller voltage
Size	4	2	4	2	2

- **Record 2:**

Parameter Name	Timestamp	OC1	OC2
Size	4	2	2

- **Record 3:**

Parameter Name	Timestamp	OC3	OC4
Size	4	2	2

- **Record 4:**

Parameter Name	Timestamp	Suspending reason + Data
Size	4	Based on the reason

3.5.4.1.6. Memory Calculation for driving data log

The approximate memory calculation for various data logs are calculated by assuming the no. of cells and no. of temperature sensors as 32.

- Battery Data Log Size

Battery Data Log	Per Sec/ Per 15 mins/ Per 10 Sec	Per Hour (B/Hr)	Per 15 Hours
One-time Data+ Timestamp	54	54 (Assuming ignition is done once in one hour)	810
Periodic data 1 sec + timestamp (B/Sec)	138	496800	7452000
Periodic data 15 mins + timestamp (B/15 min)	7	28	420
Event-based data	14	14(Assuming a battery suspension)	210
Total (Bytes)	213	496896	7453440
Total (KB)		485.240805	7278.7207

- Vehicle Data Log Size

Vehicle Data Log	Per Sec/ Per 10 Sec /Per 60 Sec	Per Hour (B/Hr)	Per 15 Hours

One-time Data+ Timestamp	30	30(Assuming ignition is done once in one hour)	450
Periodic data 1 sec + timestamp (B/Sec)	14	50400	756000
Periodic data 15 sec + timestamp (B/10 sec)	8	1920	28800
Periodic data 60 sec+ timestamp (B/60sec)	8	480	7200
Event-based data	14	14(Assuming a vehicle suspension)	210
Total (Bytes)	70	52844	792660
Total (KB)		51.60156	774.023438

- Total Data Log Size

Battery stats per 15 hours	7278	KB /15 Hours
Vehicle stats per 15 hours	774	KB/15 Hours
Total	8052	KB / 15 hours

3.5.4.1.7. Conditional data retrieval

In driving data transfer stage, the charger queries the battery for its preferred mode of data transfer. The battery can give one of the two options below.

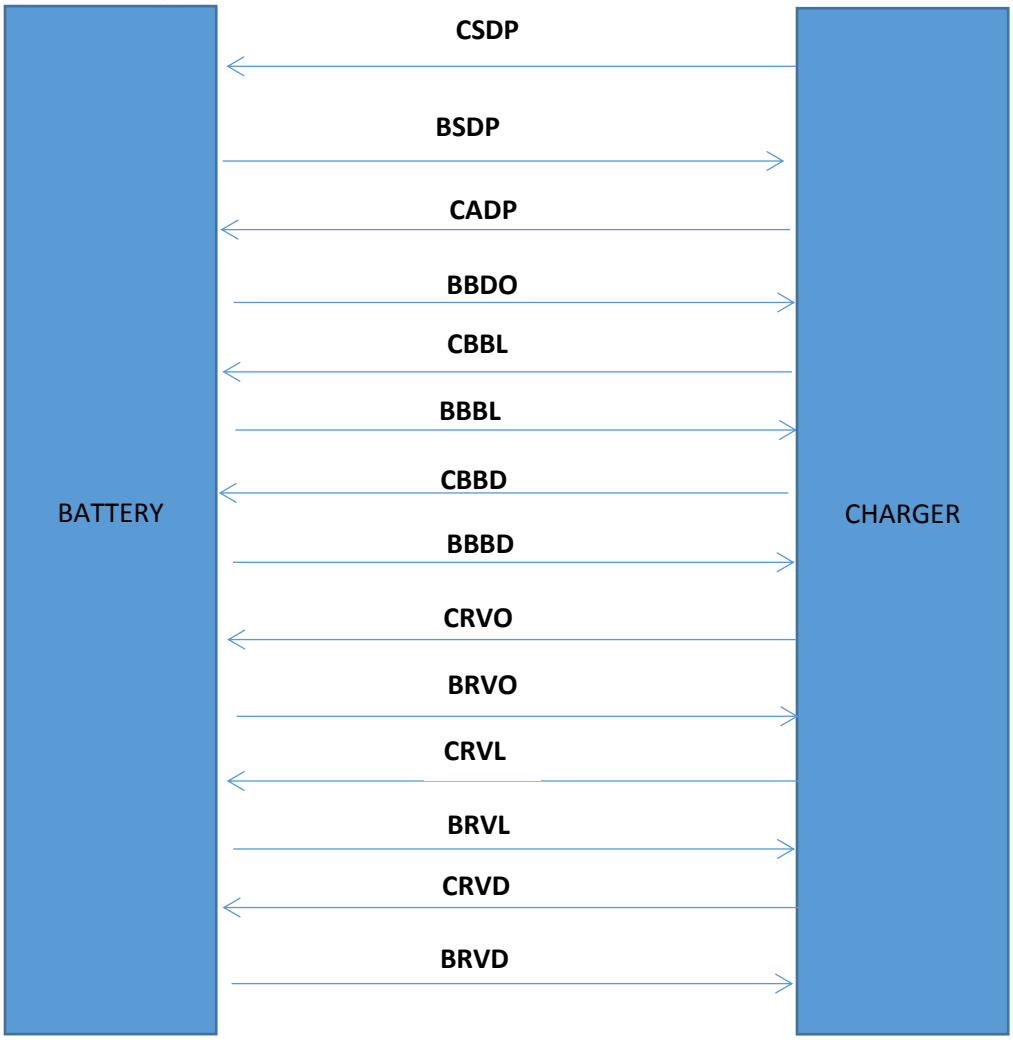
- Option 1 – Optimized for time: Default data mode with data retrieved at defined granularity.
- Option 2 - Optimized for analysis: Complete data retrieval mode when some error had occurred and data are retrieved with higher granularity for analysis.

Refer Section 5.5 for the granularity details. Charger sends the mode received from BMS to OMS through “ConditionalRetrievalMode” message in Section: 8.5.2.18 and confirms the mode to BMS based on the response from OMS.

If battery had opted for Option 2 and the OMS decides to retrieve all the data during non-peak hours, then OMS will defer the battery charging session.

Apart from the reasons indicated in battery suspending reasons, (Refer Section 3.5.6.3.1), battery can set the data retrieval mode as “complete data” whenever it has a reason to believe that all the data has to be retrieved for a detailed analysis.

3.5.4.2. Message Flow



3.5.4.3. Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period(ms)
CSDP	Charger requesting battery to indicate preferred mode of driving data retrieval	Charger - Battery	000D00H	6	1	250
BSDP	Battery response on the preferred driving data retrieval mode	Battery – Charger	001700H	6	1	250

CADP	Charger response on the driving data retrieval mode confirmation	Charger - Battery	001000H	6	1	250
CBDO	Charger Request battery discharge one-time data	Charger - Battery	002F00H	6	4	250
BBDO	Battery Response Battery discharge one-time data	Battery - Charger	003000H	6	54	250
CBBL	Charger request battery additional data list	Charger – Battery	003300H	6	1	1000
BBBL	Battery response additional data list in TSG format	Battery - Charger	003400H	6	5	250
CBBD	Charger request battery additional data	Charger – Battery	003500H	6	5	250
BBBD	Battery response battery additional data	Battery - Charger	003600H	6	Depends on data type	250
CRVO	Charger Request vehicle onetime data	Charger - Battery	003700H	6	4	250
BRVO	Battery Response vehicle one-time data	Battery - Charger	003800H	6	30	250
CRVL	Charger request vehicle additional data list	Charger - Battery	003B00H	6	1	250
BRVL	Battery Response vehicle additional data list	Battery - Charger	003C00H	6	5	250
CRVD	Charger request vehicle additional data	Charger - Battery	003D00H	6	5	250
BRVD	Battery response vehicle additional data	Battery - Charger	003E00H	6	Depends on data type	250

*For BT and VT types refer Section: 3.5.4.5.2. BBBL Packet format and Section: 3.5.4.5.6. BRVL Packet format respectively

3.5.4.4. Parameters

Message Code	Parameter Name	Description	SPN (DEC)	Size in Bytes	Delivery Option
CSDP	Data retrieval mode request parameter	Value : 0xAAH	2587	1	Mandatory
BSDP	Battery confirmation on preferred data retrieval mode.	Value : 0xAAH indicates default data transfer mode Value : 0xFFH indicates complete data transfer mode	2588	1	Mandatory
CADP	Charger confirmation on the data retrieval mode	Default data retrieval mode – Optimized for time : 0xAAH; Complete data retrieval mode – Optimized for analysis : 0xFFH Value : 0XBBH to indicate that OMS had deferred the request	2572	1	Mandatory
CBDO	One-time battery data request Value: timestamp	One-time data Request value. By default, the first time-stamp should be 01/01/2017 00:00:00. The format of timestamp is as defined in Section 5.4. : Timestamp format for periodic data	300	4	Mandatory
BBDO	One-time battery data Response Packet	Sends response packet in the format defined in the Section: BBDO packet format	301	54	Mandatory
CBBL	Additional battery data List request value: 0xAA	Charger requesting battery to send the data list.	304	1	Mandatory
BBBL	Additional battery data list Response	Battery response on data list. Response packet as defined in section BBBL packet format.	305	5	Mandatory
CBBD	Battery Data Request packet	Charger request packet as defined in section CBBD packet format	306	5	Mandatory

BBBD	Battery Data Response packet	Sends response packet in the format defined in the Section: BBBD packet format	307	Depends on data type	Mandatory
CRVO	Vehicle one-time data Request Value: timestamp	Charger Request Vehicle's one-time data Request value. By default, the first time-stamp should be 01/01/2017 00:00:00. The format of timestamp is as defined in Section 5.4. : Timestamp format for periodic data	308	4	Mandatory
BRVO	Vehicle one-time data Response Packet	Sends response packet in the format defined in the Section: BRVO packet format	309	30	Mandatory
CRVL	Vehicle additional data list request packet: Value 0xAA	Charger Request vehicle additional data list from BMS. If the battery was slave during the ride, then it will not have any vehicle data and hence battery should return the list as T+S+G: 000 indicating that there is no vehicle related data.	312	1	Mandatory
BRVL	Vehicle additional data lit response data	Battery Response packet as defined in Section BRVL packet format.	313	5	Mandatory
CRVD	Vehicle additional data request packet	Charger request packet as defined in section CRVD packet format	314	5	Mandatory
BRVD	Vehicle additional data response packet	Sends response packet in the format defined in the Section: BRVD packet format	315	Depends on data type	Mandatory

Note: Refer Annexure B2 on detailed message flow diagrams

3.5.4.5. Packet formats

3.5.4.5.1. BBDO Packet Format

Parameter Name	Timestamp	Battery Mode	Driving Protocol Version	BIN	VIN	Number of cells	Number of temp. sensors	Available energy	BMS Firmware Version	Consumed energy
Size	4	1	3	20	17	1	1	2	3	2
Example	0x17022906H	1	0x010101H	INAMRTNC121724489 8	19UYA31581L000000	0x20	0x20	0x384	0X000109H	0x64

3.5.4.5.2. BBBL Packet Format

Parameter Name	Type	Size(Bytes)	Granularity(sec)
Size (Bytes)	1	2	2
Example for BT1	1	6	1

For data retrieval of the stored battery log, the following types are defined. The example values are indicated in big endian format. The data over CAN bus to be interpreted in little endian format. For example 0x09C4 will appear as C4 09 in CAN bus.

Type Name	Type Number	Size (Bytes)	Granularity (sec)	Parameters	Example values
BT1	1	2	1	Available Energy	Value: 03 F6 Interpretation: 1014 w-hr
BT2	2	2	1	Maximum current that battery can provide	Value: 10 27 Interpretation: 10000 centi-amps
BT3	3	2	1	Battery instantaneous voltage	Value: 14 73 Interpretation: 5235 centi-volt
BT4	4	2	1	Battery instantaneous current	Value: 06 A2 Interpretation: -16.98 Centi-Amps(unsigned int)
BT5	5	1+2	1	Cell number + Individual cell voltage	Value: 00 + 0F B8 Interpretation: Cell no:0 + 4024 milli volt
BT6	6	1+2	1	Sensor number + Individual sensor temp.	Value: 00+ 0B BD Interpretation: sensor no:0 + 3005 centi degree
BT7	7	4	1	Balancing current status	Value: 00 00 00 07 Interpretation: Cell 0,1 & 2 alone balanced
BT8	8	2+4+4	0	Error code+ Threshold value+ Breach value e.g. For excessive dis-charge current, the data will be 0002(Error code) +discharge current(threshold value)+discharge current(breach value)	Value: 0001 + FFFF + FFFF Interpretation: VIN-BIN mismatch + Threshold value : FFFF + Breach Value : FFFFH
BT9*	9	2+17	0	ErrorCode of BT8+VIN number	Value: 0001 + 54 4e 31 32 33 34 35 31 32 33 34 35 31 32 33 34 33 Interpretation: VIN-BIN mismatch error code + VIN Number

BT10	10	1+2	900	Lock-smart mode + Battery ambient temperature	Value: 01 + DC 09 Interpretation: Mode: Driving; Ambient temperature: 3529 centi deg

*This will be generated only for Error code 0001H – BIN-VIN mis-match

The periodic and additional data frame

3.5.4.5.3. CBBD Packet Format

Parameter Name	Type n	Timestamp
Size in Bytes	1	4
Example	1	16022906H

Note: By default, the first time-stamp should be 01/01/2017 00:00:00. The format of timestamp is as defined in Section: Timestamp format for periodic data

3.5.4.5.4. BBBD Packet Format

Parameter Name	Timestamp	Data
Size in Bytes	4	2
Example	16022906H	700

The charger would send the default timestamp along with requested type using CBBD packet. Based on the request type, BMS would send the data corresponding to that type using BBBDP packet. This response packet would contain the next timestamp to be sent in CBBD packet.

The first request packet would have the default timestamp with type 1 say BT1 with timestamp1. After receiving the response, charger would initiate request packet with timestamp received in response packet say timestamp2. In this way, all the transfer of BT1 would be completed and the charger will initiate the transfer with the next type say BT2 with default timestamp

When CBBD is received for BT5 and BT6 with say Timestamp1, BMS will send 'n' number of responses for that timestamp, where 'n' will be equal to number of cells for BT5 and number of temperature sensors for BT6.

For e.g. if the number of cells is 32, then BMS will send 32 responses for the timestamp received in CBBD.

3.5.4.5.5. BRVO Packet Format

Parameter Name	Timestamp	VIN - Vehicle Identification Number	Effective resistance of power path	Odometer Reading	VCU Firmware version
Size	4	17	2	4	3

3.5.4.5.6. BRVL Packet Format

Parameter Name	Type	Size(Bytes)	Granularity(sec)
Size(Bytes)	1 byte	2 bytes	2 bytes
Example for VT1	1	6	0

For data retrieval of the stored vehicle log, the following types are defined. The example values are indicated in big endian format. The data over CAN bus to be interpreted in little endian format. For example 0x09C4 will appear as C4 09 in CAN bus.

Type Description	Type Number	Size (Bytes)	Granularity (Secs)	Parameters	Example Values
VT1	1	Based on suspending reason	0	Suspending reason+ Data(based on suspending data) e.g. For battery authenticity failure 4002(Error code)+Vehicle result + BMS random number	Value: 4002 + ASDE1010 + 12328901 Interpretation: Battery authenticity failure error + vehicle result + BMS random number
VT2	2	2	1	Vehicle speed	Value: 09 C4 Interpretation: 2500 m/hour
VT3	3	2	15	OC1	
VT4	4	2	15	OC2	
VT5	5	2	60	OC3	
VT6	6	2	60	OC4	
VT7	7	4	1	Odometer reading	Value: 00 00 00 64 Interpretation: 100 Km
VT8	8	2	1	Vehicle controller current	Value: 10 27 Interpretation: 10000 centi-amps
VT9	9	2	1	Vehicle controller voltage	Value: 14 73 Interpretation: 5235 centi-volt

3.5.4.5.7. CRVD Packet Format

Parameter Name	Type n	Timestamp
Size in Bytes	1	4
Example	1	16022906H

Note: By default, the first time-stamp should be 01/01/2017 00:00:00. The format of timestamp is as defined in Section: Timestamp format for periodic data

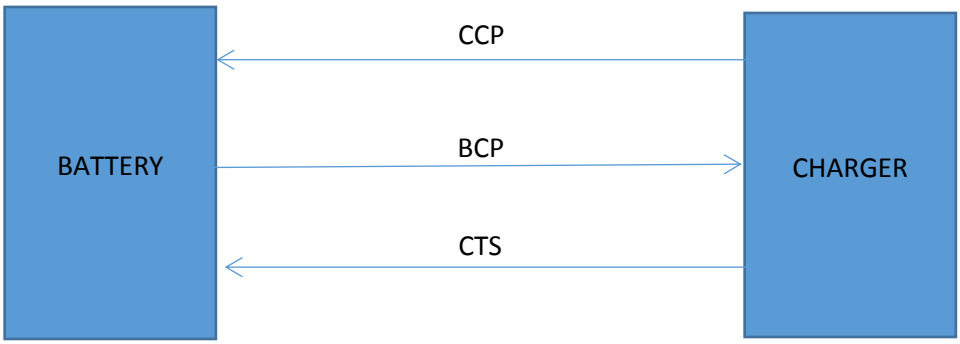
3.5.4.5.8. BRVD Packet Format or Additional Vehicle data log format

Parameter Name	Timestamp	Data
Size in Bytes	4	2
Example for OC1	16022906H	500

3.5.5. Parameter configuration stage

In this stage, charger and the BMS exchanges required parameter for charging the battery.

3.5.5.1. Message Flow



3.5.5.2. Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
CCP	Charger Charging Parameter Set Message	Charger to BMS	003F00H	6	6	250
BCP	Battery Charging Parameters Message	BMS to Charger	004000H	6	8	250

CTS	Charger Time synchronization Message(CTS)	Charger to BMS	004100H	6	7	250

3.5.5.3. Parameters

Message Code	Parameter Name	Description	SPN (DEC)	Size in Bytes	Delivery Option
CCP	Target SoC	Target SoC to be set in battery from charger	316	2	Mandatory
	Effective resistance of power path Threshold value	Threshold value for effective resistance of power path for setting in BMS. Default value is 25milli ohm. E.g.0x0037	371	2	Mandatory
	Effective resistance of power path	Effective resistance of power path value in milli-ohm	2575	2	Mandatory
BCP	Maximum charging voltage of battery pack	Battery pack charging voltage in Centi Volt	317	2	Mandatory
	Maximum charging current of battery pack	Battery maximum acceptable charging current in Centi Amperes	318	2	Mandatory
	Bulk charging current of battery pack	Initial estimated bulk charging (CC) current in Centi Amperes	319	2	Mandatory
	Charge termination current of battery pack	Battery pack CV phase charge termination current in mA	320	2	Mandatory
CTS	Charger Timestamp	Charger timestamp sent to battery to sync battery's timestamp. CTS timestamp as given in Section: CTS Timestamp Format	321	7	Mandatory

3.5.5.3.1. CTS Timestamp Format

Byte 6	Byte 5	Byte 4	Byte 3	Byte 2	Byte 1	Byte 0
Year		Month	Day	Hours	Minutes	Seconds

3.5.6. Charging stage

Throughout the charging stage, BMS will periodically send charging demand to the charger and the charger will regulate the charging voltage and charging current according to battery charging demand to ensure the normal proceeding of charging process.

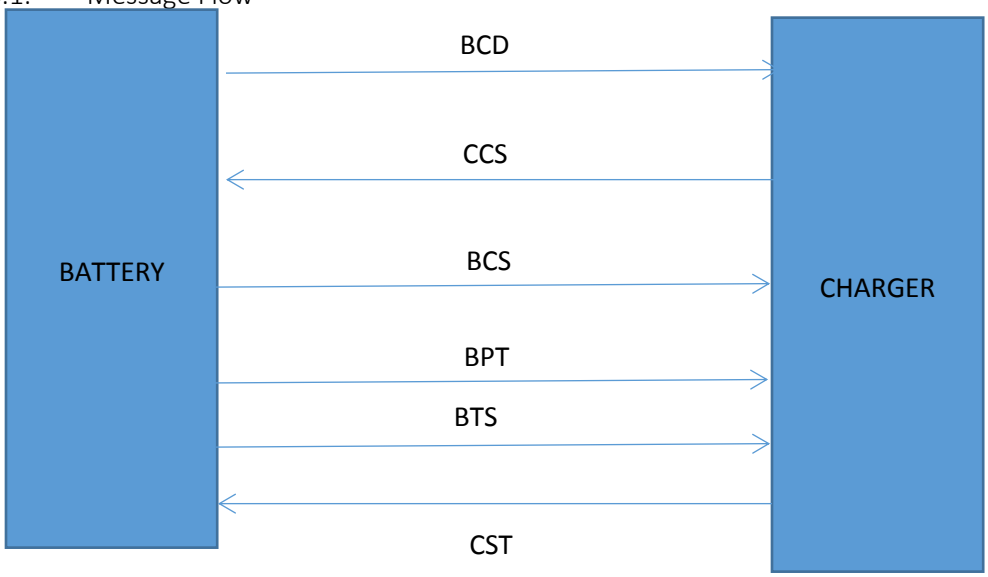
- Adaptive Charging

  The Energy Operator (EO) can decide to periodically compromise battery life cycles for faster turn-around-time for battery charging. To control this, Charger at the start of a charging session, should check with the OMS, whether the charger should accept the current demands from the battery (Optimized for larger life cycles) or should charge with higher current (Optimize for shorter charging time). The OMS would respond with one of the following choices

  - Honor battery's request of longer battery charging time(optimized for larger battery life)
  - Override battery's request (i.e, override and make it optimized for shorter charging time). Since the charger can decide to deliver more current than is sought by battery, it needs to know the limit beyond which it should NOT deliver current. This is addressed by charging at X% (Refer nonadaptivechargingcurrentpercentage in 8.5.2.3) of "Max. Charging current" as conveyed by battery in BCP message in Parameter Configuration Stage or as per battery's request, whichever is higher.

The default value will be “Honor battery’s request” (Optimized for larger life cycle). Refer Section: 8.5.2.3 for this parameter setting from OMS. Whenever charger happens to override battery’s request for the first time during a charging session, a persistent counter (adaptive charging overridden count) has to be incremented to measure this in the battery.

