Ampd Enertainer

User Manual

AMPD
ENERGY

Ampd Enertainer

User Manual

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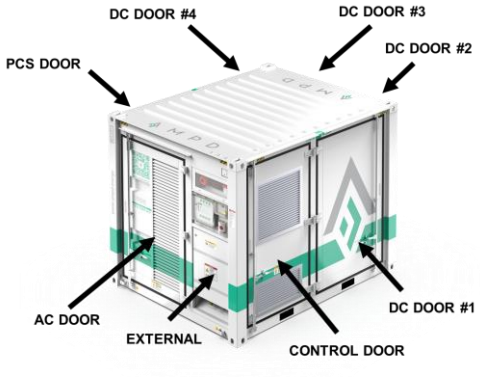
1. Overview

The Ampd Enertainer is an advanced energy storage system that provides diesel free power for the next generation of construction projects. It is using state-of-the-art lithium-ion technology to provide clean and efficient electrical energy to the heavy equipment, which would ordinarily be powered by a diesel generator. This document includes a full overview of the system as well as specifications for each subsystem.

The Enertainer is a 10 ft container that is divided into two sections, called the AC section and the DC section. There are seven available doors around the container that access these sections. Each door is marked with a label on the outside. The AC section is accessed through the control door, AC door, and PCS door. The DC section is accessed through DC door #1, #2, #3 and #4.



1.1 AC Section

The AC section is fitted with electronic controllers that communicate together to optimize the overall operation of the Enertainer. The main purpose is to control the charge and discharge of the batteries, based on conditions such as voltage, frequency, battery status, temperature, and many more parameters. They are also used for detecting and responding to abnormal conditions by producing warnings and faults. All communication signals feed to and from different controllers that manage the whole system.

The subsystems include:

- External human machine interface (xHMI)
- Uninterruptible power supply (UPS)
- System-level battery management system (system BMS)
- Energy management system (EMS)
- Charger
- Power conversion system (PCS)
- Exhaust fans

- Heater

1.1.1 xHMI

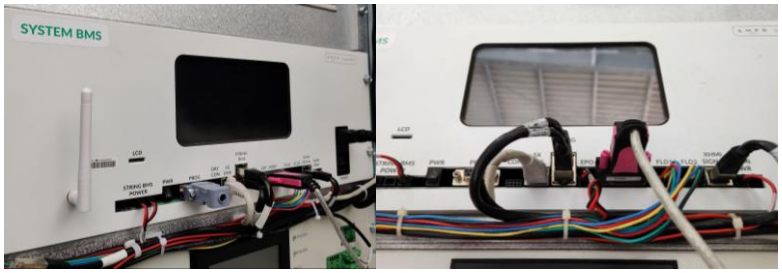
The xHMI is the external-facing panel that displays the real-time status of the Enertainer. It collects and displays all information regarding the system, input, battery, and output. The status of each of these elements are represented by four LED lights at the top of the panel, which would light up green or red depending on the situation. The left-hand side key switch is able to activate the AC output power. Switching it between on and off will only control the AC output power and will not have any impact on other functions of the Enertainer.

1.1.2 UPS

The UPS is the internal power supply module that provides single phase power to all the power electronics inside. It is rated for 1 kVA and has its own backup battery source, which can support up to 4 hours of runtime. The UPS gives power to the critical controllers to ensure that they stay online and operational.

1.1.3 System BMS

The system BMS is the main centralized controller that sends and receives the top-level commands. It represents the most important controller in the system. It is responsible for initializing the DC Bus, sending the command to the charger to charge, and sending the command to the PCS to discharge. The system BMS has the ability to energize and de-energize the DC Bus based on the battery module and battery string data. If there is any error or fault in the battery system, the DC Bus cannot be energized and the system circuit will stop.



1.1.4 EMS

The EMS manages and monitors the PCS and charger operations. It has the ability to remotely edit and save settings into the PCS and the charger without needing to interface with them physically. The EMS platform, called “EMS-Web” is accessed through the EMS Tablet PC using a specific IP address (192.168.1.100). The data is sent between the EMS and the EMS Tablet PC through an RJ-45 cable. The EMS also contains a 4G router for mobile internet connection and a GPS module for location tracking.

1.1.5 Charger

The charger is made up of two modules connected in parallel, each rated for 40 kW. It is designed to rectify AC input power to DC for the DC Bus. Both modules are designed to operate together, capable of supplying 80 kW to the system.

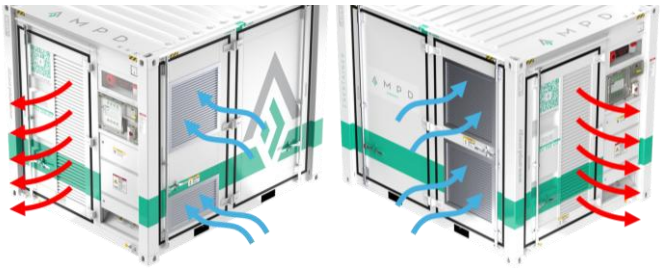
1.1.6 PCS

The PCS is the modular inverter system, each rated for 62.5 kW and firmware controlled to invert DC to AC output power. Multiple PCS modules are connected in parallel to increase the total output power. The parallel architecture allows each of them to connect and disconnect without disrupting the entire PCS circuit. The cabinet runs on 630 ~ 882 VDC power supply from the DC Bus. If the DC Bus is de-energized, the PCS will also turn off.

1.1.7 Exhaust Fans

The Enertainer is equipped with eight fans throughout the AC section. They include five door exhaust fans (attached to the AC door) and three transformer exhaust fans (on top of the output isolation transformer). Each of them is wired and programmed to provide a steady airflow to cool the Enertainer down.

⚠	**CAUTION** Do not cover or block any of the air louvers on the doors, and ensure the air filters are not clogged with heavy dust and dirt.

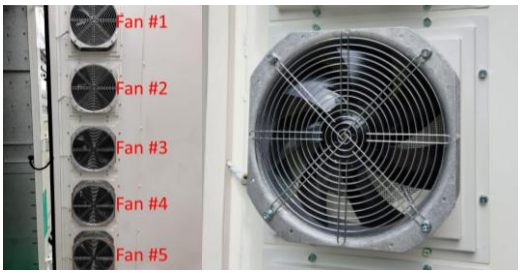


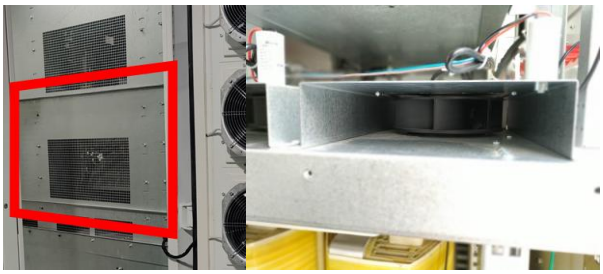
The door exhaust fan logic:

- Fan #1 = When the charger is energized
- Fan #2 = When the PCS loading is > 7%
- Fan #3 = When the PCS loading is > 20%
- Fan #4 = When charging current > 0 A
- Fan #5 = When the PCS loading is > 20%

The transformer exhaust fan logic:

- Fan #1 = When the PCS loading is > 20%
- Fan #2 = When the PCS loading is > 7%
- Fan #3 = When the PCS loading is > 20%





1.1.8 Heater

The AC section has a built-in 1.5 kW heater that is wired to turn on at low temperature conditions. The heater is supplementary to preventing other components from hitting the critical temperature level. The heater temperature relay is pre-set to 5°C. When the ambient temperature of the AC section is less than 5°C, the heater will turn on and run. When the temperature reaches 5°C or above, the heater will turn off.

⚠	**CAUTION** The heater should only be used in low ambient temperature environments. It is not recommended to keep the heater running continuously.

1.2 DC Section

The DC section consists of components that only run on DC electricity. The room is fitted with two sets of battery racks. Each rack has four columns and each column represents one battery string. Each string consists of 15 energy storage modules (ESMs) connected together in series at 630 ~ 862 VDC. Each battery string can provide up to 92 A of DC power. The architecture of the Enertainer allows the circuit to charge and discharge at the same time with no disruption.

The subsystems include:

- String-level battery management system (string BMS)
- Energy storage module (ESM)
- Pack-level battery management system (PBMS)
- Heating, ventilation, air conditioning (HVAC)

1.2.1 String BMS

The string BMS is assembled at the bottom of each column and manages the battery string connection. The string BMS communicates through RJ45 and is powered by 24 VDC power cables. The contactor inside the string BMS is energized by the system BMS. The contactor opens and closes based on the warning and critical alarm setpoints. In the event of an electrical short circuit, the MCCB for that particular string will automatically trip.

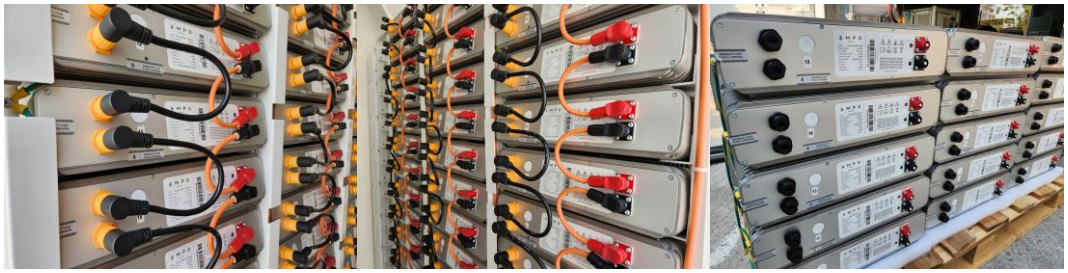
1.2.2 ESM

Each ESM has an ID number. The ID is unique and cannot be a repeated number from an existing ESM. The placement of the ESM follows the below image:

The ESM consists of 14 cylindrical cells connected in series and 16 series in parallel. The ESMs are assembled into the battery rack of the DC section. Each ESM has built-in sensors to measure the operating parameters, and those parameters are logged by the string and system BMS.

