BMS SETTINGS ANALYSIS

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Abstract: Operation and performance of lithium-ion batteries strongly depend on configuration of Battery Management System (BMS). Set parameters must ensure both safe and efficient operation of the battery and it must be coordinated with specific operation profile of connected power converter. Whereas safe operation should be provided by safety assembly controlled by BMS, the efficient operation is mainly provided by superior system through connected converter. The configuration profile of battery is presented, its communication with energy system by Victron via CAN bus is evaluated, resulting performance of the system is examined and potential limitations are highlighted. A battery safety assembly for educational purposes is presented.

Keywords: BMS, CANBUS, Victron, Orion Jr., Lithium-ion, battery, Power system

1 INTRODUCTION

Distributed electrical power generation with renewable sources such as solar energy reduces carbon footprint of electrical power. From grid operation point of view, it is also beneficial to match the generation and consumption locally. This may be achieved either by demand response or accumulation. One of the suitable accumulators are lithium-ion batteries.

Correct settings of battery parameters in BMS is essential for safe and effective battery operation. Wrong settings may result in serious damage, e.g. thermal runaway, as described in [1] and [2]. The fundamental protection is provided by BMS and supporting assembly. The assembly design is described further in the work. Furthermore, coordination of individual cells settings in BMS and whole battery settings in the inverter is important for faultless operation. Another important aspect is to be familiar with behavior of the device systems and content of communication protocol. An observation and detailed specification of the protocol is necessary if the manufacturers don’t support each other’s products explicitly. In case of inverter by Victron and BMS by Orion, the communication protocol description must have been examined and it is part of this paper. Finally, the battery was cycled and the system setup was validated with comments on specific behavior of the battery.

2 BATTERY ASSEMBLY

The Lithium-ion battery with BMS are main parts of safety assembly which is responsible for disconnection when the operational limits are exceeded. The operational limits are Charge Current Limit (CCL) and Discharge Current Limit (DCL), which are calculated in BMS and are functions of battery temperature, State of Charge (SOC), individual cells voltages and cells internal resistance. Another event leading to battery disconnection might be faults (poor wiring, general BMS fault, etc.).

The battery assembly consists of battery made of 14 cells connected in serial, while each cell is a parallel connection of two LiNiMNCoO2 (NMC) cells, cells contactor panel, current shunt, disconnection relay, BMS by Orion and fuse box. The electrical scheme of the assembly is in **Figure 1**.