3.5.6.1. Message Flow



3.5.6.2. Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
BCD	Battery charging demand Message(BCD)	BMS to Charger	004200H	4	7	1000
CCS	Charger Charging state message	Charger to BMS	004300H	4	4	1000
BCS	Battery Charging State Message	BMS to Charger	004400H	4	7	1000
BPT*	Battery temperature update	BMS to Charger	000C00H	4	2	60000
BTS	Battery Suspending Message	BMS to Charger	004500H	2	10	250
CST	Charger Suspending Message	Charger to BMS	004600H	2	10	250

*Charger should send these temperature values to OMS immediately during charging. Refer Section 8.5.2.17 for the server message

3.5.6.3. Parameters

Message Code	Parameter Name	Description	SPN (DEC)	Size in Bytes	Delivery Option
BCD	Battery current demand	Current requested by battery in Centi Amperes	322	2	Mandatory
	Battery voltage demand	Voltage requested by battery in Centi Volts	303	2	Mandatory
	Charging mode	Battery charging mode requested by battery CVC=0x01; CCC=0x02	323	1	Mandatory
CCS	Charger output voltage	Charger output voltage in Centi Volts	324	2	Mandatory

	Charger output current	Charger output current in Centi Amperes	325	2	Mandatory
BCS	Estimated remaining charging time	Estimated remaining charging time in minutes	326	2	Mandatory
	Current SOC	Battery pack instantaneous SOC in % with a rounded value	327	1	Mandatory
	Measured battery current	Measured battery current in Centi-Amperes	2570	2	Mandatory
	Measured battery voltage	Measured battery voltage in Centi-volts	2571	2	Mandatory
BPT	Maximum cell temperature	Maximum Cell temperature in 0.1°C	2594	1	Mandatory
	Minimum cell temperature	Minimum cell temperature in 0.1°C	2596	1	Mandatory
BTS	Normal, Warning or Error suspension	Battery suspending reasons	328	2	Mandatory
	BTS Threshold value	Threshold value for suspending parameter	329	4	Mandatory
	BTS Breach value	Breach value for suspending parameter	330	4	Mandatory
CST	Normal, Warning or Error suspension	Charger suspending reasons	331	2	Mandatory
	CST Threshold Value	Threshold value for suspending parameter	332	4	Mandatory
	CST Breach Value	Breach value for suspending parameter	333	4	Mandatory

3.5.6.3.1. BMS Suspending Reasons (BTS)

With two bytes, the error values could be from 1-65534 (0x1 – 0x FFFF). While error codes 0x1 – 0x7FFF are reserved for protocol specific, 0x8000 – 0xFFFF are available for manufacturer specific code. The table below summarizes the suspending / alert code range and allocated ranges.

#	Suspending /Alert code specific to	Range	Range Split
1	Overall range	0x0001-0xFFFF	NA
2	Protocol specific	0x001 – 0x7FFF	Battery Specific: 0x0001- 0x3FFF
			Charger Specific: 0x4000 – 0x7FFF

3	Manufacturer specific	0x8000 – 0xFFFF	Battery Specific:0x8000 – 0xBFFF Charger Specific:0xC000 - 0xFFFF

While suspending, BMS will give error code and threshold with breach value for that particular error code, if available. If there are no appropriate values could be sent on threshold and breach values, it has to be filled as FFFFH.

Suspension Type	**Reason**	**Hexa decimal Code**	**BTS Threshold Value**	**BTS Breach Value**
Normal Suspension	Reached the required SOC target value	0001H	FFFFH	FFFFH
Error Suspension	Battery Connection Check failure. This condition is generated when the connector effective resistance is greater than 25mohm	0002H	FFFFH	FFFFH
	Battery Authenticity failure	0003H	BMS random number challenge response	Charger random number challenge
	Charging current is over or greater than the battery demand current	0004H	Demand current	Charging current
	Charging voltage mis-match with battery demand voltage	0005H	Demand voltage	charging voltage
	Battery cell over-temperature*	0006H	Threshold temp.	Excess temp.
	Battery cell over-voltage*	0007H	Threshold value	Breach value
	Battery pack over-voltage	0008H	Threshold value	Breach value
	Battery cell under-voltage*	0009H	Threshold value	Breach value
	Battery pack under-voltage	000AH	Threshold value	Breach value
Warning Suspension	BMS component over temperature	0007H	Threshold temp.	Excess temp.

	Battery over-temperature	0008H	Threshold temp.	Excess temp.
	Battery cell over-temperature	0009H	Cell number + Threshold temp.	Cell number + Excess temp.
Other Suspensions	Other suspensions	3FFEH	Threshold value	Breach value

*Whenever battery suspends for these reasons, the battery retrieval mode should be set as "Complete data retrieval mode" and to be communicated using BCDP message in Section 3.5.7.2

3.5.6.3.2. Charger Suspending Reasons (CST)

The suspending/alert code for charger will be in the range of 0x4000-0x7FFF

While suspending, charger will give error/alert code and threshold with breach value for that particular code, if available. If there are no appropriate values could be sent on threshold and breach values, it must be filled as FFFFH.

Suspension Type	**Reason**	**Hexadecimal Code**	**CST Threshold Value**	**CST Breach Value**
Normal Suspension	Suspending due to reaching target SoC set by the charger	4001H	SoC	FFH
Error Suspension	BIN acknowledgement failure Result	4002H	FFH	FFH
	Battery authenticity failure Result	4003H	Charger Random number	Random number response
	Protocol version acknowledgment error	4004H	Charger protocol version	BMS Protocol version
	Battery parameters compatibility result failure	4005H	FFH	FFH
	Battery demand parameters compatibility result failure	4006H	FFH	FFH
	Emergency stop fault for charger	4007H	FFH	FFH
	Charger defers charging based on OMS instruction	4008H	FFH	FFH

Warning Suspension	Internal temperature of charger is excessive	4009H	Threshold temp.	Excess temp.
Other Suspension	Other Suspension	7FFFH	Threshold value	Breach Value

3.5.7. Charging log transfer stage

3.5.7.1. Charging Data Log

After charging stage, both BMS and charger will enter charging log transfer stage. During this stage, BMS will send the charging statistical data captured during the charging process to the charger.

This section describes the data log parameters captured during charging. The log data is transferred from BMS to charger using defined packet formats. These packets are formed by grouping various parameters. The charger will interpret the data based on the defined packet formats.

3.5.7.1.1. Charging Log Parameters

The following table details the parameters logged during charging:

#	Parameter Name	Description	Parameter type	Granularity	Data Size(B)
1	BIN	Unique battery Identification number	One-time	Once	20
2	Number of cells	Total number of cells in battery	One-time	Once	1
3	Number of temperature sensors	Total number of temp. sensors	One-time	Once	1
3	Start SOC	SoC at the start of charging	One-time	Once	2
4	End SOC	SoC at the end of charging	One-time	Once	2
5	Total energy received while charging	Total energy transferred in w-Hr	One-time	Once	2
6	Time required for current charging session	Time in seconds of last charging	One-time	Once	2
7	Charging life cycle number	The number of times the battery has undergone charging. This value will be available from BMS and BMS should increment this	One-time	Once	2

		counter by one for each charging cycle and store the value			
8	Battery firmware version	Firmware version of battery during charging	One-time	Once	3
9	Charger firmware version	Firmware version of charger	One-time	Once	3
10	SoH	State of Health in percentage	One-time	Once	2
11	UFD	Unique-Id for drive	One-time	Once	16
12	Last calibrated timestamp	Timestamp at which last calibration had happened. The Refer Section 5.4. for Timestamp format.	One-time	Once	4
13	Charging cycle number during last calibration	Charging cycle number when the battery was last calibrated	One-time	Once	2
14	Adaptive charging overridden count	When charger overrides battery request and continue to charge at current rate as specified by OMS	One-time	Once	2
15	Consumed energy during driving	The cumulative energy expended by the battery during driving in w-hr	One-time	Once	2
16	SoC	SoC in percentage	Periodic	60 Sec	2
17	Balancing current status	Balancing current of each cell during charging stage	Event based	0	4
18	Individual cell voltage	Individual cell voltage during charging stage	Periodic	60 Sec	2
19	Individual cell temperatures	Individual cell temperatures in 0. 1°C.during charging stage	Periodic	60 Sec	2
20	Charger output current	To be logged whenever the charger output current is higher than	Event	60 Sec	2

		the battery demand current			
21	Battery demand current	To be logged whenever the charger output current is higher than the battery demand current	Event	60 Sec	2
22	Measured battery voltage	The pack voltage as measured by battery	Periodic	60sec	2
23	Suspension reasons	Suspension reasons	Event	0	Based on type of suspension

3.5.7.1.2. Battery Data Storage format in BMS

- Charger one-time data storage format in BMS

Parameter Name	Time stamp	BIN	No. of cells	No. of temp. sensors	Start SoC	End SoC	Total energy passed while charging	Time required for last charging session
Size	4	20	1	1	2	2	2	2

Charger one-time data storage format contd..

Charging life cycle number	BMS Firmware Version	Charger Firmware Version	SoH	UFD	Last calibrated timestamp	Last calibrated charging cycle number	Adaptive charging overridden count	Consumed energy during driving
2	3	3	2	16	4	2	2	2

- Battery periodic data storage format in BMS

  Record 1:

Parameter Name	Time Stamp	SoC	Cell no.-1	Cell voltage-1	Cell no.-n	Cell voltage - n	Temp. sensor-1	Temp. sensor value-1	Temp. sensor -t	Temp. sensor value-t

Size (Bytes	4	2	1	2	1	2	1	2	1	2

Record 1 contd..

Temp. sensor -t	Temp. sensor value-t	Battery measured voltage	Charger output current	Battery demand current
1	2	2	2	2

Record 2:

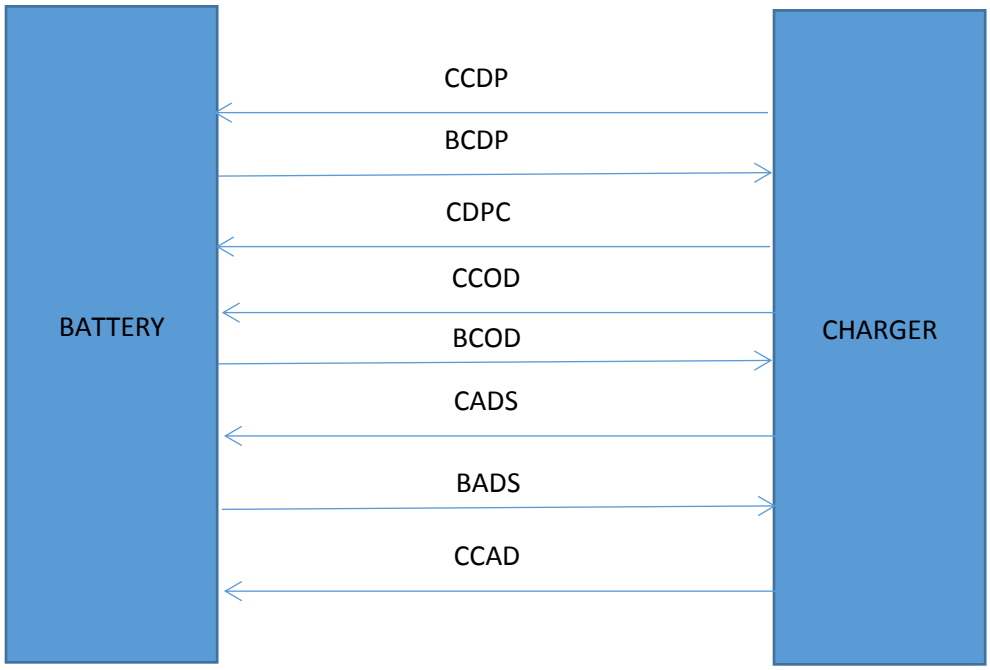
Parameter Name	Time Stamp	Balancing current status
Size (Bytes	4	4

3.5.7.1.3. Memory Calculation

Memory Calculation	
one-time data in Bytes	70
Periodic data in Bytes/60 Sec	138
Periodic data in KB / Hour	8.085938
Total KB / 2 Hours	84.17188

*For e-auto, the no. of maximum cells assumed to be 32

3.5.7.2. Message Flow



3.5.7.3. Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
CCDP	Charger requesting battery to indicate preferred mode of charging data retrieval	Charger - Battery	001A00H	6	1	250
BCDP	Battery response on the preferred charging data retrieval mode	Battery – Charger	001B00H	6	1	250
CDPC	Charger response on the charging data retrieval mode confirmation	Charger - Battery	001C00H	6	1	250
CCOD	Charger request for Battery One-time data	Charger to BMS	004700H	6	4	250
BCOD	Battery one-time data Response	BMS to Charger	004800H	6	70	250
CADS	Charger request for Battery additional data list	Charger to BMS	004B00H	6	1	250

BADS	Battery additional data list response	BMS to Charger	004C00H	6	5	250
CCAD	Charger request for battery additional data	Charger to BMS	004D00H	6	5	250
BCAD	Battery additional data response	BMS to Charger	004E00H	6	Depends on the CT type	250

Note: Refer Annexure B1 on detailed message flow diagrams

3.5.7.4. Parameters

Message Code	Parameter Name	Description	SPN (DEC)	Size in Bytes	Delivery Option
CCDP	Charging data retrieval mode request parameter	Value : 0xAAH	2592	1	Mandatory
BCDP	Battery confirmation on preferred charging data retrieval mode.	Value : 0xAAH indicates default data transfer mode Value : 0xFFH indicates complete data transfer mode	2593	1	Mandatory
CDPC	Charger confirmation on the charging data retrieval mode	Default data retrieval mode – Optimized for time : 0xAAH; Complete data retrieval mode – Optimized for analysis : 0xFFH	2594	1	Mandatory
CCOD	Request Value: timestamp	Default timestamp. By default, the first time-stamp should be 01/01/2017 00:00:00. The format of timestamp is as defined in Section: Timestamp format for periodic data	334	4	Mandatory
BCOD	Response Packet	Sends response packet in the format defined in the Section: BCOD packet format	335	70	Mandatory
CADS	Additional data list: AAH	Request different data list from BMS	338	1	Mandatory
BADS	Response data list	Response packet as defined in Section BADS packet format	339	5	Mandatory

CCAD	Request Packet	Charger request packet as defined in Section CCAD format	340	5	Mandatory
BCAD	Response data	Sends response packet in the format defined in the Section: BCAD packet format	341	Depends on the CT type	Mandatory

3.5.7.5. Packet Formats

3.5.7.5.1. BCOD Packet Format

Parameter Name	Timestamp	BIN	No. of cells	No. of temp. sensors	Start SoC	End SoC	Total energy passed while charging	Time required for current charging session
Size	4	20	1	1	2	2	2	2

Charging life cycle number	BMS Firmware Version	Charger Firmware Version	SoH	UFD	Last calibrated timestamp	Charging cycle number during last calibration	Adaptive charging overridden count	Consumed energy during driving
2	3	3	2	16	4	2	2	2

3.5.7.5.2. BADS Packet Format

Parameter Name	**Type**	**Size(Bytes)**	**Granularity(sec)**
Size(Bytes)	1 byte	2 bytes	2 bytes
Example for CT1	1	2	10

The type, size and granularity will be identified from type number, size and granularity from the following table number. For data retrieval of the stored battery log during charging, the following types are defined. The example values are indicated in big endian format. The data over CAN bus to be interpreted in little endian format. For example, 0x09C4 will appear as C4 09 in CAN bus.

Type	**Type**	**Size**	**Granularity**	**Parameters**	**Example Values**

Name	Number	(Bytes)	(Secs)		
CT1	1	4	10	Balancing current status	Value: 00 00 00 07 Interpretation: Cell 0,1 & 2 alone balanced
CT2	2	1+2	10	Cell number + Individual cell voltage	Value: 00+ 0B DB Interpretation: sensor no:0 + 3005 centi degree
CT3	3	1+2	10	Sensor number + Individual sensor temp.	Value: 00 +0F B8 Interpretation: Cell no:0 + 4024 milli volt
CT4	4	2	10	SoC	Value: 03 F6 Interpretation : 1014 w-hr
CT5	5	2	60	Charger output current	Value: 00 3C Interpretation: 60 Centi-Amps(unsigned int)
CT6	6	2	60	Battery demand current	Value: 00 3C Interpretation: 60 Centi-Amps(unsigned int)
CT7	7	2		Battery measured voltage	Value: 14 73 Interpretation: 5235 centi-volt

3.5.7.5.3. CCAD Packet Format

Parameter Name	Type n	Timestamp
Size in Bytes	1	4
Example for CT1	1	16022906H

Note: By default, the first time-stamp should be 01/01/2017 00:00:00. The format of timestamp is as defined in Section: Timestamp format for periodic data

3.5.7.5.4. BCAD Packet Format

When CCAD is received for CT2 and CT3 with say Timestamp1, BMS will send 'n' number of responses for that timestamp, where 'n' will be equal to number of cells for CT2 and number of temperature sensors for CT3.

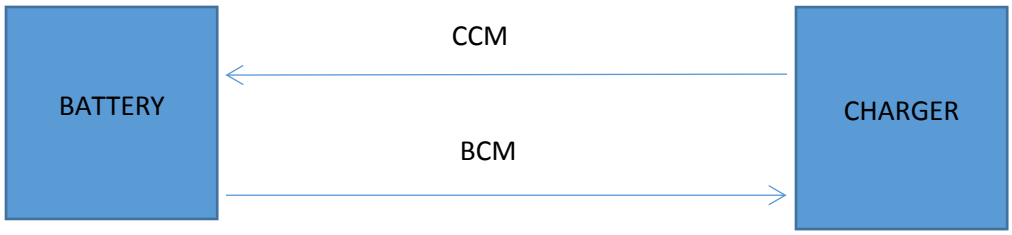
For e.g. if the number of cells is 32, then BMS will send 32 responses for the timestamp received in CCAD.

Parameter Name	Timestamp	Data
Size in Bytes	4	3
Example for CT3	16022906H	500

3.5.8. End-of-Charging Stage

In this stage, if charging is successfully terminated, the battery lock-smart is changed from charge mode (0x00) to drive mode (0x01). Battery acknowledges the mode change. If there is a time-out, then charger will indicate this as error in the suspension message.

3.5.8.1. Message Flow



3.5.8.2. Messages

Message Code	Message Description	Source – Destination	PGN (HEX)	Priority	Data Length in Bytes	Message Period (ms)
CCM	Charger Battery mode change message	Charger to BMS	004F00H	6	1	250
BCM	Battery mode change acknowledge Message	BMS to Charger	005000H	6	1	250

3.5.9.3. Parameters

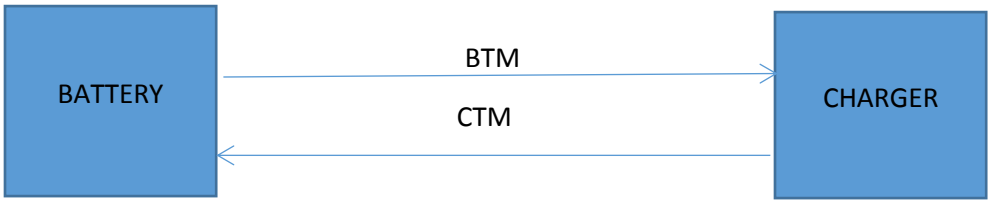
Message Code	Parameter Name	Description	SPN (DEC)	Size in Bytes	Delivery Option
CCM	Battery lock-smart mode: Drive mode:0x01	Charger requesting battery to change mode from charge mode to drive mode	342	1	Mandatory
BCM	Battery mode acknowledge	Battery acknowledging mode change. Success: 0xAA; Failure: 0XFF. • It also sets the geo-fence status as 'inside' and discharge unlock	343	1	Mandatory

		status as 'on'. This will allow the battery to discharge when assigned to a vehicle. • The battery should set the value of consumed energy to zero. It is only after this; the battery should clear out its internal memory			

3.5.9. Time-out Messages

The time-out of messages during the whole charging process is communicated using these messages. This message will carry the second byte of PGN to indicate the timed-out message.

3.5.9.1. Message Flow



3.5.9.2. Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
BTM	BMS time-out Message	Battery to Charger	005100H	2	1	250
CTM	Charger time-out message	Charger to Battery	005200H	2	1	250

3.5.9.3. Parameters

Message Code	Parameter Name	Description	SPN (DEC)	Size in Bytes	Delivery Option
BTM	Second Byte of PGN Value of timed-out message	Battery Messages time-out	344	1	Mandatory
CTM	Second Byte of PGN Value of timed-out message	Charger Messages time-out	345	1	Mandatory

3.6. Implementation Note

As seen above, the configurations of a charging session is determined by charger querying OMS using the "ConditionalRetrievalMode" and "IsBatteryAllowedToCharge" messages. If for some reason, the charger is not able to reach the OMS, then the following defaults shall apply.

1. adaptivecharging – 1 i.e allow adapative charging
2. recalib – follow what the battery suggests.
3. retmode – follow what the battery suggests

This also means that the charger should store the data retrieved from the battery and transfer it to OMS when the connectivity is restored. Also, as previously noted on "store and forward" mechanism, if the charger is not able to communicate with the OMS and also cannot hold the data that is expected from the battery because of memory constraints, then it should stop additional charging sessions.

4. Driving Protocol

The communication protocol between Vehicle and BMS will be referred as "Driving Protocol". This protocol will be divided into multiple stages based on the operation to be performed.

- When the batteries get placed inside the vehicle, the module address would be assigned by the vehicle controller automatically. VCU would reserve addresses in the range of 0x90 to 0x94 for addressing BMS modules.
- This auto-address assignment should happen only once when the battery gets placed and not on every start of the vehicle and is taken care by BMS. By default, BMS address would be 254(0xFE), Whenever vehicle is started, a vehicle start message is broadcasted to all BMS. When BMS receives this message, it checks its address and if it other than 254(0xFE), then it checks for its mode (Master/Slave) with vehicle and starts reacting based on the mode assigned by the VCU
- By default, the battery module with least address 0x90 will act as master and take care of the communication with vehicle controller as well as logging vehicle related data. If there is a failure in Master BMS, then vehicle would time-out for some message, suspend and stop as there would not be any communication with Master BMS.
- When the Vehicle is again started, BMS will have its address assigned so it will initiate the mode (Master/Slave) confirmation message to VCU. By sensing only two requests and will the Source address, VCU will identify the failure of Master BMS and will re-assign the next slave as Master.
- While assigning the Master BMS, VCU will inform the other module address as well as its role to all the BMS. This way all the BMS will come to know which the module's address which will be acting as master BMS.
- Throughout the driving protocol, various parameters are logged at different time-intervals and based on events. Refer section, 3.5.4.1. for the details on the data and their format in which to be logged and the way they must be shared with charger.
- Vehicle related data log is done only in Master BMS to avoid duplicate data in all the batteries. This decision is made based on the battery mode (Master/Slave).
- When there is a Master BMS failure and when the slave gets assigned as Master, master BMS should retain a flag to indicate that it had acted as Master earlier. This would be required at the charging protocol during data retrieval.

