# Operation & Maintenance Manual

For Samsung Energy, Medium and Power compact platform

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ESS Business Division

Samsung SDI

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***Read this manual carefully before starting operation and keep these instructions for future reference.***

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# Important Safety Instructions

## Read and Follow These Instructions

The following precautions are intended to ensure your safety and prevent property damage. Before installing this product, be sure to read all safety instructions in this document for proper installation.

| | |
|---|---|
|  | **DANGER**<br>Failure to comply with the instruction with this symbol may result in a serious accident, causing death or a severe injury. |
|  | **WARNING**<br>Failure to comply with the instruction with this symbol may result in a serious accident, causing a severe injury. |
|  | **CAUTION**<br>Failure to comply with the instruction with this symbol may result in minor or moderate injury. |
|  | ***NOTICE***<br>Provides information considered important but not hazard-related. The information relates to property damage. |
|  | **Important**<br>Indicates valuable tips for optimum installation and operation of the product. |

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## General Instructions

Please be aware that a battery presents a risk of electrical shock including high short-circuit current. Follow all safety precautions while operating the batteries.

- Remove watches, rings, or other metal objects.
- Use tools with insulated handles in order to avoid inadvertent shorts.
- Wear rubber gloves and safety boots.
- Do not put tools or any metal parts on the top of the batteries.
- Disconnect charging source and load before connecting or disconnecting terminals.
- Use proper lifting means when moving batteries and wear all appropriate safety clothing and equipment.
- Batteries shall not be disposed arbitrarily. Do not dispose of the batteries in a fire because they could explode.
- Do not open or mutilate the batteries.
- Only an authorized, trained technician shall perform annual preventative maintenance.
- The installation and maintenance of the battery should be performed only by qualified personnel who are familiar with the batteries and safety precautions.
- Do not allow unauthorized personnel to approach the batteries.
- Enter an installation site after discharge is completed. Tray installation is a heavy work that requires two or three people or a lift to perform.

## Safety Precautions

The following list of precautions provides general safety guidelines that should be followed when working with or near the Energy Storage System (ESS). Complete safety parameters and procedures are site-specific and should be developed by the customer for the installation site.

- Review and refer to all safety warnings and cautions in this manual before installation.
- Build a clear, permanent, restricted access area around the system.
- Only authorized, adequately trained electrical operators wearing appropriate Personal Protective Equipment (PPE) should be able to access the system.

The interior design of this equipment must be able to consider a “no-go area except for non-qualified personnel who are familiar with the batteries and safety precautions” depending on the location. Consult local codes and applicable rules and regulations to determine permit requirements. If required, mark enclosures appropriately before beginning work.

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## Personnel & Equipment Warnings

Personnel in contract with the battery system should be aware of the following potential hazards:



**WARNING—SHOCK HAZARD**
Do not come into contact with system connectors or terminals. Do not open the enclosure doors if proper LOTO procedures, PPE, and related trainings are not followed for the maintenance plan in accordance with the local codes and regulations.



**WARNING—ARC FLASH HAZARD**
There is an arc flash hazard associated with all electrical equipment. There is a serious risk of arc flash relating to any equipment modification (e.g. opening doors). Serious injuries can occur in arc flash incidents. Appropriate PPE and training is required in accordance with local codes and regulations.



**WARNING—FIRE HAZARD**
Fire may occur under certain fault conditions.



**CAUTION—PINCH POINTS**
Multiple pinch-points are present in most system components. Be aware that there is a serious risk of injury while working around equipment enclosures.



**CAUTION—STATIC SENSITIVE**
Electronic appliances can be damaged by electrostatic discharge. Proper handling procedures are required. Be sure to wear a grounded anti-static wrist strap and to discharge static electricity by touching a grounded surface near the equipment before you touch any system components.

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## Dangerous Voltages



**DANGER**

The ESS is powered by multiple power sources. Hazardous voltages can be present in the equipment even when it does not appear operational. Make sure that you completely understand the cautions and warnings in this installation manual. Failure to do so may result in serious injury or death.
Follow all manufacturer-published safety procedures.
Electrical equipment can present a risk of electrical shock and can cause arc flash. The following precautions must be observed when working on or around electrical equipment:

- Remove watches, jewelry, rings, and other metallic objects.
- Use the tools with insulated handles.
- Safety clothing and shoes should comply with the PPE requirements specified by local codes and regulations.

## Lock Out / Tag Out Guidelines



**DANGER**

Follow all the applicable Lock Out/Tag Out (LOTO) procedures at all times. If proper LOTO procedures are not followed, it may result in serious injury or death.
With power applied to the ESS, hazardous voltages are present on some components. To prevent accidental death or injury, do not touch any components within the enclosure unless you are specifically directed to do so. To reduce the risk of electrical shock, make sure that all equipment are properly grounded. For more information, refer to “Guide of grounding”



**WARNING**

Enclosure doors shall remain closed except when access to the enclosure interior is required. If possible, personnel should keep a safe distance from enclosures whenever the equipment is re-energized. Always comply with local, state, and national Lock Out/Tag Out (LOTO) guidelines when working with or near the ESS. The LOTO procedures should meet or exceed the requirements of all guidelines presented in SAMSUNG SDI safety documentation. Before entering potentially hazardous areas or beginning work on the ESS, complete the following tasks:

- Identify and wear protective clothing and shoes according to PPE.
- Identify and isolate all power and stored energy sources.
- Apply appropriate LOTO devices. When applying LOTO to the ESS, do not touch anything within the enclosure except as specifically directed in the work procedures.
- Complete the site-specific LOTO procedure and safety checklist before beginning work.

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## General Warnings



**DANGER**
When energized, this equipment presents a potential hazard of electric shock, death, or burn. Only authorized personnel who are thoroughly familiar with the equipment and adequately trained should install, operate, or maintain this equipment.



**DANGER**
To avoid death, personal injury, or damage to the product, follow all safety procedures as regulated by Environmental Health and Safety (EHS) guidelines.



**DANGER**
To minimize hazard of electrical shock, death, or burn, approved grounding practices and procedures should be strictly followed.



**WARNING**
To avoid personal injury or damage to equipment, personnel should adhere to the site protocol concerning working at heights.



**WARNING**
To avoid personal injury or equipment damage caused by equipment malfunction, only adequately trained personnel should modify any programmable machine.



**WARNING**
Always ensure that applicable standards and regulations are followed and only properly certified equipment is used as a critical component of a safety system. Never assume that a safety-critical control loop is functioning correctly.

## Safe Handling Instructions

### Handling of Module Assembly

Every Module Assembly including Lithium-Ion battery cells has electrical energy even before installation. Be sure to keep in mind the important features below:

- Typical voltage for Module Assembly: 80.96V
- Typical internal resistance for Module Assembly: 9.9~12mΩ( TBD )
- Max weight for Module Assembly: 54 kg

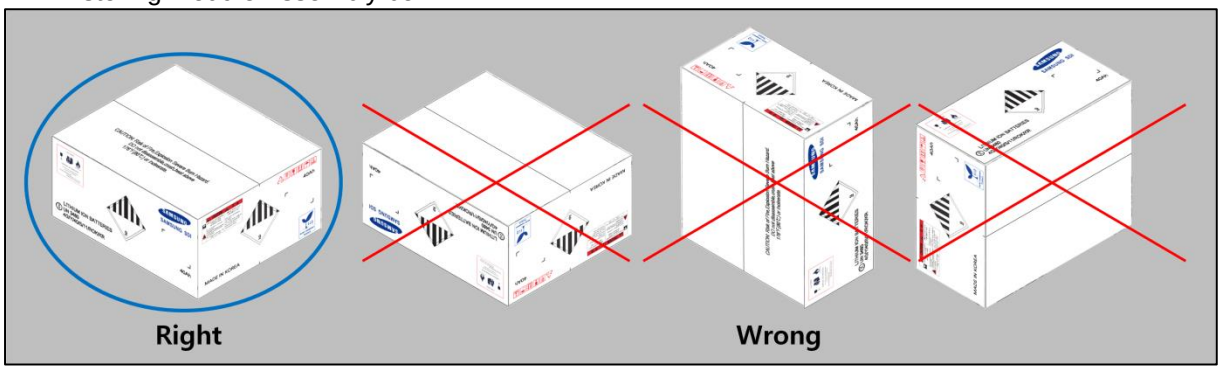
As shown above, Module Assembly has ability of flowing fault current maximum 3600A at SOC 100% (91.3V). It means that handling of Module Assembly needs caution for arc flash though it is relatively safe against electric shock. In particular, short-circuiting of positive (+) and negative (-) power terminals on the front of Module Assembly is strictly forbidden and the handling of

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heavy weight requires caution.

**Storage of Module Assembly**

Follow the guidelines below when storing a Module Assembly box.
Module Assembly box must be upright as in the figure below. Do not place upside down when storing Module Assembly box.




The required equipment units shall keep the following requirements:

- Basic rubber gloves: Safe handling and avoidance of short circuit
- Safety shoes: Caution of dropping modules
- Hard hats: Caution of dropping object

Follow the guidelines below when handling Module Assembly.

- Do not remove the covers of Module Assembly.
- Do not use metallic objects that can cause a short circuit of the positive (+) and negative (-) terminals.
- Do not give any mechanical shock to Module Assembly.
- Do not drop Module Assembly.
- Do not disassemble and damage Module Assembly.
- Do not insert foreign substances into Module Assembly.
- Do not remove any screws from Module Assembly.
- Keep Module Assembly away from water.
- Do not heat Module Assembly. Avoid exposure to direct sun light.
- Do not solder directly on the battery contacts.
- Do not use seriously scarred or deformed batteries. Dispose of them immediately according to local regulations.
- Do not damage a sheath of the cable or the connectors.
- Never smoke within 20 meters of batteries.

## Issues on Battery Cell

For more detail information, please refer the MSDS which is separately provided

**Organic Solvent Electrolyte**

SAMSUNG SDI Lithium-Ion Battery Cell contains an organic solvent-based electrolyte. Breach of individual cells may allow the cell to release some electrolyte. Direct contact with the liquid electrolyte can cause skin irritation. Electrolyte smells sour.

In the event of contact with the liquid electrolyte, follow the suggestions below to minimize the chance of injury:

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- Flush eyes immediately with cold running water for at least 15 minutes.
- Rinse skin immediately with water for at least 15 minutes.
- Remove clothing if soiled.
- Seek an immediate medical treatment

**Electrolyte Vent Product**

Though the battery system has several measures for safe use, there is still a possibility of accident. When Battery Cell is misused, damaged or abused, the Battery cell can open the vent on top of it to prevent severe explosion. In that case, the internal pressure becomes lower but electrolyte decomposition can occur outside.

- Opening vent is a serious issue. Thus, all the actions should be extremely cautious.
- The whole system except for the Aux. power should be shut down.
- Contact to SAMSUNG SDI is required.
- Check for the temperature and voltage of each cell is required. Only when the temperature goes down under 40 centigrade, authorized personnel can access near the battery and check what happened. If temperature and voltage cannot be measured and situation is not clear, stay away from the detective battery cell for at least 1 day. If an event does not occur for 1 day, limited approach is possible.
- Any type of spark or flame should be avoided not to burn the decomposed electrolyte.

**First-aid Measures**

Upon emergency, you should take the following first-aid measures for safety.

Upon Inhalation
If you unintentionally inhale generated gases or fumes from the cells, breathe in some fresh air and, consult with a physician if required.

Upon Contact to Skin
If your skin unintentionally contacts with the battery electrolyte, wash off the electrolyte immediately with plenty of water. If required, consult with a physician.

Upon Contact to Eye
If your eye unintentionally contacts with the battery electrolyte or fumes, rinse it immediately with plenty of water under the eyelids for at least 15 minutes. Seek medical treatment and contact an eye doctor or physician if you have any concerns about your injury.

Upon Ingestion
If you unintentionally swallow the spilled electrolyte, drink plenty of water and contact a physician immediately for medical treatment.

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# 1. Product descriptions

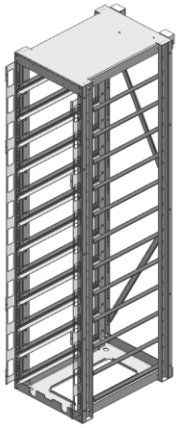
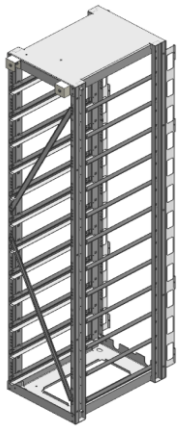
This product has been designed to reduce energy consumption cost by charging and selling residual energy. In order to install this product, check its components and prepare personal protection equipment (PPE).

### 1.1 Key components of product

1) Rack frame

Rack frame is a metallic houses for containing battery modules and switchgear. Each rack frame requires #4 AWG squared wire ground connection secured at right bottom anchor or top side bonding location.

- Dimension 442 x 702 x 1792mm (for 198S configuration)
  442 x 702 x 1958mm (for 220S configuration)
  442 x 702 x 2124mm (for 242S configuration)
  442 x 702 x 2290mm (for 264S configuration)

| Rack Frame Front | Rack Frame Rear |
|---|---|
|  |  |

2) Battery module

This is the most basic component, which contains the energy storing battery cells and a single module BMS. The module BMS integrated into the battery module monitors the status of each battery by measuring attributes such as cell voltage and cell temperature. The module BMS communicates with Rack BMS/Switchgear assembly over a rack-local UART interface. The Module BMS will deliver digitized measured voltage and temperature data to the Rack BMS and receive commands from Rack BMS to control cell balancing.

| | E2 | M2f | P3 |
|---|---|---|---|
| Nominal capacity | 94Ah | 94Ah | 78Ah |
| Nominal voltage | 80.96V | | 81.4V |
| Operating voltage | 70.4 ~ 91.3V | | 68.2 ~ 90.2V |
| Storage condition | 23±5℃ (Max -20 ~ 60℃ with further capacity degradation) | | |
| Weight | 52.5Kg | 54Kg | 54Kg |
| Dimension | 370 x 588 x 160 mm | | |

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| Module without FAN (E2) | Module with FAN (M2f, P3) |
|---|---|
|  |  |

## 3) Switch gear (Rack BMS & Switchgear assembly)

Switch gear contains protective fusing devices in order to prevent damage on cells from external short and equips DC-contactors which is controlled by rack BMS for controlling of the electrical connection of rack to the main DC-bus in case abnormal operating conditions. In addition, switch gear contains Rack BMS which collects all Module BMS information and reports this to System BMS via an internal CAN-Bus interface. The rack BMS also calculates the state of charge (SOC) and the state of health (SOH) of the rack. The rack BMS assembly requires a 24Vdc power source.