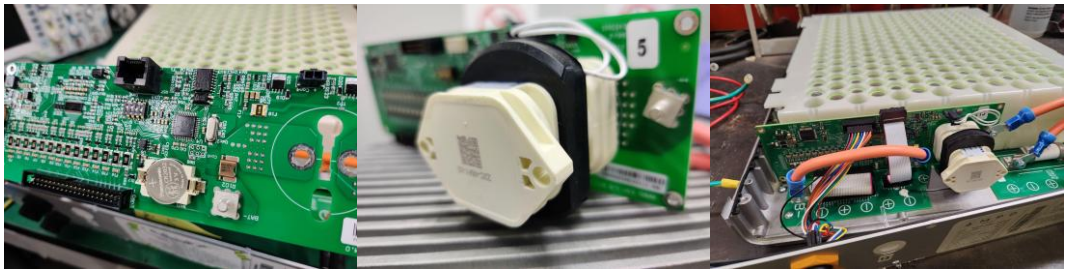
The table below summarizes the basic rating for each ESM.

	Value	Unit
Rated Capacity	44	Ah
Rated Capacity	2.3	kWh
Nominal Voltage	51.8	VDC
Max Voltage	58.8	VDC
Peak Output Current	90	A
Max Input CUrrent	22	A
Chemistry	Li-NCM	
Dimension	435.40 x 383.00 x 95.84	mm
IP Rating	IP54	
Weight	21.2	kg
Operating Temperature	0 - 40	°C



1.2.3 PBMS

Each ESM is assembled with its own pack-level battery management system (PBMS) to monitor and control the charge and discharge of all battery cells within the ESM.



1.2.4 HVAC

Attached to DC door #2 and #3 are two HVAC units, each rated for 3 kW. The HVAC is capable of cooling and heating based on the temperature setpoints for each. The temperature is measured through a built-in sensor within the casing. The power supply to the HVAC units come from the PCS. Therefore, if the PCS output power is de-energized, the HVAC units are also de-energized.

⚠	**CAUTION** Do not cover or block the inlet and outlet air vents on the HVAC units. Ensure that there is sufficient airflow going through the vents while they are running.

The HVAC working modes are:

- Cooling mode - cooling setpoint = 20°C, cooling sensitivity = 3°C
- Heating mode - heating setpoint = 10°C, heating sensitivity = 5°C

2. Safety Guidelines

While the Enertainer is designed to include multiple safety systems and safety protection layers, it is important to follow the proper safe workplace practices around electrical systems.

2.1 Work Environment

When using the Enertainer, ensure the environment is free from any hazards that could potentially cause an accident or injury. The following conditions are mandatory:

- Arrange all external cables neatly to prevent tripping or electrocution.
- Remove any debris that prevents the opening and closing of doors.
- Remove any debris that prevents the flow of air across the air vents.
- Remove any water or sources of water from the area.
- Have a level and secure working area/platform for standing.
- Ensure that the system is structurally stable, balanced, and won't tip/fall over in any direction.
- Ensure adequate lighting for visibility.

2.2 General Electrical Safety

The following practices will reduce risk of electrocution when working on or near the Enertainer:

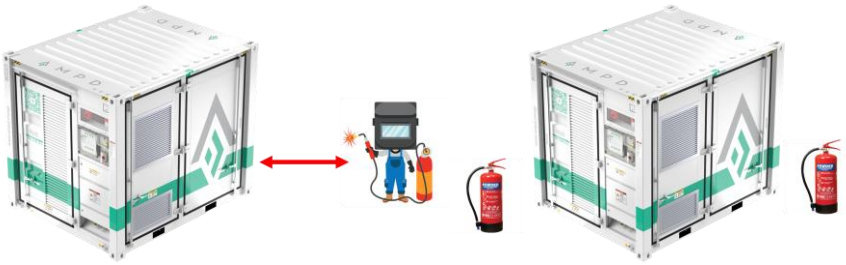
- Guard/lock/isolate all sources of electricity and exposed circuits.
- Protect/repair/replace all frayed or damaged cables.
- Do not work on the system when there are rainy or wet weather conditions.
- Cut off all sources of power (main switch or circuit breaker) if there is any contact with water.
- Avoid wearing jewelry (made of conductive material) when doing any service work.
- Ensure that appropriate PPE (Personal Protective Equipment) is worn for electrical service works.
- Ensure that the system is completely de-energized before proceeding to do any service work.
- All cable connections and terminations must comply with the national or regional electrical standards.

2.3 General Fire Safety

To mitigate and/or prevent fire from occurring in the workplace, the following rules regarding fire safety in the workplace are applicable:

- Smoking around or nearby is prohibited.

- Allocate a 1 m clearance from all sides of the Enertainer exterior.
- Remove all flammable and combustible materials away from the work area.
- Relocate all work relating to high heat or involving ignition away from the area.
- Keep external type ABC or BC fire extinguishers near the system.



2.4 Personal Protective Equipment

PPE must always be worn when doing any maintenance or service work on the Enertainer. The PPE must conform with the local/regional legislation or, in their absence, with international standards to ensure its effectiveness. The following must be worn prior to starting any work:

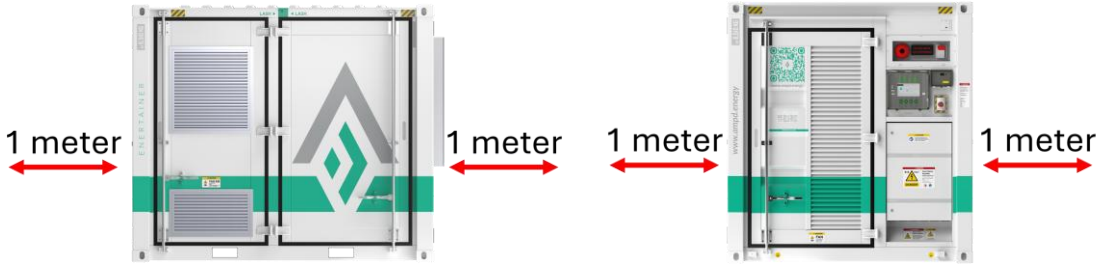
- Safety shoes
- Non-conductive gloves
- Safety glasses

3. Environmental Conditions

The Ampd Enertainer is designed for outdoor industrial applications, however caution must be taken when considering using it in harsh working environments. The Enertainer is suitable for locations where the below guidelines are met:

3.1 Industrial Environments

- Away from extreme dirt and dust clouds.
- Away from sources of heat such as open flames or engine exhausts.
- Away from oil fumes and toxic gasses.
- Away from locations where corrosive, flammable, or explosive materials are produced or stored.
- Away from areas prone to strong vibrations and seismic events.
- Away from areas sensitive to electromagnetic field interferences.
- Away from uneven, unleveled ground where it cannot support the weight of the unit.
- Away from areas where there is less than 1 m of space from surrounding structures or objects.



3.2 Wet Environments

- Away from areas prone to flooding above 20 cm from the ground.
- Away from sources of water or liquid storage.

3.3 High Temperature Environments

- Away from sources of heat such as open flames or engine exhausts.
- Away from areas where it is unventilated or has poor air ventilation.
- Away from areas where the ambient temperature can rise above 55°C (or 40°C under direct sunlight).

3.4 Low Temperature Environments

- Away from areas where the ambient temperature can drop below -10°C.

4. Logistics (Transportation and Storage)

The Enertainer is designed to be mobile, with the intention that it will regularly be transported from one location to another. The environments can vary from construction sites to industrial sites, to even storage warehouses. The following sections describe the standards to upkeep so as to minimize the risk of malfunctioning.

4.1 Preliminary Checks

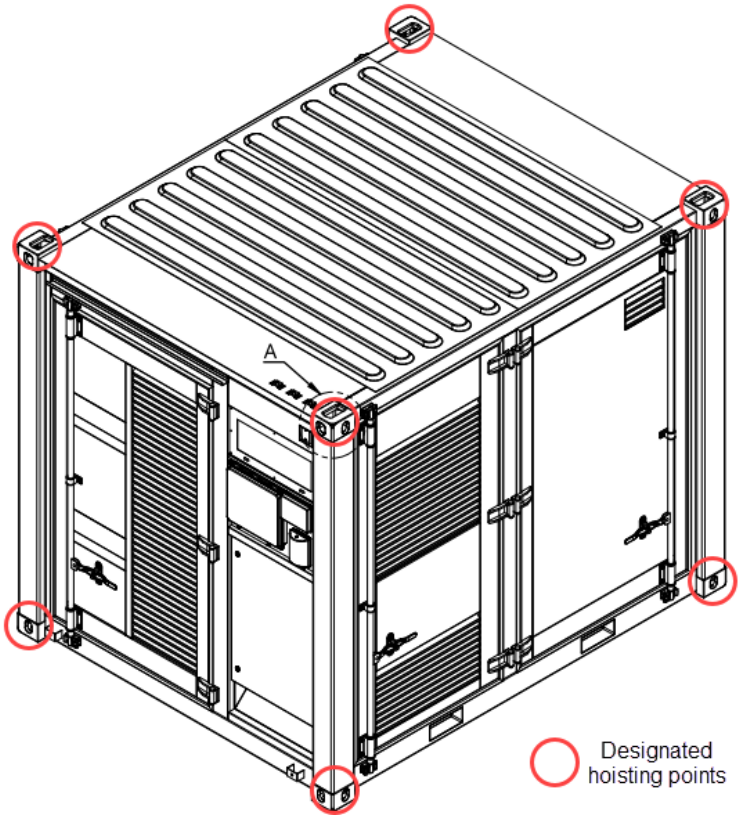
- Shut down all of the main circuits until there is nothing left energized.
- Shut off all of the switches and circuit breakers so that each subsystem is completely isolated.
- Remove all external electrical cables and connections (i.e. input and output cables).
- Close all of the doors, door seals, and outer enclosure boxes.
- Check around the enclosure to ensure there are no gaps or holes.