4.1. Physical Layer

Physical Layer conforming to this standard shall refer to ISO 11898-1:2003 and SAE J1939-14: 201612. The communication between VCU and BMS in this standard shall use the CAN interface. The communication rate between vehicle and BMS would be 500 kbit/s.

4.2. Data Link Layer

4.2.1. Frame Format

Equipment complying with this standard shall use 29-bit identifier of CAN extended frame, and the corresponding definition of each specific bit allocation shall meet the requirements as given in SAE J1939-21:2006.

4.2.2. Protocol Data Unit (PDU)

Each CAN data frame contains a single protocol data unit (PDU). The protocol data unit is composed of seven parts which respectively are priority, reserved bit, data page, PDU format, specific PDU, source address and data field.

4.2.3. PDU Format (PF)

In this standard, the PDU1 format defined in SAE J1939-21:2006 is selected.

4.2.4. Parameter group number (PGN)

The second byte of PGN is PDU format (PF) value, and both high byte and low byte are 00H.

4.2.5. Functions of transport protocol

The transport of 9~1785-byte data between BMS and charger shall use the transport protocol function. The specific connection initialization, data transport and connection closing shall comply with the provisions on message transport as given in 5.4.7 and 5.10 of SAE J1939-21:2006. As for the multi-frame message, the message period refers to the transport period for the whole data package.

4.2.6. Address allocation

Network address is used to guarantee the uniqueness of message identifier and to indicate the message source. The Vehicle address is fixed as 129(Dec) or 81H and BMS address is assigned by the VCU as a part of the protocol.

4.3. Application Layer

- The application layer is defined in manner of parameters and parameter group.
- Parameter group is numbered by PGN, and each node identifies the content of data packet according to PGN.
- Data are transported in the form of periodical transport and event-driven mode.
- In case that multiple PGN data need to be transmitted to realize one function, it requires receiving multiple PGN messages of this definition to judge the successful transmission of this function.
- The message options may be either mandatory or optional. If all the contents in the same frame of message are optional, such message may be transported by filling 1The length of message and content and format of mandatory item shall be transported as detailed in subsequent chapters.

4.4. Overall Driving Procedure

The whole driving process comprises of four stages: Auto-address assignment stage, Handshake stage, Parameter exchange stage and driving stage. After the physical connection is established, the protocol starts the communication with auto-address assignment stage followed by handshake, parameter exchange and driving stages.

The auto-address assignment stage and the handshake stage will be repeated for the number of BMS present in the vehicle and for the other stages, VCU will communicate only with Master BMS. In Parameter exchange stage and driving stage, there will be an internal communication from Slave BMS to Master BMS to update the available energy. Master BMS then does a summation of the available energy and presents it to the Vehicle.

Whenever Slave BMS suspends due to some reasons, Master BMS will receive this and present it to VCU as suspension. Whenever Vehicle suspends it would broadcast this message to indicate to all the BMS. This is required for the slave BMS to stop sending the available energy data to Master BMS for summation

In each stage, if the vehicle or BMS does not receive message from the other party or does not receive correct message within the stipulated time limit, the waiting entity will timeout (timeout means failure to receive a complete data package or correct data package within specified time); unless otherwise specified, the timeout is all 5s. After timeout, vehicle or BMS will send suspending message.

4.4.1. Suspending /Alert Types

The suspending/alert messages are three types:

- Normal Suspension – Whenever vehicle stops / ignition is off

- Warning /Alerts – These alerts are intended to warn the vehicle/user of impending potential problems that could automatically stop the vehicle. It is advisable for the user to stop the vehicle so that the warning condition does not become an error. For e.g., if there is a battery over-temperature warning, stopping the vehicle (Normal Suspension) and waiting for some-time for the temperature to come down will prevent an abrupt stopping

- Error Suspension – The vehicle will stop after error and will not start until the error gets sorted out. Some errors like BIN-VIN mismatch are non-recoverable, while others like battery or component over-temperature can be overcome with some idle time
  Figure below presents the overall driving process.

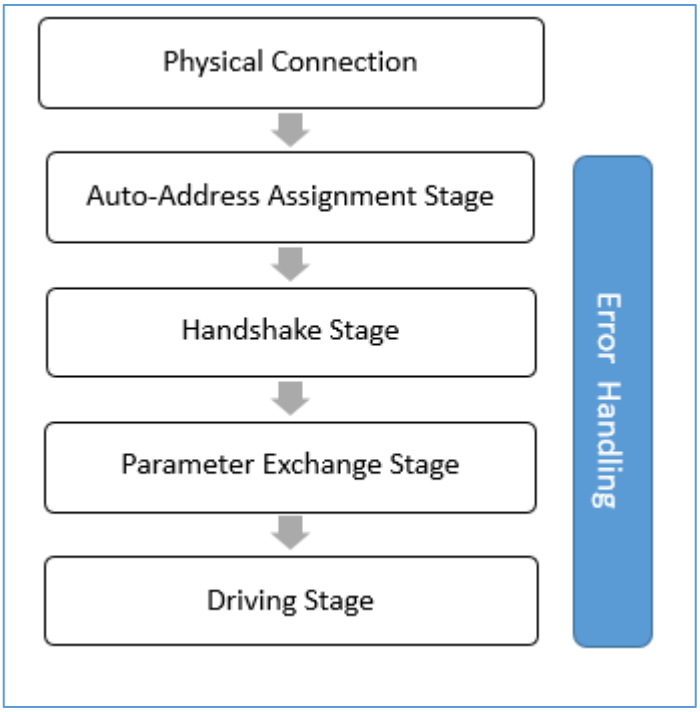


Figure: Driving Protocol Stages

4.5. Driving Protocol Stages

In driving protocol, VCU will communicate only with the master battery module in fetching the required information. Wherever required, the master module will get data from slave modules, do some calculation and present the data to the VCU. Similar condition is applicable for Error conditions also.

If there is an error in slave module, it will be communicated to Master module and master will suspend by stating the error code. If master BMS fails due to some condition, VCU will detect this through the battery mode re-iteration message from batteries and assign the next least addressed BMS as Master BMS and whenever Master BMS recovers, it would confirm its role as Master BMS with VCU and based on the response, it would start acting accordingly. Protocol has provision for extra message to handle this.
If the number of battery module count is less than the expected, then vehicle will indicate this as warning to the driver may be through dashboard

In the parameters table in each stage, the order of SPNs in the CAN communication is as per the order specified in the table itself. For any suspension during the protocol flow, the state machine will reset and start from the beginning of the protocol.

Driving Protocol version: 0.9.0.

4.5.1. Auto address assignment stage

VCU assigns addresses for all BMSes. VCU must reserve the address in the range of 0x90 -0x94 for BMS addressing irrespective of the number of batteries to be placed in the vehicle. VCU's source address (SA) is defined as 129 (81H).

Whenever Vehicle is started, vehicle broadcasts vehicle start message to BMS. BMS checks if its address is assigned, if yes then BMS confirms its role (Master/Slave) with vehicle and proceeds with handshake stage. If address is not assigned then BMS requests for an assignment

- **Message1: Indication of vehicle started from VCU**

VCU broadcasts vehicle started message to BMS. BMS checks for address assignment and if not sends Message 2 requesting for address claim else sends BMS will send a role (Master/Slave) confirmation request to VCU.

SA	DA	DATA Byte:01	DATA Byte:02	DATA Byte:03	DATA Byte:04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
81 (VCU Address)	FF (Global Address)	AA				00	00	00	00

- **Message2: Request for address claim from BMS**

BMS will send a request for address claim by generating a random number (RN1- say 2E2614D0) of 4 bytes in the data field. Bytes 1 to 4 will be used for this. Unused bytes in the data field will be filled with 0x00.

SA	DA	DATA Byte:01-04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
FE (Null Address)	81 (VCU Address)	2E2614D0	00	00	00	00

- **Message3: Broadcast response for address claim from VCU**

VCU broadcasts to CAN bus with the same random number (RN1- 2E2614D0) and allotted address (say 0x90). The allotted address will be available in the 5th byte of data field.

SA	DA	DATA Byte:01-04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
81 (VCU Address)	FF (Broadcast Address)	2E2614D0	90	00	00	00

- **Message4: BMS confirmation request for allotted address from BMS**

BMS requests VCU to confirm the usage of the allotted address by generating and sending another random number (RN2 – say 33AB7F30) and allotted address (0x90) to VCU.

SA	DA	DATA Byte:01-04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
FE (Null Address)	81 (VCU Address)	33AB7F30	90	00	00	00

- **Message5: VCU confirmation response for allotted address from VCU**

VCU broadcasts to CAN bus with the random number (RN2), allotted address (0x90) and address status (0xAA: Success; 0xFF: Failure). The address status will be available in the 6th byte of data field. If the status from VCU is a failure i.e. the address being allotted to some other BMS, then BMS must repeat and start from Message1.

When VCU broadcasts with random number, allotted address and address status in the CAN bus. Each BMS should keep a track on this message to identify the number of batteries present.

SA	DA	DATA Byte:01-04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
81 (VCU Address)	FF (Broadcast Address)	33AB7F30	90	AA	00	00

- **Message 6: BMS confirmation on allotted address**

BMS confirms to VCU on the allotted address by sending the random number 2, allotted address and the confirmation status (0xAA: Success; 0XFF: Failure)

SA	DA	DATA Byte:01-04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
FE (Null Address)	81 (VCU Address)	33AB7F30	90	AA	00	00

The failure status would occur, if BMS is unable to assign the allotted address for some reasons. In this case, the BMS must repeat and start from Message2 to get an address assigned.

When VCU sees a success status, it ensures that this address is not given to any other BMS

- **Message 7: VCU assigning master BMS**

VCU will assign BMS with least address as Master BMS. For e.g. it the batteries gets 0x90, 0x91 and 0x92 as their assigned addresses, then VCU assigns BMS with 0x90 as Master BMS. The other BMS will act as Slaves.

For Master BMS

SA	DA	DATA Byte:01	DATA Byte:02	DATA Byte:03	DATA Byte:04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
81 (VCU Address)	90 (Master BMS)	AA (Master)	90 (Self Address)	90 (Master Address)	00	00	00	00	00

For Slave BMS1

SA	DA	DATA Byte:01	DATA Byte:02	DATA Byte:03	DATA Byte:04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08

81 (VCU Address)	91 (Slave BMS1)	FF (Slave)	91 (Self Address)	90 (Master Address)	00	00	00	00	00

For Slave BMS2

SA	DA	DATA Byte:01	DATA Byte:02	DATA Byte:03	DATA Byte:04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
81 (VCU Address)	92 (Slave BMS1)	FF (Slave)	92 (Self Address)	90 (Master Address)	00	00	00	00	00

The address assignment for other BMS will happen in parallel in the same manner. In order to reduce the probability of multiple trials, each BMS should start with message 2 above after a random delay for a duration between 50 to 200 ms. The following use cases are defined to elaborate on address assigning procedure under few conditions:

Case 1: Probability of VCU receiving the same random number from two BMS (Message2)

- VCU will broadcast RN1+allotted address as defined in Message3.
- Both the BMS will receive this response and will send a confirmation request for allotted address with random number 2.
- VCU will receive the response and will send (Message5 with 0xAA in byte 06) success to first BMS and failure (Message5 with 0x00 in byte 06) to other BMS.
- BMS receiving success status will continue with Message6 onwards and BMS receiving failure status will start from Message2
- Probability of occurrence of random number 2 being same for two BMS is very less and assumed to not occur.

Case 2: Failure in Master BMS

Assuming there is a failure in Master BMS, VCU will time-out and suspend the drive. When the vehicle is again started, Master BMS is down without any communication, each BMS will confirm its role with VCU by sending a battery mode re-iteration message.

VCU will detect only two batteries are present and issue a warning to the driver and will continue with assigning the Slave with address 0x91 as Master and start with the protocol.

When master BMS had failed, VCU assigns SLAVE BMS 1 as Master:

SA	DA	DATA Byte:01	DATA Byte:02	DATA Byte:03	DATA Byte:04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
81 (VCU Address)	91 (Slave BMS1)	AA (Master)	91 (Self Address)	91 (Master Address)		00	00	00	00

The same message will be issued to Slave BMS2 also.

During the run of the vehicle, when Master resumes from its failure mode, it will initiate the battery mode re-iteration message to VCU to check whether it is Master and VCU confirms its status by sending

Message 6. Through Message 6, Master BMS will realize that it is not currently master and will start acting as slave. When Master BMS resumes and requests to confirms its status, VCU would send

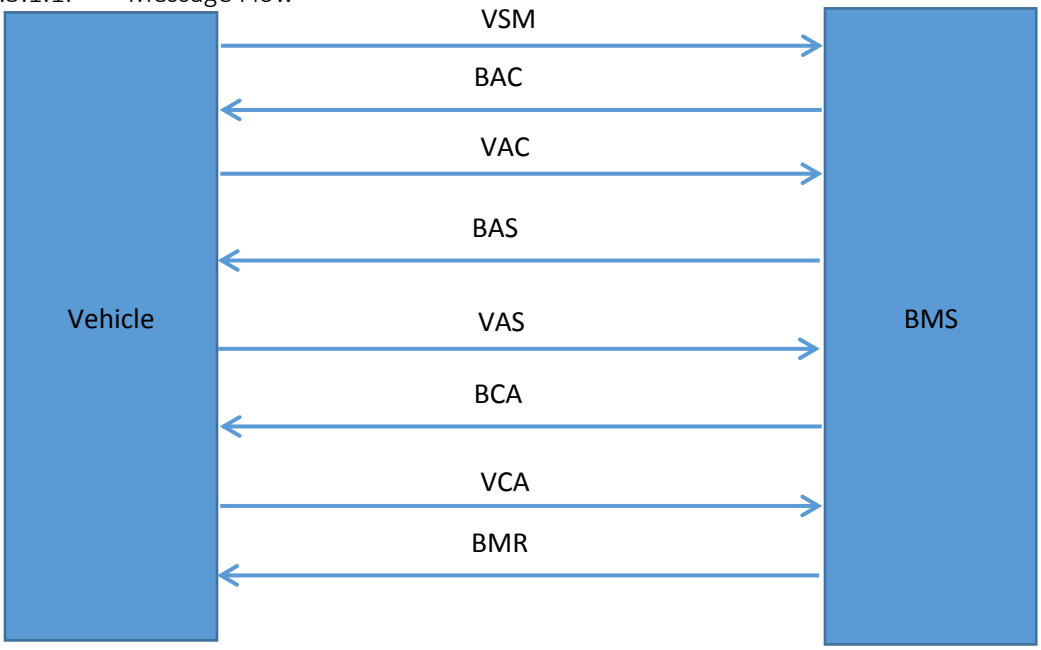
SA	DA	DATA Byte:01	DATA Byte:02	DATA Byte:03	DATA Byte:04	DATA Byte:05	DATA Byte:06	DATA Byte:07	DATA Byte:08
81 (VCU Address)	90 (Master BMS)	FF (Slave)	90 (Self Address)	91 (Master Address)	00	00	00	00	00

Case 4: When BMS resumes after a failure

When any BMS fails due to some reason, then immediately after recovery, it must check if its address is assigned and if not, it would claim by using address assignment procedure. Next it would check whether it was acting as Master BMS, if yes then it would send BMR message requesting the status of its role as Master BMS. Master BMS will send Message 6 to confirm whether it must act as Master or slave.

Refer Annexure C1 for auto-address assignment flow

4.5.1.1. Message Flow



4.5.1.2. Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
VSM	Vehicle start message	Vehicle to BMS	000F00H	4	1	250

BAC	Battery address claim request message	BMS to Vehicle	001200H	4	4	250
VAC	Vehicle broadcast response for address claim message	Vehicle to BMS	005700H	4	5	250
BAS	BMS confirmation address request Message	BMS to Vehicle	005800H	4	5	250
VAS	VCU confirmation address response. VAS message shall be used by BMS to identify the number of batteries present in the vehicle. VCU broadcasts VAS with random number, allotted address and address status in the CAN bus. Each BMS should keep track of this message and the unique allotted address to decipher the number of batteries present.	Vehicle to BMS	005900H	4	6	250
BCA	BMS confirmation request on allotted address	BMS to Vehicle	005A00H	4	6	250
VCA	Vehicle Assigning Master BMS Message	Vehicle to BMS	001300H	4	3	250

BMR	BMS mode re-iteration Message. After sending BMR message to VCA, BMS has to initiate the communication with tracking module. Refer section 7.1. for more details	BMS to Vehicle	001400H	4	1	250

BMS Mode Re-Iteration Message: This message will be used in two scenarios:

Scenario 1: Start of vehicle:

Whenever vehicle is started, it will send VSM message to indicate the start of vehicle to BMS. BMS checks if its address is assigned and if not, it would claim by using address assignment procedure by sending "BAC" message. If address is assigned, then BMS sends BMR message to check if it is Master or Slave. VCU will give the confirmation through VCA message. This would be repeated for each BMS in the vehicle

Scenario 2: Master BMS failure

Due to some reasons, when Master BMS fails to provide the required details to VCU, VCU will send Time-out message and suspend the drive.

As driver won't be aware of this, when he starts the vehicle again, VCU will receive BMR only from other BMS. As this count will be less than the expected count based on number of batteries in vehicle, vehicle will indicate this as warning to the driver.

As it had received only two requests from the BMS, by checking the source address, VCU identifies that Master BMS had failed and assigns next Slave BMS (say 91H) as Master and continues with the protocol. The VCU waiting time for BMR request from batteries could be 3 seconds. After receiving first BMR, If VCU doesn't receive other BMR within 3 seconds, then VCU will proceed with mode confirmation message. The same steps are applicable when any BMS fails.

4.5.1.3. Parameters

Message Code	Parameter Name	Description	SPN (Dec)	Size in Bytes	Delivery Option
VSM	Vehicle start; Value=0xAA	Vehicle start parameter to BMS to indicate the ignition of vehicle	370	1	Mandatory
BAC	Random Number 1	Random number 1 generated by BMS. Till VCU confirms or rejects or time out, this	356	4	Mandatory

		random number 1 to be re-used.			
VAC	Random Number 1	Random number received in BAC	260	4	Mandatory
	Allotted address	Address allotted by VCU	261	1	Mandatory
BAS	Random Number 2	Random number 2 generated by BMS. Till VCU confirms or rejects or time out, this random number 1 to be re-used.	262	4	Mandatory
	Allotted address	Allotted address in VAC	263	1	Mandatory
VAS	Random number 2	Random number 2 received in BAS message	357	4	Mandatory
	Allotted address	Allotted address by VCU in VAC message	358	1	Mandatory
	Allotted status Success=0xAA; Failure=0xFF	Allotted address status. VCU confirming the address status as success or failure	359	1	Mandatory
BCA	Random Number 2	Random number 2 generated in BAS message	360	4	Mandatory
	Allotted address	Allotted address in VAC messages	361	1	Mandatory
	Acceptance status Success=0xAA; Failure=0xFF;	BMS acceptance status for allotted address	362	1	Mandatory
VCA	Master BMS Assignment with Master: 0xAA; Slave :0xFF;	VCA assigning the BMS with least address as Master BMS. By default, it would be 90H and incase of Master BMS failure, the next least address would be 91H	363	3	Mandatory
BMR	BMR assignment request, Value=0xAA;	BMS requesting Master status	364	1	Mandatory

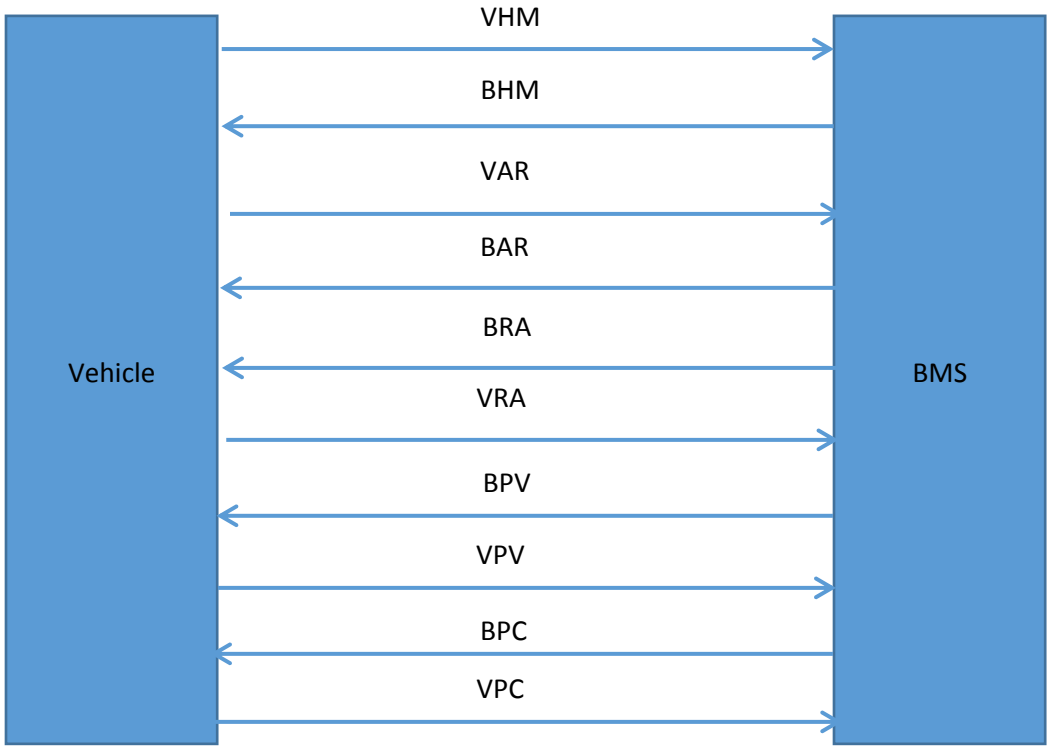
4.5.2. Handshake Stage

In this stage, the BIN-VIN matching check is done to make sure that the VIN is programmed in Swapping outlet to work with this IBN is indeed the VIN in which the BMS is placed. This is followed by battery

authenticity check by VCU and driving protocol version – compatibility check. Annexure A2 provides details on the protocol version matching.

In battery authenticity check, a random number is generated by VCU and sent to BMS. BMS runs an algorithm and sends the result to VCU. VCU runs the same algorithm and based on the result, it authenticates the battery. This battery authentication must be done with each battery module independently.