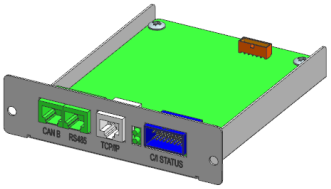
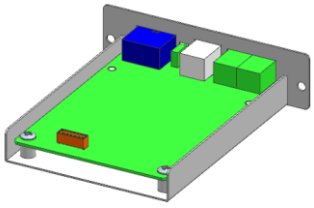
- Dimension : 418 x 415.6 x 160mm

| Module without FAN (E2) | Module with FAN (M2f, P3) |
|---|---|
|  |  |

## 4) System BMS

The system BMS assembly provides data to the PCS (or EMS) while controlling and monitoring multiple racks up to 128 through MODBUS TCP/IP or MODBUS RTU. System BMS will be installed inside of the last switchgear.

- Dimension : 142 x 135 x 35mm

| Front System BMS Assembly | Rear System BMS Assembly |
|---|---|
|  |  |

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# 2. Personnel Protection equipment (PPE)

Please be aware that a battery presents a risk of electrical shock including high short-circuit current. Follow all safety precautions while operating the batteries. During installation or maintenance the battery system, the worker shall be wear proper PPE accordance with below table

## 2.1 Arc flash calculation

### 1) E2 264S

**1. E2 Platform (264S)**

| | | Calculation & Description | During installation | | | After installation | | |
|---|---|---|---|---|---|---|---|---|
| | | | Module | Rack w/o S/G | Rack with S/G | Module | Rack w/o S/G | Rack with S/G |
| $V_{sys}$(V) | System Voltage | Battery OCV | 78.85 | 946.19 | 946.19 | 90.88 | 1,090.58 | 1,090.58 |
| $R_{sys}$(Ω) | Resistance | measured value | 0.012 | 0.149 | 0.154 | 0.012 | 0.149 | 0.154 |
| $I_{bf}$(A) | Fault current | Calculation : Vsys/Rsys | 6,571 | 6,349 | 6,143 | 7,574 | 7,319 | 7,082 |
| $I_{arc}$(A) | Arcing current | Calculation : 0.5 X Ibf | 3,285 | 3,174 | 3,071 | 3,787 | 3,660 | 3,541 |
| fuse $i^2t$ | | Derived from fusing graph | 982,226 | 733,601 | 11,037 | 1,304,892 | 975,028 | 14,669 |
| $T_{arc}$ (sec) | Arcing time | Calculation : i2t/(Iarc)^2 | 0.0910 | 0.0728 | 0.0012 | 0.0910 | 0.0728 | 0.0012 |
| **IEm** | **Arc Energy at 18" Distance [cal/cm^2]** | | **0.11277** | **1.04607** | **0.01627** | **0.14982** | **1.39002** | **0.02161** |
| Distance (inch) for different arc energy (cal/cm$^2$) | PPE Category 0 | 1.2 | 5.5 | 16.8 | 2.1 | 6.4 | 19.4 | 2.4 |
| | PPE Category 1 | 4 | 3.0 | 9.2 | 1.1 | 3.5 | 10.6 | 1.3 |
| | PPE Category 2 | 8 | 2.1 | 6.5 | 0.8 | 2.5 | 7.5 | 0.9 |
| | PPE Category 3 | 25 | 1.2 | 3.7 | 0.5 | 1.4 | 4.2 | 0.5 |
| | PPE Category 4 | 40 | 1.0 | 2.9 | 0.4 | 1.1 | 3.4 | 0.4 |
| Hazard Risk Category | | | 1 | 2 | 1 | 1 | 2 | 1 |
| PPE Category | | | 1 | 2 | 1 | 1 | 2 | 1 |

### 2) M2f 264S

**1. M2f Platform (264S)**

| | | Calculation & Description | During installation | | | After installation | | |
|---|---|---|---|---|---|---|---|---|
| | | | Module | Rack w/o S/G | Rack with S/G | Module | Rack w/o S/G | Rack with S/G |
| $V_{sys}$(V) | System Voltage | Battery OCV | 78.8 | 946.2 | 946.2 | 89.8 | 1,077.6 | 1,077.6 |
| $R_{sys}$(Ω) | Resistance | measured value | 0.011 | 0.131 | 0.136 | 0.011 | 0.131 | 0.136 |
| $I_{bf}$(A) | Fault current | Calculation : Vsys/Rsys | 7,509 | 7,221 | 6,956 | 8,553 | 8,226 | 7,924 |
| $I_{arc}$(A) | Arcing current | Calculation : 0.5 X Ibf | 3,755 | 3,610 | 3,478 | 4,276 | 4,113 | 3,962 |
| fuse $i^2t$ | | Derived from fusing graph | 1,282,907 | 948,994 | 14,151 | 1,664,156 | 1,231,637 | 18,365 |
| $T_{arc}$ (sec) | Arcing time | Calculation : i2t/(Iarc)^2 | 0.0910 | 0.0728 | 0.0012 | 0.0910 | 0.0728 | 0.0012 |
| **IEm** | **Arc Energy at 18" Distance [cal/cm^2]** | | **0.12888** | **1.18977** | **0.01842** | **0.16719** | **1.54373** | **0.02390** |
| Distance (inch) for different arc energy (cal/cm$^2$) | PPE Category 0 | 1.2 | 5.9 | 17.9 | 2.2 | 6.7 | 20.4 | 2.5 |
| | PPE Category 1 | 4 | 3.2 | 9.8 | 1.2 | 3.7 | 11.2 | 1.4 |
| | PPE Category 2 | 8 | 2.3 | 6.9 | 0.9 | 2.6 | 7.9 | 1.0 |
| | PPE Category 3 | 25 | 1.3 | 3.9 | 0.5 | 1.5 | 4.5 | 0.6 |
| | PPE Category 4 | 40 | 1.0 | 3.1 | 0.4 | 1.2 | 3.5 | 0.4 |
| Hazard Risk Category | | | 1 | 2 | 1 | 1 | 2 | 1 |
| PPE Category | | | 1 | 2 | 1 | 1 | 2 | 1 |

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## 3) P3 264S

**1. P3 Platform (264S)**

| | | Calculation & Description | During installation | | | After installation | | |
|---|---|---|---|---|---|---|---|---|
| | | | Module | Rack w/o S/G | Rack with S/G | Module | Rack w/o S/G | Rack with S/G |
| $V_{sys}$(V) | System Voltage | Battery OCV | 79.4 | 953.0 | 953.0 | 89.8 | 1,077.6 | 1,077.6 |
| $R_{sys}$(Ω) | Resistance | measured value | 0.010 | 0.122 | 0.127 | 0.010 | 0.122 | 0.127 |
| $I_{bf}$(A) | Fault current | Calculation : Vsys/Rsys | 8,022 | 7,783 | 7,477 | 9,071 | 8,801 | 8,456 |
| $I_{arc}$(A) | Arcing current | Calculation : 0.5 X Ibf | 4,011 | 3,891 | 3,739 | 4,536 | 4,400 | 4,228 |
| fuse $i^2t$ | | Derived from fusing graph | 386,078 | 290,740 | 16,354 | 493,710 | 371,793 | 20,913 |
| $T_{arc}$ (sec) | Arcing time | Calculation : i2t/(Iarc)^2 | 0.0240 | 0.0192 | 0.0012 | 0.0240 | 0.0192 | 0.0012 |
| **IEm** | **Arc Energy at 18" Distance [cal/cm^2]** | | **0.03657** | **0.34062** | **0.01994** | **0.04677** | **0.43558** | **0.02550** |
| Distance (inch) for different arc energy (cal/$cm^2$) | PPE Category 0 | 1.2 | 3.1 | 9.6 | 2.3 | 3.6 | 10.8 | 2.6 |
| | PPE Category 1 | 4 | 1.7 | 5.3 | 1.3 | 1.9 | 5.9 | 1.4 |
| | PPE Category 2 | 8 | 1.2 | 3.7 | 0.9 | 1.4 | 4.2 | 1.0 |
| | PPE Category 3 | 25 | 0.7 | 2.1 | 0.5 | 0.8 | 2.4 | 0.6 |
| | PPE Category 4 | 40 | 0.5 | 1.7 | 0.4 | 0.6 | 1.9 | 0.5 |
| Hazard Risk Category | | | 1 | 2 | 1 | 1 | 2 | 1 |
| PPE Category | | | 1 | 2 | 1 | 1 | 2 | 1 |

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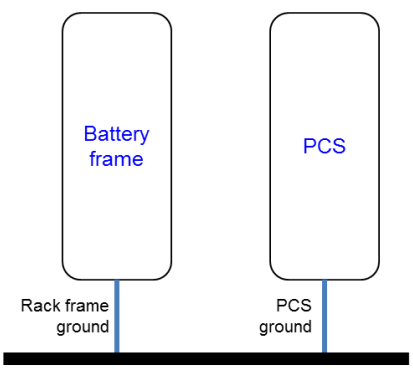
# 3. Operation of battery system

Battery system generally operates as passive system which means the battery system does not control the current flow actively before reaching the serious conditions. Therefore PCS (or EMS) have to be monitor and control the battery and all environmental condition carefully to keep the battery system in the best conditions. If the PCS (or EMS) cannot control battery system properly, the battery system can goes into the abnormal situation and it can lead to faster life degradation and battery can be irreversible damages. In order to prevent such a worst situation, each rack equips safety function consisted with BMS, DC contactors and fuses, BMS send an alarm to PCS under the situation and trip the battery system under the worse situation by itself.
In order to prevent the battery damages from abnormal situation, the following items shall be checked during installation and operation carefully.

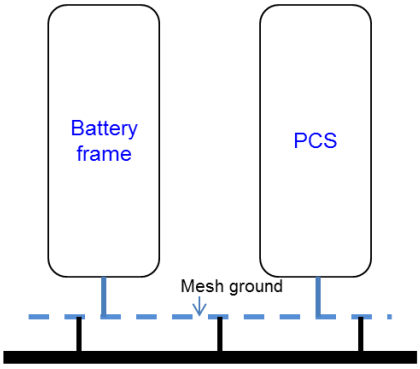
## 3.1 Battery grounding

The each Rack frame has to have separate grounding from the PCS system in order to prevent malfunction or battery damages from the spike noise comes from GND line.

**[Recommended GND scheme]**

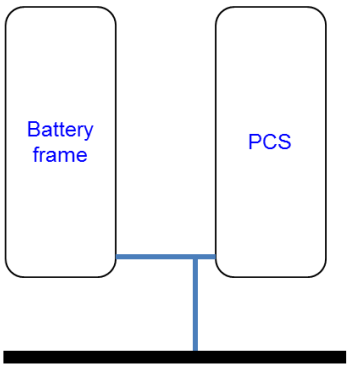



PCS and battery frame has grounded separately




Type B :
Grounding of PCS and battery frame are grounded through mesh ground.

**[Avoid GND scheme]**




Type C :
Grounding of PCS and battery frame are tied together.

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## 3.2 Common mode voltage (CMV)

In order to secure the battery operation reliably the battery GND have to be stable and it can be detected by measuring the voltage difference between the battery DC terminal and GND. The common mode voltage is important not only reliable operation but also battery safety. If the CMV is too high, the isolation of battery module can be broken and it cause safety risk as well. In addition this CMV can be varied depends on operating condition and period. Therefore it needs to be checked regularly.

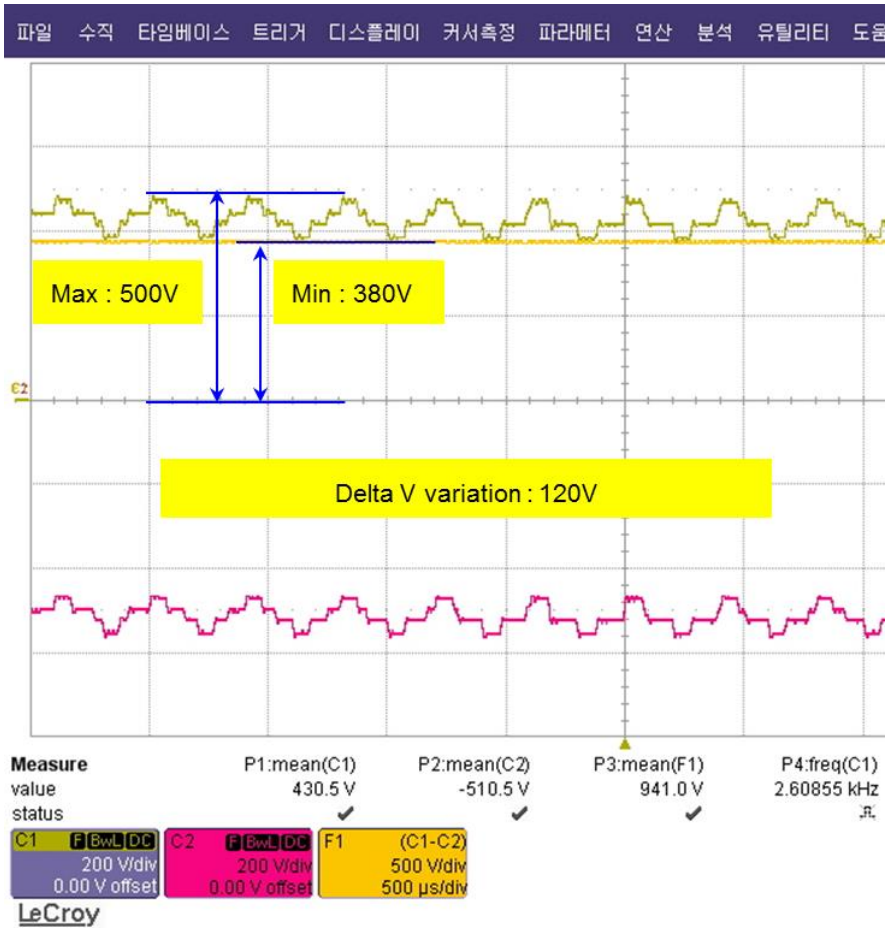
**[Recommend criteria]**

- The peak voltage shall be less than 800V
- Peak to Peak shall be less than 300V

**[How to reduce CMV]**

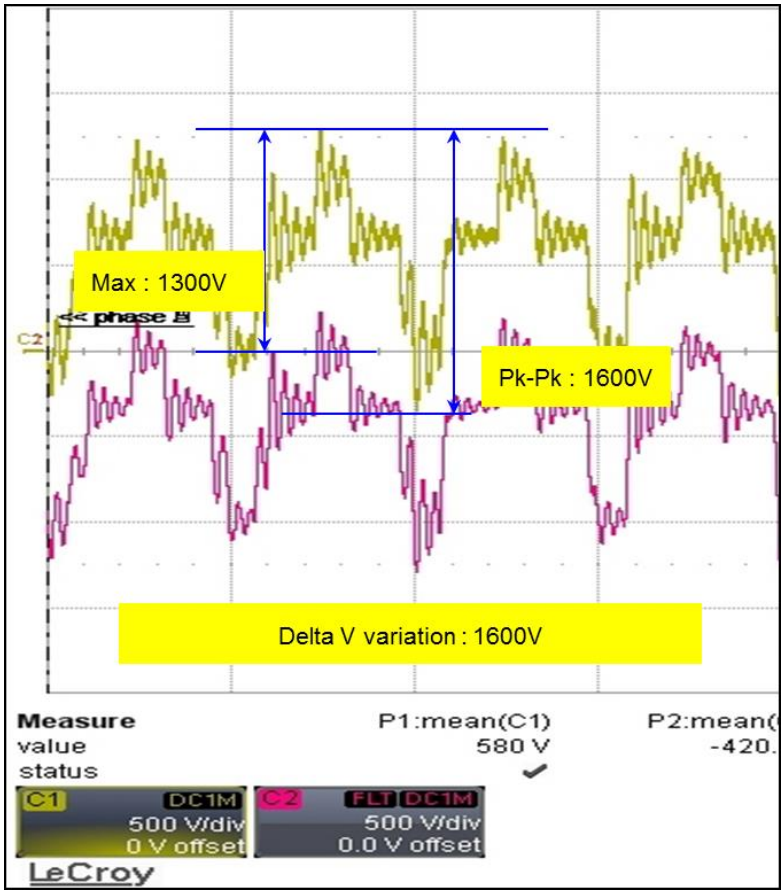
- Concrete battery frame GND and it have to be separated with PCS
- Well synchronized operation of PCS
- Etc.