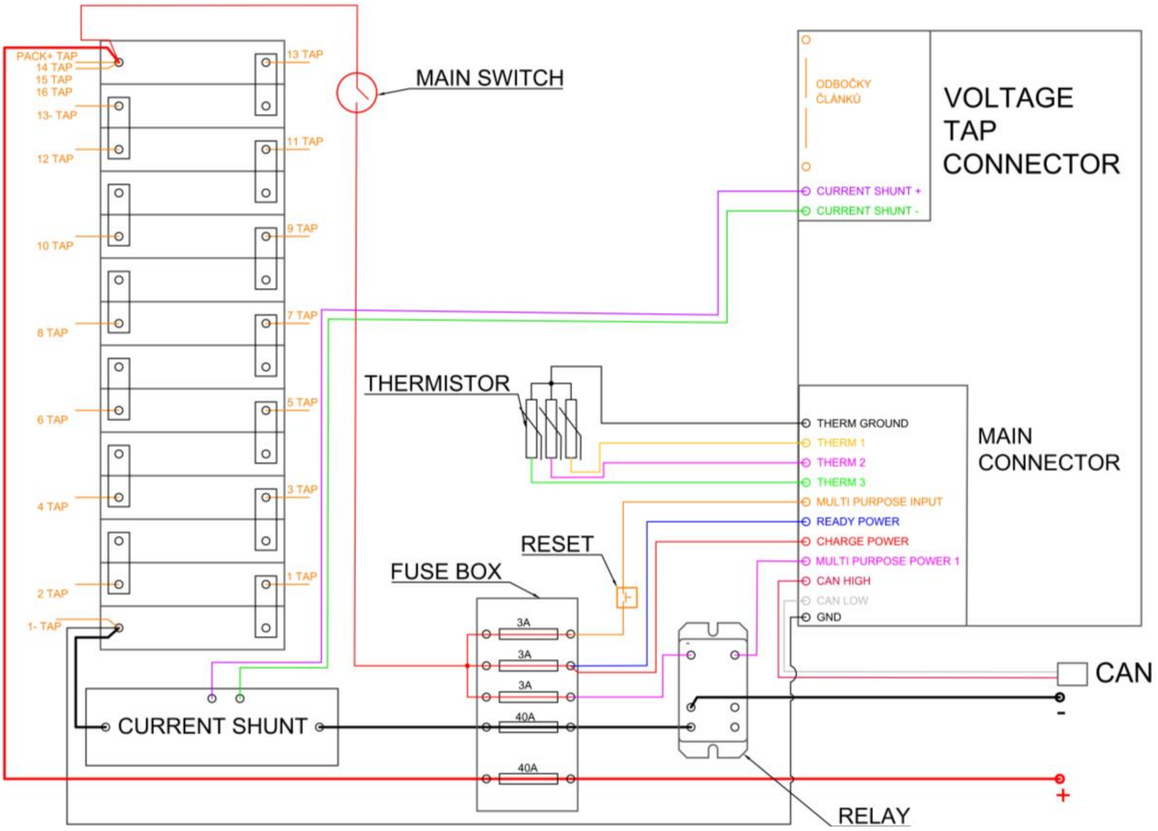


Figure 1: Battery assembly for safety disconnection.

3 DESCRIPTION OF BMS AND INVERTER COMMUNICATION

The CCL and DCL values are together with other battery parameters being sent to inverter control system through CAN bus. Although the CAN protocol is standardized, the interpretation of messages content and identification differs among manufacturers in real applications. Therefore, it is beneficial to enable the frame customization, especially in BMS's for general purpose. The BMS is also intended to operate in laboratory where inverters by various manufactures are tested and where practical workshops about different hybrid system behavior with various electrochemical accumulators are held. BMS Orion Junior has been chosen due to its ability of customization.

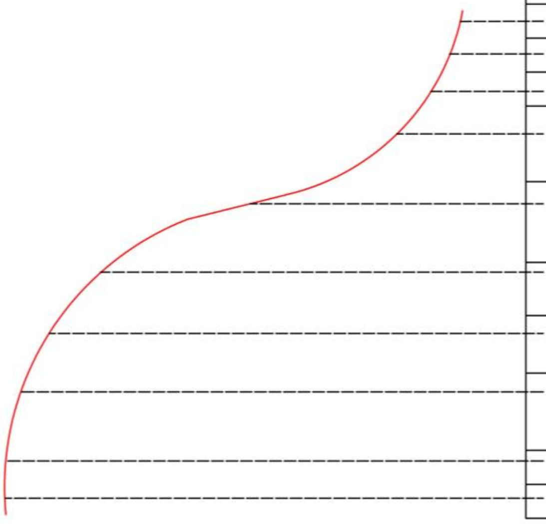
Frame ID	Byte	Data	Length	Res./Unit
0x351 / 849	Data 0	Battery charge voltage	UINT16	0.1V
	Data 1			
	Data 2	Dc charge current limitation	SINT16	0.1A
	Data 3			
	Data 4	Dc discharge current limitation	SINT16	0.1A
	Data 5			
	Data 6	Dc discharge cut voltage	UINT16	0.1V
	Data 7			
0x355 / 853	Data 0	SOC value	UINT16	1%
	Data 1			
	Data 2	SOH value	UINT16	1%
	Data 3			
0x356 / 854	Data 0	Battery voltage	SINT16	0.1V
	Data 1			
	Data 2	Battery current	SINT16	0.1A
	Data 3			
	Data 4	Battery highest temperature	SINT16	0.1C
	Data 5			

Table 1: CAN bus protocol frames derived from inverter by Victron and BMS by Orion.

The best way how to obtain the communication protocol of a device is to find it in the operational manual. If the communication protocol is not included, it is necessary to examine the frame stream from communication busbar and derive the content. This is how the protocol can be specified alternatively. Inspection of the communication between inverter and one of the explicitly compatible battery (in this case BYD) must have been done. Obtained frames together with parameters are listed in **Table 1**. After this protocol was implemented into BMS by Orion, the battery appeared as a clone of the compatible battery in the inverter control system.