4.5.2.1. Message flow



4.5.2.2. Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
VHM	Vehicle Handshake Message(VHM)	Vehicle to BMS	005B00H	6	20	250
BHM	Battery Handshake Message(BHM)	BMS to Vehicle	005C00H	6	24	250
VAR	Authenticity Request Message initiated by Vehicle	Vehicle to BMS	005D00H	6	4	250

BAR	Authenticity Response Message by battery for vehicle initiated request	BMS to Vehicle	005E00H	6	4	250
BRA	Authenticity Request Message initiated by Battery	BMS to Vehicle	000E00H	6	4	250
VRA	Authenticity Response Message by Vehicle for battery initiated request	Vehicle to BMS	001D00H	6	4	250
BPV	BMS protocol version Message	BMS to Vehicle	005F00H	6	3	250
VPV	Vehicle Protocol Version Message	Vehicle to BMS	000600H	6	3	250
BPC	Battery Protocol Version Confirmation Message	BMS to Vehicle	006100H	6	3	250
VPC	Vehicle Protocol Version Acknowledgment Message	Vehicle to BMS	006200H	6	1	250

4.5.2.3. Parameters

Message Code	Parameter Name	Description	SPN in Dec	Size in Bytes	Delivery Option
VHM	VIN	VIN - Vehicle Identification Number	264	17	Mandatory
	VCU firmware version	Firmware version of VCU	336	3	Mandatory
BHM	BIN	BIN	265	20	Mandatory
	BMS firmware version	Firmware version of BMS	337	3	Mandatory
	VIN Acknowledgment Result	Acknowledgment result by BMS on receiving VIN. This step is to confirm that the battery modules are configured for the same VIN	266	1	Mandatory

		during swapping procedure. Success = 0xAA; Failure=0XFF			
VAR*	Vehicle Random Number Challenge	Authenticity request number from vehicle check between Vehicle and BMS	267	4	Mandatory
BAR*	Battery Random Number Response	Authenticity response number from battery	268	4	Mandatory
BRA**	Battery random number request	Authenticity request number from battery	310	4	Mandatory
VRA**	Vehicle random number response	Authenticity response number from vehicle	311	4	Mandatory
BPV	BMS driving protocol version	Driving protocol version number of BMS e.g. 00H01H00H for version 1.0	269	3	Mandatory
VPV	Vehicle driving protocol version	Driving protocol version number of the vehicle	270	3	Mandatory
BPC	Confirmed version of BMS communication protocol	Based on vehicle's protocol version, BMS will confirm the version number	271	3	Mandatory
VPC	Protocol version acknowledgement	Acknowledgement on protocol version from BMS. Success = 0xAA; Failure=0XFF	272	1	Mandatory

Note: Refer Annexure A for protocol version matching scenarios

*Authenticity Check initiated by vehicle:

Random number (RN1) is generated by vehicle and sent to BMS. BMS runs an algorithm and sends the result to vehicle (Result). Vehicle runs the same algorithm and based on the result, it authenticates the battery.

For internal testing purpose, Result = RN1 / 2 could be assumed with some random number as RN1 and before final delivery, the proprietary algorithm provided by Energy Business Company has to be implemented.

**Authenticity Check initiated by Battery:

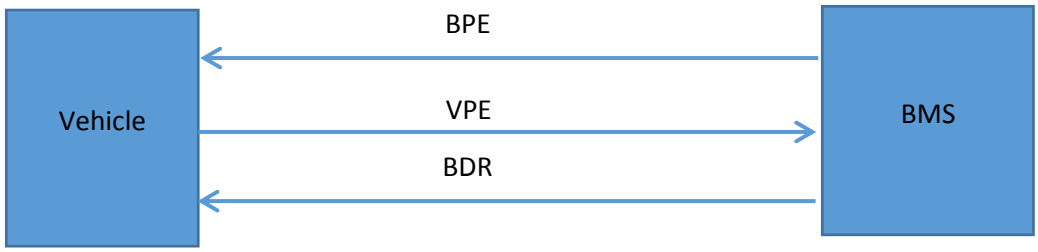
Random number (RN2) is generated by BMS and sent to Vehicle. Vehicle runs an algorithm and sends the result to BMS (Result). BMS runs the same algorithm and based on the result, it authenticates the Vehicle.

For internal testing purpose, Result = RN 2 / 2 could be assumed with some random number as RN2 . The proprietary algorithm will be provided by Energy Business company for both the stage: Authenticity check initiated by vehicle as well as from Battery as binaries. BMS and Vehicle OEMs would have to develop their firmware using the same.

4.5.3. Parameter Exchange Stage

During this stage, the parameters required for driving are exchanged between BMS and vehicle. The available energy will be provided by Master BMS. Master BMS will do all mathematical calculation and provide the required detail to vehicle.

4.5.3.1. Message Flow



4.5.3.2. Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
BPE	Battery Parameter Exchange Message. During parameter exchange stage, once a BMS is assigned as slave, it would keep sending the SoC*SoH value to Master BMS. Master BMS will do the summation of all the SoC*SoH and present it as "available energy" to the vehicle.	Master BMS to VCU and Slave BMS to Master BMS	006300H	6	4	250
VPE	Vehicle Parameter Exchange Message	Vehicle to BMS	006400H	6	6	250
BDR	Battery discharge ready message	BMS to Vehicle	001500H	6	1	250

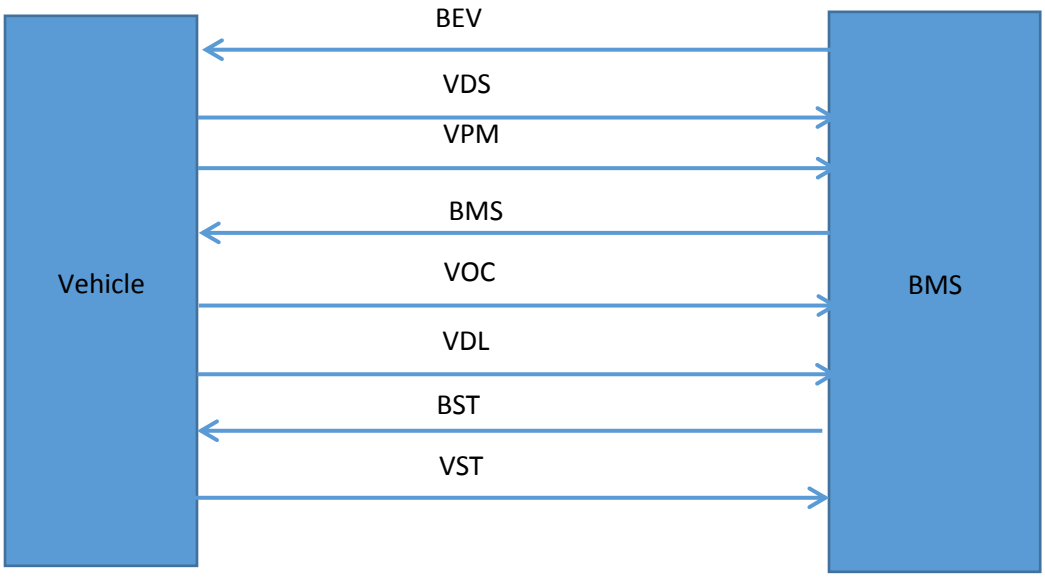
4.5.3.3. Parameters

Message Code	Parameter Name	Description	SPN in Dec	Size in Bytes	Delivery Option
BPE	Available energy in watt-hour	Summation of (SOC*SOH) of battery modules is sent by the master module to the VCU. Slave battery modules should send their (SoC*SoH) to master module	273	2	Mandatory
	Battery rated capacity in watt- hour	Summation of rated capacity of battery modules is sent by master module to the VCU. Slave battery modules should send their rated capacity to master modules.	2574	2	Mandatory
VPE	Effective resistance of power path	Effective resistance of power path in milli-ohm	274	2	Mandatory
	Start meter reading	Odometer reading at the start of the vehicle in Km	275	4	Mandatory
BDR	Battery discharge ready signal. Value-0xAA	Master BMS giving the discharge ready signal to vehicle	365	1	Mandatory

4.5.4. Driving Stage

Throughout the driving stage, the BMS and VCU communicates periodically using the defined messages. The BMS must send the available energy by maintaining some level of threshold to ensure that battery doesn't get drained to the end. This threshold value can be a proprietary parameter of battery manufacturer.

4.5.4.1. Message Flow



4.5.4.2. Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
BEV	Battery Status Message	Master BMS to Vehicle & Slave BMS to Master BMS . During driving stage, Slave BMS should keep sending the SoC*SoH value to Master BMS every 50 ms. Master BMS will do the summation of all the SoC*SoH and present it as "available energy" to the vehicle.	006500H	4	8	500
VDS	Vehicle Status Message	Vehicle to BMS	006600H	4	4	1000
VPM	Vehicle Parameters Message	Vehicle to BMS	001600H	4	6	1000

BMS	Battery Master to Slave Message	Broadcast from Master BMS (to Slave BMSes)	001900H	4	2	1000
VOC	Vehicle Open command 1 Data for logging	Vehicle to BMS	003900H	4	4	10000
VDL	Vehicle Open command 2 for data logging	Vehicle to BMS	003A00H	4	4	60000
BST	Battery Suspending /Alert Message	Master BMS to Vehicle & Slave BMS to Master BMS	006700H	2	10	500
VST	Vehicle Suspending / Alert Message	Vehicle to BMS	006800H	2	10	500

4.5.4.3. Parameters

Message Code	Parameter Name	Description	SPN in Dec	Size in Bytes	Delivery Option
BEV	Battery maximum permissible current	Calculated by the master and sent to VCU by taking minimum value of the maximum current of individual modules multiplied by number of modules in Centi Ampere.	276	2	Mandatory
	Maximum permissible regeneration current	Calculated by the master and sent to VCU by taking minimum value of the maximum current of individual modules multiplied by number of modules in Centi Ampere	277	2	Mandatory
	Available energy	Master will do the summation of (SOC*SOH) of battery modules. Each module will send (SoC*SoH)	278	2	Mandatory
	Battery ambient temperature	Battery ambient temperature in 0.1°C.	353	2	Mandatory
VDS	Vehicle controller Voltage	Vehicle controller voltage in Centi volts	279	2	Mandatory
	Vehicle controller current	Vehicle controller current in centi-amperes	354	2	Mandatory
VPM	Vehicle Speed	Vehicle speed in mph – meters per hour	280	2	Mandatory
	Odometer reading	Odometer reading	355	4	Mandatory

BMS	Battery instantaneous net current in Centi-Amp	Current sensed by master subtracted by current sensed by vehicle. Master BMS broadcasts the battery instantaneous net current (Current sensed by master subtracted by current sensed by vehicle) and all Slave BMSes can switch-off/disc-connect in case of unauthorized charging or disc-charging.	2589	2	Mandatory
VOC	OC1	Open Command 1	366	2	Optional
	OC2	Open Command 2	367	2	Optional
VDL	OC3	Open command 3	368	2	Optional
	OC4	Open command 4	369	2	Optional
BST	BMS Stops Discharging (BST)	BMS stops discharging with detailing normal, fault or error cause.	281	2	Mandatory
	BST Threshold Value	Parameter to carry the data related to Battery suspension reason with threshold value	282	4	Mandatory
	BST Breach Value	Parameter to carry the data related to Battery suspension reason with breach value	283	4	Mandatory
VST	Vehicle Stops (VST)	Vehicle stops with detailing normal, warning or error cause. This would be broadcasted over CAN bus to indicate that the vehicle is stopping	284	2	Mandatory
	VST Threshold Value	Parameter to carry the data related to vehicle suspension reason with threshold value	285	4	Mandatory
	VST Breach Value	Parameter to carry the data related to vehicle suspension reason with breach value	286	4	Mandatory

4.5.4.4. Battery Suspending/ Alert Reasons (BST)

With two bytes, the error values could be from 1-65534 (0x1 – 0x FFFF). While error codes 0x1 – 0x7FFF are reserved for protocol specific, 0x8000 – 0xFFFF are available for manufacturer specific code. The table below summarizes the suspending / alert code range and allocated ranges.

#	Suspending /Alert code specific to	Range	

1	Overall range	0x0001-0xFFFF	
2	Protocol specific	0x001 – 0x7FFF	Battery Specific: 0x0001- 0x3FFF
			Vehicle Specific: 0x4000 – 0x7FFF
3	Manufacturer specific	0x8000 – 0xFFFF	Battery Specific:0x8000 – 0xBFFF Charger Specific:0xC000 - 0xFFFF

While suspending, BMS will give error code and threshold with breach value for that particular error code, if available. If there is no appropriate values could be sent on threshold and breach values, it has to be filled as FFH.

Suspension Type	Reason	Hexa-decimal Code	BST Threshold Value	BST Breach Value
Error Suspension	BIN-VIN mis-match. Note: During this suspension battery has to store the mis-match VIN as additional value as type BT9, which would be retrieved in the charging protocol	0001H	FFFFH	FFFFH
	Discharging current is excess*	0002H	Threshold discharging current	Discharging current above threshold
	Battery cell over temperature	0004H	Cell number + Threshold cell temp.	Cell number + Excess cell temp.
	Battery connector health check. This condition is generated when the connector effective resistance is greater than 25mohm	0005H	Threshold value	Excess value
	Vehicle authenticity check failure	0006H	BMS Random number challenge	VCU Random number challenge response
	Battery lock state (Not allowed to discharge)	0007H	FFFFH	FFFFH
	Battery out of geo-fence	0008H	FFFFH	FFFFH

	Battery cell over-voltage*	0009H	Threshold value	Breach value
	Battery pack over-voltage*	000AH	Threshold value	Breach value
	Battery cell under-voltage*	000BH	Threshold value	Breach value
	Battery pack under-voltage*	000CH	Threshold value	Breach value
Warning /Alerts	BMS component over temperature*	1001H	Threshold component temp.	Excess component temp.
	Battery cell over temperature*	1002H	Threshold cell temp.	Excess cell temp.
	Battery over temperature*	1003H	Threshold battery temp.	Excess battery temp.
Other Suspension	Other suspension	3FFEH	Threshold Value(if available)	Breach value(if available)

* Whenever battery suspends for these reasons, the battery retrieval mode should be set as "Complete data retrieval mode" and to be communicated using BSDP message in Section 3.5.4.3

4.5.4.5. Vehicle Suspending Reasons (VST)

The suspending/alert code for vehicle will be in the range of 0x4000-0x7FFF

While suspending, vehicle will give error/alert code and threshold with breach value for that particular code, if available. If there are no appropriate values could be sent on threshold and breach values, it must be filled as FFFFH.

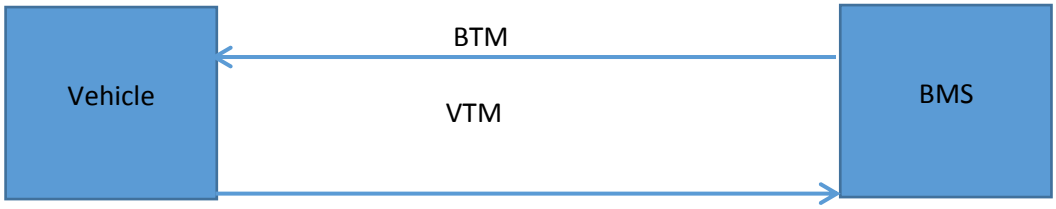
Suspension Type	**Reason**	**Hexa-decimal Code**	VST Threshold Value	VST Breach Value
Normal Suspension	Vehicle stopped by user	4001H	FFFFH	FFFFH
Error Suspension	Battery Authenticity Failure	4002H	Vehicle random number challenge	BMS random number challenge response

	Protocol version acknowledgment error	4003H	Protocol version	Protocol version
	Available energy of battery less than threshold value set by vehicle	4004H	Threshold energy	Available energy
Warning Suspension	Internal temperature of Vehicle controller is excessive	4005H	Threshold internal temp.	Excess internal temp.
	Vehicle component temperature is excess	4006H	Threshold component temp.	Excess component temp.
Other Suspension	Other suspension	7FFFH	Threshold value (If available)	Breach value (if available)

4.5.5. Time-out Messages

The time-out of messages during the whole driving process is communicated using these messages. This message will carry the second byte of PGN to indicate the timed-out message.

4.5.5.1. Message Flow



4.5.5.2. Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
BTM	Battery time-out Message	BMS to VCU	006900H	2	1	250
VTM	Vehicle Time-out Message	Vehicle to BMS	006A00H	2	1	250

4.5.5.3. Parameters

Message Code	Parameter Name	Description	SPN (Dec)	Size in Bytes	Delivery Option
BTM	Second Byte of PGN Value of timed-out message	Battery time-out messages	287	1	Mandatory
VTM	Second Byte of PGN Value of timed-out message	Vehicle time-out messages	288	1	Mandatory

5. Data Logging Retrieval Logic

The data is logged during charging and driving protocol. These data are retrieved during charging protocol in the corresponding stages. The data storage formats are provided in sections 3.5.4.1 and 3.5.7.1 for driving and charging log parameters respectively. This section details on the retrieval logic of the stored data.

- The transfer of periodic and additional data is done by the following steps: In the first message, charger initiates a request to BMS asking for the list of available data types, its size and granularity. The response is provided in Type-Size-Granularity (TSG) format with a packet size of 5 bytes. (Type-1 Byte, Size-2Bytes, Granularity-2Bytes). The end of the list is indicated by a "0" value in the TSG.
- After fetching all the list, charger initiates the transfer of type 1 by using Timestamp-Type (TT) packet format with a size of 3 bytes.
- By default, the first time-stamp should be 01/01/2017 00:00:00. The format of timestamp is as defined in Section: Timestamp format for periodic data.
- BMS parses to find the first data available for this type after the default timestamp. BMS responds with Timestamp-Data (TD) packet of size 6 bytes. This timestamp will be charger to initiate the request for the next packet of same type.
- Once all the data transfer is completed for type 1, charger repeats the same steps for other types.
- The data transfer stage is complete only after all types of data are transferred.
- The termination of TSG and TD should be '0'. This is to indicate the end of list and no additional list/data is present.

5.1. TSG Packet Format – Response packet with data list

For fetching the data storage from BMS, a Type-Size-Granularity (TSG) packet is defined to fetch the list of data types available. For event based data, the granularity should be '0' and for periodic data, the granularity will carry the periodicity of the data. The TSG packet size is of 5 bytes

The type is of 1-byte length. Type 1 – Type 100 is reserved for protocol specific and Type 101 - Type 255 is for manufacturer specific. Size is of 2 bytes length.

Granularity is of 2 bytes and captures the periodicity of data log in seconds. This is shown in table below

The TSG packet format is defined as follows:

Type Number	Size in Bytes	Granularity in Secs.
1 byte	2 bytes	2 bytes

Example event list packet:

Type	Size (Bytes)	Granularity(Secs)
Available energy	2	0

Example periodic list packet:

Type	Size (Bytes)	Granularity(Secs)
1	2	10

5.2. TT Packet Format – Request packet for data

Request packet from charger for retrieving the data will follow Timestamp-Type (TT) packet format The TT packet format is defined as follows:

Timestamp	Type n
4 bytes	1 byte

The TT packet size is 5 Bytes.

Example Packets: Example additional data packet of vehicle

Timestamp	Type n
16022909H	1(for OC1)

5.3. TD Packet Format – Response packet with data

Response packet from BMS for retrieving the data will follow the Timestamp-Data (TD) packet format. The TD packet format is defined as follows:

Timestamp	Data
4 bytes	2 Bytes

The TD packet size would 4 Bytes plus the actual data size. The whole packet will be zero, if no data is present.

Example Packets:

Timestamp	Data
16022909H	500

5.4. Timestamp Format for Periodic Data

Time Stamp Packet	0	0	0	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0
Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Time stamp	Day					Month				Year						Hour					Minutes						Seconds					

The above timestamp to be interpreted as: 02/12/2017 03:04:06. For the year component value of 1 is considered as 2017,2 as 2018 and so on.

5.5. Data retrieval with data retrieval mode

By default, BMS will log the data based on the granularity defined in Section 3.5.4.1.1. for driving data and 3.5.7.1. for charging data. Based on the data retrieval mode battery must retrieve and send the data to charger on the granularity defined in the following sections.

5.5.1. Battery data types

#	Data Types	**Data**	Data retrieval mode set as "Complete data"	Data retrieval mode set as "Default data"
1	BT1	Available Energy	1	30
2	BT2	Maximum current that battery can provide	All instances	All instances
3	BT3	Battery instantaneous voltage	1	1
4	BT4	Battery instantaneous current	1	1
5	BT5	Cell number + Individual cell voltage	1	60
6	BT6	Sensor number + Individual sensor temp.	1	60
7	BT7	Balancing current status	1	15
8	BT8	Error code+ Threshold value+ Breach value e.g. For excessive dis-charge current, the data will be 0002(Error code) +discharge current(threshold	All instances	All instances

		value)+discharge current(breach value)		
9	BT9	ErrorCode of BT8+VIN number	All instances	All instances
10	BT10	Lock-smart mode + Battery ambient temperature	900	900

5.5.2. Vehicle data types

#	Data Types	Data	Data retrieval mode set as "Complete data"	Data retrieval mode set as "Default data"
1	VT1	Suspending reason+ Data(based on suspending data) e.g. For battery authenticity failure 4002(Error code)+Vehicle result + BMS random number	All instances	All instances
2	VT2	Vehicle speed	1	1
3	VT3	OC1	15	15
4	VT4	OC2	15	15
5	VT5	OC3	60	60
6	VT6	OC4	60	60
7	VT7	Odometer reading	1	15
8	VT8	Vehicle controller current	1	60
9	VT9	Vehicle controller voltage	1	1

5.5.3. Charger data types

#	Data Types	Data	Data retrieval mode set as "Complete data"	Data retrieval mode set as "Default data"
1	CT1	Balancing current status	10	15

2	CT2	Cell number + Individual cell voltage	10	60
3	CT3	Sensor number + Individual sensor temp.	10	60
4	CT4	SoC	10	60
5	CT5	Charger output current	60	60
6	CT6	Battery demand current	60	60
7	CT7	Battery measured voltage	60	60

6. BMS – HHD – CMS Protocol

A Handheld device will be used in the Swapping outlet for handling the swapping procedure. The swapping procedure will include removing of discharged batteries, placing charged batteries and handling the billing for the swapping. The BMS and the HHD app. Communicate using Bluetooth Low Energy(BLE)

6.1. HHD Functionalities

6.1.1. Using battery swapping application

When a vehicle comes to the swapping outlet, the following sequence of operations occur.

1. The batteries would be removed from the Vehicle.
2. The MAC Id of the battery, which will be available as barcode / QR code on the battery, is scanned by the app.
3. The app connects to the scanned MAC Id through BLE (Bluetooth Low Energy) and then reads the available energy and the VIN (vehicle identification number) in which the battery was serving.
4. The mode of the battery is set to charging from driving. The BMS must change its address to 0xFF
5. The above three steps are repeated for all the batteries in the vehicle.
6. The charged batteries' BIN are scanned by the app as in Step 2.
7. The VIN of the vehicle is programmed in to the battery.
8. The above two steps are repeated for all the batteries that are to be placed in the vehicle.
9. The charged batteries' BIN and the VIN are updated to the CMS.
10. Then the individual available energies of the battery (step 3) and the VIN are sent to CMS to get the billing amount to be collected from the driver.
11. This amount will be collected from the driver using UPI-based payment.