**[Desirable CMV scheme]**




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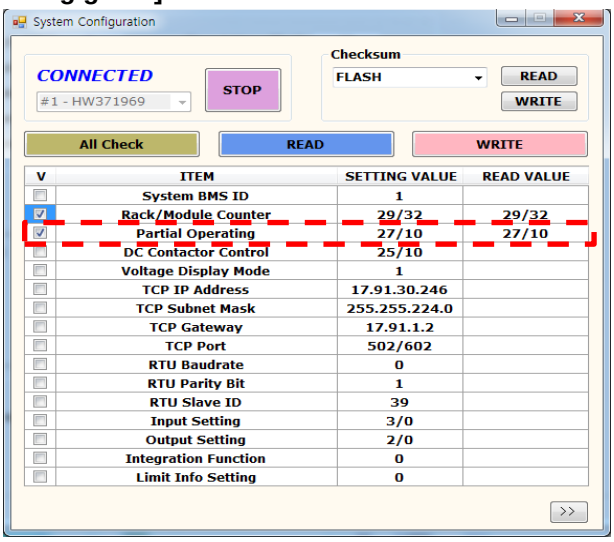
**[Avoid voltage scheme]**




## 3.3 Partial operation

In order to prevent the battery damage from the in-rush current which produce during the connecting un-balanced Rack together, it is recommended use partial operation mode in system BMS.

**[Setting guide]**




**[Setting guide]**

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Meaning of setting A/B

- A : Minimum number of Racks to start operating
- B : Voltage difference threshold to connect Rack to the grid

Setting of A

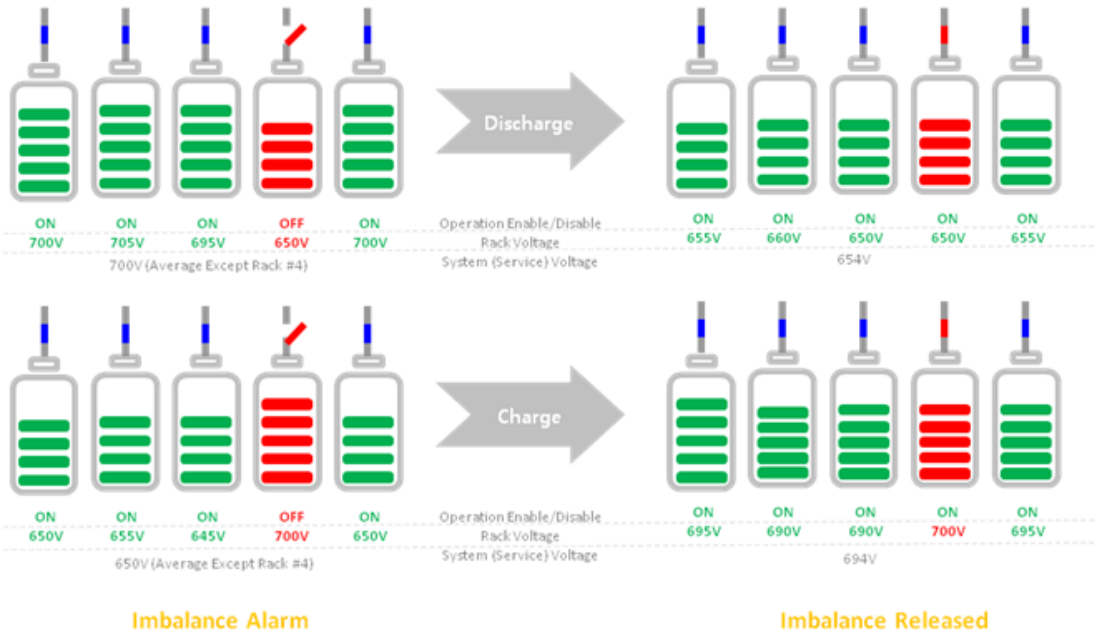
- CASE A : PCS reduce power in accordance with the number of available Rack (# of Racks * CCL (or DCL) → half of total Rack
- CASE B : PCS does not reduce the power regardless available Rack → Contact to SDI.

Setting of B

| Platform | Energy | Medium | Power |
|---|---|---|---|
| Setting | 5 | 10 | 10 |

**[Operating sequence]**

- Send a command of DC contactor ON from PCS to System BMS
- System BMS detect the each Rack voltage and check whether the available Rack (Median ± setting value) is higher than threshold value.
- If the available Rack is more than setting value, the system BMS turn on the available Rack.
- During charging (or discharging) the off rack voltage is within the threshold then the rack will be turned ON dc contactor and as a result connected grid together.




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## 3.4 Operating condition

Battery degradation is highly sensitive with temperature condition, so the temperature control is essential and keeps following guide line. If the conditions are not fulfilled, the battery system goes further capacity degradation and it can be lead the battery system out of warranty.

**[Temperature condition]**

1. Available operating temperature condition
   - Ambient temp range of 0 ~ 45degC is allowable windows without performance guarantees.
   - If the customer wants to use this temperature window, it shall be discussed and described in warranty document; otherwise the battery can be out of warranty

2. Recommended operating temperature condition
   - SDI propose 23±5degC of recommended operating temperature.
   - 23degC means the annual average ambient temperature of the battery system and the ambient temperature can be varying with ±5degC temporarily

3. Temperature uniformity
   - The ambient temperature of the Rack string shall be spread within 5degC. It means each rack's delta temperature (Max – Min) shall be less than 5degC.

**[Humidity condition]**

1. Humidity
   - 0 ~ 80%RH is recommended and any moisture condensing inside or outside of battery module is not allowed.

## 3.5 Storage condition

When the battery system needs to be stored, it is recommended to follow below condition to reduce the battery degradation and keep battery system in reliable.

**[Environment condition]**

- The battery system possible to store the temperature range of Store the battery system -20 to 60degC without warranty
- However it is required to store the battery system less than 23degC to secure the warranty requirement.
- 0~80% Humidity condition is required and any moisture condensing in/outside of battery module is not allowed.

**[SOC condition]**

- Less than SOC 20% is recommended to store. The OCV of battery module need to be monitored every 6 months, and if the OCV is lower than the threshold, the battery module need to be re-charged for further storage.

| Platform | Energy | Medium | Power |
|---|---|---|---|
| Re-charge threshold | 3.474/Cell | 3.45V/Cell | 3.417/Cell |
| Charge up to | 3.594/Cell | 3.58V/Cell | 3.577/Cell |

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## 3.6 Capacity measurement, RTE and SOH update cycle

In order to measure capacity of battery system, the following procedure is recommended to use.

**[Capacity measurement procedure]**

1. The battery system shall be discharged to below SOC 5% with 0.3C current rate and held at or less than 5% of SOC for a period of 12 hours in an active standby state. (Supplying 24V Aux power into Switchgear and without charge and discharge)

2. The battery system shall be charged with 0.3C current rate to the maximum charging voltage of the battery system. After reaching up to the maximum charging voltage, the PCS shall start constant voltage (CV) charging mode, which keep charging voltage and decrease charging current until charging current is reduced under 3A/rack or for 30minutes

3. The battery system shall be left for a period of 30 minutes in an active standby state

4. The battery system shall be discharged with 0.3C current rate to the end of discharge voltage.

5. The battery system shall be left for a period of 30 minutes in an active standby state

6. Repeat the procedure 2 to 5 and the capacity of the battery system is measured at the in front of the battery switchgear output during 2$^{nd}$ discharging period.

7. The charge and discharge C-rate can be increased to max 0.5C current rate (for E2) and 1.0C current rate (for M2f and P3), and in such case the following discharge loss shall be considered.

8. In addition, the capacity measurement procedure can be performs without CV phase, and in such case the following charge loss shall be considered. Moreover the SOH will not be updated in such test procedure.

**[RTE definition]**

RTE is defined as the ratio of total amount of discharged energy VS. total amount of charged energy which is measured 2$^{nd}$ cycle of capacity measurement procedure

**[SOH update cycle]**

During the capacity measurement procedure, the SOH will be updated automatically.

**[Reference Cycle parameter]**

| Platform | Energy | Medium | Power |
|---|---|---|---|
| Maximum Charging voltage | 4.15V/Cell | 4.15V/Cell | 4.1V/Cell |
| End of discharging voltage | 3.2V/Cell | 3.2V/Cell | 3.1V/Cell |
| C-rate base | 94 | 94 | 78 |

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## [Reference Loss table]

**[E2 Platform]**

| C-rate | Charge loss | Discharge loss | RTE |
|---|---|---|---|
| 0.1 | 1.20% | 1.10% | 95.50% |
| 0.2 | 2.40% | 2.10% | 94.50% |
| 0.3 | 3.60% | 3.00% | 93.50% |
| 0.5 | 6.00% | 4.00% | 92.50% |

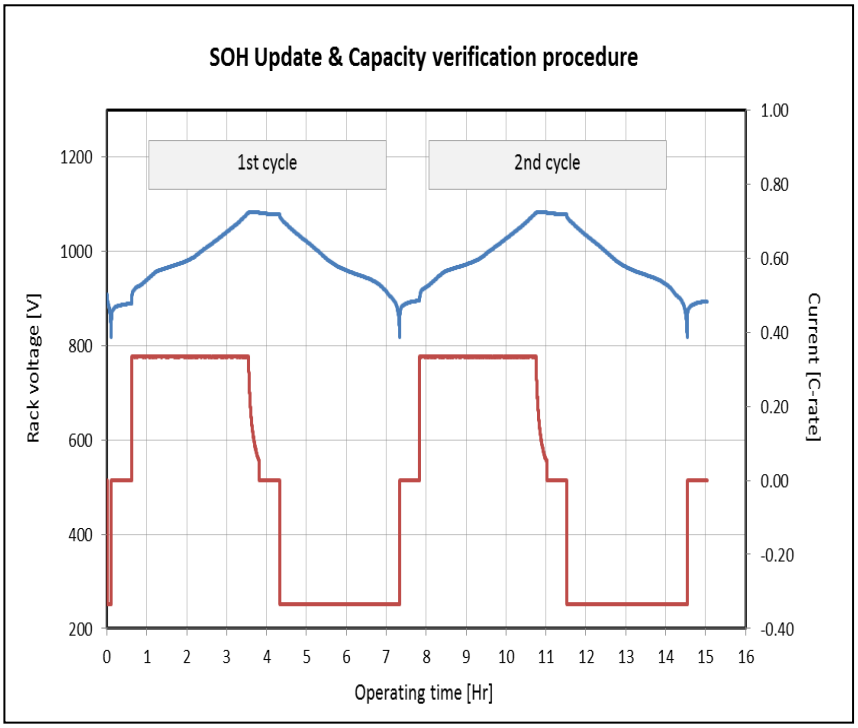
**[M2f Platform]**

| C-rate | Charge loss | Discharge loss | RTE |
|---|---|---|---|
| 0.3 | 4.50% | 3.00% | 93.50% |
| 0.5 | 7.00% | 4.00% | 92.50% |
| 1.0 | 11.00% | 6.00% | 88.50% |
| 1.2 | 14.00% | 6.50% | 88.00% |

**[P3 Platform]**

| C-rate | Charge loss | Discharge loss | RTE |
|---|---|---|---|
| 0.5 | 8.00% | 3.30% | 93.50% |
| 1.0 | 12.00% | 4.50% | 90.50% |
| 1.5 | 15.00% | 5.70% | 87.50% |
| 2.0 | 18.00% | 7.00% | 86.50% |

## [Reference Capacity measurement procedure]




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## 3.7 Data log requirement

In order to keep efficiency of performance guarantees, the below information shall be logged in customer's server (or equivalent) and can be provided to Samsung SDI when it be required.

Therefore the customers, who want to cover the performance warranty, have a responsibility to provide the listed information to SDI.