4 BMS SETTINGS

Cell voltage settings in BMS must be set in accordance with limiting voltage parameters defined by both cell and inverter operational limits. The asymmetrical distribution of voltage among cells during charging must be taken into consideration to avoid undesired disconnection. To avoid inverter disconnection due to low voltage, the minimal voltage limit of the cell in BMS is set above the inverter cut-off voltage limit. It is also possible to set SOC correction as a function of cell voltage to compensate the SOC estimation error due to cell temperature and voltage disbalance. The voltage settings per one cell are listed in**Table 2**. The capacity of the battery has been set to 5.5 Ah according to cell datasheet.



One cell voltage characteristics		
Value	**Description**	Device
4,25 V	Maximal allowed cell voltage	BMS
4,20 V	Maximal charge cell voltage	BMS
4,18 V	Maximal charge cell voltage	Victron charger
4,17 V	SOC set to 99%, when this voltage is present and SOC is lower	BMS
3,50 V	The cells balancing is enabled if one of the cells is reach this voltage	BMS
3,10 V	MInimal voltage of balanced cell	BMS
3,00 V	SOC set to10%, when this voltage is present and SOC is higher	BMS
2,95 V	Voltage when the inverter is restarted after cut-off caused by low battery voltage	Victron inverter
2,80 V	Minimal allowed cell voltage	BMS
2,75 V	Inverter cut-off voltage	Victron inverter

Table 2: Voltage parameters per one cell, values set in inverter are divided by 14 (number of cells in serial).

The DCL and CCL derating as a function of temperature and SOC is depicted in **Figure 2**. To ensure the battery disconnection before inverter disconnection, the DCL is derated to 0A at 10% of SOC.

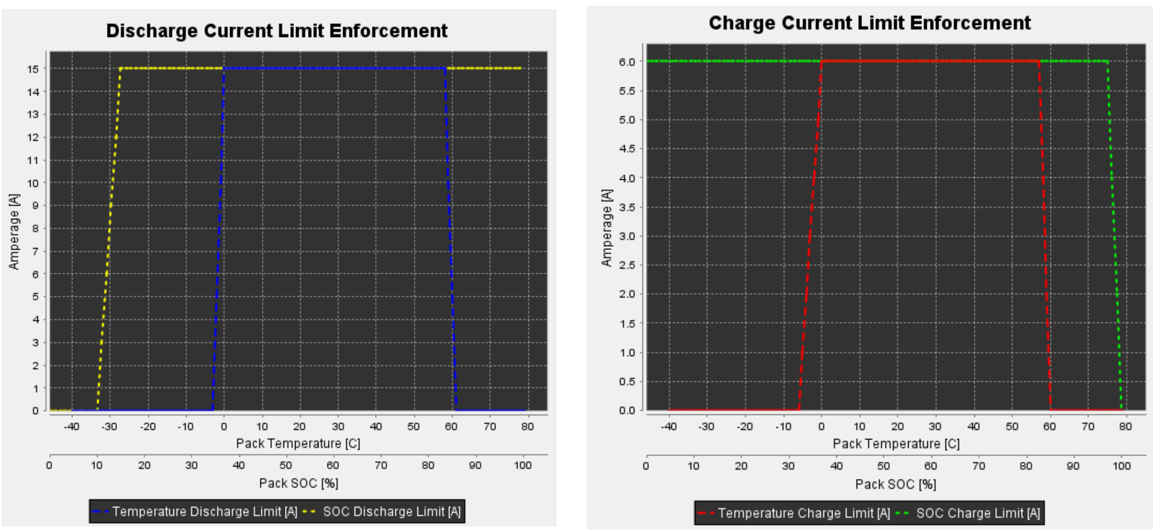


Figure 2: DCL and CCL derating as a function of temperature and SOC.

5 BMS SETTING VALIDATION

To validate the battery settings in both devices, charge and discharge curves has been recorded. The depicted curves show specific BMS and battery behaviour. In order to analyse the battery behaviour in whole operation range, the end of the measurement is considered as the moment of battery disconnection triggered by BMS.

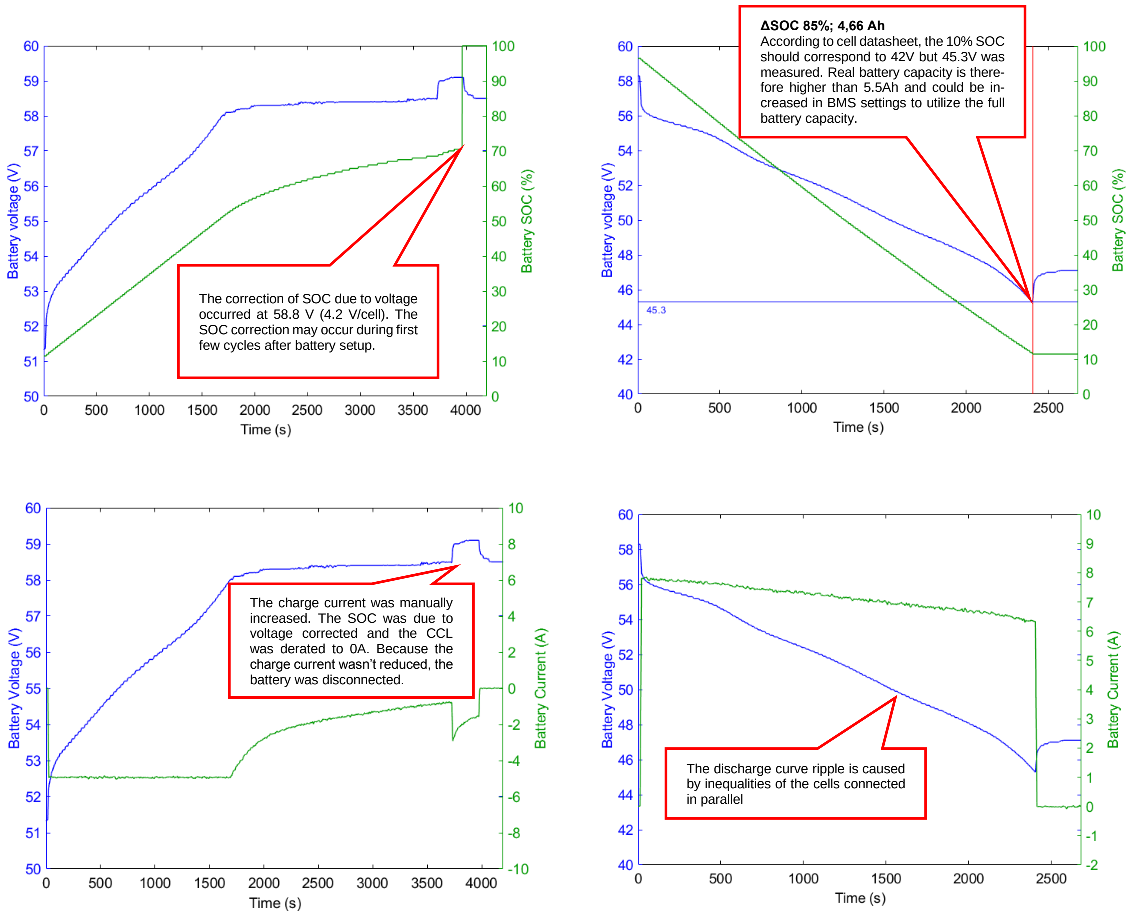


Figure 3: Battery charge using DC power source CC 5A, CV 58.5 (58.8)V (left). Battery discharge using resistor 7.5 Ω (right).

6 CONCLUSION

The paper describes design of autonomous assembly, which is responsible for safe operation of Lithium-ion batteries with BMS. The design was also validated and examples of charge and discharge curves, which led to settings adjustment, were described. Nevertheless, the battery should be cycled in full range of SOC several times after every setup to ensure correct BMS operation. During the cycling, the BMS adapts the SOC estimation algorithm to the battery parameters and thus the system works effectively.

REFERENCES

[1] MARQUES, José Miguel Branco. Battery Management Systems (BMS) for Li-Ion Batteries. Coimbra, 2014. Master thesis. Universidade de Coimbra.

[2] ZHU, Xiaoqing, a kol. Overcharge investigation of large format lithium-ion pouch cells with Li(Ni0.6Co0.2Mn0.2)O2 cathode for electric vehicles: Thermal runaway features and safety management method: Thermal runaway features and safety management method, 169, 868-880. DOI: https://doi.org/10.1016/j.energy.2018.12.041.

[3] Orion Jr. BMS Operation Manual. In: Orion Jr.BMS (Original) [online]. [cit. 2020-03-15]. Available from: https://www.orionbms.com/manuals/pdf/jr_operational_manual.pdf