6.1.2. Using driver application

When driver wants to submit/ under-take a vehicle for rent, the driver scans the QR code of the vehicle and sends to server. In turn, the application receives the passcode to lock/unlock batteries from server and communicates with battery using BLE.

6.2. BLE Specifications

This document provides the different characteristics available in the EV – Battery service in a device. If a device claims conformance to this service, all capabilities indicated as mandatory for this service shall be supported.

6.2.1. Service Dependency

This service has no dependencies on other GATT-based services

6.2.2. Byte Transmission Order

All Characteristics used with this service shall be transmitted with the least significant octet first (i.e. little endian)

6.2.3. Service Declaration

The service UUID shall be set as per the standards. Custom services, characteristics and descriptors preferably should have 128-bit UUID.

6.2.4. Service Characteristics

EV-Battery Service- UUID			**a377860c-0594-4377-9843-ede2281d3cbc**						
Characteristics Of above EV-Battery Service									
#	**Characteristic**	**Description**	**UUID**	**Mandatory / Optional**	**Read**	**Write**	**Notify**	**Indicate**	**Remarks (Size in bytes)**
1	Available Energy	Available energy in battery	b6060cf1-e288-4d85-855f-77162e8a4a47	O	Y	X	X	X	(4)
2	BIN	Battery Identification Number	7837a8a3-936d-4009-b666-f2e9033e4ac6	O	Y	X	X	X	(20)
3	VIN	Vehicle Identification Number	70d6e5bd-1289-4ff1-9eca-b20922eeb906	O	Y	X	X	X	(17)
4	Lock-smart Mode	Lock-smart mode : Drive Mode/Charge mode	323c818f-28f0-4c5e-8cf8-d112a52ae7e1	M	Y	X	X	X	Lock-smart Mode (1)
5	Consumed energy	Consumed energy in w-hr	407709de-fc3e-41d9-b926-	M	Y	X	X	X	Consumed energy (2)

			bbbb27cb5c10						
6	Protocol Version	Protocol version	0b9eec83-16b7-451b-9dc3-16d2a8ee7aa0	M	Y	X	X	X	Protocol version (3)
7	Error Codes	Error Codes stored in battery	ef7f78b2-6835-423f-9b5c-71e340cc68cf	O	Y	X	X	X	(40)
8	EV- Battery statistics	Packet to read the statistics from the battery	0cc59d16-be17-408a-bcb1-ed81ebca6f85	M	Y	X	X	X	Available Energy (2) Consumed Energy(2) BIN(20) VIN(17)(Will be all 0s if not associated with a vehicle) Smart-lock Mode(1) Unique-id for drive from CMS (UFD)(16) Geo-fence status (1)-Will be 1 i.e in-fence by default. Refer Section 7.1. for more details. Discharge status (1)
9	EV-Charged Battery VIN Association	Packet to program charged battery	dfa75d76-4078-47d3-9a03-b73495c52cb2	M	X	Y	X	X	Smart-lock Mode(1) VIN(17) UFD(16) IsTrackingEnabled(1). True indicates the presence of tracking module in vehicle
10	Temperature	Battery temperature	0b9eec83-16b7-451b-9dc3-16d2a8ee7aa0	M	Y	X	X	X	Battery temperature in 0.1 degree Centigrade(2)
11	Lock battery	Lock battery using	fef069ff-dc80-	M	X	Y	X	X	Passcode(4) Discharge status-off(1)

		passcode provided from server on vehicle submission (in case of leased vehicles)	40b8-9760-a289db7ec23b						
12	Unlock battery	Unlock battery using passcode provided from server on vehicle undertaking (in case of leased vehicles)	b5f209a1-05ff-4944-941c-29c677cb03fb	M	X	Y	X	X	Passcode(4) Discharge status-on(1)

7. BMS Functionality Guidelines

1. Based on the lock-smart mode: Drive mode/Charge mode, battery should decide on the protocol to start with.
2. All the batteries should keep storing ambient temperature every 15 mins along with the timestamp and lock-smart mode. This will be recorded continuously by the battery in all the modes either driving or charging. The same will be retrieved during the charging protocol.
3. Master-Slave Communication in driving protocol:
    - Slave BMS will keep updating the available energy to Master BMS once during parameter exchange stage and for every 500 ms during driving stage.
    - When slave BMS is suspending it should send BST (Suspending message) to Master BMS with the reason for suspension and then suspend. Master BMS will get updated about the slave status and keep running the vehicle if the available energy is sufficient to run the vehicle
    - When the vehicle stops, all the batteries will receive VST from the vehicle and the BMS should to shut-off delivering energy.
4. During driving, if a battery fails due to some reason, then based on the role assigned by VCU, it should start communicating. For e.g. if a slave is assigned as Master then it should start representing the available energy to VCU and when a master becomes slave, it should keep updating the available energy to Slave BMS who is acting as Master now.
5. All vehicle related data are logged only by Master BMS to avoid duplicate logging in slave BMS. So, when a Master BMS which has logged vehicle data turns out to be slave due to some failure and recovery, it should remember or store the battery mode as Master to enable the charging

protocol to retrieve the vehicle log. If a battery happens to be a Slave, then the list of messages related to vehicle should not be sent in the BRVL list.

6. All the data logs to be cleared only during charging protocol at the end of the corresponding transfer stages

7.1. Communication with tracking module

The tracking module to battery communication is required, if the "IsTrackingEnabled" flag is set to true in Section 6.2.4. in EV-Charged Battery VIN Association characteristics. If a vehicle or battery is to be tracked periodically from a central server, then tracking module is to be provided in the vehicle and battery communication to the tracking module is to be initiated by setting "IsTrackingEnabled" flag to be set to true over BLE.

A heartbeat message (BTO) is provided for each battery module to communicate with tracking module over CAN interface. The battery modules independently should send BIN , consumed energy and available energy using this message to the tracking module periodically. These parameters are in turn sent to server to indicate the presence of battery in the vehicles. Refer Section 9 on Tracking Module for functionality details.

The battery discharge lock/unlock message (TBD) is provided from tracking module to each battery to lock the batteries using passcode. Batteries will stop discharging when the discharge status is locked and the packs are locked with a passcode.

To unlock, the discharge status to be set to unlock and then packs are unlocked using a passcode. After the batteries are unlocked from discharge status using passcode, they should ensure that the geo-fence status is set to "inside".

7.1.1. Message Flow

7.1.2. Battery Initiated Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
BTO	Battery tracking one-time message from each battery	Multi-packet broadcast message	000700H	7	26	Event based within 1 sec after

						receiving BMR
BTP	Battery tracking periodic message from each battery	BMS to TM	000800H	4	6	5000

7.1.3. Battery Initiated Parameters

Message Code	Parameter Name	Description	SPN in Dec	Size in Bytes	Delivery Option
BTO	BIN	Battery identification number	2576	20	Mandatory
	Available energy	Available energy in watt-hour	2577	2	Mandatory
	Battery address	Module address of the battery	2578	1	Mandatory
	Consumed energy	Consumed energy	2561	2	Mandatory
	Battery Status	Master/Slave Status: 2 bits Bit 0 & Bit 1: 01H – Master, 00H - Slave; Geo-fence status: 3 bits Bit 2, Bit 3& Bit 4: 000H – Outside of Geo fence; 001H – Inside geo fence Discharge status: 3 bits Bit 5, Bit 6, Bit 7: 000H – Discharge status off; 001H – Discharge status on	2579	1	Mandatory
BTP	Available energy	Available energy in watt-hour	2580	2	Mandatory
	Battery address	Module address of the battery	2581	1	Mandatory
	Consumed energy	Consumed energy	2562	2	Mandatory
	Battery Status	Master/Slave Status: 2 bits Geo-fence status: 3 bits Discharge status: 3 bits	2582	1	Mandatory

7.1.4. TM Initiated Messages

Message Code	Messages	Direction	PGN (HEX)	Priority	Size in Bytes	Time Period (ms)
TBO	Tracking module request to each battery requesting to send Battery one-time message BTO when the TM wants to ascertain BIN	Broadcast message	000900H	4	1	Event based (Discretion of TM)

	to Battery address mapping					
TBG	Tracking module request to set the geo-fence status when server changes the geo-fence status	Broadcast message	000A00H	4	1	Event based
TBD	Tracking module request to set battery discharge status message to each battery when server changes the discharge status	TM to BMS	000B00H	4	5	Event based

7.1.5. TM Initiated Parameters

Message Code	Parameter Name	Description	SPN in Dec	Size in Bytes	Delivery Option
TBO	Battery one-time message request	Value :0xAAH	2583	1	Mandatory
TBG	Battery geo-fence status Outside geo-fence: 0x00 Inside geo-fence: 0x01	To set the battery based on geo-fencing. When vehicle breaches geo-fencing, TM sets this value as Outside geo-fence and set the value as inside geo-fence once the vehicle is inside the geo-fence. If set as Outside geo-fence, then the battery must stop discharging.	2584	1	Mandatory
TBD	Battery discharge status Discharge lock: 0x00 Discharge unlock: 0x01	To set the battery discharge state. When the lock is On(0x00), then battery should not discharge	2585	1	Mandatory
	Passcode	4-byte passcode to lock/unlock the battery based on the battery discharge status. When battery is locked, it will be locked with a passcode of 4 bytes. When unlocking the same 4 bytes password has to be provided. If the unlock passcode does not match the	2586	4	Mandatory

		lock passcode, the lock will not be removed.			

8. Charger and OMS communication

8.1. Abbreviation

OMS	Operation Management System
CIMS	Charging Infrastructure Management System
BMS	Battery Management System
HTTP	Hyper Text Transfer Protocol
TCP	Transmission Control Protocol
HHD	Hand Held(device)
CSV	Comma Separated Values
PDF	Portable Document Format
XML	extended Markup Language
GUI	Graphical User Interface
IP	Internet Protocol

Charger and OMS would communicate over a wired-Ethernet IP LAN. The OMS and Charger will have fixed IPs. The application/ /transport layer protocol would be HTTP 1.1/TCP using JSON.

8.2. Message Types

#	Message Type	Description
1	Monitoring and Management	Routing management messages
2	Diagnostics	Health check and diagnostic messages
3	Events and Alerts	Asynchronous events and alerts from Charger
4	Charging	Messages related to Charging
5	Discharging	Messages related to data transfer for Discharging
6	Software Management	Software update related messages
7	Discovery	To identify the chargers and Connectors
8	Heart Beat	Periodic heart beat messages from Charger to OMS

8.3. Messages Initiated by OMS

#	Msg. Types	Message name	Msg. Origin	Purpose
1	Discovery	GetChargerBasicConfig	OMS	To discover basic properties of the charger
2	Discovery	GetChargerAdvancedConfig	OMS	To discover detailed properties of the charger
3	Monitoring and Management	GetChargerAdminAndOperationalState	OMS	To retrieve the administrative state (Locked or Unlocked) and Operational state (Operational/Inservice Active or

				Non-operational/Out of service Failed)
4	Monitoring and Management	GetConnectorsDetails	OMS	To get the properties of all the connectors
5	Monitoring and Management	SetChargerAdminState	OMS	Enable or disable a charger to operate
6	Monitoring and Management	SetConnecterAdminState	OMS	Enable or disable a connector in a charger to operate
7	Monitoring and Management	StopTransaction	OMS	Stop a transaction on a connector id. If the connector id is zero, then stop transaction for all the connectors
8	Diagnostics	DoChargerSelfTest	OMS	Instruct charger to perform a self-test and report its health
9	Diagnostics	DoConnectorSelfTest	OMS	Instruct charger to perform a self-test of specified connector ids and report their health
10	Software Management	UpdateSoftware	OMS	Inform charger to update its software
11	Monitoring and Management	UpdateOMSIP	OMS	Bulk charger to update the IP address of OMS to send notifications for.
12	Monitoring and Management1	ChargerParamConfiguration	OMS	Bulk charger to update the parameters related to charging

8.3.1. Parameters - OMS Initiated Messages

The possible parameters for each of the messages in the above table is given in the table below

#	Message name	Parameters in Message	Parameters in Response
1	GetChargerBasicConfig	None	Make/Model/SWVersion/HWVersion/SerialNumber
2	GetChargerAdvancedConfig	None	Number of connectors, Connector ratings for each connector
3	GetChargerAdminAndOperationalState	None	AdministrativeState: Enabled/Disabled OperationalState:Locked/Unlocked
4	GetConnectorsDetails	None	Connector Ids, Admin State, Operational State, Charging Capacity

5	SetChargerAdminState	Enabled/Disabled	Status code, Status Message, Status reason, Success/Failure/Deferred
6	SetConnecterAdminState	Enabled/Disabled	Status code, Status Message, Status reason, Success/Failure/Deferred
7	StopTransaction	Connector Id	Status code, status message, Status reason, Success/Failure/Deferred
8	DoChargerSelfTest	None	Status code, Status Message, Status reason, Success/Failure/Deferred
9	DoConnectorSelfTest	Connector Id	Status code, Status Message, Status reason, Success/Failure/Deferred
10	UpdateSoftware	Path of BIN file, optionally start date/time and end date/time between which update is to be done	Status code, Status Message, Status reason, Success/Failure/Deferred
11	Monitoring and Management	IPAddress and Port of new OMS	Status code, Status Message, Status reason, Success/Failure/Deferred
12	ChargerParamConfiguration	TargetSoC to be set by charger in BMS, , Effective resistance of power path threshold value to be set by charger in BMS	Status code, Status Message, Status reason, Success/Failure/Deferred

8.4. Messages Initiated by Charger

#	Msg. Types	Message name	Msg. Origin	Purpose
1	Events and Alerts	BootedUp	Charger	To indicate to the OMS that the charger is booted up
2	Heart Beat	IAmAlive	Charger	A heart-beat message to indicate to the OMS that the charger is functioning. This is to be sent every N minutes, where N is received from OMS in response to BootedUp message
3	Charging	IsBatteryAllowedToCharge	Charger	Authentication of BIN by charger and obtaining parameters related to charging process like adaptive charging, recalibration etc.,

4	Charging	BMSChargingOnetimeDataUpdate	Charger	Update on one-time data details of charging session of BMS
5	Charging	BMSChargingPeriodicDataUpdate	Charger	Update on periodic data details of charging sessions of BMS
6	Charging	ChargingSessionPeriodicUpdate	Charger	Inform OMS of progress of charging like Current stage of charging
7	Charging	BatteryTemperatureUpdate	Charger	Inform OMS on the temperature values during charging
8	Discharging	BMSDischargeOnetimeDataUpdate	Charger	Update OMS with the one-time data collected by BMS when it was in vehicle. (Should handle case if the battery was not used and gradually discharged)
9	Discharging	BMSDischargePeriodicDataUpdate	Charger	Update OMS with the periodic data collected by BMS when it was in vehicle. (Should handle case if the battery was not used and gradually discharged)
10	Discharging	VehicleDischargeOnetimeDataUpdate	Charger	Update OMS with the one-time vehicle data collected by BMS when it was in vehicle. (Should handle case if the battery was not used and gradually discharged)
11	Discharging	VehicleDischargePeriodicDataUpdate	Charger	Update OMS with the periodic vehicle data collected by BMS when it was in vehicle. (Should handle case if the battery was not used and gradually discharged)
12	Events and Alerts	NotifyChargerStatusChange	Charger	Inform OMS of any status change of charger based on any event not triggered by OMS
13	Events and Alerts	NotifyConnectorStatusChange	Charger	Inform OMS of any status change of connector in a charger based on any event not triggered by OMS
14	Diagnostics	ChargerSelfTestResult	Charger	Inform OMS of ChargerSelfTestResult
15	Diagnostics	ConnectorSelfTestResult	Charger	Inform OMS of ConnectorSelfTestResult

16	Software Management	NotifySoftwareUpdateStatus	Charger	Inform OMS of status of charger update
17	Charging	ChargingSessionCompletionUpdate	Charger	Inform OMS of status of charging session completion
18	Charging	ConditionalRetrievalMode	Charger	Confirmation of data retrieval mode by charger

8.4.1. Parameters - Charger Initiated Messages

The possible parameters for each of the messages in the above table is given in the table below

#	Message name	Parameters in Message	Parameters in Response
1	BootedUp	Make/Model/SWVersion/HWVersion/SerialNumber	HearbeatInterval, OK
2	IAmAlive	Serialnumber, ChargerAdminState ,ChargerOperationalState, List of Connectors' AdminStatus and ConnectorsOperationalStatus	OK
3	IsBatteryAllowedToCharge	SerialNumber, BIN	Yes/No
4	BMSChargingOnetimeDataUpdate	Details of one-time BMS data for the charging session	OK
5	BMSChargingPeriodicDataUpdate	Details of periodic BMS data for the charging session	OK
6	ChargingSessionPeriodicUpdate	Serial number, ChargingSessionId, connector id, Charging Stage, SoC (%),	OK
7	BatteryTemperatureUpdate	Periodic update of battery temperature values during charging	
8	BMSDischargeOnetimeDataUpdate	Details of one-time BMS data log as per the Driving Protocol	
9	BMSDischargePeriodicDataUpdate	Details of periodic BMS data log as per the Driving Protocol	
10	VehicleDischargeOnetimeDataUpdate	Details of one-time Vehicle data log as per the Driving Protocol	
11	VehicleDischargePeriodicDataUpdate	Details of periodic vehicle data log as per the Driving Protocol	
12	NotifyChargerStatusChange	AdminState/OperationalStates of Charger	OK
13	NotifyConnectorStatusChange	AdminState, OperationalStates, Idle	OK
14	ChargerSelfTestResult	SerialNumber, self-test start time, self-test end time, self-test status code, self-test status message and self-test observations	OK
15	ConnectorSelfTestResult	SerialNumber, self-test start time, self-test end time, self-test status code, self-test status message and self-test observations	OK

16	NotifySoftwareUpdateStatus	Serial number, connector id, firmware path, upgrade status	OK
17	ChargingSessionCompletionUpdate	Update from charger on completion of a charging session	OK
18	ConditionalRetrievalMode	Seiral number,BIN, Data log mode :Driving/charging, Retmode : Dfeault data/Complete data	Retmode

8.5. Messages Syntax

This section provides the message syntax between the charger and OMS. The charger and OMS shall communicate using JSON/HTTP. All requests, responses and notifications shall have the following fields.

1	version	The version of the OMS-Charger communication protocol. The first version shall be 1.0.0
2	ts	Timestamp of request or response in the format YYYY-MM-dd HH:mm:ss.SSS where dd is date of month, MM is month of year, YYYY is year, HH is hours in 24 hour format, mm is minutes, ss is seconds and .SSS is milliseconds. All time related parameters will follow the same format.
3	operationname	the name of operation which this JSON carries

- Default URL: “https://<OMS IP Address>:<Port>/oms/<Operationname>/
  - E.g. https://10.9.x.x:8080/oms/bootedupnoti
- There will be no explicit response to notifications, unless otherwise noted, other than the standard 200 OK of HTTP header for acceptance or 403 for a message from a charger that is not registered at OMS.
- Administrative state can take values of Enabled/Disabled in response and Enable/Disable in requests
- Operational state can take values of Locked/Unlocked. A charger or connector will be locked if it is in use and unlocked if it is unused
- All Set or change operations on the chargers shall have the following fields
  - "statuscode": "statuscode" - statuscode should be zero if the operation is success and non-zero otherwise.
  - "statusmessage": "message" - If statuscode is 0, then status message should be "Success" else the string message for failure statuscode has to be filled. E.g.: Set Charger Admin State failed
  - "reason": "reason" - If statuscode is 0, then reason should be "Success" else the reason for should be filled. E.g. Charger is actively charging a battery

8.5.1. OMS Initiated Message Syntax

8.5.1.1. GetChargerBasicConfig

Messages	Request	Response	Remarks

GetChargerBasicConfig	{ "version": "version", "ts": "2017-10-22 08:14:51.443", "operationname": "getchargerbasicconfigreq" }	{ "make": "make", "model": "model", "swversion": "swver", "hwversion": "hwver", "serialnumber": "sernum", "version": "ver1", "ts": "2017-10-22 08:14:51.124", "operationname": "getchargerbasicconfigresp" }	

8.5.1.2. GetChargerAdvancedConfig

Messages	Request	Response	Remarks
GetChargerAdvancedConfig	{ "version": "version", "ts": "2017-10-22 08:14:51.151", "operationname": "getchargeradvancedconfigreq" }	{ "numofconn": "numofconn", "connrating": "connrating", "version": "version", "ts": "2017-10-22 08:14:51.297", "operationname": "getchargeradvancedconfigresp" }	Connector rating in kilowatts

8.5.1.3. GetChargerAdminAndOperationalState

Messages	Request	Response	Remarks
GetChargerAdminAndOperationalState	{ "version": "version", "ts": "2017-10-22 08:14:50.859", "operationname": "getchargeradminandoperationalstatereq" }	{ "administrativestate": "administrativestate", "operationalstate": "operationalstate", "version": "version", "ts": "2017-10-22 08:14:51.6", "operationname": "getchargeradminandoperationalstateresp" }	

8.5.1.4. GetConnectorsDetails

Messages	Request	Response	Remarks
GetConnectorsDetails	{ "version": "version", "ts": "2017-10-22 08:14:53.242", "operationname": "getconnectordetailsreq" }	{ "connectorslist": [{ "connectorid": "cid1", "adminstate": "adminstate1", "operationalstate": "ostate1", "chargingcapacity": "chcap1", "targetsoc": "targetsoc1", "chargingperiodicdataretgranularity": "chargingperiodicdataretgranularity1", "drivingperiodicdataretgranularity": "drivingperiodicdataretgranularity1", "effrespowerpath": "effrespowerpath1", "drivingdataretrievalmode": "drivingdataretrievalmode1", "chargingdataretrievalmode": "chargingdataretrievalmode1" }, { "connectorid": "cid2", "adminstate": "adminstate2", "operationalstate": "ostate2", "chargingcapacity": "chcap2", "targetsoc": "targetsoc2", "chargingperiodicdataretgranularity": "chargingperiodicdataretgranularity2", "drivingperiodicdataretgranularity":	Connectorslist has to be populated with details for each connector

		"drivingperiodicdataretgranularity2", "effrespowerpath": "effrespowerpath2", "drivingdataretrievalmode": "drivingdataretrievalmode2", "chargingdataretrievalmode": "setchargingdataretrievalmode2" }], "version": "version", "ts": "2017-10-26 12:59:31.680", "operationname": "getconnectorsdetailsresp" }	

8.5.1.5. SetChargerAdminState

Messages	Request	Response	Remarks

SetChargerAdminState	{
	“connectorid”:”cid1”,
	"status": "status",
	"version": "version",
	"ts": "2017-10-22 08:14:52.942",
	"operationname": "setchargeradminstatereq"
	}
		{
		"statuscode": "statuscode",
		"statusmessage": "message",
		"reason": "reason",
		"version": "version",
		"ts": "2017-10-22 08:14:53.91",
		"operationname": "setchargeradminstateresp"
		}
			In request status value can be Enable or Disable In reply, statuscode should be zero if the operation is success and non-zero otherwise.
			