**[Data log]**

| Category | Address (HEX) | Data | No | Unit | Precision | Log resolution [Sec] |
|---|---|---|---|---|---|---|
| System Info | 0x0001 | System Voltage | # of System BMS | V | 0.1 | 60 |
| | 0x0002 | System Current | # of System BMS | A | 0.1 | 60 |
| | 0x0003 | System SOC | # of System BMS | % | 0.1 | 60 |
| | 0x0008 | Max cell Temp of system | # of System BMS | deg C | 0.1 | 60 |
| | 0x0009 | Min Cell Temp of system | # of System BMS | deg C | 0.1 | 60 |
| Rack info | 0x0028 | Rack Voltage | # of Rack BMS | V | 0.1 | 60 |
| | 0x002D | Rack Current | # of Rack BMS | A | 0.1 | 60 |
| | 0x0032 | Rack SOC | # of Rack BMS | % | 0.1 | 60 |
| | 0x0044 | Average Cell voltage | # of Rack BMS | V | 0.001 | 60 |
| | 0x0049 | Max Cell Temperature | # of Rack BMS | deg C | 0.1 | 60 |
| | 0x004D | Average Cell temperature | # of Rack BMS | deg C | 0.1 | 60 |
| | 0x0050 | Min Cell temperature | # of Rack BMS | deg C | 0.1 | 60 |
| External | - | Ambient temperature | At least 3 / container | deg C | 0.1 | 180 |

**[Daily history]**

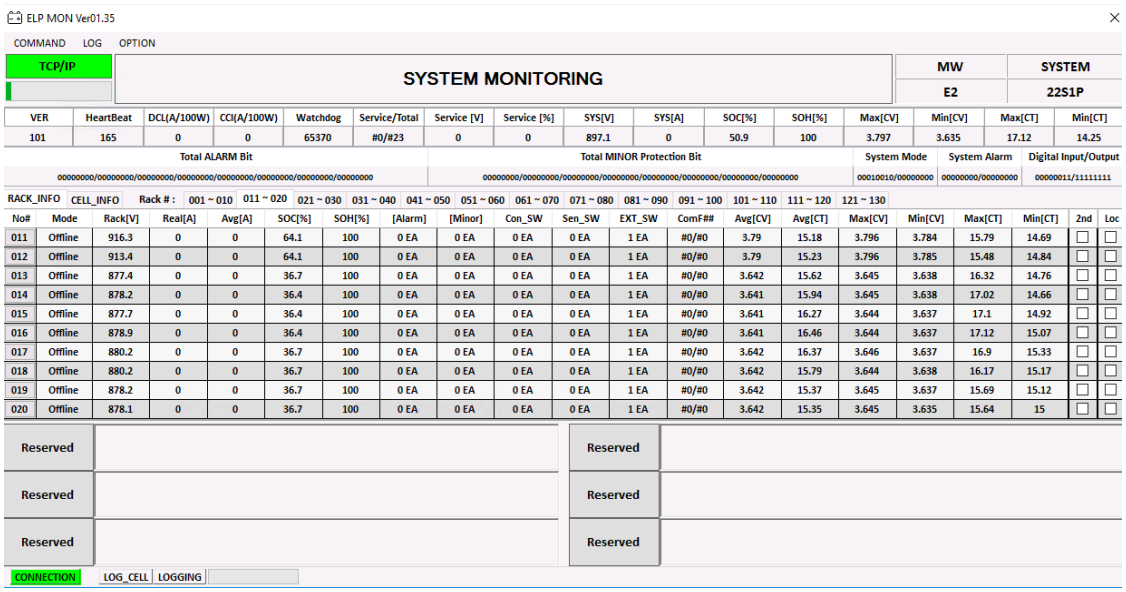
| Category | Address (HEX) | Data | No |
|---|---|---|---|
| Rack info | NA | Temperature (time average per day) | # of Rack BMS |
| | NA | Delta temperature (time average per day) | # of Rack BMS |
| | NA | Minimum SOC | # of Rack BMS |
| | NA | Maximum SOC | # of Rack BMS |
| | NA | Max charging power | # of Rack BMS |
| | NA | Max discharging power | # of Rack BMS |
| | NA | Discharge throughput | # of Rack BMS |

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## 3.8 Analysis of abnormality

If the customer want to request abnormal behaviors of battery system, the battery data log file which is recorded by ELP_MON program is required. The minimum logged period shall be faster than 4sec and SDI can be request further information depend on phenomena.

### [ELP_MON screen shot Example]



ELP MON Ver01.35

COMMAND LOG OPTION

TCP/IP

SYSTEM MONITORING

MW E2 SYSTEM 22S1P

| VER | HeartBeat | DCL(A/100W) | CCI(A/100W) | Watchdog | Service/Total | Service [V] | Service [%] | SYS[V] | SYS[A] | SOC[%] | SOH[%] | Max[CV] | Min[CV] | Max[CT] | Min[CT] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 101 | 165 | 0 | 0 | 65370 | #0/#23 | 0 | 0 | 897.1 | 0 | 50.9 | 100 | 3.797 | 3.635 | 17.12 | 14.25 |

| Total ALARM Bit | Total MINOR Protection Bit | System Mode | System Alarm | Digital Input/Output |
|---|---|---|---|---|
| 00000000/00000000/00000000/00000000/00000000/00000000/00000000/00000000 | 00000000/00000000/00000000/00000000/00000000/00000000/00000000/00000000 | 00010010/00000000 | 00000000/00000000 | 00000011/11111111 |

RACK_INFO CELL_INFO Rack # : 001 ~ 010 011 ~ 020 021 ~ 030 031 ~ 040 041 ~ 050 051 ~ 060 061 ~ 070 071 ~ 080 081 ~ 090 091 ~ 100 101 ~ 110 111 ~ 120 121 ~ 130

| No# | Mode | Rack[V] | Real[A] | Avg[A] | SOC[%] | SOH[%] | [Alarm] | [Minor] | Con_SW | Sen_SW | EXT_SW | ComF## | Avg[CV] | Avg[CT] | Max[CV] | Min[CV] | Max[CT] | Min[CT] | 2nd | Loc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 011 | Offline | 916.3 | 0 | 0 | 64.1 | 100 | 0 EA | 0 EA | 0 EA | 0 EA | 1 EA | #0/#0 | 3.79 | 15.18 | 3.796 | 3.784 | 15.79 | 14.69 | ☐ | ☐ |
| 012 | Offline | 913.4 | 0 | 0 | 64.1 | 100 | 0 EA | 0 EA | 0 EA | 0 EA | 1 EA | #0/#0 | 3.79 | 15.23 | 3.796 | 3.785 | 15.48 | 14.84 | ☐ | ☐ |
| 013 | Offline | 877.4 | 0 | 0 | 36.7 | 100 | 0 EA | 0 EA | 0 EA | 0 EA | 1 EA | #0/#0 | 3.642 | 15.62 | 3.645 | 3.638 | 16.32 | 14.76 | ☐ | ☐ |
| 014 | Offline | 878.2 | 0 | 0 | 36.4 | 100 | 0 EA | 0 EA | 0 EA | 0 EA | 1 EA | #0/#0 | 3.641 | 15.94 | 3.645 | 3.638 | 17.02 | 14.66 | ☐ | ☐ |
| 015 | Offline | 877.7 | 0 | 0 | 36.4 | 100 | 0 EA | 0 EA | 0 EA | 0 EA | 1 EA | #0/#0 | 3.641 | 16.27 | 3.644 | 3.637 | 17.1 | 14.92 | ☐ | ☐ |
| 016 | Offline | 878.9 | 0 | 0 | 36.4 | 100 | 0 EA | 0 EA | 0 EA | 0 EA | 1 EA | #0/#0 | 3.641 | 16.46 | 3.644 | 3.637 | 17.12 | 15.07 | ☐ | ☐ |
| 017 | Offline | 880.2 | 0 | 0 | 36.7 | 100 | 0 EA | 0 EA | 0 EA | 0 EA | 1 EA | #0/#0 | 3.642 | 16.37 | 3.646 | 3.637 | 16.9 | 15.33 | ☐ | ☐ |
| 018 | Offline | 880.2 | 0 | 0 | 36.7 | 100 | 0 EA | 0 EA | 0 EA | 0 EA | 1 EA | #0/#0 | 3.642 | 15.79 | 3.644 | 3.638 | 16.17 | 15.17 | ☐ | ☐ |
| 019 | Offline | 878.2 | 0 | 0 | 36.7 | 100 | 0 EA | 0 EA | 0 EA | 0 EA | 1 EA | #0/#0 | 3.642 | 15.37 | 3.645 | 3.637 | 15.69 | 15.12 | ☐ | ☐ |
| 020 | Offline | 878.1 | 0 | 0 | 36.7 | 100 | 0 EA | 0 EA | 0 EA | 0 EA | 1 EA | #0/#0 | 3.642 | 15.35 | 3.645 | 3.635 | 15.64 | 15 | ☐ | ☐ |

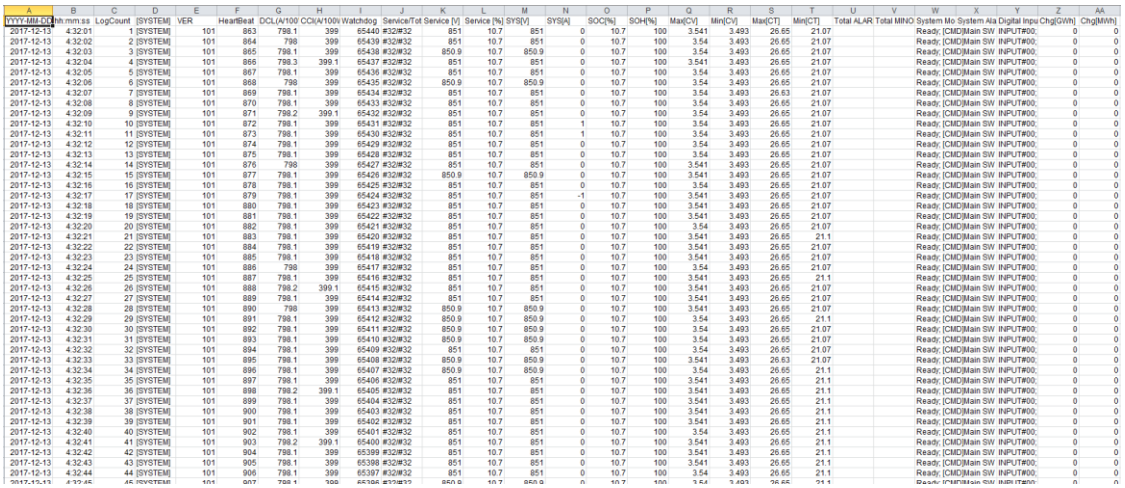
Reserved Reserved

Reserved Reserved

Reserved Reserved

CONNECTION LOG_CELL LOGGING

### [ELP_MON Log Example]



| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | AA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YYYY-MM-DD | hh:mm:ss | LogCount | [SYSTEM] | VER | HeartBeat | DCL(A/100 | CCI(A/100W | Watchdog | Service/Tot | Service [V] | Service [%] | SYS[V] | SYS[A] | SOC[%] | SOH[%] | Max[CV] | Min[CV] | Max[CT] | Min[CT] | Total ALAR | Total MINO | System Mo | System Ala | Digital Inpu | Chg[GWh] | Chg[MWh] |
| 2017-12-13 | 4:32:01 | 1 | [SYSTEM] | 101 | 863 | 798.1 | 399 | 65440 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:02 | 2 | [SYSTEM] | 101 | 864 | 798 | 399 | 65439 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:03 | 3 | [SYSTEM] | 101 | 865 | 798.1 | 399 | 65438 | #32/#32 | 850.9 | 10.7 | 850.9 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:04 | 4 | [SYSTEM] | 101 | 866 | 798.3 | 399.1 | 65437 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:05 | 5 | [SYSTEM] | 101 | 867 | 798.1 | 399 | 65436 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:06 | 6 | [SYSTEM] | 101 | 868 | 798 | 399 | 65435 | #32/#32 | 850.9 | 10.7 | 850.9 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:07 | 7 | [SYSTEM] | 101 | 869 | 798.1 | 399 | 65434 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.63 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:08 | 8 | [SYSTEM] | 101 | 870 | 798.1 | 399 | 65433 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:09 | 9 | [SYSTEM] | 101 | 871 | 798.2 | 399.1 | 65432 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:10 | 10 | [SYSTEM] | 101 | 872 | 798.1 | 399 | 65431 | #32/#32 | 851 | 10.7 | 851 | 1 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:11 | 11 | [SYSTEM] | 101 | 873 | 798.1 | 399 | 65430 | #32/#32 | 851 | 10.7 | 851 | 1 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:12 | 12 | [SYSTEM] | 101 | 874 | 798.1 | 399 | 65429 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:13 | 13 | [SYSTEM] | 101 | 875 | 798.1 | 399 | 65428 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:14 | 14 | [SYSTEM] | 101 | 876 | 798 | 399 | 65427 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:15 | 15 | [SYSTEM] | 101 | 877 | 798.1 | 399 | 65426 | #32/#32 | 850.9 | 10.7 | 850.9 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:16 | 16 | [SYSTEM] | 101 | 878 | 798.1 | 399 | 65425 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:17 | 17 | [SYSTEM] | 101 | 879 | 798.1 | 399 | 65424 | #32/#32 | 851 | 10.7 | 851 | -1 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:18 | 18 | [SYSTEM] | 101 | 880 | 798.1 | 399 | 65423 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:19 | 19 | [SYSTEM] | 101 | 881 | 798.1 | 399 | 65422 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:20 | 20 | [SYSTEM] | 101 | 882 | 798.1 | 399 | 65421 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:21 | 21 | [SYSTEM] | 101 | 883 | 798.1 | 399 | 65420 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:22 | 22 | [SYSTEM] | 101 | 884 | 798.1 | 399 | 65419 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:23 | 23 | [SYSTEM] | 101 | 885 | 798.1 | 399 | 65418 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:24 | 24 | [SYSTEM] | 101 | 886 | 798 | 399 | 65417 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:25 | 25 | [SYSTEM] | 101 | 887 | 798.1 | 399 | 65416 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:26 | 26 | [SYSTEM] | 101 | 888 | 798.2 | 399.1 | 65415 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:27 | 27 | [SYSTEM] | 101 | 889 | 798.1 | 399 | 65414 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:28 | 28 | [SYSTEM] | 101 | 890 | 798 | 399 | 65413 | #32/#32 | 850.9 | 10.7 | 850.9 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:29 | 29 | [SYSTEM] | 101 | 891 | 798.1 | 399 | 65412 | #32/#32 | 850.9 | 10.7 | 850.9 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:30 | 30 | [SYSTEM] | 101 | 892 | 798.1 | 399 | 65411 | #32/#32 | 850.9 | 10.7 | 850.9 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:31 | 31 | [SYSTEM] | 101 | 893 | 798.1 | 399 | 65410 | #32/#32 | 850.9 | 10.7 | 850.9 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:32 | 32 | [SYSTEM] | 101 | 894 | 798.1 | 399 | 65409 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:33 | 33 | [SYSTEM] | 101 | 895 | 798.1 | 399 | 65408 | #32/#32 | 850.9 | 10.7 | 850.9 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.63 | 21.07 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:34 | 34 | [SYSTEM] | 101 | 896 | 798.1 | 399 | 65407 | #32/#32 | 850.9 | 10.7 | 850.9 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:35 | 35 | [SYSTEM] | 101 | 897 | 798.1 | 399 | 65406 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:36 | 36 | [SYSTEM] | 101 | 898 | 798.2 | 399.1 | 65405 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:37 | 37 | [SYSTEM] | 101 | 899 | 798.1 | 399 | 65404 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:38 | 38 | [SYSTEM] | 101 | 900 | 798.1 | 399 | 65403 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:39 | 39 | [SYSTEM] | 101 | 901 | 798.1 | 399 | 65402 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:40 | 40 | [SYSTEM] | 101 | 902 | 798.1 | 399 | 65401 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:41 | 41 | [SYSTEM] | 101 | 903 | 798.2 | 399.1 | 65400 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:42 | 42 | [SYSTEM] | 101 | 904 | 798.1 | 399 | 65399 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:43 | 43 | [SYSTEM] | 101 | 905 | 798.1 | 399 | 65398 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.541 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |
| 2017-12-13 | 4:32:44 | 44 | [SYSTEM] | 101 | 906 | 798.1 | 399 | 65397 | #32/#32 | 851 | 10.7 | 851 | 0 | 10.7 | 100 | 3.54 | 3.493 | 26.65 | 21.1 | | | Ready; [CMD] | Main SW | INPUT#00; | 0 | 0 |

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# 4. Communication protocol

All of the battery status and operating information will be passed to PCS through MODBUS TCP/IP protocol which is provided separate protocol document. In this chapter, the detail description of each data will be described. For more detail information, please refer the protocol document.