4.2 Lifting

The corner blocks of the container are made of casting steel of the grade SCW480. Each block can be used as a hoisting point for lifting and moving. Refer to the safe lifting procedures and standards provided by your regional occupational health and safety council.

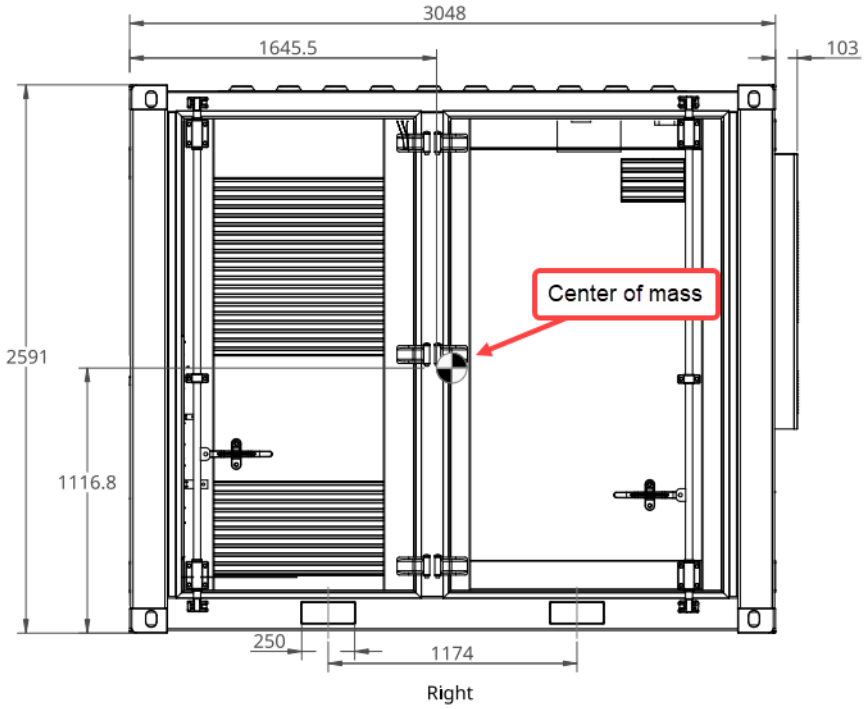
Lifting must be done in accordance with ISO 3874.

- **The lifting crane must be rated to lift at least 9 tonnes or more.**
- **Keep a safe distance of two (2) meters away from the crane, truck, and the container when lifting.**
- **Ensure that the area underneath the object while being lifted is cleared with no person nearby.**
- The object must be kept level and balanced while suspended in the air.
- The object must be moved slowly while being moved.
- The object must sit on a flat and level ground.



4.3 Land Transportation

- **The straps must be fed through the top corner blocks and/or on the designated LASH point.**
- **The object must sit on a stable flat surface, able to support a weight of 9 tonnes or more.**
- The object must be transported on a flatbed truck or a lorry crane.
- The object body must be secured to the vehicle.
- The straps must not be compressed against the HVAC units.



4.4 Storage

- Floor loading can support 11 kN/m².
- Stacking Enertainers must be done on floor loading of 20 kN/m².
- Ambient temperature: 0 ~ 40°C, recommended storage temperature: 20 ~ 30°C.
- Relative humidity: 5 ~ 80%.
- Dry, ventilated and clean.
- Keep all access doors closed and sealed.
- Avoid contact with corrosive organic solvents, gasses and other substances.
- Avoid exposing electrical and electronic components to direct sunlight.

5. Built-In Safety Systems

5.1 Fire Suppression System

The fire suppression system (FSS) is an automated extinguishing system built to detect and suppress fire upon detection of heat and smoke.

The FSS is divided into four main parts:

1. Fire Extinguisher
2. Fire Alarm Control Panel
3. Status Indicator
4. Smoke and Heat Sensors

5.1.1 Fire Extinguisher (Aerosol and FM-200)

There are fire extinguishers installed in the AC and DC section, which will activate together upon signal. These extinguishers are using aerosol technology. The generators consist of packaging filled with a dry solid extinguishing agent, which following activation, is discharged as a dry aerosol. It is effective in extinguishing gas and liquid fires in electrical equipment. There are no toxic substances nor any risk of increased air pressure within the enclosure.

For the Enertainers that are using FM-200 technology, there is an FM-200 gas tank with an automatic valve that will open and discharge the extinguishant evenly between the AC section and DC section. The gas agent, Heptafluoropropane, is a colourless, odourless halocarbon. The agent is non-conductive, therefore after suppression, it leaves no residue and does not damage electrical and electronic equipment.

⚠	**CAUTION** Do not stand near any fire extinguisher before or during the release as the high temperature may result in injury.

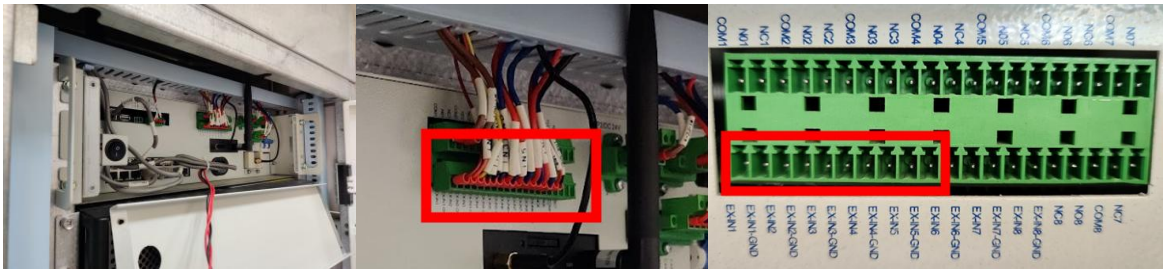
5.1.2 Fire Alarm Control Panel

The fire alarm control panel (FACP) is located behind the control door. Its main operation is to control the series of smoke and heat sensors, fire alarm, and the fire extinguisher triggers. When one of the sensors is triggered, the fire alarm will activate, giving indication of the presence of smoke or heat inside. When multiple sensors are activated together, it will initiate a signal to release the extinguishant.

The FACP sends out dry contact relay signals to the EMS. The relay signals, as registered on the FACP, are separated into three zones.

- Zone 1 - AC section heat sensor or DC section heat sensor
- Zone 2 - AC section PCS heat sensor or AC section EMS heat sensor
- Zone 3 - DC section smoke sensor

The relay signals feed into the EMS IO terminal as five normal-open dry contact inputs. The meaning of each dry contact input will vary depending on the configuration of the EMS firmware (“VIP” setting).



VIP	4.0	5.0	6.0
Country	AE, AU, TW, UK, US	SG	HK
EX-IN1	FSS FACP fault	1st Stage Fire Alarm	FSS FACP fault
EX-IN2	FSS release	2nd Stage Fire Alarm	FSS release
EX-IN3	FSS heat	FACP Fault	FSS heat
EX-IN4	FSS AC heat	AC Smoke Detector Alarm	FSS AC heat
EX-IN5	FSS DC smoke	DC Smoke Detector Alarm	FSS DC smoke

At the front of the Enertainer, there is the status indicator. The status of the FSS can be monitored and the manual release of the extinguishant can be triggered on the outside. This function is given to users in case there are any emergencies that require immediate fire suppression.

⚠	**CAUTION** The manual release button should be pressed if there is a serious risk of fire or smoke inside the Enertainer.

5.1.3 Smoke and Heat Sensors

Smoke and heat sensors are installed on the ceiling of the Enertainer, all feeding signals to the FACP. There are a total of five sensors installed, three heat sensors in the AC section, and one smoke and one heat sensor in the DC section. The names of the sensors and where the signals are wired are as follows:

- AC heat sensor = received as Zone 1
- DC heat sensor = received as Zone 1
- PCS heat sensor = received as Zone 2
- EMS heat sensor = received as Zone 2
- DC smoke sensor = received as Zone 3

To activate the first stage fire alarm (aka single stage fire alarm), trigger either:

- Zone 1 or
- Zone 2 or
- Zone 3

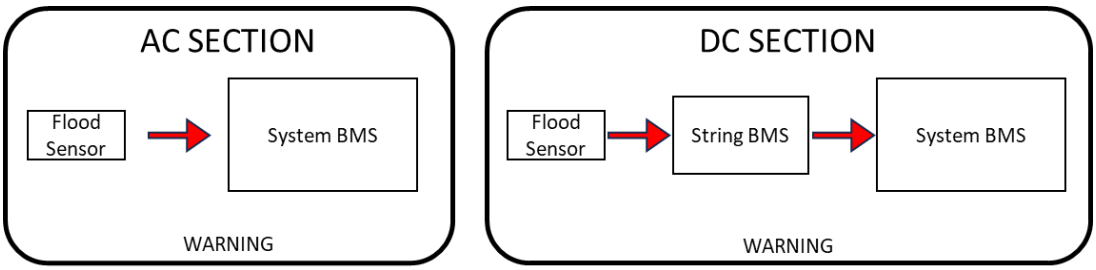
To activate the second stage fire alarm (aka compound stage fire alarm), trigger either:

- Zone 1 + Zone 2 or
- Zone 2 + Zone 3 or
- Zone 1 + Zone 3

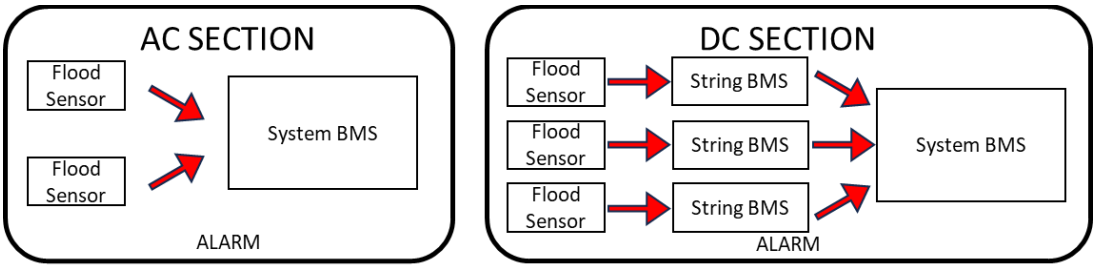
5.2 Flood Sensors

The Enertainer is equipped with six flood sensors distributed among the floor of the container. There are two sensors in the AC section and four sensors in the DC section. The flood sensors use optical level switch technology where it will measure light reflection and refraction at the sensor tip. If there is no liquid, the LED light will reflect. If there is a liquid at the lens, the LED light will refract, thus triggering the warning/alarm signal.