			If statuscode is 0, then status message has to be "Success" else the string message for failure statuscode has to be filled. E.g: Set Charger Admin State failed.
			If statuscode is 0, then reason has to be "Success" else the reason for has to be filled. E.g. Charger is actively charging a battery

8.5.1.6. SetConnecterAdminState

Messages	Request	Response	Remarks

SetConnecterAdminState	{
	“connectorid”: connid”,
	"status": "status",
	"version": "version",
	"ts": "2017-10-22 08:14:53.242",
	"operationname": "setconnecteradminstatereq"
	}
		{
		"statuscode": "statuscode",
		"statusmessage": "message",
		"reason": "reason",
		"version": "version",
		"ts": "2017-10-22 08:14:53.392",
		"operationname": "setconnecteradminstateresp"
		}	

8.5.1.7. StopTransaction

Messages	Request	Response	Remarks

StopTransaction	{
	"connectorid": "connid",
	"version": "version",
	“ts": "2017-10-24 15:55:21 .515",
	"operationname": "stopchargingreq"
	}
		{
		"connector": "connector",
		"statuscode": "statuscode",
		"socatsuspension": "socatsuspension",
		“chargingmode” : ”chargingmode”,
		"statusmessage": "statusmessage",
		"reason": "reason",
		"status": "status",
		"version": "version",
		"ts": "2017-10-24 15:59:45.208",
		"operationname": "stopchargingresp"
		}
			If OMS happens to stop transaction, the charger will return socatsuspension and Charging mode. The values of Charging mode could be "CCC" or "CVC". If the suspension happens before charging state, both the socatsus

			pension and Charging mode would be "NA" .

8.5.1.8. DoChargerSelfTest

Messages	Request	Response	Remarks
DoChargerSelfTest	{ "version": "version", "ts": "2017-10-22 08:14:50.563", "operationname": "dochargerselftestreq" }	{ "statuscode": "statuscode", "statusmessage": "message", "reason": "reason", "version": "version", "ts": "2017-10-22 08:14:50.711", "operationname": "dochargerselftestresp" }	

8.5.1.9. DoConnectorSelfTest

Messages	Request	Response	Remarks
DoConnectorSelfTest	{ “connectorid” : “connid” "version": "version", "ts": "2017-10-22 08:14:50.563", "operationname": "doconnectorselftestreq" }	{ "statuscode": "statuscode", "statusmessage": "message", "reason": "reason", "version": "version", "ts": "2017-10-22 08:14:50.711", "operationname": "doconnectorselftestresp" }	

8.5.1.10. UpdateSoftware

Messages	Request	Response	Remarks
UpdateSoftware	{ "binpath": "path", "startdate": "start", "enddate": "end", "version": "version", "seqnum": "seqnum", "ts": "2017-10-22 08:14:53.539", "operationname": "updatesoftwarereq" }	{ "statuscode": "statuscode", "statusmessage": "message", "reason": "reason", "version": "version", "ts": "2017-10-22 08:14:50.711", "operationname": "updatesoftwareresp" }	path is the location of firmware. Charger should download the software between start date and end date using FTP. The response only indicates the acceptance of the request and not the status of software upgrade itself which is notified via NotifySoftwareUpdateStatus. The sequence number "seqnum" should be part of the NotifySoftwareUpdateStatus.

8.5.1.11. UpdateOMSIP

Messages	Request	Response	Remarks
UpdateOMSIP	{ "ipaddress": "ip", "port" : "port", "version": "version", "ts": "2017-10-22 08:14:52.328", "operationname": "updateomsipreq" }	{ "statuscode": "statuscode", "statusmessage": "message", "reason": "reason", "version": "version", "ts": "2017-10-22 08:14:50.711", "operationname": "updateomsipresp" }	To change the OMS IP to a new IP

8.5.1.12. ChargerParamConfiguration

Messages	Request	Response	Remarks
ChargerParamConfiguration	{ "connectorid":"cid1", "targetsoc": "targetsoc", ", "effrespowerpath":" effrespowerpath", "version": "version",	{ "statuscode": "statuscode", "statusmessage": "message", "reason": "reason", "version": "version",	To set parameters in the charger. If it is for specific connector then

	"ts": "2017-10-22 08:14:52.328", "operationname": "chargerparamconfiguration" }	"ts": "2017-10-22 08:14:54.711", "operationname": " chargerparamconfiguration " }	connectorid carries the id number and if it is for all connectors, connectorid will be '0'. 1.TargetSoC to be set by charger in BMS 2. .Effective resistance of power path threshold value – 25 mOhm default value.

8.5.2. Charger Initiated Message Syntax

8.5.2.1. BootedUp

Messages	Request	Response	Remarks

BootedUp	{
	"make": "make",
	"model": "model",
	"swversion": "swversion",
	"hwversion": "hwversion",
	"serialnumber": "sno",
	"version": "ver",
	"ts": "2017-10-22 08:16:18.807",
	"operationname": "bootedupnoti"
	}
		{“heartbeatinterval”: “heartbeatinterval”
		"version": "version",
		"ts": "2017-10-22 08:14:50.711",
		"operationname": "bootedupnotiresp"
		}
			Heartbeat interval in minutes

8.5.2.2. IAmAlive

Messages	Request	Response	Remarks

IAmAlive	{
	"chargeradminstate": "chargeradminstatus",
	"chargeroperationalstate": "chargeroperationalstate",
	"connstslist": [{
	"connectorid": "1",
	"adminstatus": "adminstatus",
	"operationalstatus": "operstatus"
	}, {
	"connectorid": "2",
	"adminstatus": "adminstatus",
	"operationalstatus": "operstatus"
	}],
	"serialnumber": "sno",
	"version": "version",
	"ts": "2017-10-24 15:52:00.642",
	"operationname": "iamalivenoti"
	}
			Has to be repeated for all connectors

8.5.2.3. IsBatteryAllowedToCharge

Messages	Request	Response	Remarks

IsBatteryAllowedToCharge	{
	"serialnumber": "sno",
	"bin": "bin",
	"timesincerecalib": " timesincerecalib ",
	"cyclessincerecalib": "cyclessincerecalib",
	"version": "version",
	"ts": "2017-10-22 08:16:20.626",
	"operationname": "isbatteryallowedtochargereq"
	}
		{
		"bin": "bin",
		"statuscode": "statuscode",
		"statusmessage": "message",
		"adaptivecharging": "adaptivecharging” ",
		"
		nonadaptivechargingcurrentpercentage": "nonadaptivechargingcurrentpercentage” ,
		"recalib":"recalib",
		"reason": "reason",
		"version": "version",
		"ts": "2017-10-22 08:14:50.711",
		"operationname": "isbatteryallowedtochargeresp"
		}
			Charger should charge the battery only if the status code is 0 i.e, success.
			When recalib(ratio n) is set to “allowed”, then adaptivechar ging has to be set to “yes”. When adaptivechar ging is set to “yes”, then the charger has to honour the request of battery demand current.

8.5.2.4. BMSChargingOnetimeDataUpdate

Messages	Request	Respon se	Remarks
BMSChargingOneTimeDat aUpdate	{ "ufd": "ufd", "chargerfwver": "chargerfwver", "bmsfwver": "bmsfwver", "consumedenergy":"consume denergy", "chargingstarttime": "2017-10-24 19:40:52.75", "chargingendtime": "2017-10-24 19:40:52.75", "serialnumber": "serialnumber", "connectorid": "connid", "bin": "bin",		Charging energy is the energy taken for charging the battery UFD will be alphanumeric value written to the battery by HHD chargerfwver is the firmware version of charger captured during charging bmsfwver is the firmware version of BMS captured during charging sessionid is a value formed by concatenating serialnumber of charger , timestamp of

	"numberofcells": "numofcells", "numberoftempsensors": "numoftempsensors", "startsoc": "startsoc", "endsoc": "endsoc", "chargingenergy": "chargingenergy", "chargingdurationinseconds": "chargeduration", "charginglifecyclenumber": "lifecyclenumber", "soh":"soh", "lastcalibratedts":"lastcalibratedts, "lastcalibchargingcycleno": "lastcalibchargingcycleno", "adapchargingoverriddencount":" adapchargingoverriddencount", "chargingsessionid": "chargingsessionid", "version": "version", "ts": "2017-10-24 19:40:52.75", "operationname": "chargingonetimedatanoti" }		start of charging session(after removing the space, - , : and . between date and time a and connectorid ie. serinalnumber.tsofstartofsession.cnid E.g: serialnumber= sno tsofstartofsession=YYYY-MM-dd HH:mm:ss.SSS Connector id = 4 Then the charging session id would be sno.YYYYMMddHHmmssSSS.4 Chargingstarttime is the time at which the battery had entered the charging stage Chargingendtime is the time at which the battery had completed the charging stage

8.5.2.5. BMSChargingPeriodicDataUpdate

Messages	Request	Response	Remarks
BMSChargingPeriodicTimeDataUpdate	{ "cpdlist": [{ "bmvlist": [{ "datats": "datats", "bmv": "bmv" }, { "datats": "datats", "bmv": "bmv" }], "bdclist": [{		Cellvoltagelist and temperature list has to be repeated for total number of cells and total number of temperature sensors respectively

	"datats": "datats",
	"bdc": "bdc"
	},
	{
	"datats": "datats",
	"bdc": "bdc"
	}
	],
	"coclist": [{
	"datats": "datats",
	"coc": "coc"
	},
	{
	"datats": "datats",
	"coc": "coc"
	}
	],
	"soclist": [{
	"datats": "2017-10-24 19:44:44.85",
	"soc": "soc"
	}, {
	"datats": "2017-10-24 19:44:44.85",
	"soc": "soc"
	}],
	"bcslist": [{
	"datats": "datats",
	"bcs": "bic"
	},
	{
	"datats": "datats",
	"bcs": "bic"
	}
	],
	
	"cellvoltagelist": [{
	"datats": "datats",
	"cvl": [{
	"cellid": "cellid",
	"cellvoltage": "cellvoltage"
	},
	{
	"cellid": "cellid",
	"cellvoltage": "cellvoltage"
	}
	]		

```
}, {
"datats": "datats",
"cvl": [{
"cellid": "cellid",
"cellvoltage": "cellvoltage"
},
{
"cellid": "cellid",
"cellvoltage": "cellvoltage"
}
]
}],
"temperaturelist": [{
"datats": "datats",
"templst": [{
"tempsensorid":
"tempsensorid",
"temperature": "temperature"
},
{
"tempsensorid":
"tempsensorid",
"temperature": "temperature"
}
]
}, {
"datats": "datats",
"templst": [{
"tempsensorid":
"tempsensorid",
"temperature": "temperature"
},
{
"tempsensorid":
"tempsensorid",
"temperature": "temperature"
}
]
}]
}],
"version": "version",
"ts": "2017-10-24 19:44:44.85",
"chargingsessionid":
"chargingsessionid",
"serialnumber":
"chargerserialnumber",
"connectorid": "connectorid",
```

	"sessionid": "sessionid", "operationname": "chargingperiodicdatanoti" }		

8.5.2.6. ChargingSessionPeriodicUpdate

Messages	Request	Response	Remarks

ChargingSessionPeriodicUpdate	{
	"sessionid": "sessionid",
	"serialnumber": "chargerserialnumber",
	"connectorid": "connectorid",”bin”:”bin”,
	"currentstage":
	"stageasdefinedinchargingprotocol",
	"version": "version",
	"ts": "2017-10-22 23:24:45.399",
	"operationname": "chargingsessionnoti"
	}		

8.5.2.7. BMSDischargeOnetimeDataUpdate

Messages	Request	Response	Remarks

BMSDischargeOnetimeDataUpdate	{
	"botdlist": [{
	"datats": "2017-10-22 23:00:13.897",
	"batterymode": "battmode",
	"drivingprotocolversion": "drivver",
	"bin": "bin",
	"vin": "vin",
	"numofcells": "numofcells",
	"numoftemperaturesensors":
	"numoftempsens",
	"ae": "availenergy",
	"consumedenergy":
	"consumedenergy",
	"bmsfwverdri":"bmsfwverdri"
	}, {
	"datats": "2017-10-22 23:00:13.941",
	"batterymode": "battmode",
	"drivingprotocolversion": "drivver",
	"bin": "bin",
	"vin": "vin",
	"numofcells": "numofcells",
	"numoftemperaturesensors":
	"numoftempsens",
	"ae": "availenergy",
	"consumedenergy":
	"consumedenergy",
			bmsfwverdri is the version of BMS captured during driving protocol

	"bmsfwverdri":"bmsfwverdri" }], "serialnumber": "chargerserialnumber", "connectorid": "connectorid", "sessionid": "sessionid", "version": "ver", "ts": "2017-10-22 23:00:13.941", "operationname": "bmsdischargeonetimedatanoti" }		

8.5.2.8. BMSDischargePeriodicDataUpdate

Messages	Request	Response	Remarks

BMSDischargePeriodicDataUpdate	{
	"bpdlist": [{
	
	"aelist": [{
	"datats": "datats",
	"ae": "availableenergy"
	},
	{
	"datats": "datats",
	"ae": "availableenergy"
	}
	],
	"mclist": [{
	"datats": "datats",
	"mc": "maxcurrent"
	},
	{
	"datats": "datats",
	"mc": "maxcurrent"
	}
	],
	"bivlist": [{
	"datats": "datats",
	"biv": "biv"
	},
	{
	"datats": "datats",
	"biv": "biv"
	}
	],
	"biclist": [{
	"datats": "datats",
	"bic": "bic"
			Cellvoltagelist and temperature list has to be repeated for total number of cells and total number of temperature sensors respectively

```
},
{
"datats": "datats",
"bic": "bic"
}
],
"bcslist": [{
"datats": "datats",
"bcs": "bcs"
},
{
"datats": "datats",
"bcs": "bcs"
}
],

"cellvoltagelist": [{
"datats": "datats",
"cvl": [{
"cellid": "cellid",
"cellvoltage": "cellvoltage"
},
{
"cellid": "cellid",
"cellvoltage": "cellvoltage"
}
]
}, {
"datats": "datats",
"cvl": [{
"cellid": "cellid",
"cellvoltage": "cellvoltage"
},
{
"cellid": "cellid",
"cellvoltage": "cellvoltage"
}
]
}],
"temperaturelist": [{
"datats": "datats",
"templst": [{
"tempsensorid": "tempsensorid",
"temperature": "temperature"
},
{
"tempsensorid": "tempsensorid",
```

	"temperature": "temperature"
	}
	]
	}, {
	"datats": "datats",
	"templst": [{
	"tempsensorid": "tempsensorid",
	"temperature": "temperature"
	},
	{
	"tempsensorid": "tempsensorid",
	"temperature": "temperature"
	}
	]
	}],
	"batambtemplist": [{
	"datats": "datats",
	"locksmartmode":
	"locksmartmode",
	"batteryambienttemperature":
	"batteryambienttemperature"
	}],
	"suspreasonlist": [{
	"datats": "datats",
	"errorcode": "errorcode",
	"thresholdvalue": "thresholdvalue",
	"breachvalue": "breachvalue"
	}],
	"vinbinmismatchlist": [{
	"datats": "datats",
	"errorcode": "errorcode",
	"vin": "vin"
	}]
	}],
	"serialnumber": "serialnumber",
	"connectorid": "connectorid",
	"sessionid": "sessionid",
	"version": "version",
	"ts": "ts",
	"operationname":
	"batteryperiodicdatanoti"
	}		

8.5.2.9. VehicleDischargeOnetimeDataUpdate

Messages	Request	Response	Remarks
VehicleDischargeOnetimeDataUpdate	{ "votdlist": [{		

	"datats": "2017-10-22 22:52:41.359",
	"vin": "vin",
	"powerpatheffres":
	"powerpatheffres",
	"odometer":"odometer ",
	"vcufwver": "vcufwver"
	}, {
	"datats": "2017-10-22 22:52:41.388",
	"vin": "vin",
	"powerpatheffres":
	"powerpatheffres",
	"odometer":"odometer ",
	"vcufwver":"vcufwver"
	}],
	"serialnumber":
	"chargerserialnumber",
	"connectorid": "connectorid",
	"sessionid": "sessionid",
	"version": "ver",
	"ts": "2017-10-22 22:52:41.388",
	"operationname":
	"vehicledischargeonetimedatanoti"
	
	}		

8.5.2.10. VehicleDischargePeriodicDataUpdate

Messages	Request	Response	Remarks

VehicleDischargePeriodicDataUpdate	{
	"vpdlist": [{
	"spdl": [{
	"spd ": "speed",
	"datats": "2017-26-10
	22:29:27.135"
	}, {
	"spd": "speed1",
	"datats": "2017-26-10
	22:29:27.135"
	}],
	"odol": [{
	"odo": "odometer",
	"datats": "2017-26-10
	22:29:27.135"
	}, {
	"odo": "odometer1",
	"datats": "2017-26-10
	22:29:27.135"
	}],
			Speed is in centikms/hr and odometer is in kms

```
"vsd1List": [{
"datats": "2017-26-10 22:29:27.135",
"oc1": "oc1",
"oc2": "oc2"
}, {
"datats": "2017-26-10 22:29:27.135",
"oc1": "oc1",
"oc2": "oc2"
}],
"vsd2List": [{
"datats": "2017-26-10 22:29:27.135",
"oc3": "oc4",
"oc4": "oc4"
}, {
"datats": "2017-26-10 22:29:27.135",
"oc3": "oc4",
"oc4": "oc4"
}],
"vcl": [{
"datats": "2017-26-10 22:29:27.135",
"vct": "vehcontrollerct"
}, {
"datats": "2017-26-10 22:29:27.135",
"vct": "vehcontrollerct"
}],
"vvl": [{
"datats": "2017-26-10 22:29:27.135",
"vvt": "vehcontrollervoltage"
}, {
"datats": "2017-26-10 22:29:27.135",
"vvt": "vehcontrollervoltage"
}],
"suspreasonlist": [{
"datats": "datats",
"errorcode": "errorcode",
"thresholdvalue": "thresholdvalue",
```

	"breachvalue": "breachvalue" }] }], "serialnumber": "chargerserialnumber", "connectorid": "connectorid", "sessionid": "sessionid", "version": "version", "ts": "2017-26-10 22:29:27.101", "operationname": "vehicleperiodicdatanoti" }		

8.5.2.11. NotifyChargerStatusChange

Messages	Request	Response	Remarks
NotifyChargerStatusChange	{ "serialnumber": "sno", "adminstate": "adminstate", "operationalstate": "operationalstate", "version": "version", "ts": "2017-10-22 08:16:20.919", "operationname": "notifychargerstatuschangenoti" }		

8.5.2.12. NotifyConnectorStatusChange

Messages	Request	Response	Remarks
NotifyConnectorStatusChange	{ "serialnumber": "sno", "connectorid": "cnid", "adminstate": "adminstate", "operationalstate": "operationalstate", "version": "version", "ts": "2017-10-22 08:16:20.919", "operationname": "notifyconnectorstatuschangenoti" }		

8.5.2.13. ChargerSelfTestResult

Messages	Request	Response	Remarks

ChargerSelfTestResult	{
	"serialnumber": "sno",
	"selfteststarttime" : "starttime"
	"selftestendtime" : "endtime"
	"selfteststatuscode" : "code"
	"selfteststatusmesg" : "mesg"
	
	"selfteststatusobservations : "observations"
	"version": "version",
	"ts": "2017-10-22 08:16:20.919",
	"operationname": "chargerselftestnoti"
	}
			For a successful self test, the code should be zero. If this is not implemented, then the code should be 1.

8.5.2.14. ConnectorSelfTestResult

Messages	Request	Response	Remarks
ConnectorSelfTestResult	{ "serialnumber": "sno", "connectorid": "cnid", "selfteststarttime" : "starttime" "selftestendtime" : "endtime" "selfteststatuscode" : "code" "selfteststatusmesg" : "mesg" "selfteststatusobservations : "observations" "version": "version", "ts": "2017-10-22 08:16:20.919", "operationname": "connectorselftestnoti" }		For a successful self-test, the code should be zero. If this is not implemented, then the code should be 1.

8.5.2.15. NotifySoftwareUpdateStatus

Messages	Request	Response	Remarks
NotifySoftwareUpdateStatus	{ "serialnumber": "sno", "path" : "pathoffirmware", "seqnum": "seqnum", "upgradestatus" : "upgradestatus", “swversion”:”swver”, "version": "version", "ts": "2017-10-22 08:16:20.919", "operationname": "swupdatenoti" }		

8.5.2.16. ChargingSessionCompletionUpdate

Messages	Request	Response	Remarks
ChargingSessionCompletionUpdate	{ "sessionid": "sessionid", "serialnumber": "serialnumber", "connectorid": "connectorid", "bin": "bin", "binwasmaster": "false", “ufd” : “ufd” "vin": "vin", "starttime": "2017-10-22 23:24:45.399", "endtime": "2017-10-22 23:24:45.399", "startsoc": "startsoc", "endsoc": "endsoc", "chargingcompletioncode": "chargingcompletioncode", "chargingcompletionmessage": "chargingcompletionmessage", "chargingenergy": "chargingenergy", "version": "version", "ts": "2017-10-22 23:24:45.399", "operationname": "chargingsessioncompnoti" }		starttime is the time at which the address assignment stage is started and endtime is the time at which end of charging stage is completed

8.5.2.17. BatteryTemperatureUpdate

Messages	Request	Response	Remarks
BatteryTemperatureUpdate	{ "sessionid": "sessionid", "serialnumber": "chargerserialnumber", "connectorid": "connectorid", "bin": "bin", "cellmaxtemp": "maximum temperature of cell", "cellmintemp": "minimum temperature of cell", "version": "version",		

	"ts": "2017-10-22 23:24:45.399", "operationname": "batterytemperatureupdate" }		

8.5.2.18. ConditionalRetrievalMode

Messages	Request	Response	Remarks
ConditionalRetrievalMode	{ "sessionid": "sessionid", "serialnumber": "sno", "bin": "bin", "datalogtype": "datalogtype", "retmode": "retmode", "version": "version", "ts": "2017-10-22 08:16:20.626", "operationname": "conditionalretrievalmode" }	{ "sessionid": "sessionid", "bin": "bin", "retmode": "retmode", "reason": "reason", "version": "version", "ts": "2017-10-22 08:14:50.711", "operationname": " conditionalretrievalmode " }	Battery should send data at granularity as defined for the mode set by charger. For datalogmode "0" i.e., "charging stage" deferred is not a valid option.