## 4.1 System information

| Address (Hex) | Data | Description |
|---|---|---|
| 0001 | System Voltage | Average of rack voltage (not included in protected racks)<br>It can be changed to display Median, Min or Max voltage by setting of system BMS |
| 0002 | System Current | Total amount of current of racks |
| 0003 | System SOC | Average SOC value of operating racks<br>If one racks reach to SOC 0% or SOC 100%, the displayed value will be changed to 0% or 100% instead of average SOC |
| 0004 | System SOH | Minimum value of each rack's SOH (not included protected racks) |
| 0005 | System Mode | Bit 15 Charge mode : The battery is charging<br>Bit 14 Discharge mode : The battery is discharging<br>Bit 13 Main SW ON : PCS send SW ON command<br>Bit 12 Main SW OFF : PCS send SW OFF command<br>See more detail in Modbus protocol |
| 0006 | Max Cell Voltage | Maximum cell voltage among all cells in system.<br>(Include protection racks) |
| 0007 | Min Cell Voltage | Minimum cell voltage among all cells in system.<br>(Include protection racks) |
| 0008 | Max Cell Temp | Maximum cell temperature among all cells in system.<br>(Include protection racks) |
| 0009 | Min Cell Temp | Minimum cell temperature among all cells in system.<br>(Include protection racks) |
| 000E<br>~<br>0015 | Protection & Alarm summary | See more detail in Chapter 6 |
| 0016 | DCHG Current limit | The recommended discharge current limit for the Rack.<br>The PCS control the discharge current not exceed this number x available number of Rack |
| 0017 | CHG Current limit | The recommended charge current limit for the Rack.<br>The PCS control the charge current not exceed this number x available number of Rack |
| 0018 | Watchdog response | It responds by inverting the watchdog query |
| 0019 | System heart bit | It increases by 1 every one second using the internal timer. |
| 001A | Connecting Status | MSB: Number of Racks in Service.(Online)<br>LSB: Total Rack Count. |
| 001B | Service voltage | The average rack voltage of available racks(DC Contactors closed) |
| 001C | Service SOC | The average state of charge(SOC) of available racks |
| 001F<br>~<br>0024 | Amount of charge & discharge current | Total accumulated charge & discharge energy (Optional) |

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## 4.2 Rack information

| Address (Hex) | Data | Description |
|---|---|---|
| 0028 | Rack voltage | Rack voltage detected value |
| 002D | Rack current (Real) | Real time sensing current value |
| 0030 | Rack current (AVG) | Average current value of 3sec |
| 0031 | Rack mode | Decimal Value 0 : None<br>Decimal Value 1 : Initialize - During booting sequence<br>Decimal Value 2 : Offline - DC Switch Off<br>Decimal Value 3 : Online - DC Switch On |
| 0032 | SOC | State of Charge of the Rack |
| 0033 | SOH | State of Health of the Rack |
| 0038<br>~<br>003F | Alarm & Protection | Alarm & Protection, refer chapter 6 |
| 0040<br>~<br>0051 | Min, Max, AVG Cell Temp & Voltage with positioning | Min, Max and AVG Cell voltage and temperature information |
| 0052 | DCHG Current limit | Recommended discharge current limit of the Rack |
| 053 | CHG Current limit | Recommended charge current limit of the Rack |
| 0054 | Rack Switch control info | Bit 0 : Rack Grid switch ON command |
| 0055 | Rack Switch sensor info | Bit 0 : DC Switch feedback (+)<br>Bit 1 : DC Switch feedback (-) |
| 0056 | Rack External sensor info | Bit 0 : Rack Fuse Normal |
| 0057 | Comm fault position | Module ID which doesn't communicate with Rack BMS |

## 4.3 Writing command

| Address (Hex) | Data | Description |
|---|---|---|
| 0000 | Switch control | 0xABCD : A( - ), B(-), C(-), D(Grid On)<br>Value : 0x5(On), 0x3(Off), Others(No Function)<br>0x0003: All rack's switch OFF<br>0x0005: All rack's switch ON<br>Others : No Function |
| 0001 | Reset | 0xABCD : A( - ), B( - ), C(Protection), D(-)<br>Value : 0x5(Reset), Others(No Function)<br>0x0050: All rack's protection reset<br>Others: No Function |
| 0002 | Watchdog Query | When this value is requested, the value which is inverted in "Watchdog Response" is written. |

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# 5. Maintenance activities

In order to operating battery system safely and reliably, the performing of periodic maintenance activities is recommended as below. The listed items and interval can be negotiable.

## 5.1 Daily inspection

| | | Operation | Tool |
|---|---|---|---|
| Environment | Temp | Measure ambient temperature with dedicated temperature sensor<br><br>1. The nearest battery Rack from HVAC Top / Bottom<br>2. The farmost battery Rack from HVAC Top / Bottom<br><br>[Criteria]<br>Temperature shall be within the range 23±5degC<br>Uniformity shall be less than 5degC | Self-logged temperature & humidity sensor is recommended |
| | Humidity | Measure humidity inside of battery room.<br><br>[Criteria]<br>Less than 80% RH and non-condensing. | |
| Battery log | | Check the battery log per day and check whether there is any abnormality or faulty had occurred.<br>Refer Chapter 3.7<br><br>[Criteria]<br>No alarm nor protection<br>△SOC, SOH < 5 % | EMS |
| SOC calibration | | Store the battery system more than 20min with active standby mode. | PCS |

## 5.2 Monthly inspection

| | | Operation | Tool |
|---|---|---|---|
| Environment | Temp | Check the 1 month average temperature trend<br><br>[Criteria]<br>AVG Temperature shall be less than 23degC<br>Uniformity shall be less than 5degC | Self-logged temperature & humidity sensor is recommended |
| | Humidity | Check the 1 month average humidity trend<br><br>[Criteria]<br>Not higher than 80% RH for the period | |
| Visual inspection | | Check whether any wire distortions or changed color<br>Check whether metallic parts rusty<br>Check whether smell like chemicals<br><br>[Criteria]<br>No distortion, rusty nor chemical smells | Human |
| SOC calibration | | Discharge the battery system to pass SOC60%, SOC40% or SOC8% (One of them) | PCS |

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## 5.3 Annual inspection

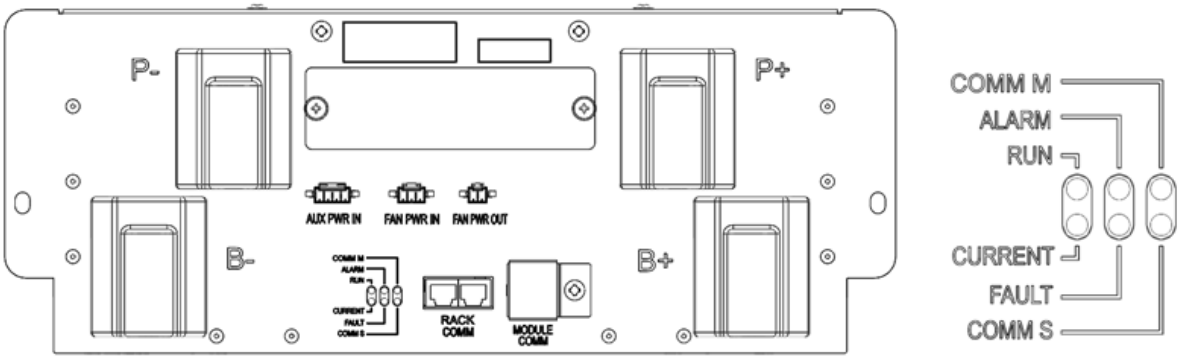
| | | Operation | Tool |
|---|---|---|---|
| Environment | Temp | Check the 1 year temperature trend.<br>Calibration of temperature sensor<br><br>[Criteria]<br>AVG Temperature shall be less than 23degC<br>Uniformity shall be less than 5degC | Self-logged temperature & humidity sensor is recommended |
| | Humidity | Check the 1 year humidity trend<br>Calibration of humidity sensor<br><br>[Criteria]<br>Not higher than 80% RH for the period | |
| Battery log | | Check the 1 year battery log information.<br>Share information to SDI to check cycle degradation | EMS |
| Battery room inspection | | Check the HVAC, Fire sensor, FFS operation<br>Visual check of battery system<br>- No distortion of wire nor rusty in metallic housing<br>- No loose of power connection<br>- No chemical smells in battery room | - |
| Capacity measurement | | Capacity measurement and SOH update cycle in accordance with chapter 3.6 | PCS |
| Battery functionality | | **DC contactor operation check :**<br>- Send turn ON/OFF command to S-BMS under no load circumstance and check whether operating correctly<br><br>**24 Aux Accuracy**<br>- Measure the 24V SMPS output with DMM.<br>- 24V±5%<br><br>**Insulation Resistance**<br>- Measure the insulating resistance between Battery(+) and GND, Battery(-) and GND in BCP with DC1000V for 60seconds<br>- All racks DC contactor shall be turned ON<br>- The resistance shall be higher than 100Mohm<br><br>**CMV measurement**<br>- Check the CMV in accordance with chapter 3.2 | |

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# 6. Troubleshooting

The each switchgear assembly equips 6 LED lamps to indicate the status of battery system.

**[Front face of switchgear assembly]**

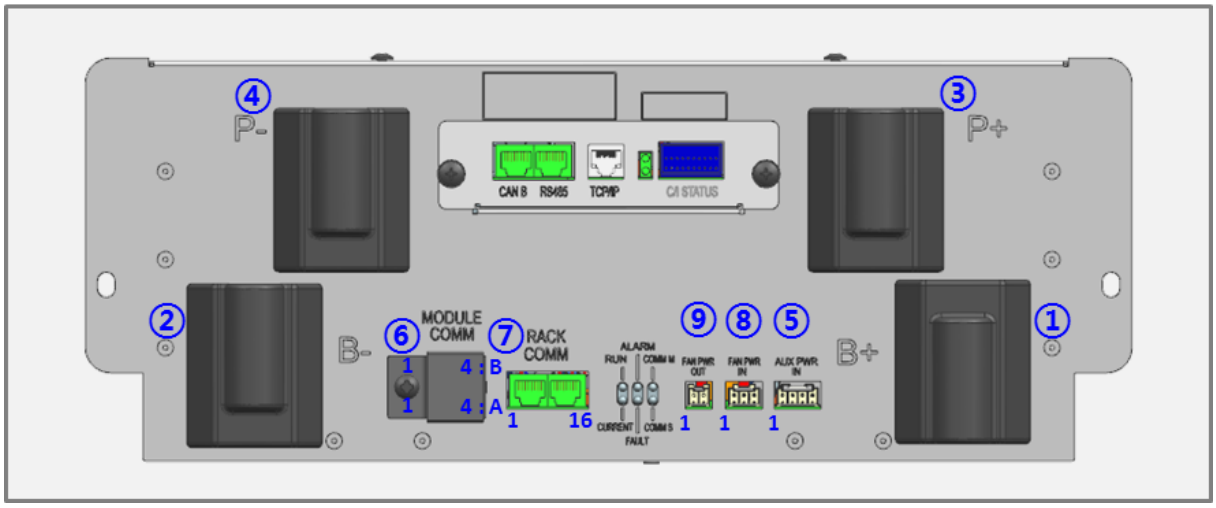



**[Description of LED operation]**

| LED | Operation | Description | Comment |
|---|---|---|---|
| RUN (Green) | LED ON<br><br>LED Twinkle | Rack in Ready Status(DC contactor open)<br><br>Rack Closed DC contactor to Charge or Discharge | Normal state |
| Current (Green) | LED Twinkle | Rack detected charge or discharge current | Normal state |
| Alarm (Yellow) | LED Twinkle | Rack detected Alarm signal | Caution state |
| Fault (Red) | LED Twinkle | Rack detected Trip signal<br>→ When either one or more racks become tripped, with a red light on, you can re-operate this rack (or racks) only after clearing such trip through an applicable computer program.<br><br>Whenever any trip happens on a rack (or racks), you need to command "reset" first to re-operate the rack (or racks) that is (are) tripped. Here, such "reset" of the rack (or racks) will only be achieved when it reaches (or they reach) the release level in a Protection mode.<br><br>Note that such trip will not be cleared even after reset of the applied rack (or racks) if this "release condition" is not achieved. | Abnormal state<br>- System stop |
| Comm. M (Yellow) | LED Twinkle | Rack Communication signal<br>→ Module to Switchgear Communication status display. | Normal state |
| Comm. S (Yellow) | LED Twinkle | Rack Communication signal<br>→ Switchgear to System BMS Communication status display. | Normal state |

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**[Switchgear Pin description]**




| | Function | Pin No | Description | Comment |
|---|---|---|---|---|
| ① | Battery Plus | NA | Connected to the highest module + | E2, M2f : AWG#4 (25sq) M8 screw<br>P3 : AWG#1/0 (50sq) M8 screw |
| ② | Battery Minus | NA | Connected to the lowest module - | |
| ③ | Grid Plus | NA | Connected to PCS + | |
| ④ | Grid Minus | NA | Connected to PCS - | |
| ⑤ | Aux Power IN (DF63-4EP-3.96C) | 1 | 24V Aux power in GND | Cable for BMS power supplying<br>Excluded in SDI supply scope<br>(DF63-4S-3.96C, Hirose)<br>UL3688 AWG#16 cable |
| | | 2 | 24V Aux power in (+) | |
| | | 3 | - | |
| | | 4 | - | |
| ⑥ | Module communication (S08B-J21DK-GGXR) | 1A | - | Included in SDI supplied scope<br>(J21DF-08V-KX-L, JST) |
| | | 1B | UART_RXLP | |
| | | 2A | - | |
| | | 2B | UART_RXLN | |
| | | 3A | - | |
| | | 3B | URT_TXLP | |
| | | 4A | - | |
| | | 4B | UART_TXLN | |
| ⑦ | Rack Communication (IM25G-008-256) | 1,9 | CAN High | Included in SDI supply scope<br>General RJ45 plug can be used |
| | | 2,10 | CAN Low | |
| | | 3,11 | CAN_CAN | |
| ⑧ | FAN Power IN (DF63-3EP-3.96C) | 1 | FAN Power IN (+) | Cable for FAN power supplying.<br>Excluded in SDI supply scope<br>(DF63-3S-3.96C, Hirose)<br>UL3688 AWG#16 cable |
| | | 2 | FAN Power IN (-) | |
| | | 3 | - | |
| ⑨ | FAN Power OUT (DF63-2EP-3.96C) | 1 | FAN Power out (+) | Included in SDI supply scope<br>(DF63-2S-3.96C, Hirose)<br>UL3688 AWG#16 cable |
| | | 2 | FAN Power out (-) | |

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## 6.1 Alarm/Fault word define

The system BMS set the alarm/Fault bit when one of the alarm/Fault bits among racks is set.

| Address | Bit | Name | Description |
|---|---|---|---|
| 0x0015 Alarm#1 | 15 | permanent UV | Permanent Under Voltage Fail. |
| | 14 | rack fuse fail | Rack Fuse Fail. |
| | 13 | rack I sensing fail | Rack Current Sensor Fail. |
| | 12 | rack V sensing diff | Rack Voltage Sensing Difference. |
| | 11 | rack OV | Rack Over Voltage. |
| | 10 | rack UV | Rack Under Voltage. |
| | 9 | rack DCHG OCP | Rack Discharge Over Current. |
| | 8 | rack CHG OCP | Rack Charge Over Current. |
| | 7 | R-S comm fail | Rack <-> System Communication Fail. |
| | 6 | R-M comm fail | Rack <-> Module Communication Fail. |
| | 5 | module T-imb | Cell Temperature Imbalance. |
| | 4 | module V-imb | Cell Voltage Imbalance. |
| | 3 | module OV | Cell Over Voltage. |
| | 2 | module UV | Cell Under Voltage. |
| | 1 | module OT | Cell Over Temperature. |
| | 0 | module UT | Cell Under Temperature. |
| 0x0013 Alarm#3 | 15 | DCHG Operation limit | Cell Discharge Operation Limit. |
| | 14 | CHG Operation limit | Cell Charge Operation Limit. |
| | 13 | additional protection fail | NA |
| | 12 | fan fail | Fan Operation Fail. |
| | 11 | dcsw2_fail | Rack's DC Switch#2(-) Fail. |
| | 10 | dcsw1_fail | Rack's DC Switch#1(+) Fail. |
| | 9 | dcsw2_sensing_fail | Rack's DC Switch#2(-) Sensing Fail. |
| | 8 | dcsw1_sensing_fail | Rack's DC Switch#1(+) Sensing Fail. |
| 0x0012 Alarm#4 | 2 | DC SW count fail | Rack's DC Switch count fail. |
| | 1 | module PCB OT | M-BMS Over Temp |
| | 0 | module PCB UT | M-BMS Under Temp |

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## 6.2 Protection map

| No | Item | | Caterogy | | | Description | Protection Criteria | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | P.Fail | Fault | Alarm | | E2 | M2 | P3 |
| 1 | Cell | OVP | | O | O | Individual Cell voltage is higher than pre-define condition | 4.23 | 4.23 | 4.2 |
| 2 | | UVP | | O | O | Individual Cell voltage is lower than pre-define condition | 2.5 | 2.5 | 2.5 |
| 3 | | OTP | | O | O | Cell temperature is higher than pre-define condition | 65 | 65 | 65 |
| 4 | | UTP | | | O | Cell temperature is lower than pre-define condition | -21 | -21 | -21 |
| 5 | Voltage | OVP | O | O | O | Rack voltage protection (Higher than pre-defined condition) | 4.23 * Series | 4.23 * Series | 4.20 * Series |
| 6 | | UVP | O | O | O | Rack voltage protection (Lower than pre-defined condition) | 2.50 * Series | 2.50 * Series | 2.50 * Series |
| 7 | Over Current | Charge | O | O | O | Overload current protection. Charge direction | 90A | 130A | 187A |
| 8 | | Discharge | O | O | O | Overload current protection, Discharge direction | 130A | 165A | 285A |
| 9 | Sensing Error | Voltage | | | O | Measured voltage ≠ Sum of Cell voltage | 77V | 77V | 77V |
| 10 | | Current | | | O | No communication between MCU and Current sensor | 3s | 3s | 3s |
| 11 | Imbalance | Voltage | | | O | Max Cell V - Min Cell V ≥ 300mV | 300mV | 300mV | 300mV |
| 12 | | Temp | | | O | Max Cell T - Min Cell T ≥ 20degC | 20degC | 20degC | 20degC |
| 13 | DC Contactor | Sensor | | O | | DC Contactor Sensor information ≠ Contactor command | Not equal | Not equal | Not equal |
| 14 | | Contactor | | O | | Contactor OFF but still current flowing. | ≥ 600mA | ≥ 600mA | ≥ 600mA |
| 15 | Comm | Rack - Module | | O | O | No communication between Rack BMS and Module BMS | 30s | 30s | 30s |
| 16 | | Rack - System | | O | O | No communication between Rack BMS and System BMS | 30s | 30s | 30s |
| 17 | Auxiliary | Current limit | | | O | Charge (or discharge) current is higher than current limit value | ≥ Limit | ≥ Limit | ≥ Limit |
| 18 | | Fan fault | | | O | FAN does not operating properly | NA | FAN Fault ON | FAN Fault ON |
| 19 | | PCB OTP | | O | | PCB temperature is higher than pre-defined value | 80 | 80 | 80 |
| 20 | | PCB UTP | | O | | PCB temperature is lower than pre-defined value | -21 | -21 | -21 |

## 6.3 Check item related with fault message

### 6.3.1 Cell under voltage

| Expected failure | Description | Required Parts |
|---|---|---|
| Over discharge the module | Check the Min/Max voltage through Log data.<br>1. UV happened at End of discharge period<br>→ Cell balancing<br>2. Deep discharge even under operation level :<br>→ Modify PCS operation scheme. | DMM<br>M-BMS<br>Wire harness |
| Mis-reading of voltage | Open the cover then<br>1. Measure the individual cell voltage using DMM<br>→ Replace the module<br>2. Check wire harness connection status<br>→ Replace wire harness<br>3. Check connection point between wire harness and M-BMS<br>4. Fault in M-BMS<br>→ Replace M-BMS | |

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### 6.3.2 Cell Over voltage

| Expected failure | Description | Required Parts |
|---|---|---|
| Over charge the module | Check the Min/Max voltage through Log data.<br>1. OV happened at End of charge period<br>→ Cell balancing<br>2. Over charge even above operation level :<br>→ Modify PCS operation scheme. | DMM<br>M-BMS<br>Wire harness |
| Mis-reading of voltage | Open the cover then<br>1. Measure the individual cell voltage using DMM<br>→ Replace the module<br>2. Check wire harness connection status<br>→ Replace wire harness<br>3. Check connection point between wire harness and M-BMS<br>4. Fault in M-BMS<br>→ Replace M-BMS | |

### 6.3.3 Cell Under Temperature

| Expected failure | Description | Required Parts |
|---|---|---|
| Real temperature is too low | Check the Min/Max temperature through Log data.<br>1. Check the ambient temperature is in a normal range | DMM<br>M-BMS<br>Wire harness |
| Mis-reading of temperature | Open the cover then<br>1. Measure the individual thermistor resistance using DMM<br>→ 10Kohm at 25degC is normal<br>2. Check wire harness connection status<br>→ Replace wire harness<br>3. Check connection point between wire harness and M-BMS<br>4. Fault in M-BMS<br>→ Replace M-BMS | |

### 6.3.4 Cell Over Temperature

| Expected failure | Description | Required Parts |
|---|---|---|
| Real temperature is too High | Check the Min/Max temperature through Log data.<br>1. Check the ambient temperature is in a normal range<br>2. Check whether the operating C-rate is higher than guide<br>3. Check FAN operation is normal or not | DMM<br>M-BMS<br>Wire harness<br>FAN |
| Mis-reading of temperature | Open the cover then<br>1. Measure the individual thermistor resistance using DMM<br>→ 10Kohm at 25degC is normal<br>2. Check wire harness connection status<br>→ Replace wire harness<br>3. Check connection point between wire harness and M-BMS<br>4. Fault in M-BMS<br>→ Replace M-BMS | |

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### 6.3.5 Comm Fault (Module & Rack)

| Expected failure | Description | Required Parts |
|---|---|---|
| Analysis of Log | Check whether fault happened temporary or continuously. | DMM<br>M-BMS<br>Oscilloscope<br>Rack BMS<br>Communication cable |
| Temporary failure | 1. Temporary fault (sometimes good and sometimes bad)<br>- Check the noise level in communication line<br>- Check the cable connection (Pull out and pull in again) | |
| Permanent failure | 1. Permanent failure (no communication at all)<br>- Check the setting values in Rack BMS (module count)<br>- Check the cable connection<br>- Check the cable conduction test using DMM<br>- Replace Rack BMS and Module BMS one by one | |

### 6.3.6 Comm Fault (System & Rack)

| Expected failure | Description | Required Parts |
|---|---|---|
| Analysis of Log | Check whether fault happened temporary or continuously.<br>Check whether all racks cannot be communicated or one of Rack cannot be communicated | DMM<br>System BMS<br>Oscilloscope<br>Rack BMS<br>Communication cable |
| Temporary failure & All racks cannot communicate | - Check the noise level in communication line<br>- Check the cable connection (Pull out and pull in again)<br>- Check the cable connection of Rack BMS to System BMS<br>- Check the terminal resistor<br>- Check 24V Power supply is normal | |
| Temporary failure & one of racks cannot communicate | - Check the noise level in communication line<br>- Check the cable connection (Pull out and pull in again)<br>- Check the terminal resistor<br>- Check 24V Power supply is normal<br>- Check the CAN ID of each Racks | |
| Permanent failure & All racks cannot communicate | - Check the noise level in communication line<br>- Check the cable connection (Pull out and pull in again)<br>- Check the cable connection of Rack BMS to System BMS<br>- Check the terminal resistor<br>- Check 24V Power supply is normal<br>- Check System BMS setting : Rack count<br>- Check Rack BMS CAN ID<br>- Swap the System BMS | |
| Permanent failure & one of racks cannot communicate | - Check the noise level in communication line<br>- Check the cable connection (Pull out and pull in again)<br>- Check the terminal resistor<br>- Check 24V Power supply is normal<br>- Check System BMS setting : Rack count<br>- Check Rack BMS CAN ID<br>- Swap the Rack BMS | |

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### 6.3.7 Charge Over current protection

| Expected failure | Description | Required Parts |
|---|---|---|
| Analysis of Log | Check the log file<br>1. Check whether the large amount of charge current beyond the limitation has been applied<br>→ Modify PCS operation scheme.<br>2. Check whether the battery racks connected into the grid with different voltage range<br>→ Modify PCS operation scheme. Set of partial operation | DMM<br>Rack BMS<br>Shunt Resistor<br>Cable harness |
| Rack BMS | - Check whether the CAL value is normal<br>- Check the FW Checksum and EEPROM Checksum<br>- Check any component damages on Rack BMS<br>→ Change the Rack BMS | |
| Switchgear inside | - Shunt resistance 0.05mΩ ± 5%<br>- Check the cable connection of shunt resistance | |

### 6.3.8 Discharge Over current protection

| Expected failure | Description | Required Parts |
|---|---|---|
| Analysis of Log | Check the log file<br>1. Check whether the large amount of charge current beyond the limitation has been applied<br>→ Modify PCS operation scheme.<br>2. Check whether the battery racks connected into the grid with different voltage range<br>→ Modify PCS operation scheme. Set of partial operation | DMM<br>Rack BMS<br>Shunt Resistor<br>Cable harness |
| Rack BMS | - Check whether the CAL value is normal<br>- Check the FW Checksum and EEPROM Checksum<br>- Check any component damages on Rack BMS<br>→ Change the Rack BMS | |
| Switchgear inside | - Shunt resistance 0.05mΩ ± 5%<br>- Check the cable connection of shunt resistance | |

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### 6.3.9 Rack under voltage

| Expected failure | Description | Required Parts |
|---|---|---|
| Over discharge the Rack | Check the Min/Max cell voltage through Log data.<br>1. UV happened at End of discharge period<br>→ Cell balancing is required<br>2. Deep discharge even under operation level :<br>→ Modify PCS operation scheme. Voltage cutoff<br>3. Module has different voltage level<br>→ Check individual cell voltage using DMM | DMM<br>R-BMS<br>Wire harness |
| Mis-reading of voltage | 1. Compare measured rack voltage with actual Rack voltage<br>→ If the difference is too big, Replace the Rack BMS<br>2. Check the Fuse status<br>→ If open, replace a fuse<br>3. Check the connection status of power cable<br>4. Check any damages on Rack BMS<br>→ Replace R-BMS<br>5. Check the FW Checksum and EEPROM Checksum | |

### 6.3.10 Rack Over voltage

| Expected failure | Description | Required Parts |
|---|---|---|
| Over charge the Rack | Check the Min/Max cell voltage through Log data.<br>1. OV happened at End of charge period<br>→ Cell balancing is required<br>2. Over charge even beyond the operation level :<br>→ Modify PCS operation scheme. Voltage cutoff<br>3. Module has different voltage level<br>→ Check individual cell voltage using DMM | DMM<br>R-BMS<br>Wire harness |
| Mis-reading of voltage | 1. Compare measured rack voltage with actual Rack voltage<br>→ If the difference is too big, Replace the Rack BMS<br>2. Check the connection status of power cable<br>3. Check any damages on Rack BMS<br>→ Replace R-BMS<br>4. Check the FW Checksum and EEPROM Checksum | |

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### 6.3.11 Rack Fuse Fail

| Expected failure | Description | Required Parts |
|---|---|---|
| Check the log | 1. Check the log file whether there are inrush current existing<br>2. Check whether partial operation is set or not<br>→ If not, set partial operation | DMM<br>R-BMS<br>Fuse<br>Micro switch<br>Wire harness |
| Check the fuse | 1. Check the fuse connectivity using DMM<br>→ If disconnected, replace the Fuse<br>2. Check R-BMS and cable connection<br>→ Check any damages on Rack BMS<br>3. Check the operation of micro switch | |

### 6.3.12 Sensing voltage difference

Check the battery system following chapter 6.3.10 mis-reading of voltage

### 6.3.13 Voltage imbalance

Check the battery system following chapter 6.3.1 and 6.3.2

### 6.3.14 Temperature imbalance

Check the battery system following chapter 6.3.3 and 6.3.4

### 6.3.15 Current sensing error

| Expected failure | Description | Required Parts |
|---|---|---|
| Check the Rack BMS | Replace the Rack BMS | R-BMS |

### 6.3.16 Current limit error

| Expected failure | Description | Required Parts |
|---|---|---|
| Analysis of log | Check the current was over the operation limit<br>→ Change the PCS scheme. Not over the limit | R-BMS |
| Rack BMS | Check the FW and EEPROM checksum<br>Check any damages on Rack BMS component | |

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### 6.3.17 FAN Fault

| Expected failure | Description | Required Parts |
|---|---|---|
| SMPS | Check the 24V Aux power supply normally. 24V±5%<br>Check the capacity of SMPS is enough (15.6W/EA) | R-BMS<br>M-BMS<br>FAN power cable<br>FAN |
| FAN and Connection | Check the wire connection<br>Check the FAN → Replace the FAN | |
| BMS | Check any damages on Rack BMS component<br>Check the damages on Module BMS component | |

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# Appendix 1 BMS Setting manual

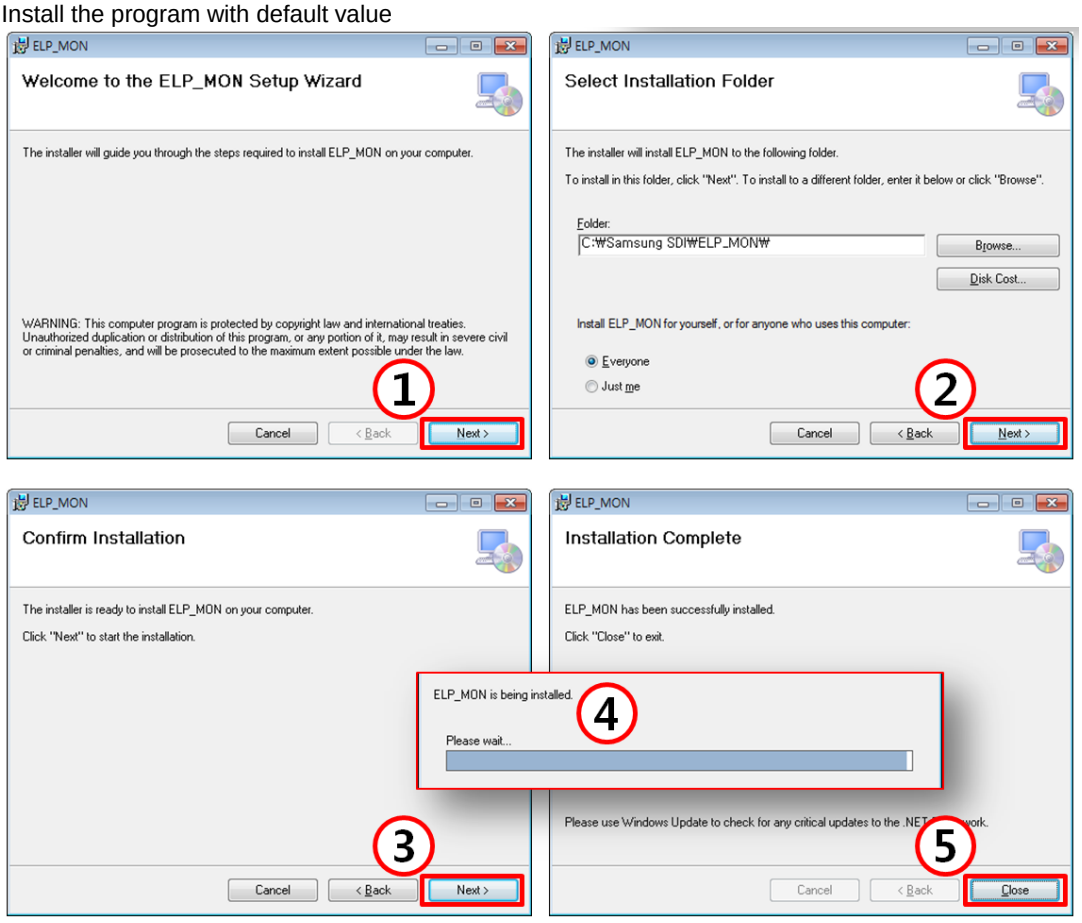
Installation of program

### 1. Preparation

- In case installed previous version of ELP_MON, it should be removed before installation
- Higher version of Microsoft. NET Framework 4.5 is required : Install with default value
- Higher version of VCI V3 Driver 3.5.4 is required (V4 cannot be supported) : Install with default value
  https://www.ixxat.com/docs/librariesprovider8/default-document-library/downloads/vci-v3/vci_3_5_4_4543.exe?sfvrsn=10 or www.ixxat.com

### 2. Program installation

- Unzip “ELP_MON_XXXX” program which is provided by Samsung SDI and execute SETUP.EXE
- Install the program with default value

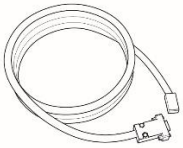
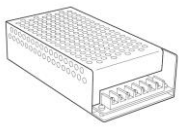
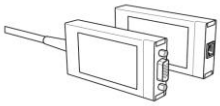
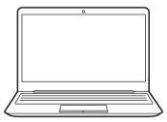



- After finishing installation, ELP_MON icon is placed in desktop windows

### 3. List of required tool

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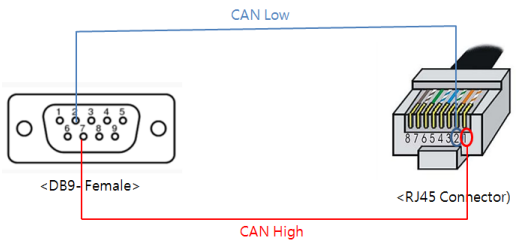
- The tools described in this table are not included in supply scope.

| No | Item | Picture | Description |
|---|---|---|---|
| 1 | **Power Supply cable to SG**<br>(Connector: Can be connected to the SMPS terminal) |  | SG Power Supply –Connector<br>(DF63-4S-3.96C, Hirose) |
| 2 | **ID Writer Cable**<br>Connecting between Rack BMS and IXXAT<br>(must be made by customer as described below) |  | RJ45 (8 pin) and D-SUB female (9 pin) |
| 3 | **24Vdc SMPS (Power Supply)**<br>(must be sourced by customer) |  | Output 24Vdc, 150W, 6.3A(max currnet) |
| 4 | **IXXAT**<br>(must be sourced by customer) |  | USB-to-CAN V2 (IXXAT) |
| 5 | **Notebook PC**<br>English Language Window 7 recommended<br>(must be sourced by customer) |  | Service pack: SP1<br>Minimum hardware requirements<br>• 1 GHz of faster 32-bit processor<br>• 1 GB RAM (32-bit) or 2 GB RAM (64-bit)<br>▪ 16 GB available hard disk (32-bit) or 20 GB (64-bit) |

* Preparing of ID Writer cable
  - 120ohm termination resister shall be inserted between #2 and #7 pins of D-sub connector
  - Pin description

| Connector A | Pin No. | Connector B | Pin No. | Remarks |
|---|---|---|---|---|
| D-SUB (Female) | 2 | RJ45 | 2 | CAN Low |
| | 7 | | 1 | CAN High |

- Connection scheme

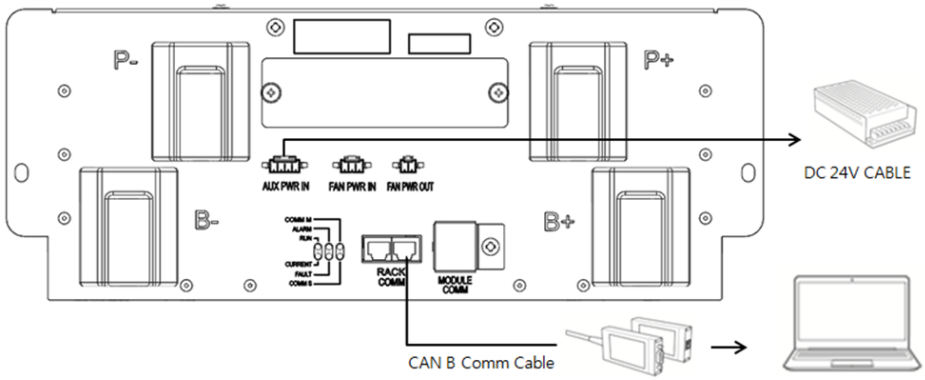



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## Setting of Rack BMS

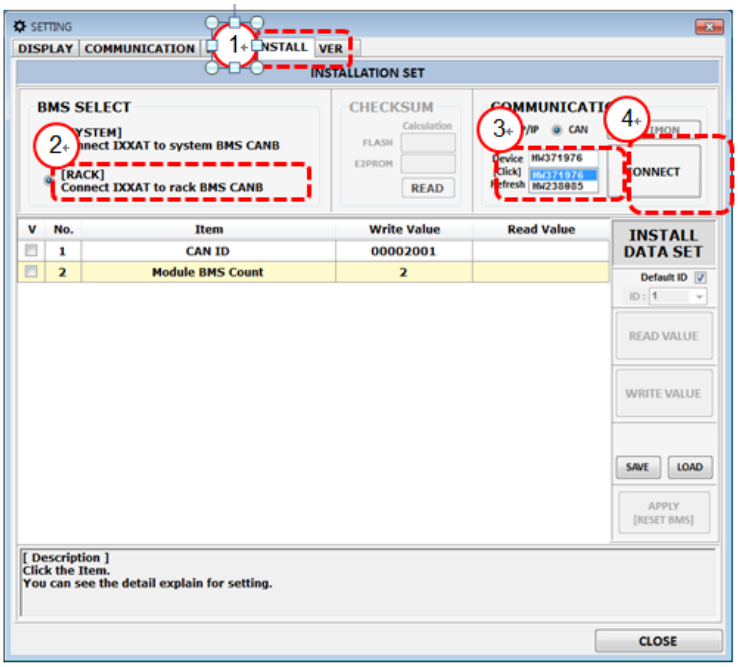
### Cable connection between Rack BMS and ELP_MON

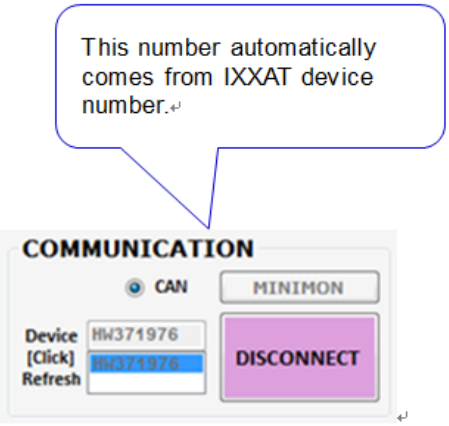
- Supply 24V external power to “Aux PWR IN” in Rack BMS using #1 and #3 in Table 3.1
- Connect “Rack COMM” port and laptop using “ID Write Cable” listed in Table 3.1
- Connection scheme




### Rack BMS Setting

- Execute “ELP_MON” icon in the desktop menu
- Select “INSTALL” tab and setting like below picture



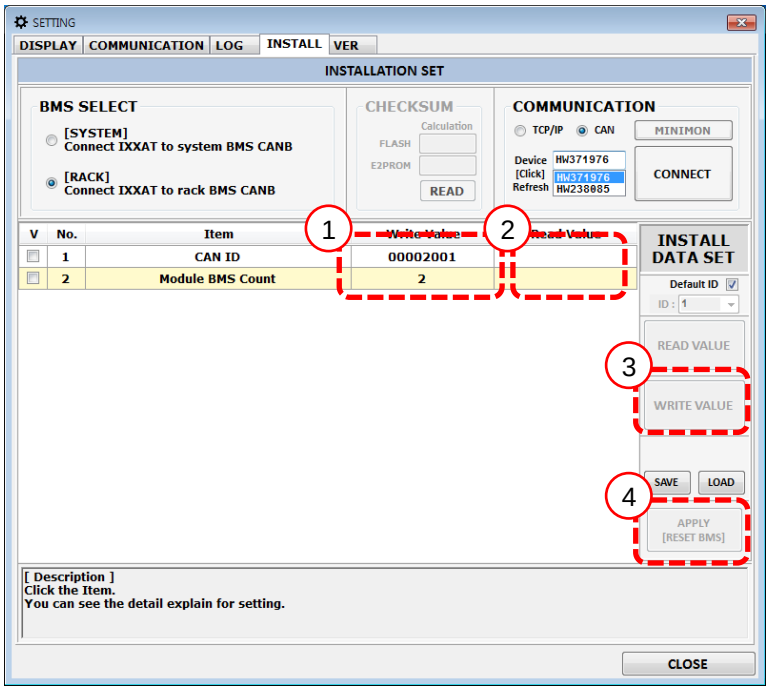

- Select CAN ID and Module BMS count
- Input CAN ID (0x00002001 ~ ) Module BMS Count (2~24)
- Module BMS Count : It is depending on configuration (# of modules)

| Configuration (# of module) | Module BMS Count |
|---|---|
| 198S (9 modules) | 18 |

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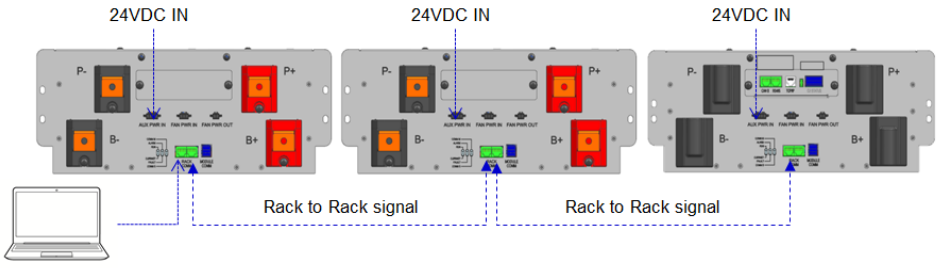
| | |
|---|---|
| 220S (10 modules) | 20 |
| 242S (11 modules) | 22 |
| 264S (12 modules) | 24 |

- Click the Write Value then ELP_MON write the value to Rack BMS and automatically read the value again.
- If the read value is right, Click “APPLY [RESET BMS]”
- Repeat this procedure for every rack one by one. Please be sure that all rack should have an identical RACK ID.



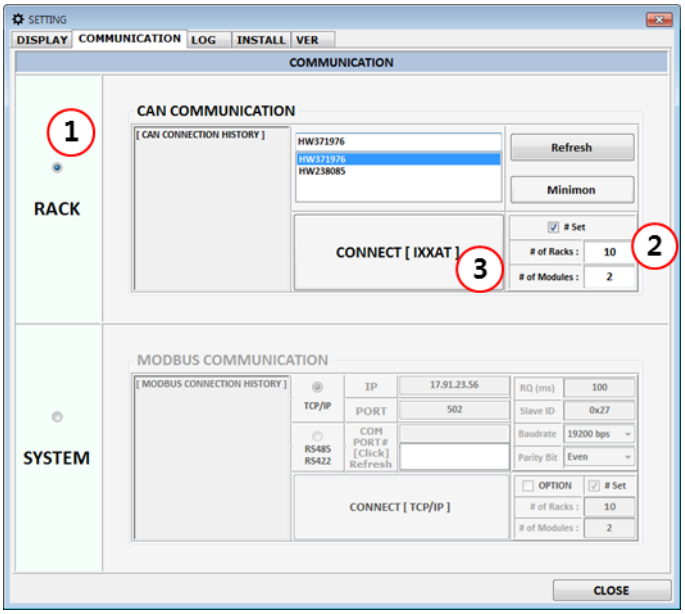

**Communication check after Rack setting**

- After installation completed (and before connecting P(+) and P(-) to the grid) the initial check for battery operation is required
- Connection scheme :

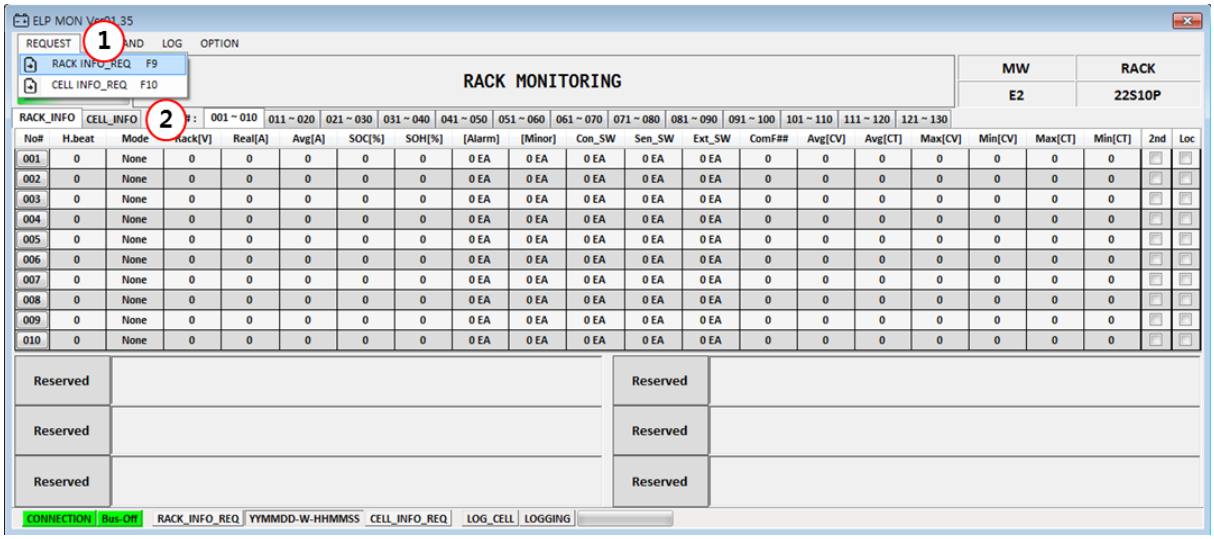



- Execute ELP_MON after supplying 24V to Rack BMS
- Select communication tab in the setting window
- Set the # of Racks(Number of Racks), # of Modules(Number of modules connected to the Rack BMS)
- Select Connect

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- Select REQUEST tab and click RACK_INFO_REQ then Rack BMS data appears in each rows.
- Check all Racks information is displayed in each rows and whether if the AVG Cell V and Temp is in abnormalities.

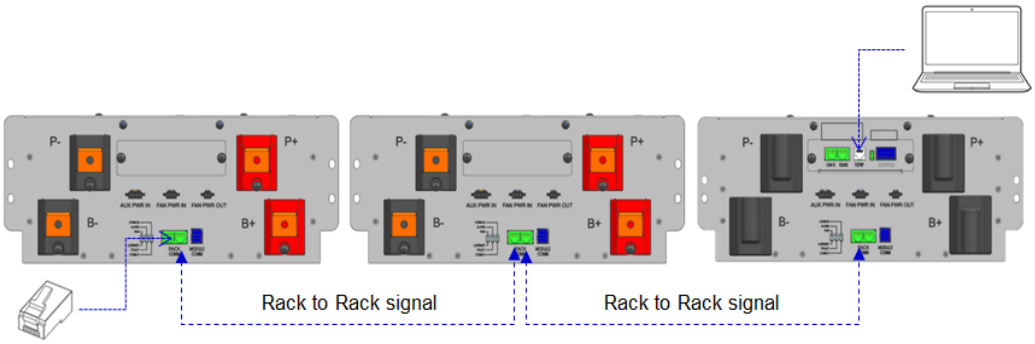



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## Setting of System BMS

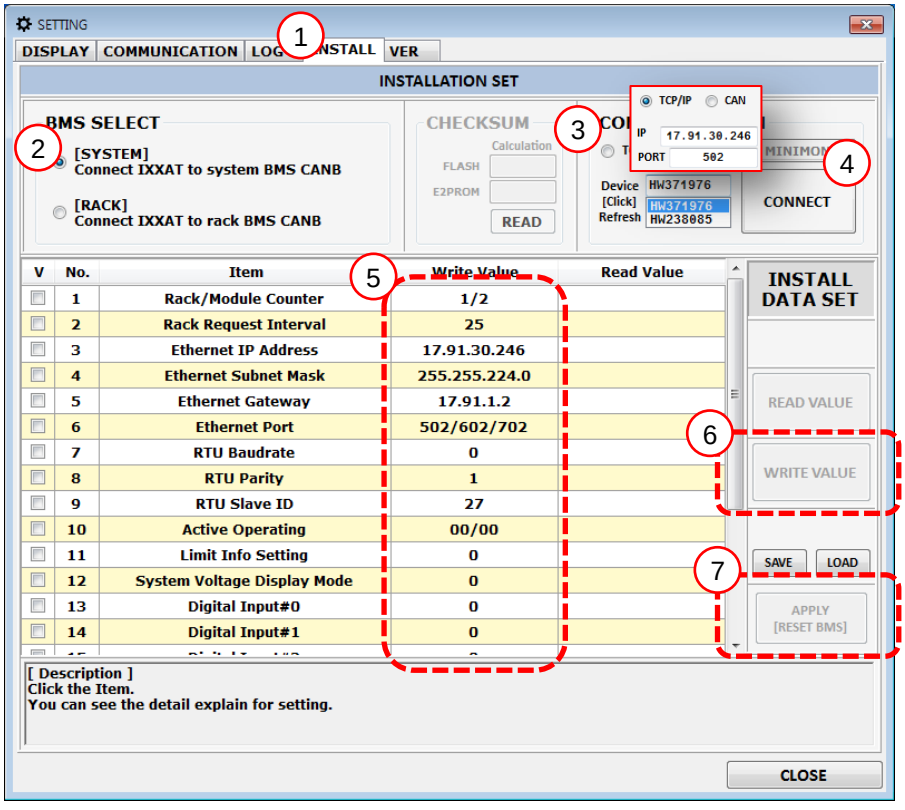
### Cable connection between System BMS and ELP_MON

- Supply 24V external power to each Rack BMS
- Connect “TCP/IP” port in system BMS and laptop using “ID Write Cable” listed in Table 3.1
- Connection scheme




### System BMS Setting

- Execute “ELP_MON” icon in the desktop menu
- Select “INSTALL” tab and select System then check TCP/IP in Communication. Finally select connect
- Input proper value and push write value and check whether the read value is right. After that




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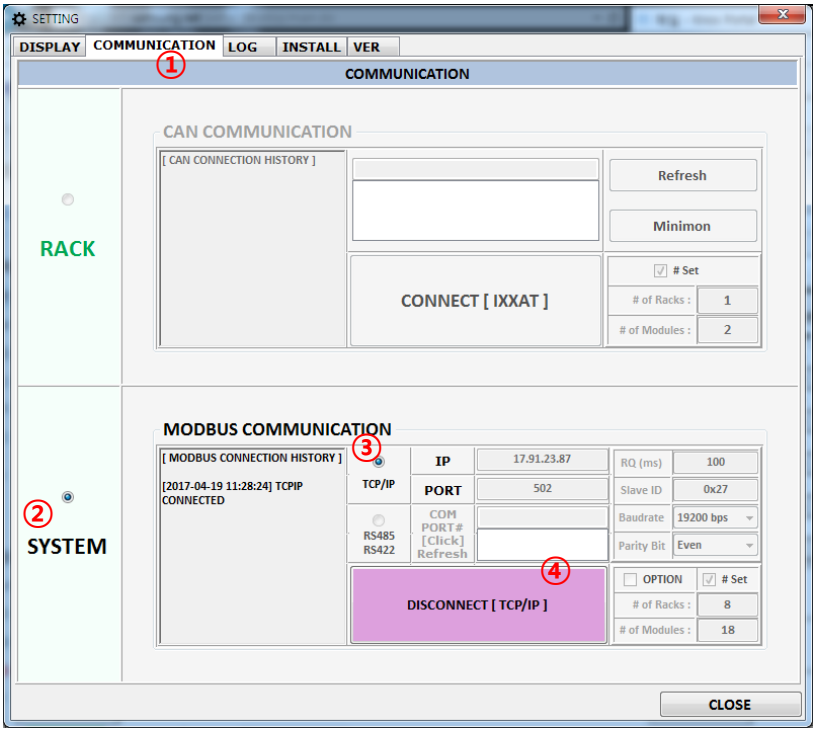
push Apply.

- Reference setting of EEPROM in accordance with 198S8P configuration

| No | Item | Setting | Description |
|---|---|---|---|
| 1 | Rack /Module counter | 08/18 | |
| 2 | Rack Request interval | 25 | |
| 3 | Ethernet IP address | | Depending on EMS setting |
| 4 | Ethernet subnet mask | | Depending on EMS setting |
| 5 | Ethernet gateway | | Depending on EMS setting |
| 6 | Ethernet port | 502/602/702 | |
| 7 | RTU Baud rate | NA | |
| 8 | RTU Parity | NA | |
| 9 | RTU Slave ID | NA | |
| 10 | Active Operating | 04/10 | Partial operating. |
| 11 | Limit info setting | 0 | Charge & discharge limit will show in 0.1KW unit |
| 12 | System V display mode | 0 | Averaged voltage information will be displayed |
| 13~22 | Digital input | NA | |

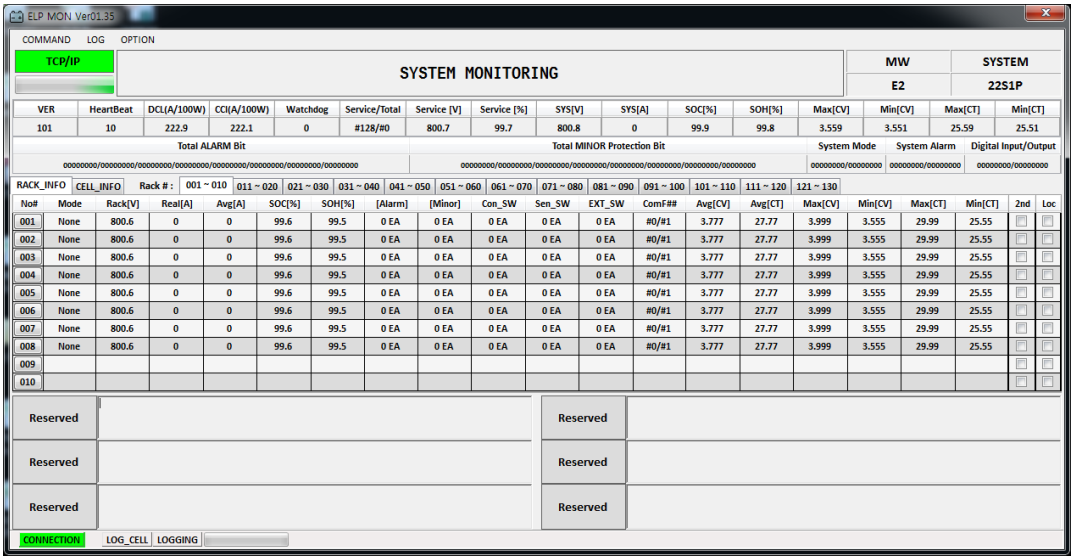
**Communication check after System installation**

- Select Communication – system – TCP/IP - Connect




- Check whether all rack information are displayed and any abnormalities are existed or not.

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- After checking data's upload in "ELP_MON", check data below:

| Item | Content |
|---|---|
| Rack SOC | Check SOC of each Rack |
| Rack Voltage | Check Voltage of each Rack |
| Module Cell Voltage, Temperature | Check module Cell Voltage and Temperature |
| Switchgear(DC, Charge-off SW, Fuse) Status | Check Contract point of Switch and Fuse |
| Flag Status | Check status of Trip & Alarm |

- If data are not uploaded in ELP_MON or any problem occurs, check the connection condition of 24V aux power and communication cable.

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