MPLhE Series

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

VERSION 3.0

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LiFePO4 Battery Module for Telecommunications

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Operations Manual

Product Overview

MPINarada MPL series 36V/48V/51.2V lithium iron phosphate (LFP) batteries are a safe and reliable product for backup power systems at equipment sites, meeting the reserve power requirements of network, communication, and transmission equipment. They are stackable in 19"
/ 23" for a 2 or 4 post rack or cabinet configuration.

These battery modules can fit with a variety of 36V/48V/51.2V telecom power systems. They offer many features, such as flexible configuration, modular design, remote monitoring with multi-group parallel communication, intelligent battery management (BMS) with protection functions for voltage, current, and temperature, high energy density, long service life, high charge and discharge rates, etc.

MPINarada MPL-LFP chemistry makes it one of the safest technologies, suitable for high- and low-temperature operation as well as high discharge rates. These LFP batteries are ideal for the growth of telecommunications and as a direct replacement for VRLA. These batteries have UL9540A certification, tested for no thermal runaway, no fire and no explosion.

Note that the 48NPFC batteries have been replaced by the 36V/48VMPLhE versions shown on the next page. The 36/48MPLhE batteries are identical (except for color and identification labels) to the original NPFC models in terms of installation, functionality and operation.
Therefore, the instructions in this manual apply to both the NPFC and MPLhE versions of the MPINarada Batteries.

Main applications

- Micro-telecommunications stations
- Radio and Cell Towers
- Equipment Cabinets
- Network Equipment in Central Offices
- Transmission Equipment
- A variety of communication equipment.

Characteristics

- Simple installation and load/charge system integration.
- Advanced Intelligent Lithium Battery Management System (BMS) Technology
- Configuration flexibility and parallel connection support.

Compliance

- UL1642, Standard for Lithium Batteries
- UL2054, Standard for Household and Commercial Batteries
- EN 61000-6-1:2007, Electromagnetic Compatibility (EMC)
- EN 61000-6-3:2007+A1:2011, Electromagnetic Compatibility (EMC)
- IEC 62133:2012, Battery safety testing
- UL1973 and UL9540A (no thermal runaway, no fire and no explosion)
- UN 38.3 Transportation

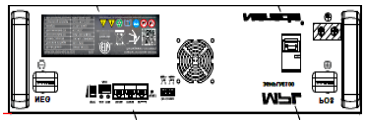
Battery Images

36MPLhE100

48MPLhE100

48MPLhE100-16

48MPLhE200



Battery Sizes

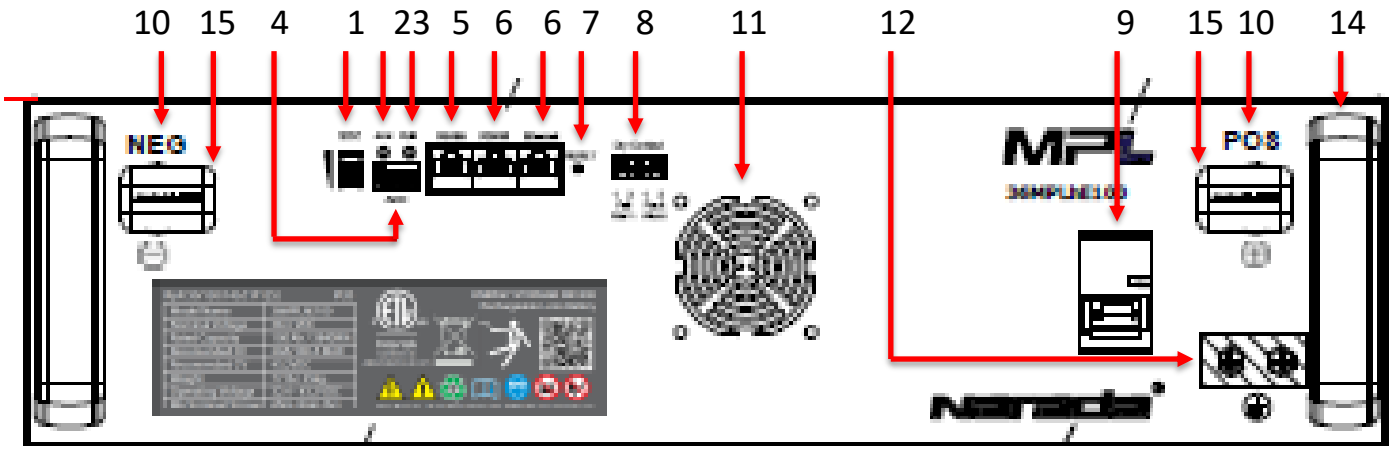
Model	V	Capacity (Ah)	Maximum Flow Rate (A)	Width		Depth		Height		Rack Units	Weight		Terminal bolt
				Mm	in	Mm	in	Mm	in		Kg	Lbs.	
36MPLhE100	38.4	100	100	520	20.47	326	12.8	133.5	5.24	3U	35	77.16	M6
48MPLhE100	48	100	100	442	17.4	400	15.8	133.5	5.24	3U	38.5	84.9	M6
4848MPLhE100-16S	51.2	100	100	442	17.4	440	17.3	133.5	5.24	3U	41.5	91.5	M6
48MPLhE200	48	200	100	442	17.4	480	18.9	222	8.74	5U	71.5	157.6	M8

Terminal bolt for

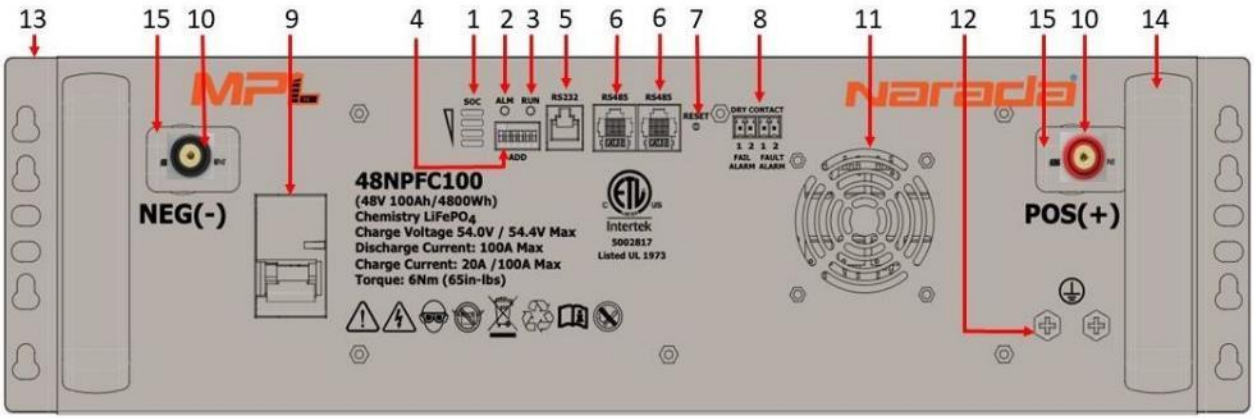
36MPLhE100, 48MPLhE100, 4848MPLhE100-16 and 48MPLHE200

Torque for M6 and M8= **7 Nm or 62 in/lbs.**

Front Panel Layout for 36MPLhE100



Front Panel Layout for 48MPLhE100



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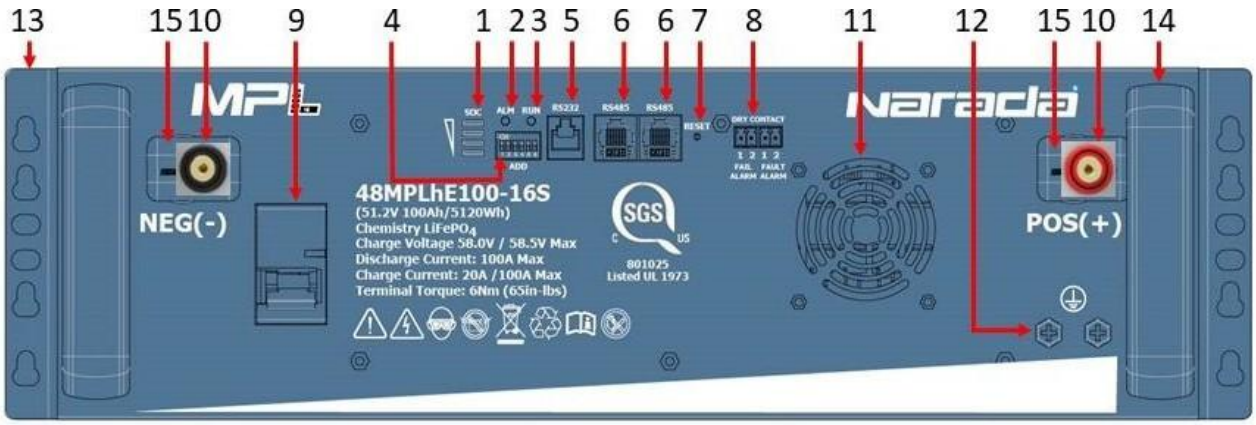
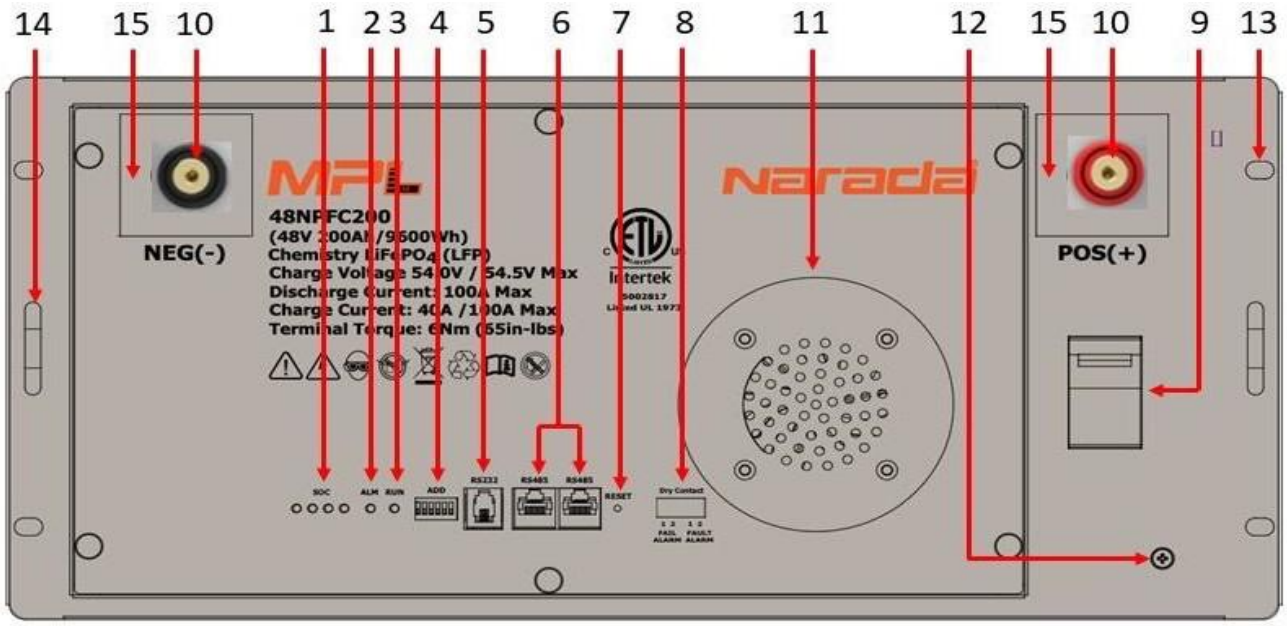
Front Panel Layout for 48MPLhE100-16



Front Panel Layout for 48MPLhE200



Description of the front panel layout

No	Battery Marking	Function	Descriptive
1	SOC LED Lights	Capacity indicator	There are four green lights, each showing 25% of the state of charge. 4 lights = 75%-100%
2	ALM	Alarm Indicator	There is a red LED on the front panel. If this light is on, it indicates an alarm status. Detailed information can be found in Appendix 1.2
3	RUN	Operating status	There is a green LED on the front panel indicating the working status. Detailed information can be found in Appendix 1.2
4	ADD	Address Com	These are the DIP switch settings. Setting 1 of the DIP switch is raised for single battery installation or communications. If other batteries are installed in parallel, each has its dedicated soaking setting to identify it. See the table of ADD Com addresses on pages 24 and 25.
5	RS232	Com Port	This port is used to download firmware updates and changes to parameter settings, alarms, battery operating status, etc. Customers will not need to use this port without MPINarada support.
6	RS485	Com Ports	These two ports are used to monitor the BMS system. Only one port is used on a single battery installation to connect to the monitoring station or laptop. The second port is used when more than one battery is in parallel, and it is connected to the next battery via its RS-485 port. Please see the images on pages 18 and 20 of this manual.
7	RESET	Reset Location	The reset is used when the battery is in sleep mode, behaving abnormally, or to force it into sleep mode. Insert a small pin-type device into the opening and press the reset.
8	DRY CONTACTs	Wiring connection	These connections are used for basic remote alarms. The fault alarm can capture and send a notification in case of battery failure, charge/discharge MOS failure, cell voltage less than 0.5V, NTC disconnection, etc. The fault alarm can capture output short circuits, charge/discharge overheating, and charge/discharge overcurrent.
9	Circuit breaker	Power circuit breaker on/off	Power ON means that the battery is working and that power is present on the positive and negative terminals. De-energizing means that no power is present on the positive and negative terminals. The BMS will remain active, and the SOC lights will remain on for a limited time.
10	NEG– POS +	Electrical connection	The power connections connect the battery to the power plant's positive and negative buses. Use the appropriate PPE and insulating tools when making these connections. M6 bolts for battery terminals are supplied with the battery.
11	FAN	Cooling	This fan runs when needed to cool. If an optimal temperature of 25°C (or less) is maintained, the fan will operate minimally. If the fan fails, contact MPINarada to have the battery replaced. It is not usable in the field.
12	GND	Grounding	The battery must be grounded for safety reasons.
13	Mounting bracket	Rack/cabinet mount	The battery will come with the 19-inch and 23-inch battery brackets.
14	Handles	Rack Handling	The handles are used to slide the battery in and out of the rack. They should not be used to transport the battery from one place to another.
15	Battery terminal caps	Power Terminal Covers	Black terminal cover for the negative power terminal. Red terminal cover for positive power terminal.

STORAGE

Storage Temperature	Charging interval	Procedure for charging a single module
0 °C to 30 °C	Every 6 months	1. **Charging with 0.2 °C to 100% SOC** 2. **Discharge with a SOC of 0.2 °C to 50%** 3. **Charge at 0.2°C per module for 4 hours**
30 °C to 40 °C	**Every 3 months**	

- Long-term battery storage should be at 50% to 80% SOC.
- Storage temperature range is 0°C to 40°C.
- Storing the battery at temperatures above 40°C or below 0°C will reduce the life span.
- Store batteries in a dry, low-temperature, well-ventilated place.
- Degraded battery performance after long-term storage; Keep the shelf life as short as possible before installation.
- Recharge the battery after storage and before use to recover capacity loss due to self-discharge during storage and transportation.
- The battery should be recharged during long-term storage to recover the loss of capacity due to self-discharge based on the above recommendations.

METHOD FOR CHARGING BATTERIES IN STORAGE

1. Obtain a variable power supply capable of supplying up to 60 amps.
2. Caution: Voltage and ampere adjustments should be made according to the variable power supply instructions. Be sure to use the appropriate PPE to perform the following tasks:
3. Set the power supply voltage to 43.2 V for 36MPLhE100, 54V for 48MPLhE100 and 48MPLhE200, 58.4V for the 48MPLhE100-16
4. Set the Battery Ampere to 0.2°C setting. Set the amps in +0.2°C increments for each battery in parallel, depending on the number of batteries that will be charged. For example, 48MPLhE100 >
   1 battery: set amps to 20; 2 batteries: set amps to 40. Continue to adjust the battery count and ampere value based on the variable power limit. Less than 0.2°C is acceptable.
5. Turn off the charger power, turn off the battery circuit breaker
6. Connect the positive (red) wire of the power supply to the positive (red) terminal of the battery.
7. Connect the negative (black) wire from the power supply to the negative (black) terminal on the battery.
8. First, turn on the battery (Breaker up) and then turn on the power switch on the power supply.
9. The battery should start charging; The power reading should indicate the battery voltage level, which will increase as the charge progresses.
10. Charge the battery until the SOC LEDs reach 100% (4 lights).
11. Once the battery is fully charged.
    a) Turn off the power supply first
    b) Then turn off the battery (circuit breaker off).
12. First, remove the black wire from the negative (black) terminal of the battery.
13. Remove the red wire from the positive (red) terminal of the battery.
14. Repeat these instructions for each battery to be recharged.

HOW IT WORKS (Working Principle)

The MPLhE battery system includes a lithium battery, a battery protection system, a cell-balancing unit, a monitoring module, and a charge-and-discharge management module. Its schematic diagram is shown in Figures 1-4.

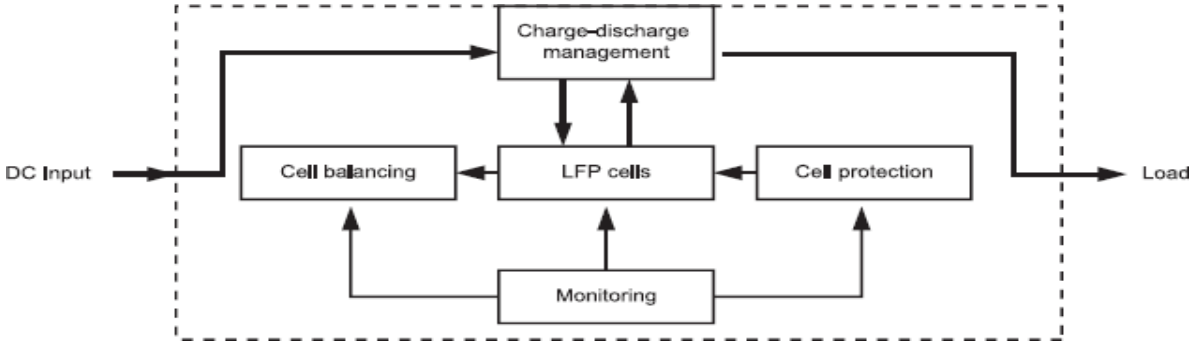


Fig. 1-4 Diagram

LFP Cells	The battery cells provide the stored energy.
Cell Protection	Protects LFP cells from overcharging, overdischarging, overcurrent, overheating, and short circuits.
Cell Balancing	The battery adjusts the cell voltages to ensure they match as closely as possible.
Monitoring	Support for a centralized monitoring system (optional according to customer requirements)

Working Principle of MPLhE Battery

The rectifier's DC power supply is divided into two circuits: one directly supplies the load, and the other charges the lithium battery cells.

When the main power is turned on, the system provides power to the loads. It also charges the lithium batteries. In the event of a power outage, the lithium cells in the battery provide DC power to the load, ensuring uninterrupted operation of the equipment.

Battery Management System (BMS)

- Smart BMS technology is adopted for the MPLhE battery modules to ensure automatic battery management.
- The BMS has a centralized monitoring unit. When connected to compatible equipment, such as the power plant, functions such as remote measurement, remote communication, and remote control are available. The battery units can be remotely monitored by the control center's operating staff. MPLhE batteries are compatible with modern requirements for the development of communication technologies.
- It is combined with the technologies of using a battery and a computer. The parameters and status of AC/DC rectifiers and distributions can be detected.
- Excellent electromagnetic compatibility. The BMS used for the battery modules of MPLhE batteries does not interfere with each other.
- The BMS protects against over-charge and over-discharge, overheating, overcurrent, short circuit, etc., to ensure reliable safety and service life.
- With patented cell balancing technology, the BMS provides high efficiency for cell balancing and extends the life of the system.
- Configuration flexibility supports the expansion of parallel connections up to 16 modules.

TECHNICAL SPECIFICATIONS

DISCHARGE PERFORMANCE

DC discharge at 40.5 at a different constant current flow rate.
All MPLHE batteries perform at a similar curve.

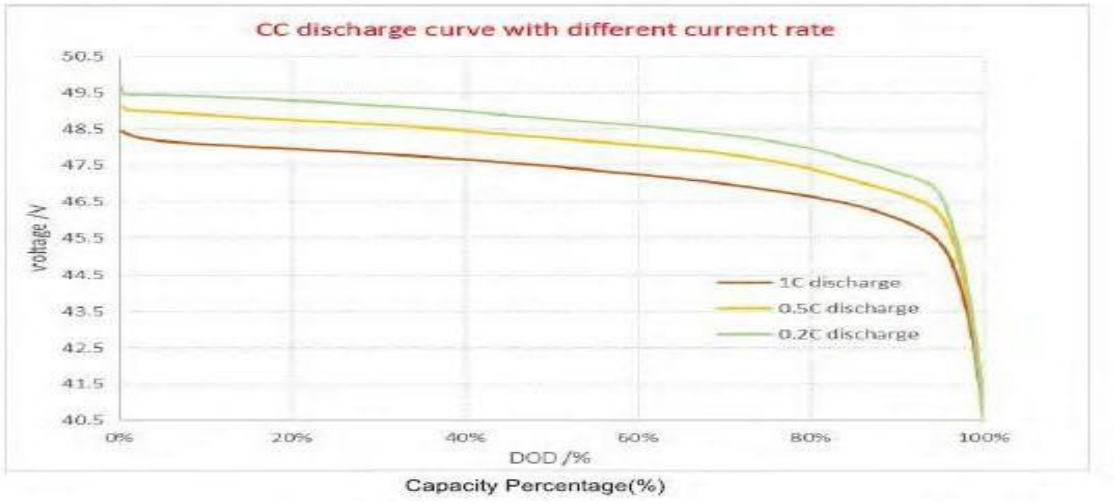


Fig.2-1 Discharge curve at different constant currents of the MPLhE series

CHARGE PERFORMANCE

DC charging with different constant-current rates and a 54.5V constant-voltage. All MPLHE batteries perform at a similar curve.

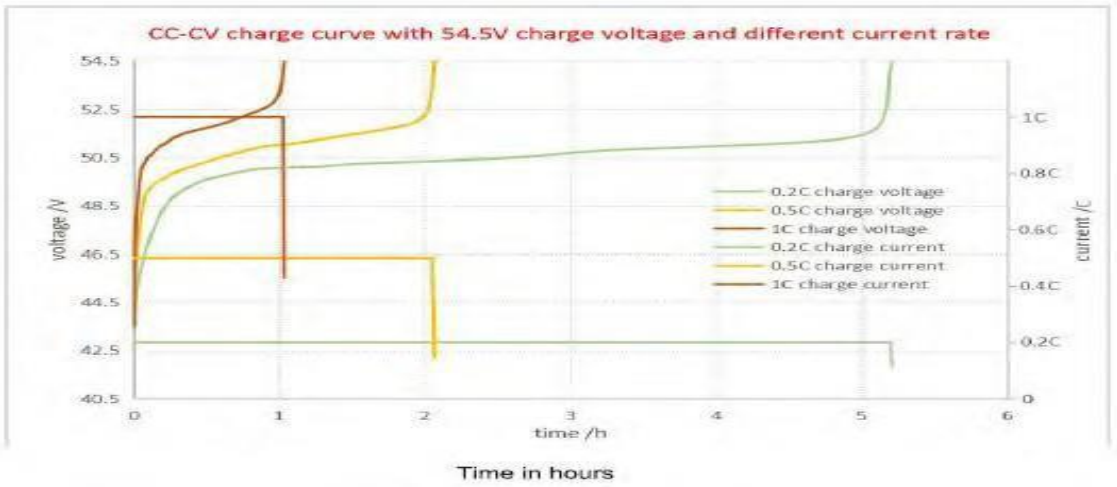


Fig 2-2 Load curve at different current limitations of MPLhE series

OPERATING PARAMETERS

Battery Charging Parameters

Model	Capacity (Ah)	Rated Load Current (A)	Charging Current Limit (A)
36MPLhE100	100	20	100
48MPLhE100	100	20	100
48MPLhE100-16S	100	20	100
48MPLhE200	200	40	100

BMS, and Battery Operating Parameters

Parameters	Units	Value
Charging voltage for 36MPLhE100	V	43.2 ± 0.5
Charging voltage for 48MPLhE100 and 48MPLhE200	V	54 ± 0.5
Charging voltage for 48MPLhE100-16s.	V	57.5 ±0.5
Equalization Load Voltage	V	N/A
Rated Load Current	One	0.2 °C
Charging Current Limit	One	0.5°C ~ 1.0°C
No equalization required	day	N/A
LVBD (Low Voltage Battery Disconnect) 48MPLhE100 48MPLhE200 48MPLhE100-16s 36MPLhE100	V	 > 40.5 V > 43.2 V > 32.4 V

Parallel Operation Based on Discharge Rate (C)

36MPLhE100	0.5C to 1C, P≤4	0.5 to 0.2C P≤6	0.2C P≤8	
48MPLhE100	5 Modules 0.91C	9 Modules 0.57C	12 Strings 0.48C	16 Modules 0.33C
4848MPLhE100-16S	5 Modules 0.91C	9 Modules 0.57C	12 Modules 0.48C	16 Modules 0.33C
48MPLhE200	0.5C to 1C, P≤4	0.5 to 0.2C P≤6	0.2C P≤8	

MPINarada / Narada only supports up to 16 battery modules per power plant. There are slight differences in internal impedance between parallel batteries, depending on how the charging current is distributed between them. This limits the number of batteries required in parallel for different loads. The table above shows charging indications based on the number of parallel batteries. Exceptions can be made for certain load profiles with short-term currents above these limits. Please consult with MPINarada for sizing outside of these guidelines. Prolonged discharge below 5 A per battery may result in inaccurate SOC calculation. For this reason, the number of batteries must be compared to the discharge rate to keep the current above five amps.

Operating Environmental Temperature Limits

Temperature Range (0C)	Discharge	-20 ~+60
	Charge	0 ~ +60
	Storage	0~+40
Recommended Range (0C)	Discharge	+15~+35
	Charge	+15~+35
	Storage	+15~+30
Humidity		5% - 95%

An equalization charge is not required for lithium iron phosphate (LFP) batteries.

The rectifier parameters should be adjusted to meet the site's specific requirements, depending on the number of battery units used.

If more than two batteries are connected in parallel, the maximum recommended limit of charging current is 0.5 °C.

MPLhE series lithium batteries can be used up to 5000 meters (about 3.11 mi) in altitude. If the altitude is above 5000 meters (about 3.11 mi), the decrease in air pressure and temperature will affect the battery's performance and lifespan.

INSTALLATION MANUAL

SAFETY AND WARNING

The MPLhE family of batteries for installation, operation, and maintenance should follow the important recommendations in the manual.

Read the installation and operation manual COMPLETELY before you begin.

Contact MPINarada if you have any questions before you begin.

The installation, operation, and maintenance of the MPLHE Series LiFePO4 Battery System should follow the important recommendations in this manual:

- Equipment should be installed by professionally trained personnel.
- Always wear proper Protective Personal Equipment such as Eyeglasses, Insulated Tools and Rubber Gloves.
- Battery maintenance should be performed by experienced professionals.
- Be aware of preventative measures to avoid the potential dangers of improper battery handling.
- Note: Be aware of the risk of electric shock for large currents in the event of a battery short circuit. Pay attention to the following points during operation:
  - Remove watches, rings, or other metal objects from the body.
  - Use insulated tools.
  - Do not place metal tools or objects on the battery.
  - Do not plug the battery system into the main grid (AC) power outlet.
- Please check the shipping box for damage. If the battery appears to be damaged, please notify the supplier immediately.
- Do not put the battery system in a fire; Do not use or store the battery near hot temperature sources.
- Do not use liquids or other cleaning objects on the battery system.
- Do not open the battery; Do not hit, throw or step on the battery.
- Be sure to follow the charging and discharging settings in this manual.
- The battery terminals are energized, even when the power to the grid is cut off or interrupted. Always use the battery terminal covers to prevent electric shock or short circuits.
- If you find liquid residue or white powder on the product, prohibit use. Log out and contact vendor support immediately.

				
Handle with Care	Read Manual Carefully	Warning	Electrical Danger	Wear Eye Safety PPE
				
Short Circuit Danger	UL Canada / USA Listed	Do Not Expose to Fire	Recycle used Batteries and Packaging	Do Not Dispose of Batteries in Garbage. Send for Recycling

Please be aware of the following marks and their meaning.

INSTALLATION

Unpacking and inspection

- Read this manual before attempting the installation of the MPLhE batteries.
- Inspect the packaging before unpacking; Contact the supplier immediately if any damage is found.
- These batteries should be installed and used by professionals.
- Be sure to keep the extra brackets and bolts. They may be required as part of the installation in racks or cabinets.

Preparing for installation

- Batteries should not be placed in direct sunlight or near a heat source.
- Batteries should be installed with good ventilation to ensure sufficient heat dissipation.
- Batteries should be placed in areas where the environment is clean and low in humidity.
- The tools required for installation are as follows: If applicable, the tools used must be insulated.




Once the battery module has been unpacked and no physical damage is apparent, turn on the battery by moving the circuit breaker switch to the "on" position. The state of charge (SOC) and operating light should turn green.

Note that for safe air or sea freight transport, LiFePO4 batteries must be shipped at a state of charge between 30% and 50%, corresponding to a voltage range of 48 V to 50 V. This practice is in accordance with UN38.3 guidelines. These batteries are considered to be "in storage" during shipping or transport.

IMPORTANT NOTE: The following recommendations should be followed after unpacking the battery and before installation.

After unpacking, the battery could be in **standby mode** and needs to be reset for 1 second (see the reset table in Appendix 4). It is recommended to always reset the battery after unpacking; it does not harm the battery. After the reset, measure the voltage to confirm that the battery is working and active. (The battery could have been put into standby mode if it had been stored for a period of time.)

After the above verification step, the measured voltage will be less than the float voltage rating. It is recommended to pre-charge the battery before installation. (See manual for the process of recharging the stored battery)

Pre-charging of the battery module is optional. Upon establishing electrical connectivity between the rectifiers and the battery system, and energizing the power plant, the integrated charging circuitry will initiate automatic recharging of the battery to its rated state of charge (SOC). Depending on the number of batteries and rectifiers available, it may take some time to reach 100% state of charge (SOC).

Installing the Battery Modules

Battery Module Mounts

(See Appendix 8 for part numbers)

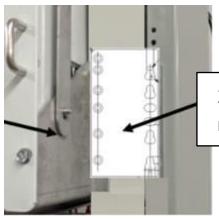
MPLHE series battery modules are designed for horizontal installation in cabinets or racks.

- The 36 MPLhE100, 48MPLhE100, 48MPLhE100-16 and 48MPLhE200 battery modules come with the 19" L bracket pre-installed.
- For the 48MPLhE100 and 4848MPLhE100-16 models, the 23" L extension plate brackets are packaged in the battery module box for use in a 23" rack configuration.
- The 48MPLhE200 is a heavy battery. Therefore, it is recommended that the front mounting brackets on the battery be used in conjunction with a shelf to support the battery.
- If no shelf is to be used, then the supplied 48MPLhE200 center mounting bracket should be used.
- These batteries can also be installed on a customer-supplied rack or cabinet shelf. For the 48MPLhE200, a battery shelf is recommended whenever possible. If not, use the center mounting bracket, as shown below.

19" L-Bracket
36MPLhE100
48MPLhE100
48MPLhE100-16

Can be rotated for Mid Mount

Use the Extension Plate for 23" rack installation for the 36MPLhE100, 48MPLhE100, and 48MPLhE100-16



For 48MPLHE200, the front bracket for 19" is fixed. Use the 19" support bracket for center mount. Recommended if not using a shelf.

For 48MPLHE200. The extension plate/bracket shown above is used to extend the bracket to a 23" mount.

The L-brackets for 36MPLhE100, 48MPLhE100 and 48MPLhE100-16S can be removed and rotated 180° for a center-mount installation.

The minimum spacing between batteries is 10 mm (approx. 0.39 in) or greater.

Example of a complete set of batteries in a cabinet.

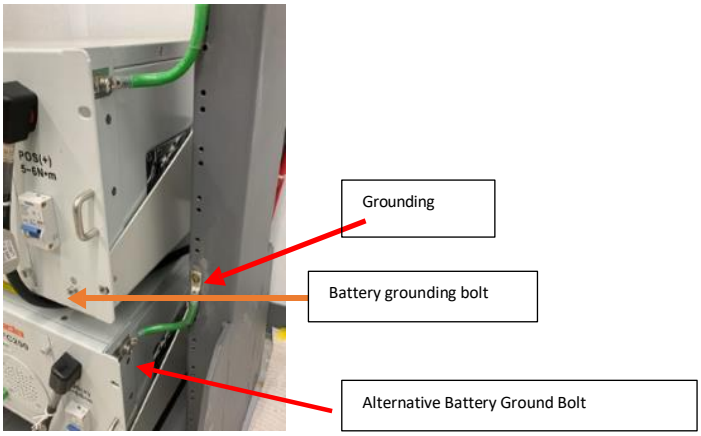
Mount the appropriate bracket to the battery, then insert and secure the battery module horizontally in a cabinet or rack. Attach the two battery mounting brackets (left and right) to the cabinet or rack posts using bolts suitable for locking the rack or cabinet in place. Batteries can be inserted in any order, but it is recommended to start at the bottom to allow for future growth and a lower center of gravity.

Stacking the MPLhE Batteries directly on top of each other should be limited to 2 batteries. Use Rubber anti-vibration pads with a thickness of 10 mm or greater to provide separation between batteries. MPINarada does not supply these anti-vibration pads.

Ground connection

After mounting the battery module to the rack/cabinet, connect the battery to ground using a sheathed GREEN flexible cable; the grounding wire should be at least 6 AWG. The ground bolt connection is on the front of the battery module or, if preferred, on the right side of the cabinet (as shown).

NOTE: The rack or cabinet must be grounded to the building ground to provide an effective battery grounding system.



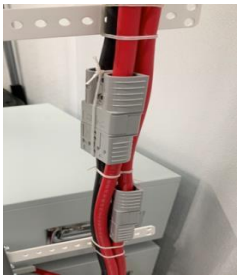
Ground connection for MPLhE series batteries

Preparing Cables for Connections – Cable

(Use stranded cable for maximum installation flexibility)

⚠ **NOTE: Do not make any final connections to the Power Plant until later in the instructions.**

- Cable lengths should be as equal as possible for all batteries. This will ensure that the discharge power of each battery is shared equally among the installed batteries.
- The length of the cable between the battery module and the busbar of the power station should not exceed 2.5 m / 8 ft.
- Use the National Electrical Code (NEC) to select the cable size for the permitted cable capacities. Use and cut your red (positive) and black (negative) cables to the appropriate lengths.
- The 36MPLhE100, 48MPLhE100, 48MPLhE100-16S, and 48MPLhE200 all have a maximum flow rate of 100 amps.
- To make it easier to test and/or replace battery modules, consider adding battery quick/disconnect connectors on the power cable (not supplied by MPINarada). Make sure they are properly installed and that the connections are sized to the cable conductor. (See image for example)
- Pass the negative (black) and positive (red) cables from the rack side to their respective busbars.
- Lace or tie the cables to the rack bracket and post to keep them organized.



Cable lugs

The battery connections and busbar protections are similar to those of VRLA battery installations.

Make sure the battery circuit breaker is "OFF" and remains off until all final connections are complete.

Use only UL/ULC-approved lugs.

For battery terminal connection, a flared (or bell) cylinder lug with an inspection window is recommended. Use the manufacturer's recommended crimping and crimping die for the selected lug. This is important to ensure a secure, correct connection of the cable to the lug. Improper compression of the lugs could result in a high-resistance connection over time. For the battery terminal connection, the torque of the M6 or M8 bolt is 7 Nm (62 in-lbs.).

Battery Termination at Terminal

For busbar cable connection: Long lug with flared barrel or bell, preferably a 2-hole connection. Use the manufacturer's recommended crimping and crimping die for the selected lug. This is important to ensure a secure, correct connection of the cable to the lug. Improper compression of the lugs could result in a high-resistance connection over time. Tighten the cable mounting lug (or bell entry lug) according to the lug manufacturer's recommendations.

Busbar Termination Terminal

The terminals are constructed of cathode metal and are less active than the lead terminals found in lead-acid batteries. In addition, MPLHE LFP batteries are typically installed in dry environments with lower levels of floating sulphur dioxide.

If you use tin-coated copper or copper lugs, there is no significant risk of galvanic corrosion because these materials are also cathodic.

Customers can still use conductive grease if they feel that the installation is in a high-humidity environment or in outdoor cabinets that are not environmentally controlled.

Using conductive grease on terminal connections is optional and will not affect the battery's performance.

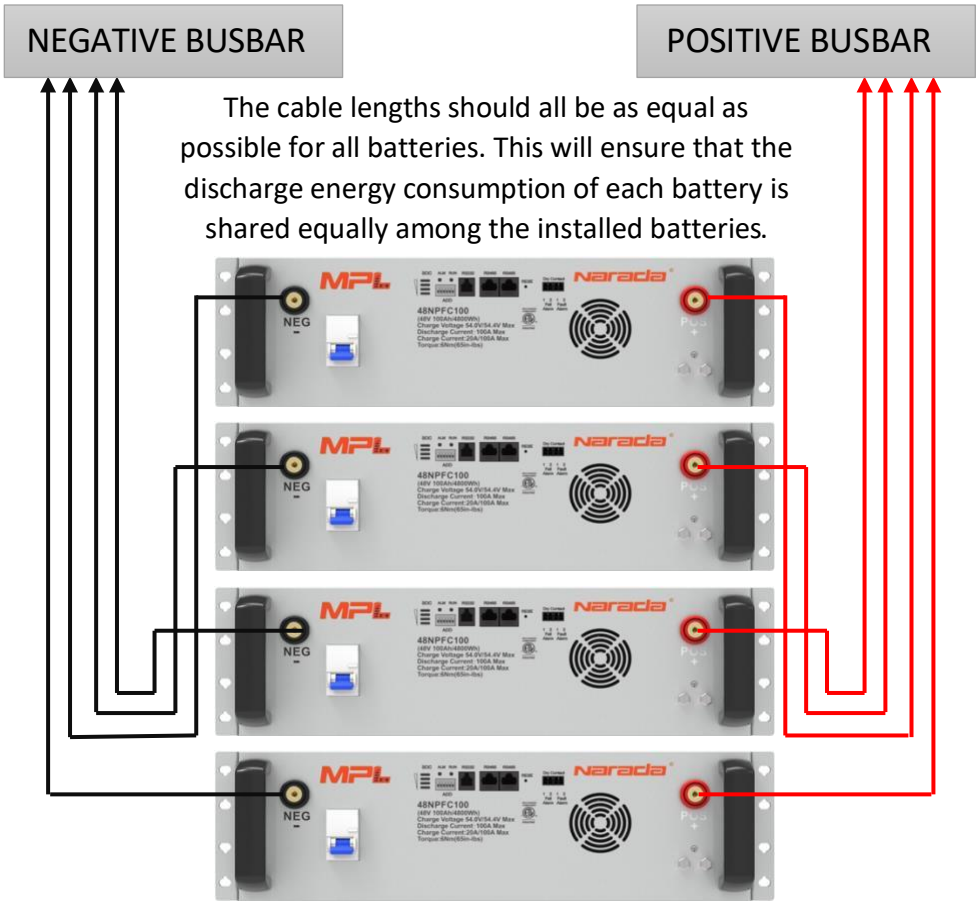
Final Connections

Battery Cable Installation

Note: Make sure the battery circuit breaker is "off" and the busbar power is isolated.

- Do not connect cables to the power plant busbars until the operations team has released the work activity to proceed.
- If multi-battery modules are connected in parallel, please note the following:
  - No more than 8 – 36MPLhE100, 48MPLHE100 or 48MPLhE100-16 battery modules and 6 - 48MPLHE200 connected in parallel in the rack or cabinet. Consider the space required for cable management in the rack or cabinet.
- Connect the negative '-' of the battery output cable with the negative busbar of the power plant and then connect the positive '+' of the battery output cable with the positive copper busbar of the power plant, separately for each LFP battery in the rack or cabinet.

Fig. 4-2 Parallel connection arrangement for MPLhE series batteries



Turn on the battery module.

- **Important note:** To protect against potential inrush, only turn on the battery breaker after the power plant busbars have been energized.

- If the DC power plant supply is not energized, keep the battery off (circuit breaker in the off position) until the main power busbar has been turned on.

- When the battery and cable installation is complete, the battery module remains inactive.

- Once the main DC power plant busbars are turned on (busbars energized), turn on the batteries one at a time and allow them to charge fully. Pre-charging the batteries before installation will shorten the time required for the power plant to fully charge them to 100% SOC and reduce the rectifiers' charging load. The battery will also now enter its operating state, and discharge/charge will be available.

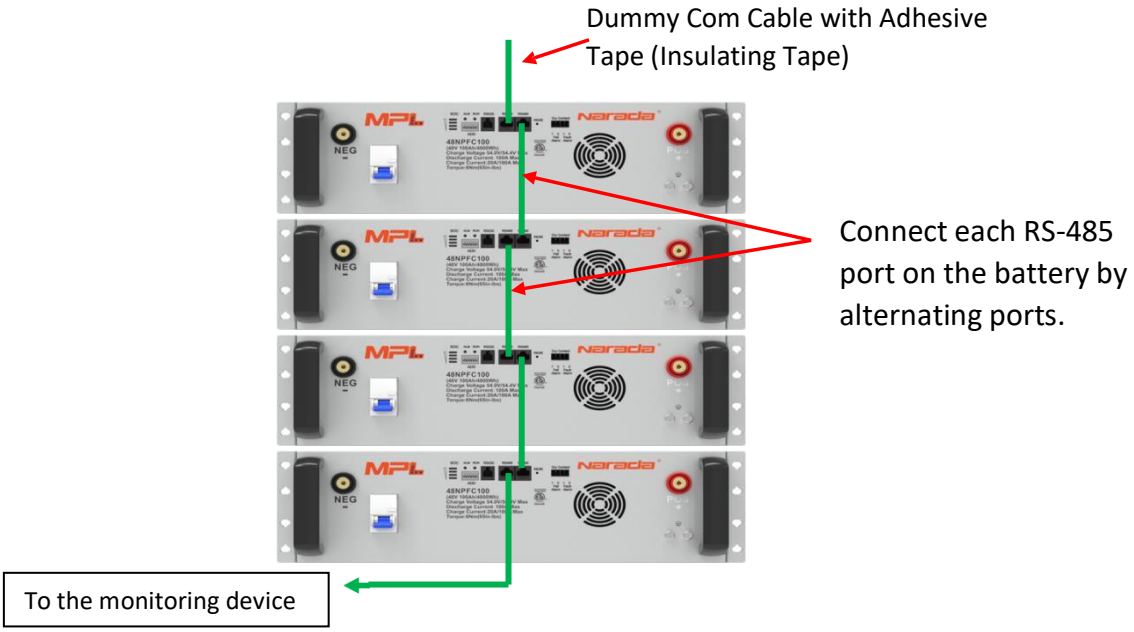
- After charging to 100% SOC, verify the battery system voltage. Turn off the battery breaker, connect a multimeter (VDC setting) to the positive and negative battery terminals, observing polarity. Turn on the battery. Check that the voltage is between 40 VDC and 42 VDC for the 36MPLhE100, and between 48 VDC and 54 VDC for the 48MPLhE100 and 48MPLhE200. For the 48MPLhE100-16S, the voltage is between 51.2 V DC and 58 V DC, and the red ALM LED is off for more than 30 seconds. The voltage readings may not reach the float voltage level for the battery because the BMS is running the charge-balancing algorithm. This is normal.

RS-485 Communication Connection

- If monitoring only one battery module in operation at a time, communication is between the battery module and the computer using an RS-485 cable. The dip setting for the battery needs to be set 1 on (up), and 2, 3, 4, 5, and 6 are off (down).

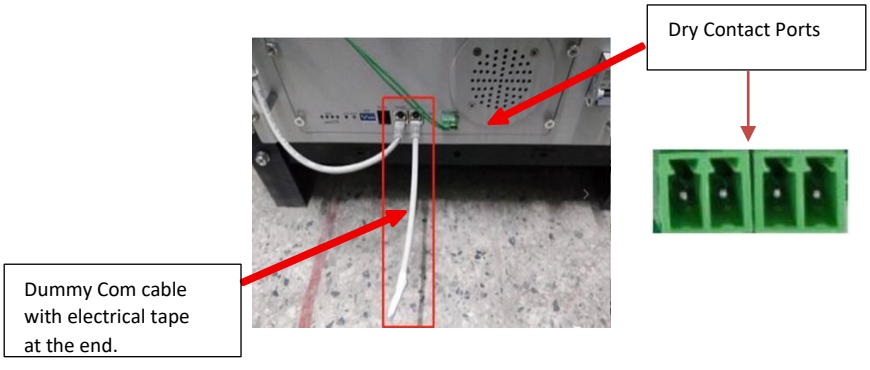
- If more than one battery module is working and monitoring as a group, the communication is done using RS-485 between the battery modules and a connection to the monitoring device. See Appendix 2 below for DIP switch settings for each battery.

How to run and connect the RS-485 cables for group battery monitoring



How to Handle the Empty RS-485 Port for MPLHE Series Batteries and View of Dry Contacts

The last battery in each rack has an empty RS-485 port. To avoid interference with communication, it must be connected using a cable with an RJ45 (Dummy Com Cable) terminal. The other end of the cable should be covered with electrical tape. (See image) There is no need to add a resistor.



Contact MPINarada for the appropriate laptop software and BMS Manual for use with on-site direct battery monitoring.

Contact MPINarada for the BMS Modbus Tables for programming remote monitoring devices.

RS232 Port

- The RS232 port is for factory use only.

Dry Contacts

Dry Contact Port Assignment	***Dry contact port 1 (pin 1 and pin 2):*** cell failure (cell voltage too low, less than n*1.7 V, n = number of cells), voltage difference too large (greater than 800 mV).
	Dry Contact Port 2 (Pins 3 and Pins 4): BMS Failure (Charge/Discharge MOS damage, 940 damage, disconnection of the battery)

- The dry contact should be connected after the battery is connected.
- Dry contacts, if necessary, should be wired to the communication and alarm ports of the power plant.
- Maximum load capacity of dry contact is: 30V/1A
- Dry contacts are normally closed.

See APPENDIX 5 for the system commissioning checklist.

MAINTENANCE

GENERAL

The MPLhE batteries are self-contained and require minimal attention. However, proper maintenance will extend a battery's life and help ensure it meets its design requirements. A good battery maintenance program will also help determine when batteries need to be replaced. If maintenance procedures other than those recommended in this document are used, users should consider their application and reliability needs. Battery maintenance should be performed by personnel who are familiar with batteries and the required safety precautions. Proof of maintenance performed may be required for warranty purposes.

- A single Module failure is not critical but needs to be addressed. The remaining batteries will continue to operate normally.
- Clean any dust with a medium-powered vacuum when it collects on the vent.
- Clean the battery case with a clean, dry cloth. If you need additional cleaning, please use a neutral cleaner (such as cleaning wipes). Alcohol or ammonia should never be used
- Transporting the battery must be handled gently to avoid violent contact.
- Prevent liquid splashes on the battery.
- Inspect and tighten M6 or M8 bolts to 7 Nm or 62 in-lbs. on the battery power terminals every two years.

TROUBLESHOOTING AND SOLUTIONS

Trouble	Troubleshooting	The solutions
The battery cannot discharge.	Undervoltage protection	Charging the battery
	Overheating protection or under temperature (cell temperature below -20 °C or above 70 °C)	Regulating the temperature of cells in range from -20°C to 70°C for flow
	The battery output is short-circuited.	Clear short circuits and charge the battery.
	Overcurrent protection.	Remove non-critical load and recharge the battery.
	System failure	Turn off the system and call for service.
The battery cannot be charged.	The battery is fully charged.	No action required.
	Surge protection	No action required.
	Overheating protection or under temperature (cell temperature below -10°C or above 70°C)	Regulate the cell temperature in the range of 0°C to 55°C for charging
	System failure	Turn off the system and call for service.
All LED indicators are on	System failure	Shutdown system Call the maintenance service
Communication Failure	Communication cable failure	Inspect the communication cable
	Stopping System Communications Management	Press the RESET button.
	System failure	Shutdown system Call maintenance for service
BMS reset	Resetting the BMS may correct some error messages and/or system functions. See APPENDIX 4.4 for reset instructions.	The battery has returned to normal operation.

The LED indicators' different flashing states correspond to their operating states or alarms. Appendix 1 provides detailed information.

APPENDIX 1 – LED Flash Instructions

Appendix Table 1.1 – Description of SOC LEDs

				SOC Range Indication
●	●	●	●	75% - 100%
●	●	●	◎	50% - 75%
●	●	◎	◎	25% - 50%
●	◎	◎	◎	0% - 25%

Note: ● means light on, ◎ means the light is off

Appendix Table 1.2 – Description Of Running Indicators

Battery Status	Narada Default Setting Normal/ ALM/ Protect	RUN	ALM	Battery LED	Explanation
		●	●	● ● ● ●	
Breaker OFF	Sleep Mode	OFF	OFF	OFF	
Standby	Normal	Flash 1	OFF		If Temperature Alarm , then ALM LED = Flash 3 When SOC is too low ALM is OFF
	ALM	Flash 1	OFF		
Charge	Normal	Flash 2	OFF		
	ALM (without Temperature)	Flash 2	OFF		If Temp alarm the ALM = Flash 3
	Overcharge Protection	Flash 1	OFF	According to the battery SOC indicator 1 GREEN = 0% -25% 2 GREEN = 25% - 50% 3 GREEN = 50% - 75% 4 GREEN = 75% - 100%	
	Over Temp Protection, Under Temp Protection, Over Current Protection	Flash 1	Flash 2		
	Charge Current Limit	ON	ON		
Discharge	Normal	ON	OFF		
	Alarm (excluding discharge overcurrent alarm)	ON	Flash 3		Special Case description; If discharge over current alarm the ALM = OFF
	Over discharge Protection	Flash 1	OFF		
	Over Temp Protection Under Tempo Protection Over Current Protection Short Circuit Protection	Flash 1	Flash 2		
Invalid	Fault	OFF	ON	OFF	Faults refer tto Hardware faults such as BMS Voltage sampling device, charging MOS damage, temperature sensor disconnection etc.

Appendix Table 1.3 – LED Indicator Flashing Instructions

Flash status	Interval ON	Interval OFF
Flash 1	0.25 sec	3.75 sec
Flash 2	0.5 sec	0.5 sec
Flash 3	0.5 sec	1.5 sec

APPENDIX 2 – INSTRUCTIONS FOR SETTING ADDRESS DIP SWITCH

The ADD DIP switch applies to modules that are connected in parallel. The ADD consists of 4 binary bits, and the maximum number of parallel modules per power plant is 16.

Table 2.1 – Instructions for the Communication Addresses

Instructions for ADD Dialing				Module No.	Binary Code	Remarks
1	2	3	4			
OFF	OFF	OFF	OFF	Pack 1	0000	Master PACK, supports RS232
ON	OFF	OFF	OFF	Pack 2	0001	Expansion PACK
OFF	ON	OFF	OFF	Pack 3	0010	Expansion PACK
ON	ON	OFF	OFF	Pack 4	0011	Expansion PACK
OFF	ON	OFF	OFF	Pack 5	0100	Expansion PACK
ON	OFF	ON	OFF	Pack 6	0101	Expansion PACK
OFF	ON	ON	OFF	Pack 7	0110	Expansion PACK
ON	ON	ON	OFF	Pack 8	0111	Expansion PACK
OFF	OFF	OFF	ON	Pack 9	1000	Expansion PACK
ON	OFF	OFF	ON	Pack 10	1001	Expansion PACK
OFF	ON	OFF	ON	Pack 11	1010	Expansion PACK
ON	ON	OFF	ON	Pack 12	1011	Expansion PACK
OFF	OFF	ON	ON	Pack 13	1100	Expansion PACK
ON	OFF	ON	ON	Pack 14	1101	Expansion PACK
OFF	ON	ON	ON	Pack 15	1110	Expansion PACK
ON	ON	ON	ON	Pack 16	1111	Expansion PACK

Table 2.2 – DIP Switch instructions for Parallel Communication

Please also refer to the BMS Manual available from MPINarada support.

PACK 1 0000 ADD	PACK 2 0001 ADD	PACK 3 0010 ADD	PACK 4 0011 ADD	PACK 5 0100 ADD	PACK 6 0101 ADD	PACK 7 0110 ADD	PACK 8 0111 ADD
PACK 9 1000 ADD	PACK 10 1001 ADD	PACK 11 1010 ADD	PACK 12 1011 ADD	PACK 13 1100 ADD	PACK 14 1101 ADD	PACK 15 1110 ADD	PACK 16 1111 ADD
NOTE: Counting of ADD shall begin from 0000, without interruption, or parallel communication cannot be available							

APPENDIX 3 – COMMUNICATION PROTOCOL FOR RS-232 AND RS-485

The front panel has an RS-485 port for communication between the battery and the PC, and another for communication between the battery modules connected in parallel.

The cable part number, NPFC-COM-RS485, for the above batteries should be included on the PO at one per site.

The cable is delivered in 2 parts. Connect the cables to the DB9.

Contact MPINarada for the latest laptop configuration file, BMS reader software, and BMS-PC manual.

BMS settings can be viewed on laptops or with customer-provided remote monitoring software. MPINarada support provides the Modbus BMS table to program the remote monitoring software.

APPENDIX 4 – RESET BUTTON INSTRUCTIONS

Appendix Table 4.1 – Definition of the Reset Button

Button	Sleep	Press the button for 3 seconds and release it. The BMS will sleep and the LED indicator will light up for 0.5 seconds from "RUN".
	Activation	Press the button and release it after 1S, the BMS will be activated, and the LED indicator will light up for 0.5 seconds from "L1".
	Reset	Press the button and release it after 10S. The BMS will be reset. The LED light will be on successively from "L1" for 0.5 seconds.

APPENDIX 5 - Procedures for the Commissioning of MPLHE Batteries

Note: If your company has a preferred commissioning procedure, it should be followed. The following is a recommended procedure for those without a standard process.

Commissioning item	Analysis and verification procedure	Step-by-step procedure	Expected results
IMPORTANT: Do not connect to the main power supply until the following steps are complete.			
Visual inspection	Check for physical damage, loose connections, and proper mounting	1. Visually inspect the battery case for dents, cracks, or leaks. 2. Make sure the terminals are clean and free of corrosion. 3. Confirm that all fasteners and brackets are secure. 4. Check for proper cable routing without pinch points or tight bends. 5. Check that all battery labels are intact and legible.	No visible damage, secure connections
Checking the battery voltage	Measure the individual battery voltage using a multimeter.	1. Turn OFF the battery breaker. 2. Set the multimeter to DC voltage mode. 3. Connect the positive (red) wire to the positive terminal of the battery. 4. Connect the negative (black) wire to the negative terminal. 5. Record the voltage reading. 6. Turn ON the battery breaker 7. Compare the measured voltage with the manufacturer's specifications.	Voltage within the range specified by the manufacturer
Polarity Verification	Confirm the correct polarity of the battery terminals	1. Observe the battery terminals; Check for positive (+) and negative (-) marks. 2. Use a multimeter to confirm polarity before connecting to the system. 3. If the polarity is incorrect, correct the wiring immediately and check again before continuing.	Correct polarity, no inverted connections
Battery Management System (BMS) Check	Verify the functionality of the BMS and communication with the monitoring system	1. Turn on the BMS and check the boot sequence. 2. Check the software display or interface to see if there are any error codes or warnings. 3. Confirm communication with the monitoring equipment through the designated interface. 4. The BMS manual will provide detailed instructions on how to access and view the BMS screens. Contact MPINarada support for the manual or www.MPINarada.com	BMS up and running, no error codes

Commissioning item	Analysis and verification procedure	Step-by-step procedure	Expected results
Load test	Apply a controlled load and monitor voltage drop	1. Connect a calibrated load to the battery system. 2. Slowly increase the load to the recommended test level. 3. Monitor the voltage drop using a multimeter or monitoring system. 4. Observe the behavior of the system to check stability. 5. Record the data and compare it to the manufacturer's specifications.	The voltage remains stable within acceptable limits.
Temperature Monitoring	Check the battery temperature during operation	1. Use an infrared thermometer or built-in sensors to measure the temperature of the battery. 2. Record readings at different intervals during operation. 3. Compared to the acceptable operating temperatures set in the manual.	Temperature within the safe operating range
Capacity testing	Discharge the battery at the rated load and measurement capacity	1. Unplug external power sources. 2. Apply a constant charge to discharge the battery to its rated capacity. 3. Monitor the progress of discharges and record the operating time until the cut-off voltage is reached. 4. Check the results against the manufacturer's specifications.	Capacity meets or exceeds the manufacturer's specifications.
Testing of safety features	Check protections against overload, over-discharge, and short circuit	1. Check for overload and discharge protection warnings. 2. Simulate controlled fault conditions (e.g., overcurrent test) if it is safe to do so. 3. Reset the system after each test and confirm regular operation.	The security mechanisms are working properly.
Final system integration	Ensure proper integration with the telecommunications power system	1. Connect the battery system to the telecommunications equipment by following the wiring diagrams. 2. Check the communication with the energy management system or power distribution unit. 3. Perform a system-wide test, including a simulated failure. 4. Check the proper switching operation during the power outage.	Flawless and fault-free operation

APPENDIX 6 - Maintenance Procedures Checklist

Here is a detailed step-by-step maintenance checklist for MPI Narada's Lithium-Ferrous Phosphate (LFP) batteries.

Power Technician _____

Narada LFP Battery Care Procedure Site _____

Stage	Procedure	Step-by-step instructions	Completion Date
1. Security checks	Check **the condition of PPE** and use them for the maintenance procedures (gloves, goggles, insulated tools).	1. Wear insulated (rubber) gloves and safety glasses before handling batteries. 2. Make sure insulated tools are used to avoid accidental short circuits.	
	Make sure the **fire suppression system is** operational.	1. Check that the fire extinguishers are properly charged and have an expiration date. 2. Check that the sensors on the fire suppression system are active.	
	Confirm **that the battery system** is properly grounded. Confirm the Building ground.	1. Inspect the grounding cables to check for secure connections. 2. Use a multimeter to check the continuity between points on the ground.	
2. Visual inspection	Check for any physical damage to the battery case.	1. Look for cracks, dents, or swelling on the battery case. 2. Report any damage immediately.	
	Inspect **busbars, lugs, and interconnects** for corrosion or loose connections.	1. Use a flashlight to inspect the busbars and lugs. 2. Tighten loose connections using an insulated wrench or screwdriver. 3. Clean corrosion with an approved battery terminal cleaner.	
	Check that the **BMS light** is working properly.	1. Check the LED indicators on the front panel of the battery. 2. Refer to the BMS manual for the meaning of the LED status.	
	Make sure the **rack is properly mounted** and that all connections are secure.	1. Check that the batteries are securely mounted in the racks. 2. Make sure the cables are routed correctly to avoid strain. Tighten and secure the mounting bolts.	

Stage	Procedure	Step-by-step instructions	Completion Date
3. Battery Management System (BMS) Monitoring	Review BMS logs for voltage, current, and temperature readings.	1. Access the BMS interface through the monitoring system. 2. Record voltage, current, and temperature values.	
	Check that the battery voltage is approximately 40V to 41V for the 36MPLhE100, 50.3 V to 51 V for 48MPLhE100 and 200, and 53.6 to 54.4 V for 48MPLhE100-16	1. Use a multimeter to measure the battery voltage. 2. Compare readings with BMS logs. Note that these voltages are the "resting" voltages.	
	Check the **state of charge (SOC)** and **health status (SOH).**	1. Go to the SOC/SOH section of the BMS interface. 2. Record the values and compare them to the expected return.	
	Identify **active alarms** and document them.	1. Check the alarm register in the BMS. 2. Investigate and resolve any critical alarms.	
	Record the **current number of battery cycles**.	1. Locate the number of cycles in the BMS interface. 2. Compare with expected service life.	

Stage	Procedure	Step-by-step instructions	Completion Date
4. Charging	Confirm that the charging voltage is 43.2 V ± 0.2 V for the 36MPLhE100. Confirm that the charging voltage is 54.0 V ± 0.5 V for the 48MPLhE100 and 48MPLhE200. Confirm that the charging voltage is 57.5 V ± 0.5 V for the 48MPLhE100-16	1. Use a Voltmeter to Measure the Load Voltage of Rectifiers .2. Adjust the settings if the voltage is out of range.	
4A. LVDC Level	Make sure the discharge voltage does not drop below **32.4V** for the 36MPLhE100. Make sure the discharge voltage does not drop below **40.5V** for the 48MPLhE100 and 48MPLhE200. Make sure the discharge voltage does not drop below **43.2V** for the 48MPLhE100-16	1. Monitor discharge cycles in the BMS. 2. Prevent deep discharges by adjusting the loading settings.	
	Avoid deep discharges below 80%; the BMS handle the charge cycles.		
5. Controlled Load Test	Apply a **controlled release** at a rate of **0.5 C to 1 C**.	1. Connect a test load to the battery system. 2. Set the flow rate from 0.5C to 1C. 3. Monitor voltage drop and recovery time.	
6. Temperature and humidity management	Maintain the operating temperature between **15°C and 35°C**.	1. Use a temperature sensor to check the status of the battery room. 2. Adjust the HVAC settings if the temperature is out of range.	
	Ensure **adequate ventilation** to prevent overheating.	1. Check the airflow around the battery racks. 2. Clean ventilation filters if necessary.	
	Check the **humidity levels** in the battery room (must be below **60% RH).**	1. Use a hygrometer to measure humidity. 2. Adjust dehumidifiers if the humidity is too high.	
7. Storage and Handling	Please charge the battery to **50% of its capacity before long-term storage**.	1. Use the BMS to set the battery charge level to 50%.	
	Store in a **cool, dry environment** away from direct sunlight.	1. Make sure the temperature of the storage area is controlled. 2. Keep batteries out of direct sunlight or heat sources.	
	Avoid stacking batteries without proper support.	1. Use approved storage racks to prevent damage.	

APPENDIX 7 - Emergency Shutdown Procedures for LFP-Caused Events.

Note: If your company has a preferred Emergency Shutdown Procedure, it should be followed. The following is a recommended procedure for those without a standard process.

This detailed process ensures the LFP battery system can be safely shut down in an emergency, prioritizing personnel safety and minimizing damage. Contact the control center immediately, and if visible flames or smoke are coming from the batteries, call 911 for the fire department.

Procedural stage	Test and verification procedure	Step-by-step procedure	Expected result
Identify emergencies	Confirm the presence of fire, smoke, or other critical hazards	1. Observe the surroundings for signs of fire, smoke or other hazards. 2. Listen for alarm notifications or emergency alerts, e.g., fire 3. If conditions indicate an emergency, contact the control center and be ready to shut power down as instructed by the control center	Emergency confirmed, evacuation initiated
Alert staff	Inform all staff and emergency responders	1. Activate the emergency alarm system if available. 2. Use the radio or telephone to notify emergency response teams. 3. Ensure that all personnel evacuate to designated safety areas.	The staff was informed, and the evacuation was underway.
If smoke or fire is coming from LFP batteries.	Turn the battery circuit breakers to the OFF position.	1. Locate the circuit breaker on the front of the battery. 2. Turn the circuit breakers to the Off position. 3. Call 911	The battery is no longer active.
Disconnect the external power supply.	Turn off the main power to the battery system.	1. Locate the main battery disconnect switch or circuit breaker. 2. Use gloves and insulated tools to turn off the power supply safely. 3. Confirm that the system is turned off using a multimeter or voltage tester.	The power supply is cut off, preventing the flow of energy.

Procedural stage	Test and verification procedure	Step-by-step procedure	Expected result
Deploy fire suppression services (if required)	Use appropriate fire suppression methods (e.g., Class D fire extinguishers for lithium fires)	1. In the event of a fire, locate the designated lithium-ion fire extinguisher. 2. Point the fire extinguisher at the base of the flames. 3. Anti-release agent according to the manufacturer's instructions. 4. Continue suppression efforts until the fire is contained or emergency responders take control.	The fire was successfully extinguished, and the danger was contained.
Secure the area	Restrict access to the affected area until emergency responders arrive	1. Establish barriers or restrict entry points to the affected battery system area. 2. Ensure that all staff remain at a safe distance. 3. Wait for instructions from emergency responders before entering the site.	Secure area, preventing unauthorized access.
Report on the incident	Document shutdown actions and report to the appropriate authorities	1. Record the time, the stopping steps performed, and the conditions observed. 2. Notify supervisor and emergency services. 3. Submit a formal incident report for investigation and review.	Recorded incident; Investigation opened.
Assessing the system after an emergency	Inspect the battery system before reactivating it.	1. Perform a detailed inspection to detect burns, melted components, or structural damage. 2. Verify the status of the LMS and ensure that all system functions are operational. 3. Confirm the approval of the site engineers before restoring normal operation.	The system has been evaluated and is safe to use or replace.