8.6. *Data Types*

#	Parameters	Data Type	Length	Units	Remarks
1	Make	String	250		
2	model	String	250		
3	swversion	String	50		Current software version after the upgrade is done successfully
4	hwversion	String	50		
5	serialnumber	String	250		
6	heartbeatinterval	Integer		minutes	
7	chargeradminstate	String			Enumeration of Enabled or Disabled
8	chargeroperationalstate	String			Enumeration of Locked or UnLocked
9	chargingstarttime	String			Similar to ts format
10	chargingendtime	String			Similar to ts format

11	connectorid	Integer			This contains the id of the connector. Connector id is in the range of '1' to 'n'.
12	bin	String	50		BIN is currently 20 bytes. 50 is specified for future expansion
13	numberofcells	Integer			
14	numberoftempsensors	Integer			
15	startsoc	Float		Percentage	startsoc of 10.5 has to be represented as integer 1050
16	endsoc	Float		Percentage	endsoc of 80.5 has to be represented as integer 8050
17	chargingenergy	Float		Whr	
18	chargingdurationinseconds	Integer			
19	charginglifecyclenumber	Integer			
20	chargingsessionid	String			sessionid is a value formed by concatenating serialnumber of charger , connectorid, timestamp of start of charging session(after removing the space, - , : and . between date and time a and connectorid ie. serinalnumber.tsofstartofsession.cnid Connector id has to represented in three digits. i.e connector id 4 would be represented as 004 E.g: serialnumber= sno tsofstartofsession=YYYY-MM-dd HH:mm:ss.SSS Then the charging session id would be sno.YYYYMMddHHmmssSSS
21	currentstage	String			Enumeration of one of the below charging protocol stages Auto address assignment stage, Handshake stage, Battery authenticity check stage, Driving log transfer stage, Parameter configuration stage, Charging stage, Charging log transfer stage, End-of-charging stage (or) Suspension("BMS" or "Charger") along with error code e.g:

					Suspension(Charger) – 0x4008 50 56 (or) Timeout(PGN)
22	selfteststatuscode	Integer			selfstatuscode should be zero if the operation is success and non-zero otherwise.
23	selfteststatusmesg	String	500		If selfstatuscode is 0, then selfstatus message has to be "Success" else the string message for failure selfstatuscode has to be filled. E.g: Set Charger Admin State failed
24	selfteststatusobservations	String	500		Generic field to report on self-test
25	path	String	500		Path where the software binary can be downloaded from
26	upgradestatus	String	500		Enumeration of "Successfully upgraded" or "File fetch failed" or "Storing file locally failed" or "Upgrade failed" or "General failure - <Specifics that need to be notified to OMS>"
27	binwasmaster	String			Enumeration of "true" or "false"
28	vin	String	17		Vehicle Identification Number
29	chargingcompletioncode	Integer			Same as statuscode
30	chargingcompletionmessage	String	500		Same as status message
31	bcs	Integer			Balancing current status
32	cellid	Integer			Id of the Cell
33	cellvoltage	Float		Centi-volt	
34	tempsensorid	Integer			Temperature sensor ID
35	temperature	Float		0.1 Deg C	
36	batterymode	Integer	Enumeration of 0 or 1		1 implies master and 0 implies slave
37	drivingprotocolversion	String	50		
38	ae	Float		Wh	Available energy
39	mc	Float		Centi-Amp	Maximum current
40	biv	Float		Deci-volt	Battery instantaneous volt

41	bic	Float		Deci-amp	Battery instantaneous current
42	powerpatheffres	Float		Milli Ohm	Threshold value of effective resistance of power path. Default value is 25mOhm
43	spd	Float			Speedometer Reading
44	odo	Float			Odometer reading
45	oc1	Integer			Open command 1
46	oc2	Integer			Open Command 2
47	oc3	Integer			Open command 3
48	oc4	Integer			Open command 4
49	targetsoc	Integer			SoC of 80.5 has to be represented as integer 8050
50	port	Integer			Port number of OMS server
51	ip	String			IP address or hostname of OMS server
52	ufd	String	16		Written by HHD over BLE when battery is assigned to a vehicle in a swapping station.
53	effrespowerpath	Integer		Milli Ohm	Threshold value of effective resistance of power path. Default value is 25mOhm
54	vct	Float			Vehicle controller current
55	locksmartmode	Integer			Charge Mode:0x00;Drive mode:0x01
56	batteryambienttemperature	Float			
57	errorcode	Integer			
58	thresholdvalue	Float			
59	breachvalue	Float			
60	chargerfwver	String	50		Charger firmware version
61	vehiclespeedvvt	Float			Vehicle controller voltage
62	bmsfwver	String	50		BMS firmware version during charging
63	bmsfwverdri	String	50		BMS firmware version during driving
64	vcufwver	String	50		VCU firmware version
65	socatsuspension	Float		Percentage	SoC value in response to Stop transaction initiated by OMS.
66					
67					
68	chargingmode	Integer			CVV =1; CVC=0;

69	soc	Float			SoC logged during driving. SoC of 80.5 has to be represented as integer 8050
70	soh	Float			SoH stored during charging one-time data. SoH of 72.5 % to be represented as 7250
71	cellmaxtemp	Integer		0.1 deg	Maximum temperature of cell
72	cellmintemp	Integer		0.1 deg	Maximum temperature of cell
73	datalogtype	integer			1-driving stage, 0- charging stage
74	retmode	Integer			1-default data mode, 2-complete data mode, 3- deferred mode
75	adaptivecharging	Integer			0 – Don't allow adaptive charging ; 1- Allow adaptive charging
76	nonadaptivechargingcurrentpercentage	Float			Percenatge of maximum current to be provided for charging by charger if adaptivecharging is set to 0
77	lastcalibratedts	Timestamp			Timestamp
78	lastcalibchargingcycleno	Integer			
79	adapchargingoverriddencount	Integer			Number of cycles in which battery has been charged at a current which is greater than demand current
80	recalib	Integer			0-allowed 1-not-allowed
81	seqnum	Integer			A sequence number to indicate which "UpdateSoftware" command does the "NotifySoftwareUpdateStaus" refers to.
82	timesincerecalib	Integer			Time in seconds since last recalibration was done in this battery
83	cyclessincerecalib	Integer			Number of charge cycles that has elapsed since last recalibration was done in this battery
84	consumedenergy	Float	w-hr		Consumed energy

9. Tracking Module

Tracking module referred as TM is used for vehicle tracking and indirectly battery tracking. This module will be the interface for stopping vehicle when it breaches the defined geo-fence. This module will also be used to lock/unlock the batteries from discharging based on a command from the server.

When the batteries are locked (i.e., they cannot discharge) and the driver tries to re-start the vehicle, driving protocol starts with VSM message to BMS and batteries suspends drive by indicating this reason. Refer Section 4.5.4.4. for suspension reason. The tracking module source address is fixed as 83H.

- Vehicle tracking

  Vehicle tracking is done by communicating the GPS co-ordinates of vehicle location periodically to CMS over HTTP APIs. This periodicity and server IP to be configurable. The default granularity is _30 seconds_.

- Battery tracking module
  - Should have CAN interface (with a pre-defined CAN identifier) to listen to periodic messages from battery modules and relay the same information to server over HTTP APIs.
  - Should have the ability to receive some commands from server and relay the same over CAN interface. The server can send the message to GPS/GPRS module via an (encrypted) SMS or in response to the periodic location update command sent
  - Refer Section 7.1 for more details

10. References

SAE J1939 – Recommended practice for a serial control and communications vehicle network

SAE J1939 / 14_201612 - Physical layer, 500 Kbps

SAE J1939 / 21_200612 – Data link layer

SAE J1939 / 71_200112 – Vehicle application layer

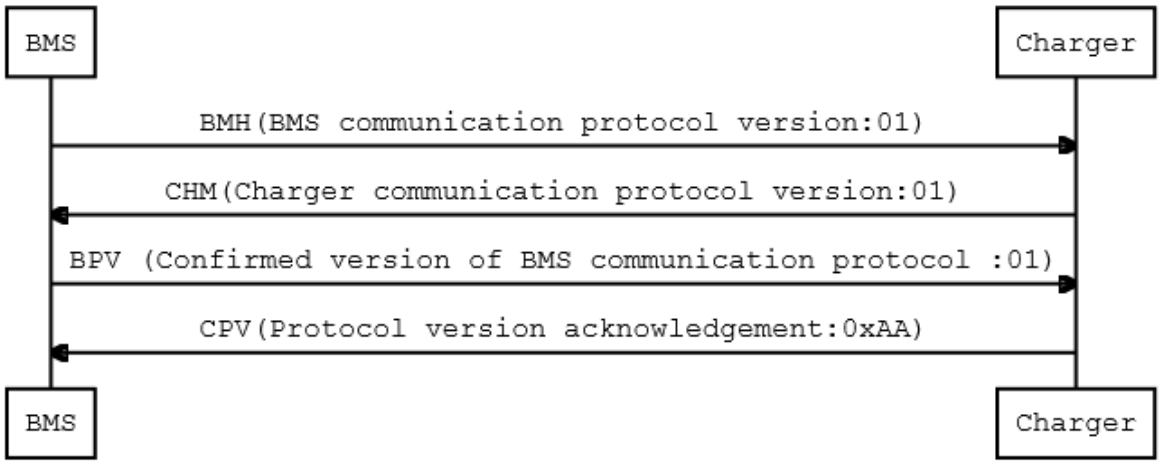
SAE J1939 / 73_199602 – Application Layer - Diagnostics

SAE J1939 DA_201707 – Digital Annex of serial control and communication heavy duty vehicle network data – Jul 2017

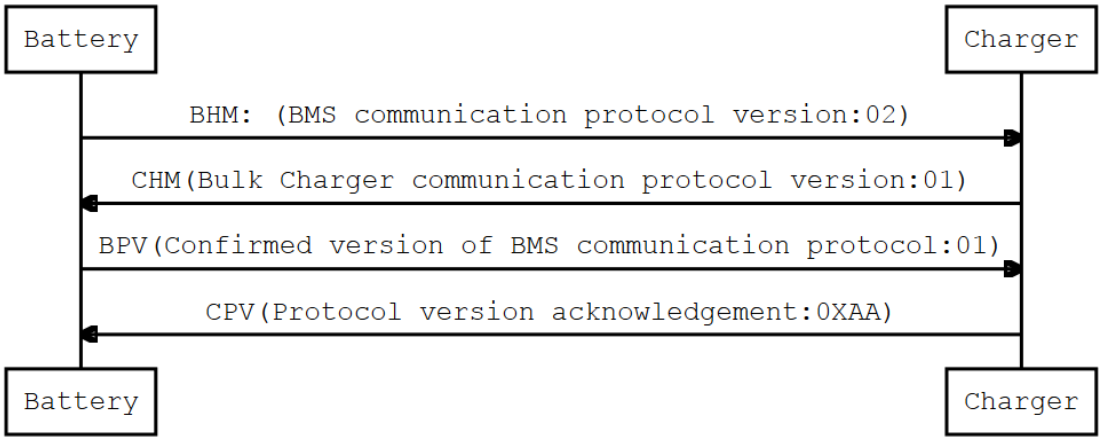
Annexure A: Protocol Version Matching Flow

A1. Charging Protocol Version Matching

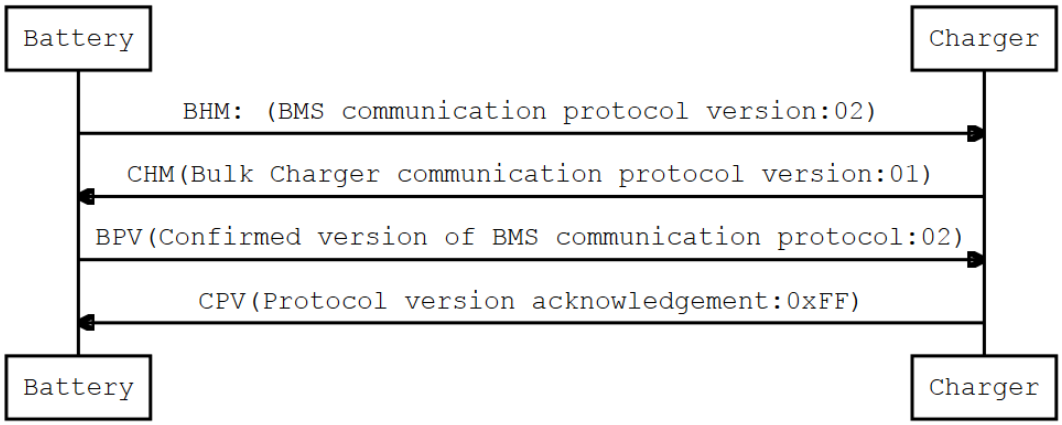
Case 1: BMS communication protocol version is '01' and Bulk Charger communication protocol version is '01'. BMS confirms the protocol version as 01. The result would be "**Success**" to indicate charger will also communicate with protocol version 01 . The same scenario would be applicable whenever both the entities are in the same version.



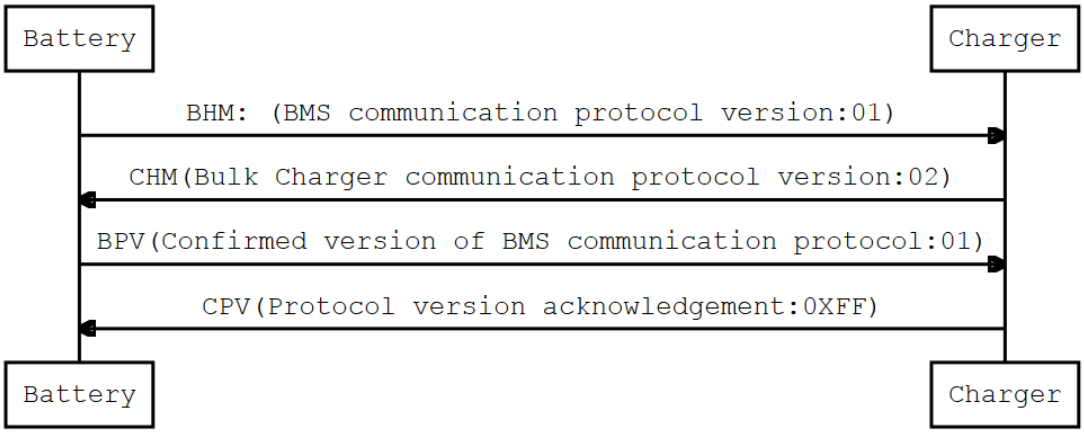
Case 2: BMS communication protocol version is '02' and Bulk Charger communication protocol version is '01'. BMS confirms protocol version as '01' only. The result would be "**Success**" if charger is capable of backward compatibility to communicate with protocol version '01' itself.



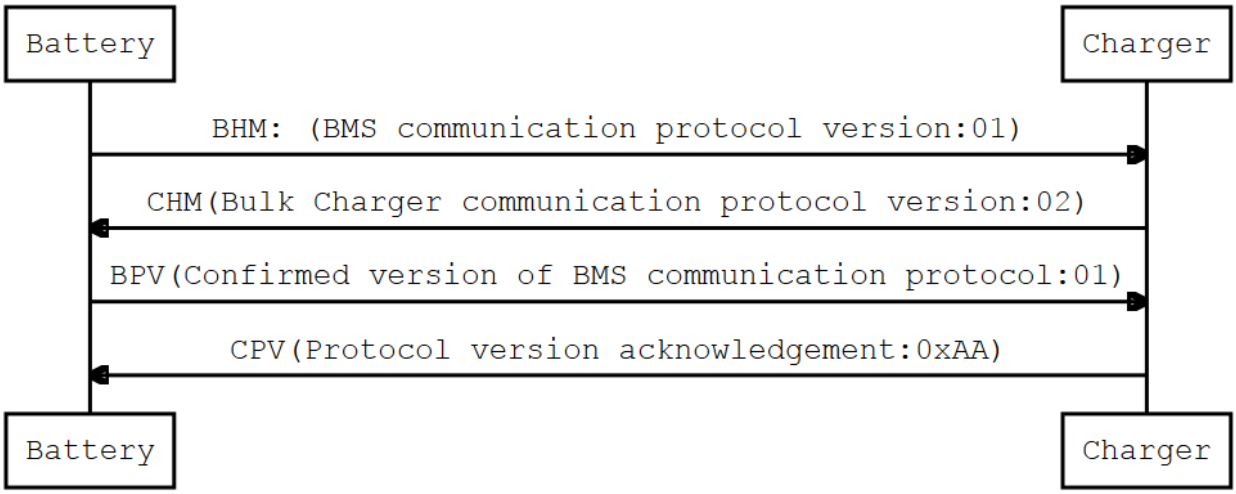
Case 3: BMS communication protocol version is '02' and Bulk Charger communication protocol version is '01'. BMS confirms protocol version as '02' only. The result would be "**Failure**" as charger is at lesser version than the version requested by BMS.



Case 4: BMS communication protocol version is '01' and Bulk Charger communication protocol version is '02'. BMS confirms the protocol version as '01'. The result would be "**Failure**" if the charger is not capable of backward compatibility of protocol with Version '01'.

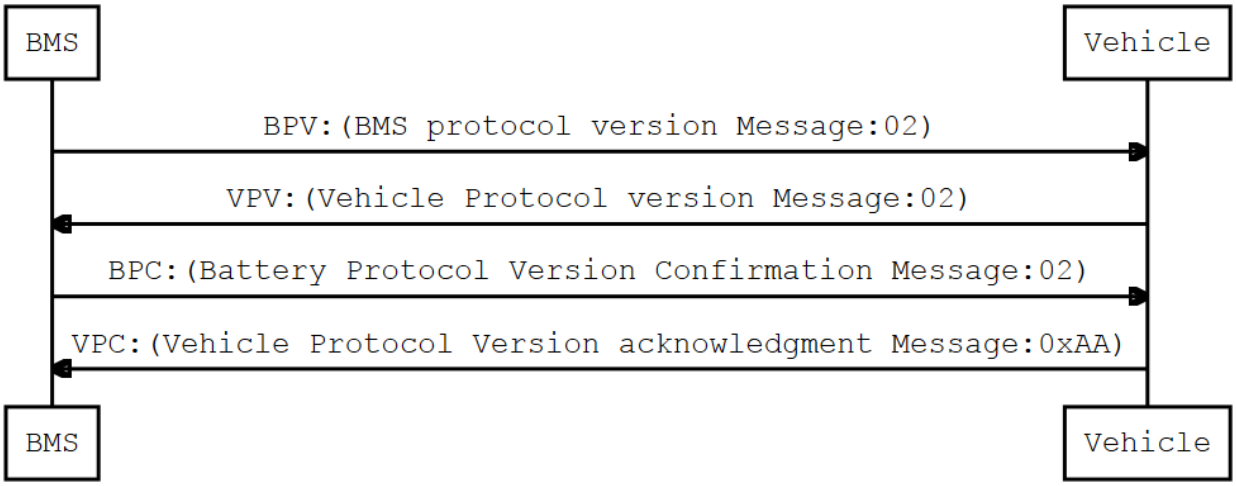


Case 5: BMS communication protocol version is '01' and Bulk Charger communication protocol version is '02'. BMS confirms with protocol version '01'. The result would be "**Success**" if charger is capable of backward compatible to communicate with protocol version 01.

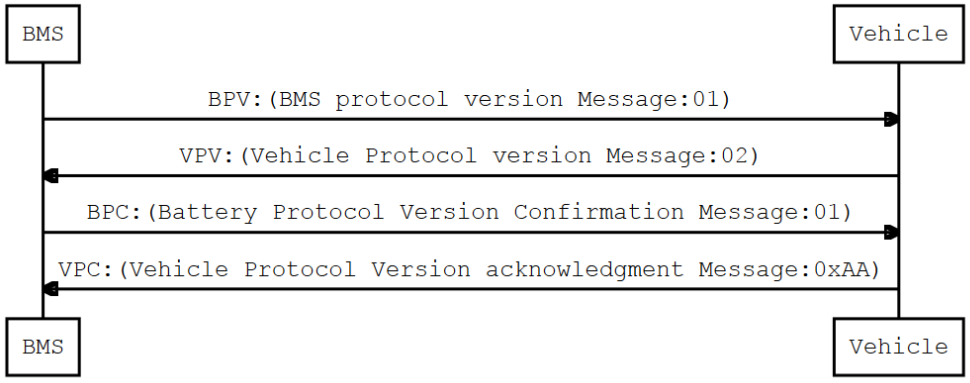

Battery
Charger
BHM: (BMS communication protocol version:01)
CHM(Bulk Charger communication protocol version:02)
BPV(Confirmed version of BMS communication protocol:01)
CPV(Protocol version acknowledgement:0xAA)
Battery
Charger

A2. Driving Protocol Version Matching Flow

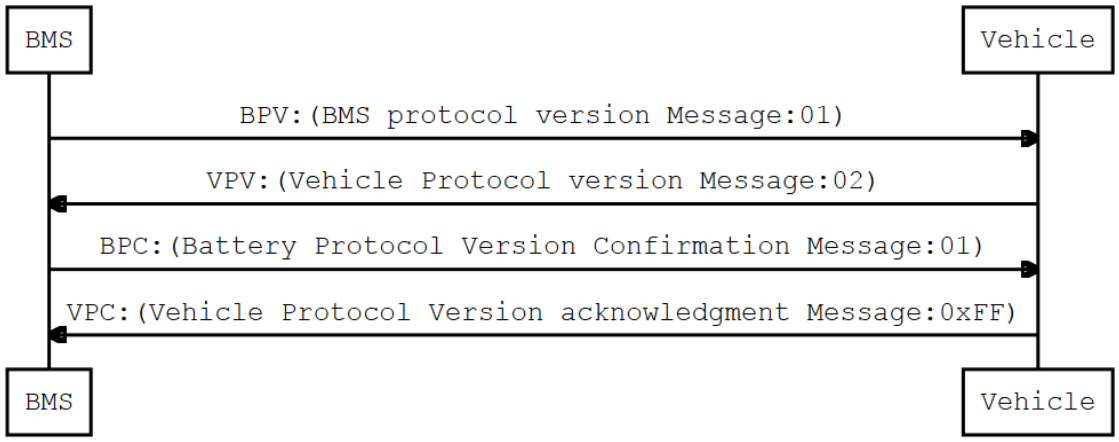
Case 1: BMS protocol version is '02' and Vehicle Protocol version is '02'. BMS confirms protocol version as 02. The result would be "**Success**" to indicate that vehicle will communicate with protocol version 02 with BMS. The same scenario is applicable whenever both the entities are in the same version.