When the photoelectric level switch senses this change, the receiver will send a signal to the system BMS. Once the signal is received by the system BMS, it will immediately activate the flood detection warning.



If there are two sensors triggered in the AC section, it will trigger the flood detection alarm. If there are three sensors triggered in the DC section, it will also trigger the flood detection alarm. When the alarm is activated, it will cause the system to stop temporarily until the system is reset or the alarm is cleared.



5.3 Hydrogen Sensor

In Singapore, the Enertainer is equipped with a gas leak detector installed in the DC section. This sensor is used to detect hydrogen (H_2) concentration in the air in real time. When the concentration is over the alarm-level threshold, the sensor will trigger relays to sound an alarm and flash a strobe light. This hydrogen sensor alarm box will only alert the nearby personnel and will not automatically stop the system.

5.4 Emergency Stop

The Enertainer's emergency stop (power off) button is located on the container exterior. In any emergency situation that involves the need to stop and safely isolate the system, this button should be pressed. This button, when activated, will trigger relays to the system BMS, EMS, charger, and PCS to stop and change to an alarm state.

⚠	**CAUTION** The button should not be used as the standard procedure for powering off the Ampd Enertainer.

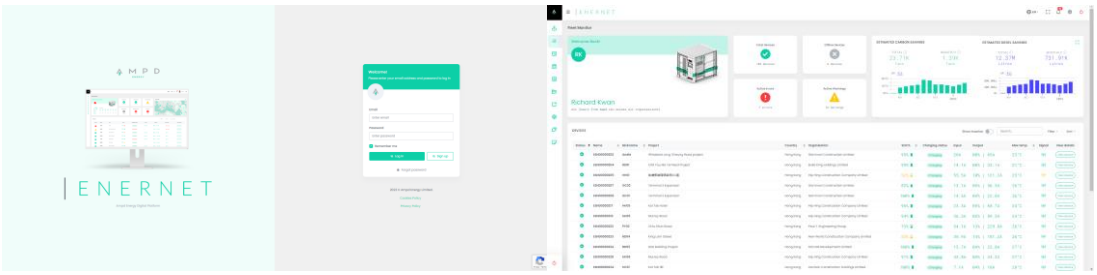
6. Internet Connectivity

The Enertainer is equipped with a 4G router in supporting internet connectivity. It uses a SIM card (with a data plan) to communicate with the carrier's surrounding cell towers to generate a reliable signal. When connected to this network, the Enertainer's internet-connected devices can send and receive data, as well as display a real-time status on a monitoring dashboard.

6.1 Enernet

The Ampd Enernet platform is an all-in-one online portal giving access to end-users to view and observe their device. It is a platform that contains detailed fleet-wide remote monitoring and data analytics. The main pages of Enernet include:

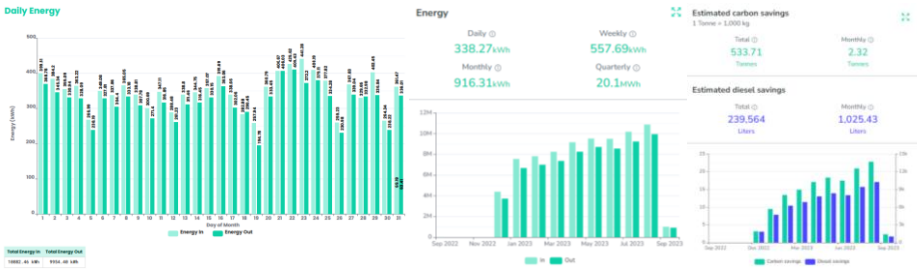
- Fleet Monitor: the list of devices and their critical data values, alarms and warnings, and connectivity.
- Devices: detailed information per device regarding the status, performance, energy usage and history.
- Projects: Location name, address, equipment/load on the project, and devices associated with the project.
- Fleet Map: The pinned location of each device on a map.



Enernet features an estimated carbon footprint reduction and diesel fuel savings analysis. It is able to generate these values on the basis of its usage and application on a construction site. If the usage of the Enertainer is as intended, it will calculate a monthly value of CO_2 reduced as compared to using a similarly sized diesel generator. On top of the calculation, it can output the data into a formal report for record.

The calculation methodology is based on the following assumptions:

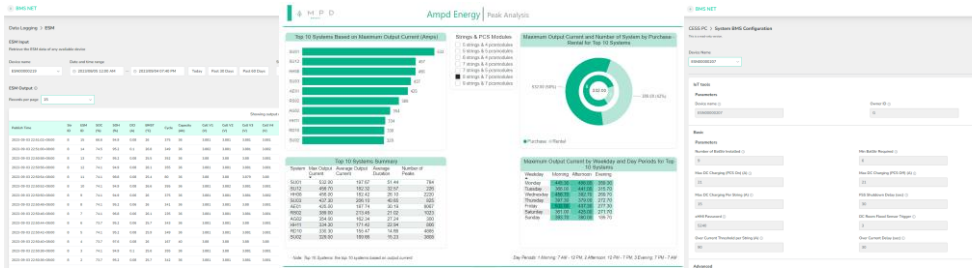
1. The size of the diesel generator replaced by the Enertainer.
2. The volume of diesel fuel burned/consumed by the generator.
3. The CO_2 emission intensity factor by the grid electricity supplier (if recharged by grid).
4. The CO_2 emission intensity factor by the diesel generator (if recharged by generator).



6.2 BMS Net

BMS Net is an internal online portal for technicians, engineers, and service staff, providing precise data for troubleshooting and servicing. The platform is used to monitor the fleet as does Enernet with additional capabilities in capturing the full event log (not just warnings and alarms). The logs are to be used for identifying the historical behaviors of the device that may lead to or give insight to the errors faced (if any).

There are additional features from BMS Net including data logging (reading the raw values), data analysis (trends and performance), and CESS PC (setting configuration).



For those who intend to service the Enertainer, it is recommended to use BMS Net.

7. Electrical Installation

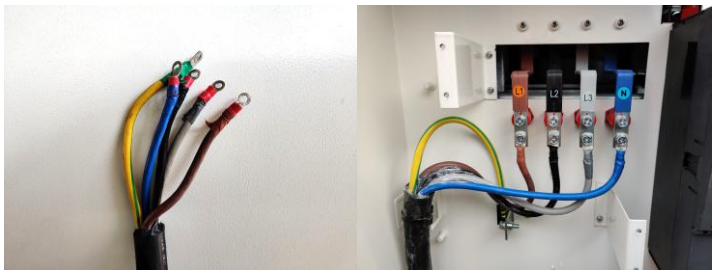
This section provides general guidance on electrical installation on the Enertainer for the customer's qualified electrician(s). It includes the specifications of the cables that the Enertainer uses for supplying power to construction site equipment. The requirements may vary depending on the region and the conditions of each installation site.

Ensure that the Enertainer is turned off completely first before connecting any cables to the input and output busbar terminals.

	**WARNING** The Enertainer should be installed by a qualified technician and electrician in accordance with the information contained in this manual. If any issues arise during installation, contact your Ampd Energy representative for assistance.

7.1 Input Connection Busbars

The input cable, which supplies electrical power to the Enertainer, must be able to supply 90 A at 380 ~ 415 VAC. The input busbars on the Enertainer have M6 bolts and nuts for a secure connection. Ensure that the input cable is compliant with the local electrical regulation requirements. For more details, refer to the table below.



	Color	Bolt Size
L1	Brown	M6
L2	Black	M6
L3	Grey	M6
N	Blue	M6
PE	Yellow/Green	M6

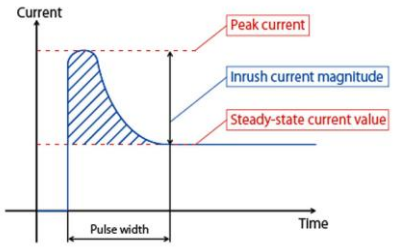
7.2 Output Connection

The Enertainer offers three phase 380 ~ 415 VAC output power to the load. The output cable, which is connected between the Enertainer to the load, must be rated high enough to safely supply the electrical power. The output busbars on the Enertainer have M12 bolts and nuts to secure the connection. Ensure that the output cable is compliant with the local electrical regulation requirements. For more details, refer to the table below.

	Color	Bolt Size
L1	Brown	M12
L2	Black	M12
L3	Grey	M12
N	Blue	M12
PE	Yellow/Green	M12

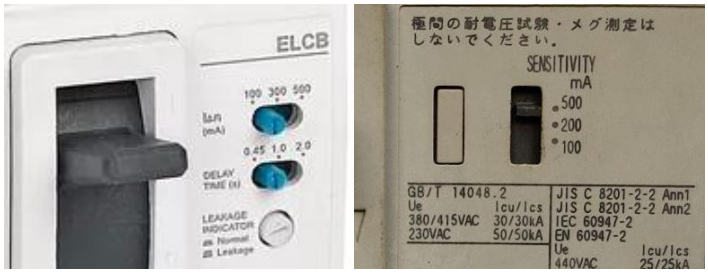
7.3 Inrush Current

When the Enertainer undergoes a cold startup of the system, the internal transformer will produce inrush current (or input surge current). The maximum instantaneous input current drawn by the isolation transformer can be as high as 110 A. When considering the switchgear for the input power supply, it is advised to use a D curve type circuit breaker.



7.4 Leakage Current

During the product operation, there will be some leakage current (300 ~ 400 mA) produced by the Enertainer. When it is charging, the leakage current could flow upstream and trip any earth leakage/residual current circuit breakers (ELCB/RCCB) on-site, thus disrupting the charging. In order to sustain the power supply to the construction site and not be disrupted by the circuit breaker trip, ensure that all upstream leakage current settings are set to 500 mA.



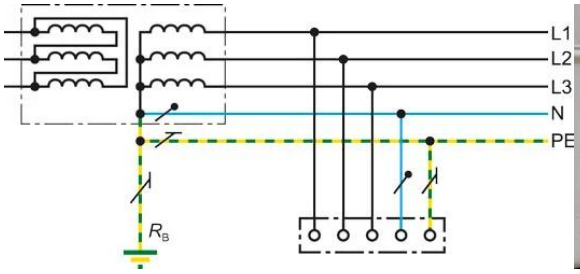
7.5 Earthing/Grounding System

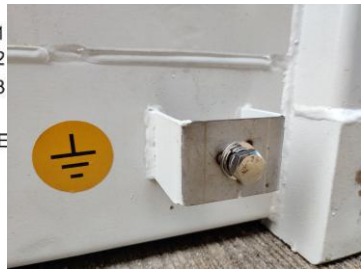
Since electrical installations can introduce the risk of an electric shock by touching any live metal parts, an earthing (i.e. grounding) system, which allows an electrical installation to have an alternate path for a fault current to flow to the earth, must be installed.

⚠	**WARNING** The Enertainer should not be operated without securing a protective earthing/grounding system.

The earthing terminal of the Enertainer must be connected to an earthing electrode system that complies with the local or regional electricity supplier earthing standard. In the event of an internal short circuit, the maximum fault current produced by the Enertainer is 1,400 A in 80 ms. The minimum cross sectional area of the earth conductor, connected to the Enertainer earthing point, should be sufficient to allow the current to flow into the earth safely. This cross sectional area is normally half the size of the main conductor cables.

The earthing wire should be connected to any of the earthing points, located at the foot of the container. In a typical electrical setup, the Enertainer should be connected to a TN-S or a TT earthing system.





8. Using the Product

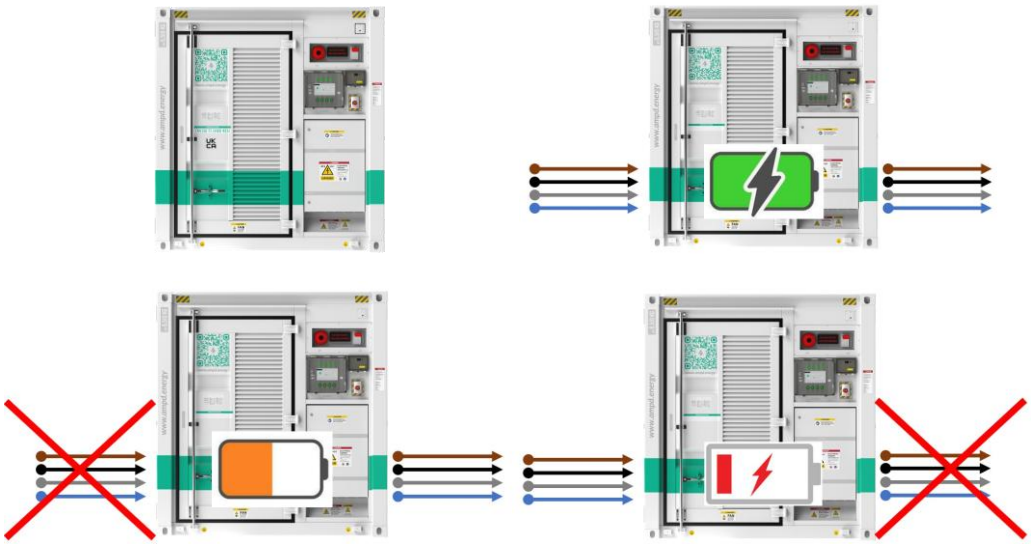
8.1 Turning On the System

To turn the system on, follow the Ampd Enertainer Full Commissioning Procedure.

8.2 Operative States

The Ampd Enertainer can run under the following conditions:

- Standby mode (no input charging, no output discharging)
- Running mode (input charging and output discharging)
- Discharging mode (output discharging only)
- Charging mode (input charging only)



The following practices will best protect the Enertainer from experiencing problems during operation:

- Do not exceed the product operating specifications written on the datasheet and user manual.
- Do not discharge the batteries down to SOC 0%.
- Do not leave the system off at SOC 10% or less.
- Do not leave any doors or access panels open while the system is energized and in operation.
- Do not touch any of the internal components while the system is energized or live.
- Do not turn off or disable the FSS during operation, only set it to manual mode during maintenance.
- Do not turn off the HVAC during operation.
- Do not leave the UPS on battery mode during operation.
- It is recommended to run the input charging and output discharging through the internal isolation transformers.
- It is recommended to turn on the surge protection device (SPD) on the PCS during operation.
- It is recommended to only run intermittent loads on the Enertainer instead of constant loads.
- It is recommended to spread out all single phase loads across all lines to balance the PCS operation.
- It is recommended to charge the batteries to SOC 100% at least once per week to balance the battery voltages.

8.3 User Interface

8.3.1 xHMI

Dual-color LED indicators provide a status of the Enertainer regarding the system, input, battery, and output. The two colors are either red and green, and the lights will either hold or flash.

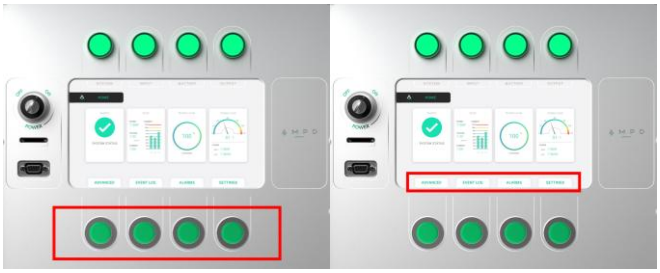
Color code chart of the LED indicators:

	System	Input	Battery	Output
Red		Input is under voltage	All battery strings are offline	Output is under voltage
Red (flashing)	Subsystem is in alarm state		Battery strings initializing	Sleep Mode is enabled
Green (flashing)		Input is normal but charger is disabled	SOC is less than 20%	
Green	All subsystems are normal	Input is normal	All battery strings are normal	Output is normal

The LCD screen can be divided into four columns (the top of the screen shows the heading):

- System: subsystem and controller status.
- Input: AC input power (charging).
- Battery: DC power for the batteries.
- Output: AC output power (discharging).

At the bottom of the screen are four buttons (“Advanced”, “Event Log”, “Alarms”, “Settings”) that the user can select. Navigation can be done either through the push buttons or on the touch screen itself.

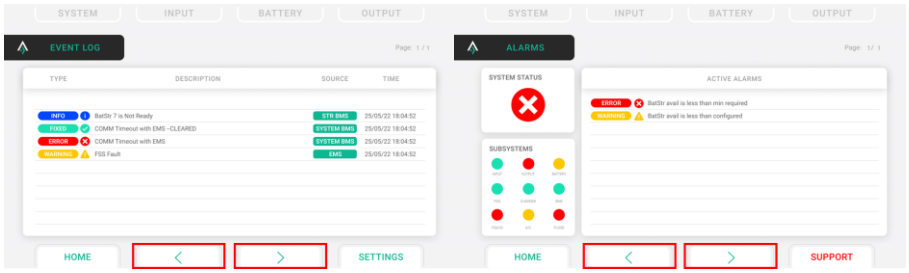


On the “Advanced” page, the left hand side of the screen will display the status of every subsystem in the Enertainer. The color will change depending on what state it is in.

	Red (error)	Yellow (warning)	Green (normal)
Input		AC input under voltage	AC input is normal
Output		AC output under voltage	AC output is normal
Battery	Battery strings are offline	Battery strings are disconnected, SOC is less than 20%	Battery strings are normal
PCS	PCS is in alarm/fault state, PCS is offline		PCS is normal
Charger	Charger is in alarm/fault state, charger is offline		Charger is normal
EMS	EMS is offline		EMS is normal
FSS	Smoke detector is activated, heat detector is activated, FSS fault		FSS is normal
A/C		HVAC is offline	HVAC is normal
Flood	Flooding alarm activated	Flood sensors triggered	Flood sensors are normal

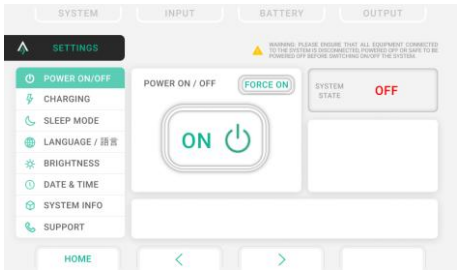
- The data under the “Input” column comes from the charger.
- The data under the “Battery” column comes from the system BMS.
- The data under the “Output” column comes from the PCS.

The history of events and list of warnings and alarms can be accessed through the “Event Log” and “Alarms” button from the LCD screen display:



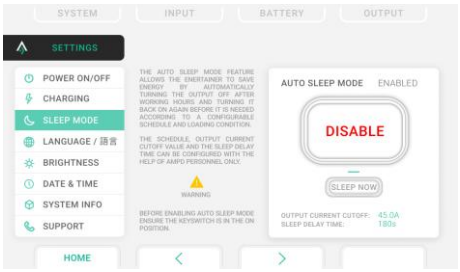
On the “Settings” page, the following options are available:

Power On/Off: Initializing/de-initializing the DC Bus



Charging: Enabling/disabling the charger, changing the charging current

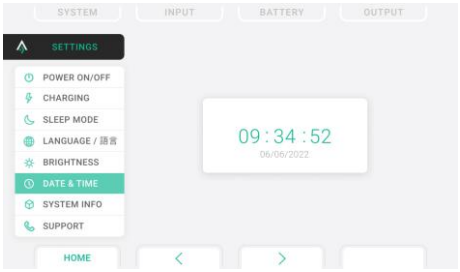
Sleep Mode: Enabling/disabling the auto sleep mode function



Language: Selecting the language between ENG/CHI

Brightness: Adjusting the screen brightness

Date & Time: Displaying the system date and time



System Info: Displaying the system name and firmware version

Support: Displaying the support hotline

The key switch to the left of the xHMI screen is used to toggle the PCS on and off. By changing the key to the "ON" position, it will signal the PCS to enable the "RUN" function. During this time, the PCS contactors will close and the AC output power will be live on the busbars. By changing the key to the "OFF" position, it will signal the PCS contactors to open and the AC output power will be de-energized on the busbars.

8.3.2 System BMS User Interface

During the system BMS startup, use your finger to touch the LCD screen to access the menu.

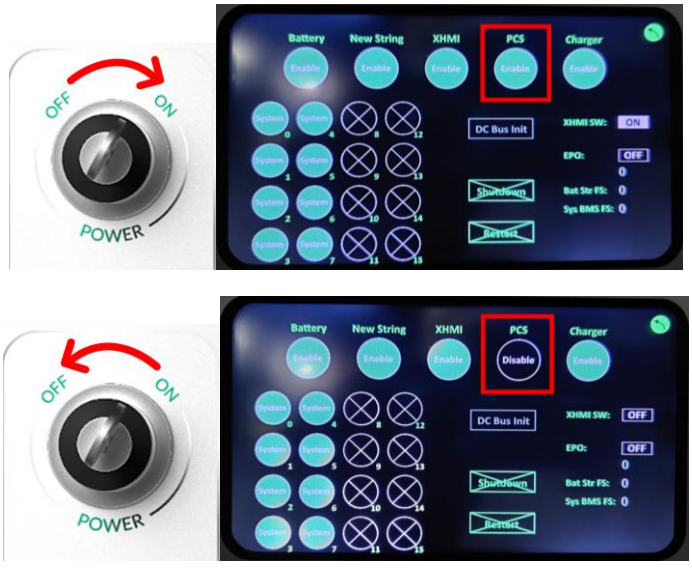
The “Battery String” page is for displaying, controlling, and operating the DC bus. At the top of the screen, the five icons called “Battery”, “New String”, “XHMI”, “PCS”, and “Charger” can be enabled or disabled by pressing them. At the bottom of the screen, there are circles representing each battery string in the DC section.

When the string BMS is not powered on, the circle will be blank. If the string BMS is on, it will show “?”. When the string BMS is ready to engage, the “?” will change to “System”. If the system is not configured, then it will have a white “X” symbol.

The logic of DC Bus initialization is based off the following conditions:

- The system BMS will calculate the average voltage among all the strings. Whichever has a string voltage closest to the average will connect first.
- If all the string voltages are within the range of ± 14 VDC of the average voltage, then all of them will connect and attempt to balance automatically.
- If any of the strings has a voltage outside of the range of ± 14 VDC of the average voltage, then it means that particular string is not balanced and it will not connect until the voltage is closer in range.

If the xHMI icon is enabled before the PCS, then it will lock the PCS icon, and will only be activated remotely by the xHMI key switch. In this case, the xHMI key switch will control if the PCS is enabled or disabled.

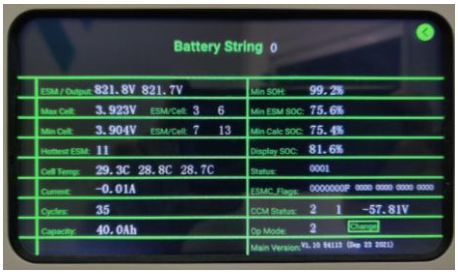


If the xHMI icon is disabled, the PCS can be controlled by the System BMS.

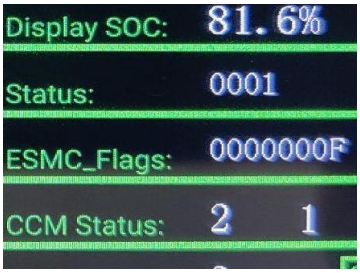
8.3.3 String BMS User Interface

The string BMS data is also viewed using the system BMS LCD screen.

Each battery string can be clicked on to view more detailed information. The numbers displayed on the screen are a collection of data points from every ESM's PBMS, represented as a maximum and minimum value. In order for the entire system to function optimally, it is important that all battery cells, ESMs, and battery strings are balanced with each other in terms of voltage, temperature, cycle, and capacity.



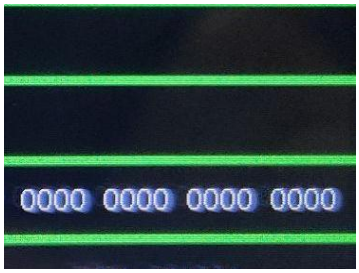
When a string BMS is receiving errors from the PBMS, it will flag a signal to the system BMS in the form of an ESMC_Flag. This is a code that designates the type of warning or error it is experiencing. The ESMC_Flag that flags no errors nor warnings is shown as "0000000F".



The status of the string will also change depending on the error or fault:

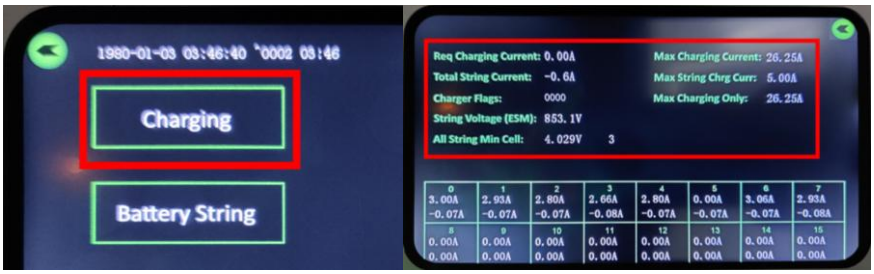
- Critical error (e.g. cell undervoltage, cell overvoltage, overcurrent, or overtemperature), the string will disconnect from the DC Bus and the icon will show a red "SHUTDOWN".
- Communication loss, the string will disconnect from the DC Bus and the icon will show a "?"
- Power loss, the string will disconnect from the DC Bus and the icon will show a black circle.

When a communication connection is broken, either by means of a cable being disconnected or having poor contact, the string BMS will send the signal to the system BMS to flag it. On the right hand side of the String BMS page, there are a series of "0"s which designate the signal connection from ESM 1 to ESM 15. The order is counted from right to left. When a connection is established and normal, it will show "0".



If there is a connection that is broken in between, it will show “1”. The placement of the “1” will determine which position on the rack the connection stops. There are a total of 15 ESMs in one string and, therefore, the furthest left digit is not used.

The “Charging” page displays all information pertaining to the charging of each battery string, reported by the String BMS.



The “Battery Info" page displays all information pertaining to the voltage and temperature of each battery string, reported by the String BMS and PBMS.

The information displayed on the page will depend on which string BMS address is selected from the home screen. Use the “+” and “-” buttons to select the string address. After selecting a particular string BMS address, there will be subpages at the bottom that will show different ESM data values regarding:

- 2S20~2S3F = Measured ESM voltages
- 2S40~2S5F = Minimum cell temperature, maximum cell temperature
- 2S60~2S7F = Cycle count, minimum voltage cell number and maximum voltage cell number
- 2S80~2S9F = Minimum cell voltage, maximum cell voltage

8.3.4 EMS User Interface

On the EMS tablet PC desktop, open the icon “EMS-Web”. This platform holds many controls and configuration parameters. It can only be accessed through a password.

NOTE

Only certified Ampd Enertainer technicians can access and configure the EMS settings. Contact your Ampd Energy representative for the password.

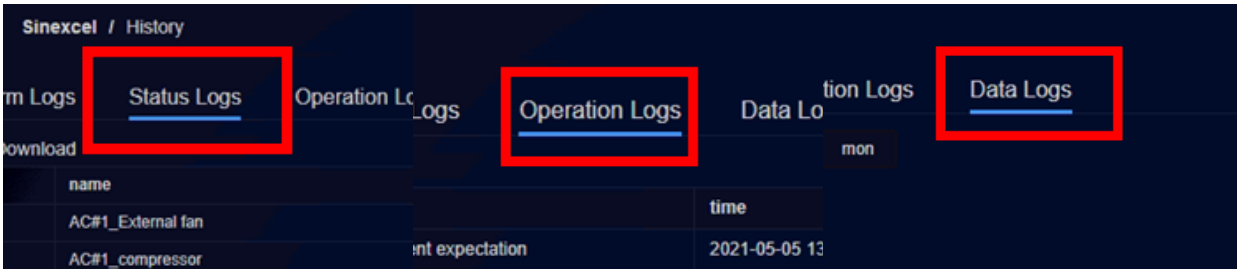
When successfully logged in, the platform will take you to the home page with a side panel directory. On the “PCS” page, you can view the voltage, current, and power in greater detail. The data is retrieved by the PCS, measured in a 10 millisecond basis.

On the “Other” page, you can adjust the settings for the HVAC units. device/envicool 1 and 2 refer to the backside HVAC units #1 and #2. “Cooling Point” is the internal temperature of the DC section which will either trigger to turn on or turn off the compressor. The parameter “Cooling Sensitivity” will give the temperature reading a +/- range. Below that are two other points, “Heating Point” and “Heating Sensitivity”, which control the electric heater.

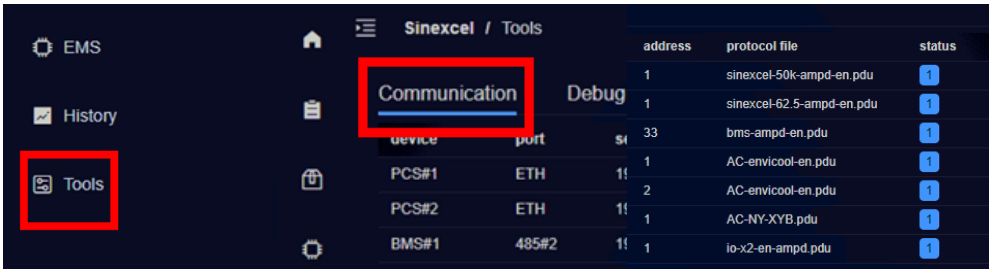
In addition to the HVAC units, two sensors installed in the AC section and DC section can be viewed on the “Other” page. Sensor #1 will be measuring the AC section ambient temperature and humidity. Sensor #2 will be measuring the DC section ambient temperature and humidity.

On the “History” page, it will display different logs which will indicate its historical condition and performance. The alarm log will record instances where an alarm is triggered, along with a start time and an end time. Each line will have a specific name which describes the condition that triggered the alarm.

“Status Logs” will record all subsystem status when changes are executed by the EMS. “Operation Logs” will record all operational commands given from the EMS to any particular subsystem. “Data Logs” will graph all the measurable parameters in real time.

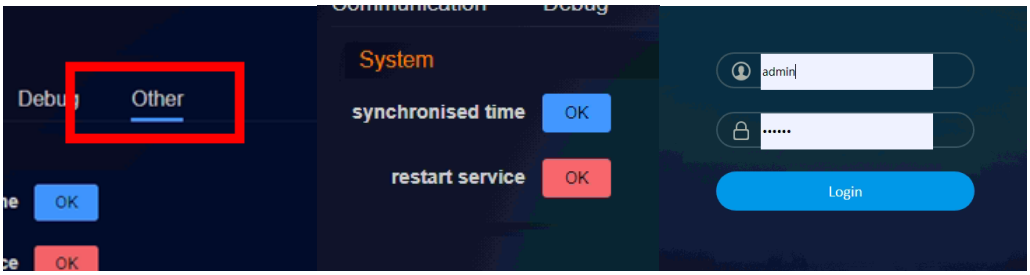


The “Tools” page contains three subtabs. “Communication” shows the connection status of other devices in communication with the EMS. If the status shows “1”, then the communication is normal. If the status shows “0”, then the communication is off.



“Debug” allows the EMS user interface to configure the parameters of the other devices. If the communication is normal, then remote changes can be made. If the communication is off or has an issue, no changes can be made.

On the “Other” tab, there are two buttons where you can synchronize the time of the EMS and restart the EMS-Web interface. After pressing the “Restart Service” button on the web interface, it will redirect you to the login page again where you will be prompted to enter login credentials.



The restart button on “EMS-Web” will only apply to the web controls of the EMS and will not affect any of the signals between the other subsystems. Restarting the hardware system will need to be done through the power on/off button on the front of the EMS.

8.3.5 Charger User Interface

All of the navigation for the charger is done through its built-in screen. After successfully energizing the charger, the screen will light up. There are seven different displays:

1. DC charging current (per module)
2. DC Bus voltage
3. DC firmware version
4. AC firmware version
5. Group (not used)
6. Mode (automatic or manual)
7. Address number

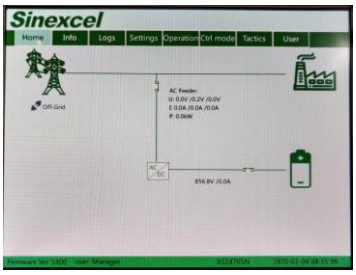
When configuring any parameters, the chargers must be set from automatic to manual. The screen will either show “A” or “M”.

	NOTE Only certified Ampd Enertainer technicians can access and configure the charger settings. Contact your Ampd Energy representative for more assistance.

8.3.6 PCS User Interface

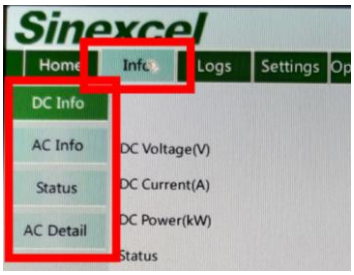
When the touch screen monitor lights up, it will open the main home screen of the PCS. At the top of the screen, there are five available pages to choose from:

- Home
- Info
- Logs
- Ctrl Mode
- User



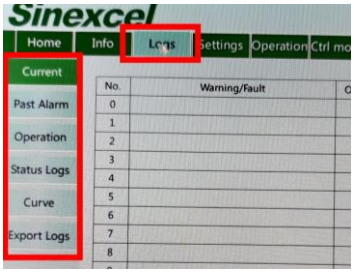
The “Info” page displays all the values for every sensor in the PCS, measuring parameters such as voltage, current, power, power factor and temperature. These values give indication of the operation of the PCS and if there is any abnormal behavior. On the left hand side, there are the following subpages:

- DC Info
- AC Info
- Status
- AC Detail



On the “Logs” page, the user can view all the different types of activities and commands given to the PCS. The log will also record the faults and errors from the PCS side while it is running. On the left hand side, there are the following subpages:

- Current
- Past Alarms
- Operation
- Status Logs
- Curve
- Export Logs

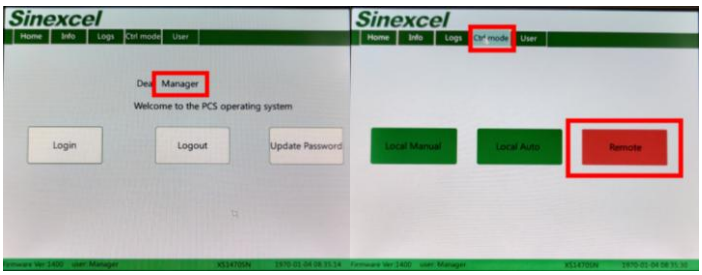


To make any changes to the settings of the PCS, the user needs to login and enter the correct password. If the login was successful, settings and operation modes can be changed.

	NOTE Only certified Ampd Enertainer technicians can access and configure the PCS settings. Contact your Ampd Energy representative for the password.

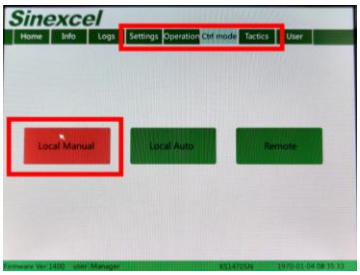
On the navigation panel, click on “Ctrl Mode”. It will display the following three types of control modes that the user must select:

- Local Manual
- Local Auto
- Remote



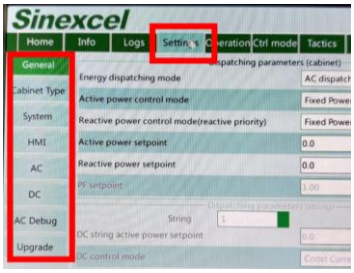
Selecting “Local Manual” allows the user to locally set and adjust all of the operating parameters of the PCS through the PCS touch screen. By selecting “Remote”, all configuration settings cannot be changed. Upon selecting “Local Manual”, you will see three more options appear on the navigation bar:

- Settings
- Operation
- Tactics



On the “Settings” page, the user can change and adjust the parameters regarding the overall operation of the PCS. On the left hand side, there are the following subpages:

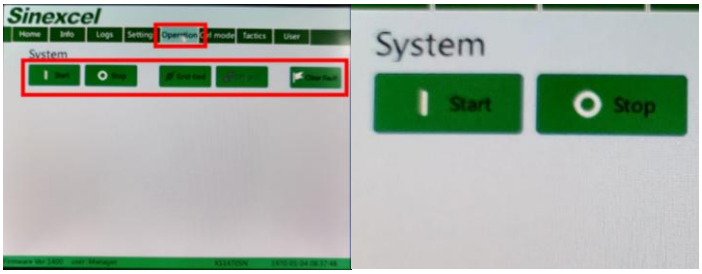
- General
- Cabinet Type
- System
- HMI
- AC
- DC
- AC Debug
- Upgrade



On the “Operation” page, it will display five buttons, which will change the status by sending immediate commands to the PCS communication board. The options are as follow:

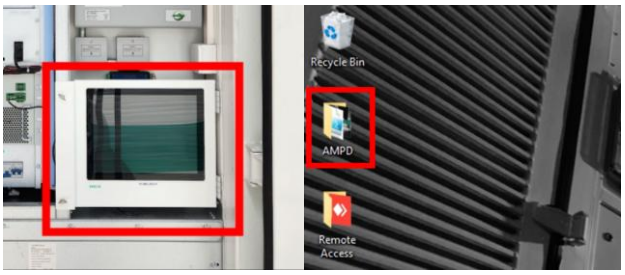
- System Start
- System Stop
- Grid Tied
- Off Grid (the system is permanently set to Off-Grid by default)
- Clear Fault

Pressing “System Start” and “System Stop” will signal the PCS modules to turn on and turn off. In turning on the PCS, AC output power will be powered on. Turning off the PCS, AC output power will be powered off.



8.4 Settings Configuration

The system BMS can be configured to fit the desired use case and application. The configuration is done through CESS programs, which are located in the EMS Tablet PC. On the desktop, open the folder called “AMPD”. Inside, there are three .exe files.



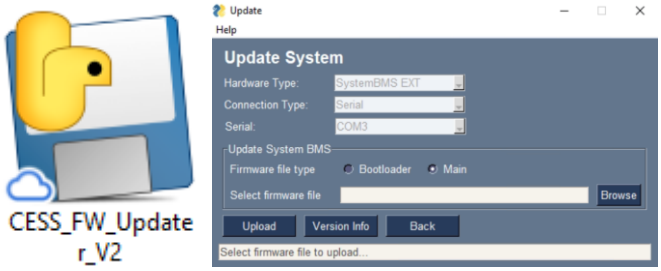
NOTE

This can only be done if the RS232-USB2.0 communication cable is connected between the system BMS (EXT port) and the EMS tablet PC.

CESS_Cfg.exe is used to configure internal operating system settings. Within the program, users are able to:

- Set the operating parameters
- Set the particle photon wifi parameters
- Set the date/time of the system BMS

CESS_FW_Updater_V2.exe is used to upgrade the firmware for the system BMS, string BMS, and PBMS. As long as the EMS Tablet PC has an internet connection, this program can be used as a remote, over-the-air firmware update method.



CESS_Scheduler.exe is used to change the scheduling parameters of the system BMS. The schedules are for auto sleep mode and battery charging. Within this program, users are able to:

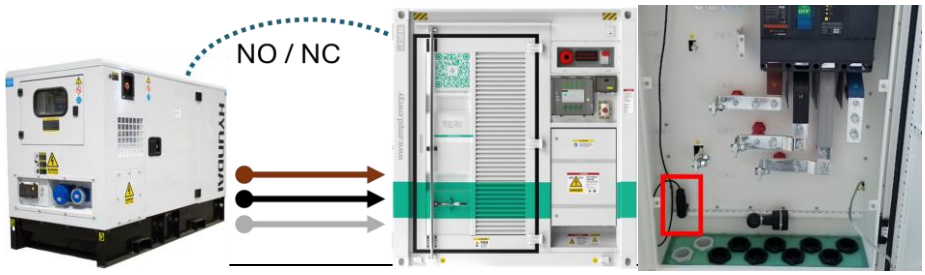
- Edit battery charging parameters (e.g. when to start charging, when to stop charging, etc.)
- Edit auto sleep mode parameters (e.g. when to start sleeping, when to stop sleeping, etc.)

NOTE

Only certified Ampd Enertainer technicians can access and configure the system BMS settings. Contact your Ampd Energy representative for more assistance.

8.5 Generator Auto On/Off Control

The Enertainer has the capability to auto start and stop a generator using a dry contact signal. The logic follows the SOC, whereby a low battery SOC (e.g. 30%) will trigger the generator to turn on and a high battery SOC (e.g. 95%) will trigger the generator to turn off. This configuration requires a generator that is capable of turning on and off automatically/remotely.

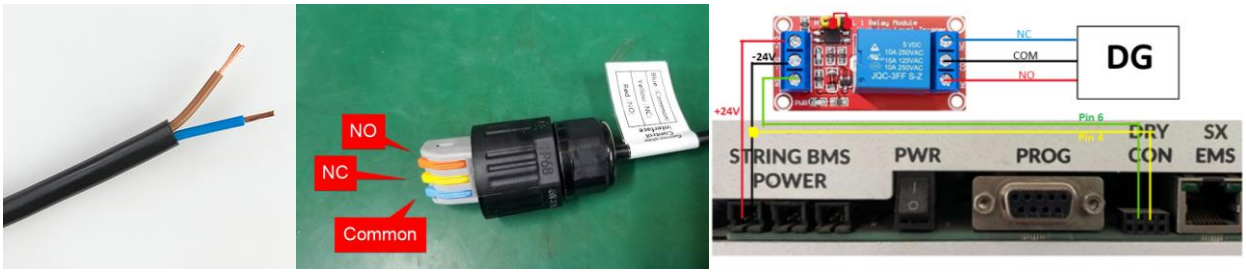


NOTE

This feature will not work if the generator experiences any internal issues (e.g. low fuel level, low oil pressure, high engine temperature alarm). Check to make sure the generator is well and regularly maintained.

A two-core flexible copper cable needs to connect from the Enertainer to the generator's dry contact port. The generator must have the capability to auto-start through a dry contact signal, either as a NO (Normally Open) or NC (Normally Closed). The two dry contact wires must be connected to the Enertainer's DG isolator box. Three ports are shown as red (normal open), yellow (normal close), and blue (common).

- If the generator's auto-start is a NO signal, then the DG isolator will have red and blue connected.
- If the generator's auto-start is a NC signal, then the DG isolator will have yellow and blue connected.

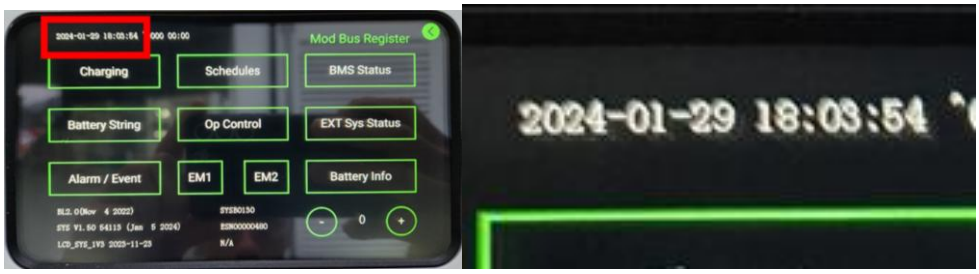


The generator auto on/off function must be set up through the CESS_Scheduler.exe program. This setup requires the user to input the battery SOC triggers (from 0 - 100%) and the time trigger (00:00 - 24:00). If the battery SOC meets both conditions, the system BMS will send the close/open signal to the generator.

The SOC and time settings will depend on the user's preference and working schedule.

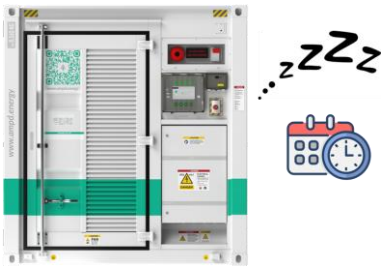
NOTE

To enable this generator auto on/off feature, users must ensure the system BMS date and time are synchronized to the correct time zone.



8.6 Auto Sleep Mode

The Enertainer has the capability to automatically turn on and off the output power based on a schedule. This schedule is programmed on the system BMS when to send the command to the PCS to enable and disable. The PCS upon receiving this command will react by turning on or off the contactors. This is an energy-saving feature that will preserve and extend the battery life, and further reduce the carbon emissions.

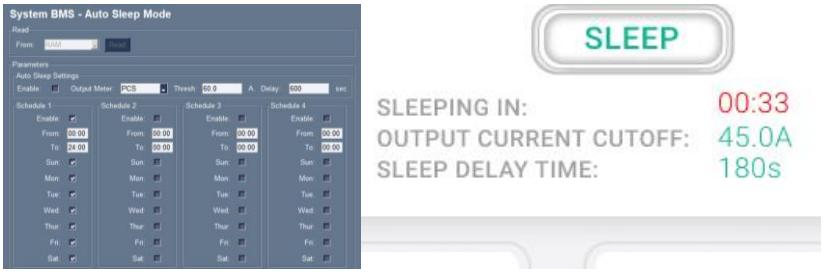


The auto sleep mode feature comes with a few conditions prior to implementation:

- The output power is not in use and can be turned off - unexpected shutdowns may cause problems on the load equipment and/or personnel nearby.
- The AC input power is connected and constantly turned on - auto sleep mode will automatically disable if the AC input power is disconnected (or cut).
- All input and output circuit breakers are left turned on.

The auto sleep mode function is set up through the CESS_Scheduler.exe program. This setup requires the user to input the following parameters:

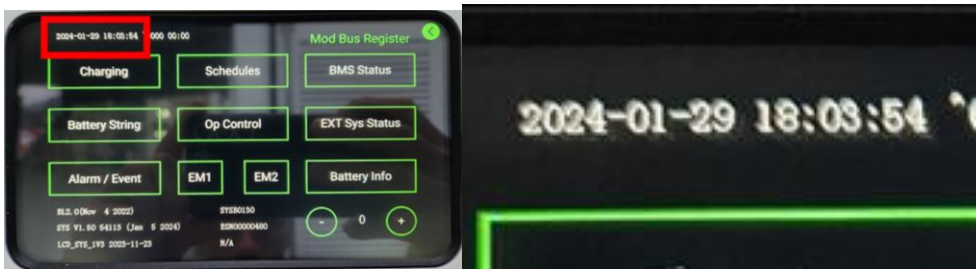
- The output power threshold (in A)
- The output power delay time (in seconds)
- The auto turn-on time (from 00:00 - 24:00)
- The auto turn-off time (from 00:00 - 24:00)
- The working days applicable (from Mon - Sun)



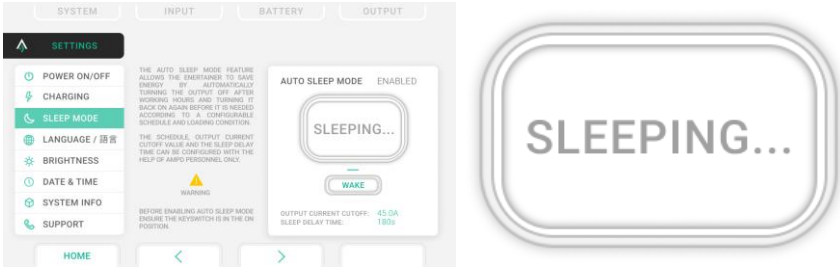
The “auto turn-on time” and “auto turn-off time” represents the working hours of the Enertainer. Outside of those hours, the auto sleep mode will enable. The “working days” represent the applicable days of the Enertainer that will enable auto sleep mode. Outside of those days, the auto sleep mode will be disabled.

NOTE

To enable this auto sleep mode feature, users must ensure the system BMS date and time are synchronized to the correct time zone.



The xHMI settings page will display the current state of the auto sleep mode. When all of the setup parameters are met, auto sleep mode will enable and the output power will turn off. This state is called “sleeping”, as shown on the xHMI screen.



If the auto sleep mode is activated by accident or unintentionally, or if the user wants to reinstate AC output power again, the user can reset it back to normal by pressing the “wake up” button.