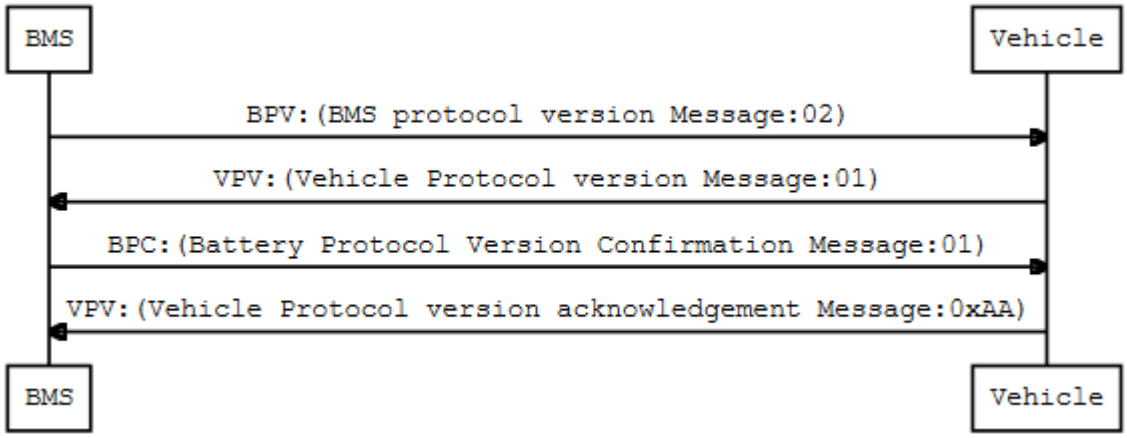
Case 2: BMS protocol version is '01' and Vehicle Protocol version is '02' .BMS confirms protocol version as 01 only. The result would be "**Success**" if the vehicle protocol is backward compatible to communicate with protocol version 01 with BMS.



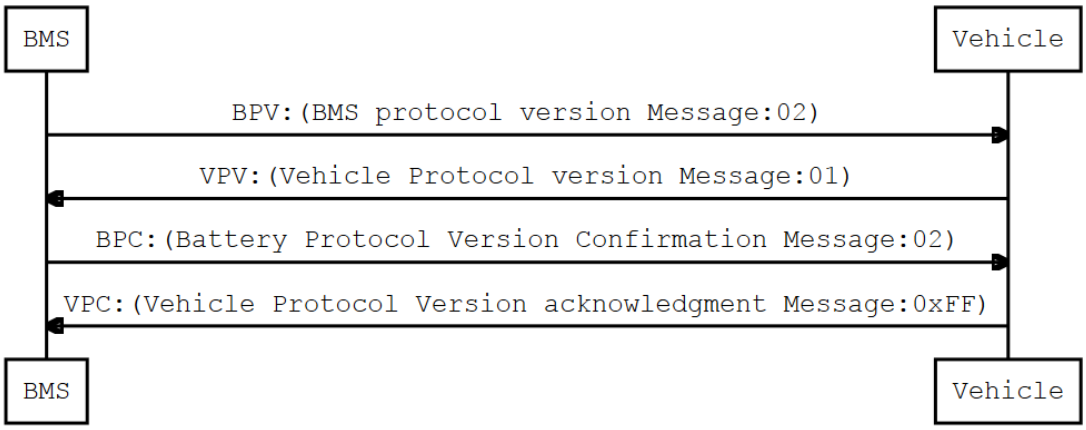
Case 3: BMS protocol version is '01' and Vehicle Protocol version is '02'. BMS confirms the version as '01'. The result would be "**Failure**" if vehicle is not capable of backward compatible to communicate with protocol version '01' with BMS.



Case 4: BMS protocol version is '02' and Vehicle Protocol version is '01 .BMS confirms the version as '01'. The result would be "**Success**" if vehicle version is backward compatible to communicate with protocol version '01' with BMS



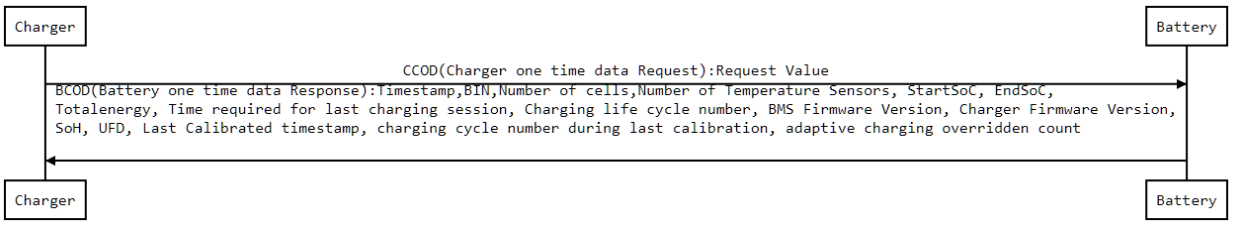
Case 5: BMS protocol version is '02' and Vehicle Protocol version is '01'. BMS confirms version as '02'. The result would be "**Failure**" if BMS protocol is not capable of backward compatible to communicate with protocol version '01' of vehicle.


BMS
Vehicle
BPV:(BMS protocol version Message:02)
VPV:(Vehicle Protocol version Message:01)
BPC:(Battery Protocol Version Confirmation Message:02)
VPC:(Vehicle Protocol Version acknowledgment Message:0xFF)
BMS
Vehicle

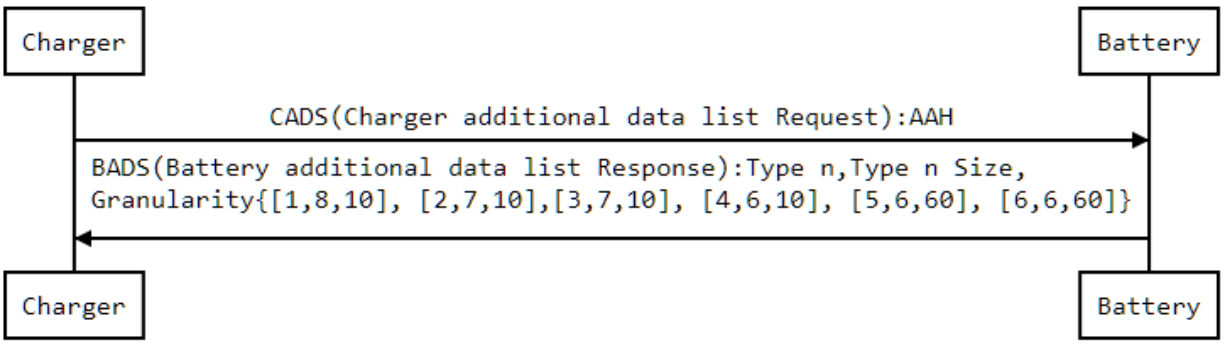
Annexure B: Data Log Message Flow Diagrams

B1. Charging Data Log messages

B1.1 Charger sends CCOD (Charger One time data) Request to the Battery. Battery replies with BCOD (Battery one time data) response. The corresponding BCOD Packet has Timestamp, BIN, Number of Cells, Number of Temperature Sensors, Start SOC, End SOC, Total energy passed while charging, Time required for Last charging, Charging Life cycle number, BMS firmware version, Charger firmware version, SoH, UFD, Last Calibrated timestamp, charging cycle number during last calibration, adaptive charging overridden count



B1.2 Charger sends CADS (Charger additional data list) Request to the Battery. The CADS Request value is AAH and Battery replies with BADS (Battery additional data list) response. The corresponding BADS Packet has Type n, Size (Bytes), Granularity (Secs).Battery informs charger on the defined data types namely {[1,8,10], [2,7,10], [3,7,10],[4,6,10], [5,6,60], [6,6,60]},



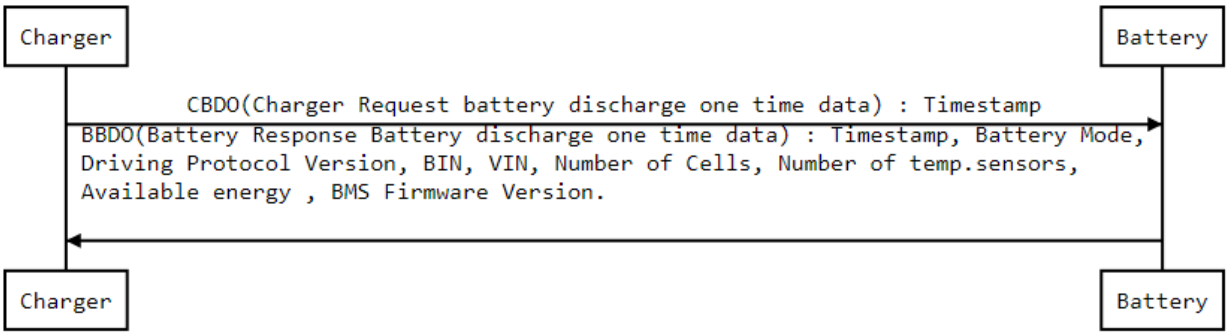
B1.3 Charger sends CCAD (Charger additional data request) Request to the Battery. The CCAD Request packet will have Type n and Timestamp. For instance CCAD requesting Type 1 and with default timestamp 16022906H . The Battery response with BCAD (Battery additional data) response packet. The Response

packet will have Timestamp (8800000H), Type (one) and data (500). Next CCAD requesting Type one data with timestamp as 8800000H received from previous packet. The Battery response with BCAD (Battery additional data) response packet. The Response packet will have Timestamp (19023906H), Type (one), Size (2), Granularity (10) and data (1000) as an example

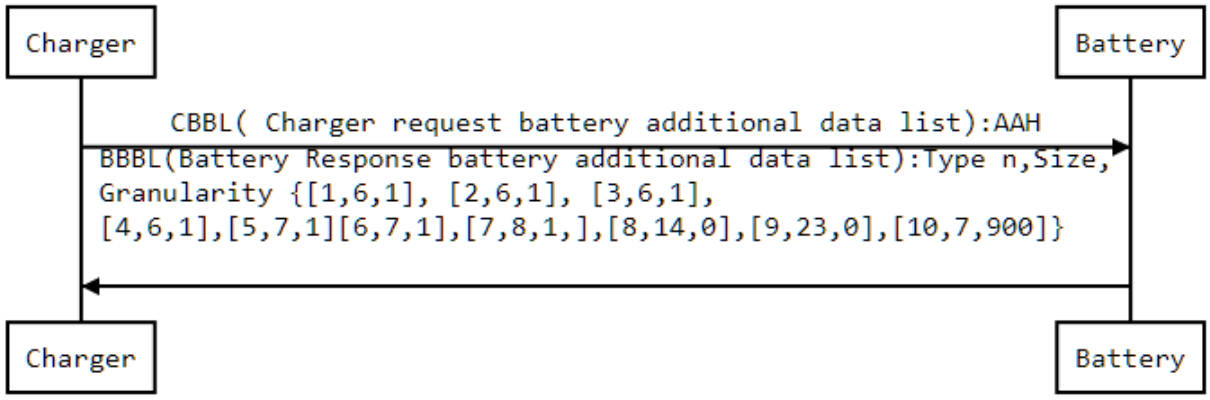
Similary the iterations will repeat for each type until the end of packet with “0” value is reached

B2. Driving Data Log Messages

B2.1 Charger sends CBDO (Charger request battery discharge onetime data) Request to the Battery. Battery replies with BBDO (Battery response battery discharge one-time data). The corresponding BBDO (Battery request battery discharge onetime data) packet has



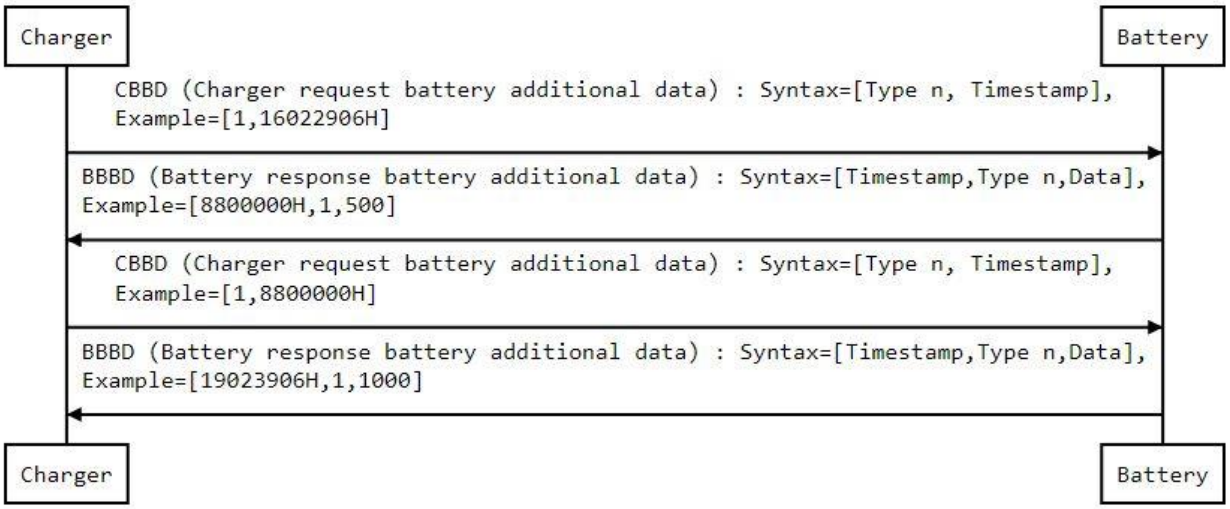
B2.2 Charger sends CBBL (Charger request Battery additional data list) Request to the Battery. CBBL Requests with value 0xAAH. The Battery replies with BBBL (Battery response battery additional data list) packet. The corresponding BBBL packet has Type n, Size, Granularity.



B2.3 Charger sends CBBD (Charger request battery additional data) Request to the Battery. CBBD Request has type n and Timestamp. The Battery replies with BBBD (Battery response battery additional data) packet. The corresponding BBBD packet has Timestamp, Type n and data.

For instance CBBD request type one with default timestamp (16022906H) and Battery replies with BBBD packet. The BBBD packet has timestamp (8800000H), type (one) and data (500). Next CBBD requests type

one with timestamp as (8800000H) and Battery replies with BBBD packet. The BBBD packet has timestamp (19023906H), type (one) and data (1000).

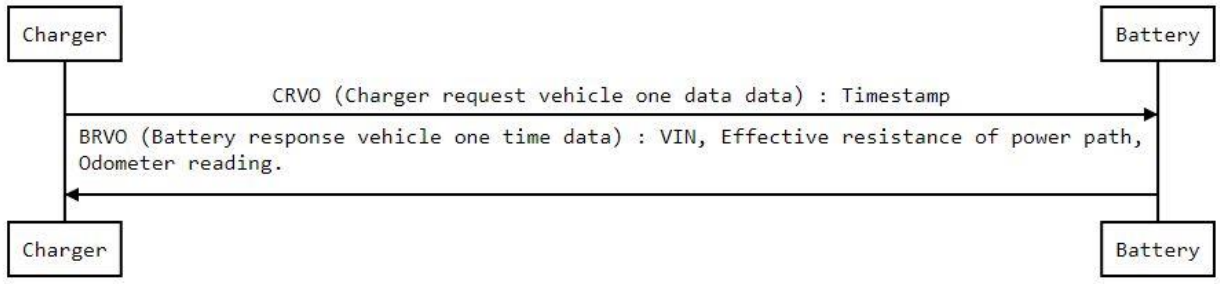


Similary the iterations will repeat for each type until the end of packet with “0” value is reached.

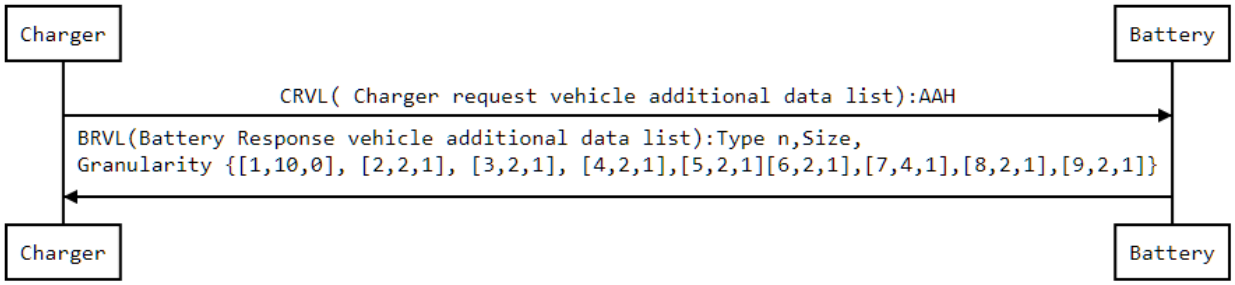
For battery data type 5 & 6 (BT5 and BT6), for a single request there would ‘n’ responses where ‘n’ equals the cell count and temperature sensor count for cell voltage and temperature sensor values respectively.

For e.g if there are 32 cells, then for type 5 request with timestamp1, there would be 32 responses. If ‘n’respons is not received then chanrger has to send the previous timestamp to retrive that record

B2.4 Charger sends CRVO (Charger request vehicle one data data) Request to the Battery. CRVO Requests with 0xAA value. The Battery responds with BRVO (Battery response vehicle one time data). The corresponding BBDP packet have

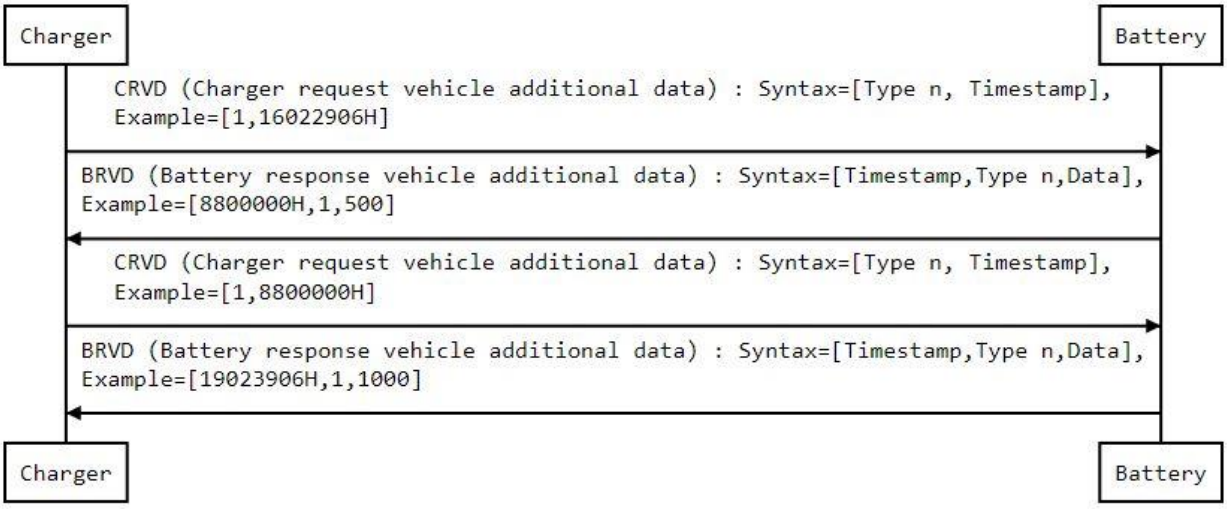


B2.5 Charger sends CRVL (Charger request vehicle additional data list) Request to the Battery. CRVL Requests with value 0xAAH. The Battery replies with BRVL (Battery response vehicle additional data list) packet. The corresponding BRVL packet has Type n, Size, Granularity. For instance, battery has 9 different size of data with different granularity.



B2.6 Charger sends CRVD (Charger request vehicle additional data) Request to the Battery. CRVD Request has type n and Timestamp. The Battery replies with BRVD (Battery response vehicle additional data) packet. The corresponding BRVD packet has Timestamp, Type n and data.

For instance, CRVD request type one with default timestamp (16022906H) and Battery replies with BRVD packet. The BRVD packet has timestamp (8800000H), type (one) and data (500). Next CRVD requests type one with timestamp as (8800000H) and Battery replies with BRVD packet. The BRVD packet has timestamp (19023906H), type (one) and data (1000).



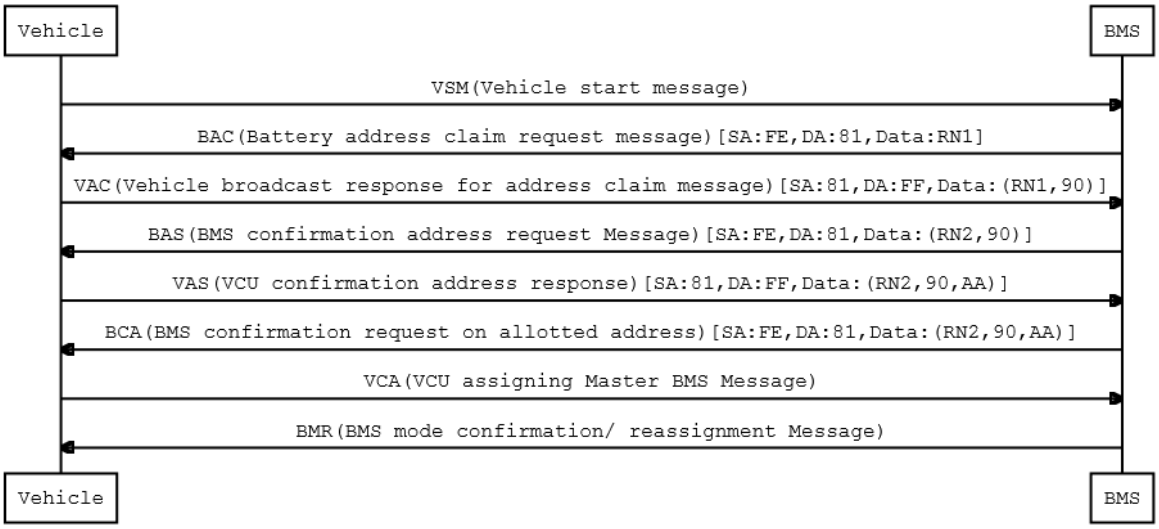
Similary the iterations will repeat for each type until the end of packet with “0” value is reached.

Annexure C: Auto-address assignment flow

C1. Driving protocol

The Vehicle sends a start message to BMS and on receiving VSM, BMS checks for address-assignment. If address is not assigned then it starts with address claim request (BAC) and the flow follows and ends at VCU assigning the Master among the BMS.This is repeated for each BMS.

If address is already assigned, then each BMS sends mode re-iterationmessage (BMR) to VCU and in turn VCU confirms the mode using VCA message,



C2. Charging protocol

In case of charging protocol, there will not be any start message from charger. BMS will complete address assignment by the procedure listed in the flow diagram below: