KiloVault®- HLX Series
Lithium Iron Phosphate (LiFePO4)
Deep Cycle Solar Batteries

Installation and User's Manual

Release Date: August 13, 2019

Revision: 20190813

Contents

The KiloVault® HLX series of solar lithium batteries are specifically designed and tested for the beating that serious hybrid, off-grid inverters, and solar charge controllers can throw at them. Compared to traditional deep cycle batteries, the HLX Series' lithium battery technology more efficiently stores and delivers the renewable energy that you have generated, with no maintenance on your part.

This manual contains important information regarding the safe use of KiloVault® HLX series batteries. Your battery is an electrical device that will provide years of useful service with proper care. Ensure you read and understand the instructions contained in this manual before use.

FEATURES:

- Flexible: Works in 12Volt (V), 24V, or 48V configurations
- Gives You More: Use the full battery capacity, discharging it 100%
- Long-life: Even after 2000 full discharges, 80% of the total battery capacity remains
- Maintenance Free: No watering or cleaning of hazardous chemicals required
- High Efficiency: Providing up to 12% more useable stored energy
- Smart Investment: Lower cost per watt-hour/cycle and longer lifespan than lead batteries
- Safer: No thermal run-away issues as with other lithium technologies
- Heavy Duty: Takes up to 150 Amp (A) of continuous charging/discharging current, meeting the tough demands of serious inverters and chargers
- Integrated Battery Management System (BMS)
- Bluetooth Monitor Application
- 3-Year Limited Warranty

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1. Safety Information

1.1. Definitions

	**Warning:** Indicates a condition that can cause personal risk or injury.
	**Caution:** Indicates a condition that can cause equipment damage.
	**Note:** Indicates points of particular emphasis that make operation more efficient or convenient.
	**Disclaimer:** Indicates information limiting the scope of responsibility.

1.2. Important Safety Information

It is essential to read, understand, and follow these instructions when using KiloVault® batteries.

	**Warning:** High voltage risk, improper use may cause personal injury or death.
	**Warning:** Do not use a battery that appears damaged in any way.
	**Warning:** All batteries present the risk of shock, use protective measures when handling. • When working with or installing batteries use electrically insulated gloves and tools • Remove personal metal items such as watches, rings, bracelets, etc.
	**Warning:** High voltage connections of batteries (configurations of greater than 36V DC nominal) are dangerous. DC voltages over 52V can stop the adult human heart and a fully charged 48V nominal system is over this level. Use appropriate safety measures including the removal of metal personal items and insulated gloves.

	**Warning:** A small risk of spark exists while making electrical connections. • Ensure the installation area is free of explosive gasses and liquids. • Ensure the batteries are not installed in confined areas containing explosive substances. This includes flammable fuel powered machinery, holding tanks, pipe fittings, and connectors.
	**Warning:** In the unlikely event of a fire, when possible first shut off the source of electricity. Class ABC extinguishers are recommended in close proximity of your power generating equipment and are best suited for multipurpose fire types such as wood, flammable liquids, and electrical appliances.
	**Warning:** Respiratory irritation may be caused if the battery is punctured or cracked.
	**Warning:** Skin contact with a punctured or otherwise open battery can cause irritation.
	**Warning:** To avoid risk of shock or fire, ensure all wires are properly sized and in good condition.
	**Warning:** Verify all equipment to be connected to the batteries is turned **off** before making any electrical connections.
	**Warning:** Do not submerge the batteries. This can cause personal injury and will void your warranty.
	**Warning:** Do not attempt to disassemble the batteries. This can cause personal injury and will void your warranty.

2. Overview

2.1. Product Technology

- 12 Volt Lithium Iron Phosphate (LiFeP04) with Bluetooth
- Model Types: KLV1800HLX (150Ah/1800Wh) / KLV3800HLX (300Ah/3600Wh)
- LiFeP04 chemistry prevents thermal runaway as opposed to other lithium technologies.
- IP55 Rated
- KiloVault® batteries can be used in RV applications for electrical appliances ONLY. They can NOT be used to crank over motors in such vehicles.

2.2. Battery Management System

Every KiloVault® battery contains a BMS that helps protect it from over voltage charging/discharging, over current charging/discharging, and extreme temperatures while charging and discharging. While this system is robust, batteries must be installed using appropriate inverter charge controller settings, devices to protect them from open photovoltaic (PV)/solar panel voltage, and other high voltage charging sources. Failure to adhere to proper installation requirements will void the warranty and may damage the system.

2.3. Bluetooth Monitoring Application

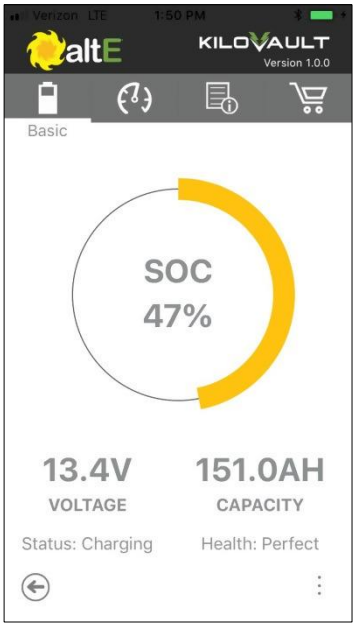
The KiloVault® smartphone Bluetooth app enables you to view general information about the selected individual battery. It can help troubleshoot when attempting to detect the cause of the battery bank going off-line. The app is available for free download for both Android and iPhone phones. Each battery is identified by a unique serial number located on the battery label.

	**Disclaimer:** The KiloVault® Bluetooth Application is provided as is and is solely intended to gather general information. It is not intended to replace a volt meter, nor guaranteed to work with every device.
	**Note:** Your Android/iPhone must support Bluetooth Low Energy (BLE). Additionally, for the Android app to work you must permit access to *Location* and *Local Storage*.

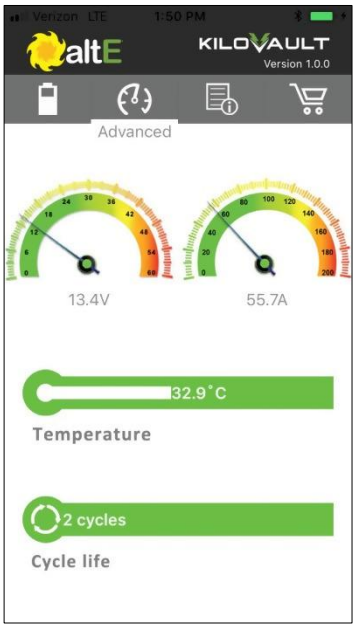
The information displayed includes:

<table>
<tr><th colspan="2">Basic View</th></tr>
<tr><td>

- State of Charge (SOC)
- Voltage
- Capacity
- Status (Charging/Discharging/Standby)
- Health

</td><td> 
</td></tr>
<tr><th colspan="2">Advanced View (swipe right to access)</th></tr>
<tr><td>

- Voltage
- Amps (Charging or Discharging)
- Temperature (Internal Battery Temperature)
- Cycle life (Number of times cycled)

</td><td> 
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3. Installation Requirements

3.1. Pre-Installation

IMPORTANT - PLEASE READ FIRST!

1) Each battery must be individually charged to <u>exactly</u> a voltage between 14.1V and 14.2V (choose one and use it for all batteries) before placing it into operation with other batteries. Otherwise, the batteries will independently hit *full* or *empty* and shut off before others in the same battery bank.
2) Equalization charging <u>must be turned off</u> in your solar charge controller or AC charger. If left on, the equalization charge will raise the voltage too high, damage the batteries, and void the warranty.
3) Bulk/Absorption charge voltage should be set to no higher than 14.1V for a 12V system, 28.2V for 24V system, and 56.4V for a 48V system (and lower for high amp chargers). Anything higher risks one or more batteries automatically shutting off in a high voltage protection mode.
4) Low Voltage Cut-Off on the inverter should be set for no lower than 12.0V, 24.0V and 48.0V for a 12V, 24V and 48V system, respectively. Voltages lower than this risks one or more batteries automatically shutting off in a low voltage protection mode.
5) When turning on breakers to inverters, charge controllers, battery monitors, etc. connected to the batteries wait 45-60 seconds between powering up each device. The KiloVault® battery management system has special circuitry designed to detect short circuits and protect the battery. Many brands of inverters, charge controllers and battery monitors will present a very high but very brief surge that can be interpreted as a short. The BMS can handle one of these perceived shorts every 45-60 seconds. Alternatively, in most circumstances all devices can be powered up at once but the batteries will go into auto-protect mode and turn off for 30-60 seconds but then restart normally.
6) Be sure to tighten the battery terminals before operating. Failure to do so will lead to the terminals overheating, melting the case, and potentially causing a fire.

	**Note:** Due to transportation regulations, LiFePO4 batteries cannot be shipped fully charged. As a result, if you have purchased more than one battery for your system *all* batteries must be fully charged to *exactly* the same voltage before using.

3.1.1. All Batteries Must Be Fully Charged to the Same Voltage Prior to Use

It is very important that each battery be individually charged to exactly the same voltage initially and not less than 14.1 volts before putting the batteries into operation (not applicable if you are using only one battery). Selecting a voltage at 14.1 to 14.2V is recommended but alternatively a precisely selected low voltage will work, such as one between 11.5-12.0V.

	**Note:** After a 12 to 24 hour rest period following the initial charge the voltage will drop to approximately 13.3-13.6V. This is normal, the batteries will not require re-charging. The same holds true when drawing down the batteries. Once the batteries hit the determined low voltage point and the load is disconnected, the voltages will rise back up.

Do not charge the batteries initially to just 13.0 - 13.9 volts. There is a very gradual charge voltage versus capacity curve when charging, especially between 13.6 to 13.9V. Charging them to a value in this range (unlike lead acid batteries) can result in a very broad difference in the actual state of charge versus any other battery in your bank. As a result, any one battery in your bank will prematurely shut down during charging or discharging. See the charging graph below to understand the characteristics of the LiFePO4 charging curves.

Many automotive type battery chargers will not reach 14.1V. Please check charger specifications when selecting your charger or you can contact your KiloVault® distributor for a list of recommended chargers.

3.1.2. Do Not Use DC Chargers Exceeding 150 Amps

Although a nominal charge rate of 100A is recommended on an on-going basis, you can use whatever is available as long as it does not exceed 150A. After the charger is removed for the initial pre-installation charge, allow them to rest for a minimum of two hours.

	**Note:** After the 2-hour rest period, use a DC Voltage meter to ensure that the voltage difference between each of the batteries is not more than 0.2 volts. Failure to take these preliminary charging steps will result in reduced capacity, make the batteries prematurely shutdown during charging or discharging, and could void your warranty.

If the batteries are not charged to exactly the same voltage (preferably above 14.0V), then they are not truly all at the same state-of-charge. As a result, the BMS in one or more batteries will protectively shutdown the battery because it has either reached its high voltage maximum ahead of the other batteries, or prematurely reached its completely discharged voltage. This situation protects the battery bank by placing it into an open condition.

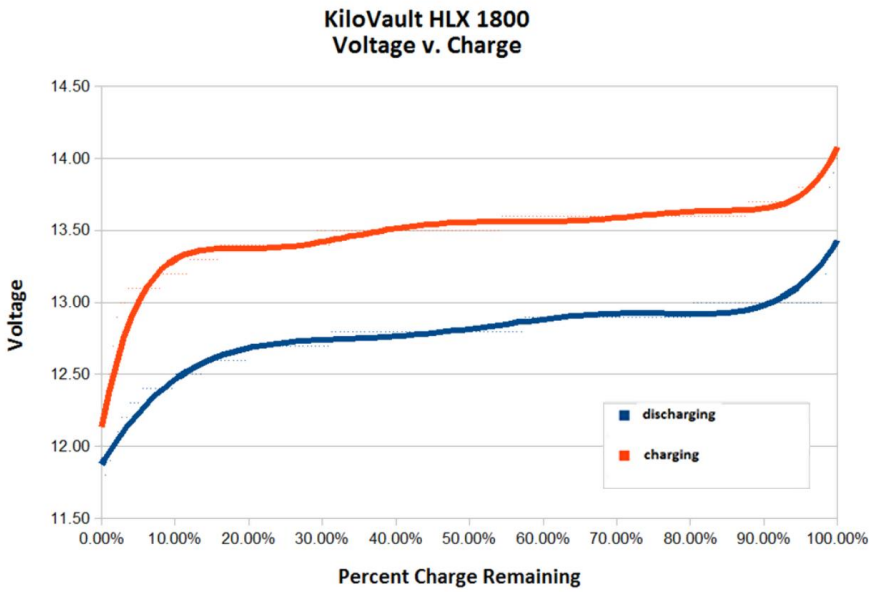

Figure 1: Voltage vs. Charge

There is very little voltage difference between 10% and 95% full in LiFePO4 batteries. To ensure batteries are at the same charge level they all must be initially charged to the same voltage at the tail upper end.

3.1.3. Add Batteries of Exact Same Model Together

	Caution: All batteries in a bank must be the same model. Mixing different batteries will result in unexpected shutdowns and possible damage to the system.

When expanding your battery bank only combine the same model batteries together. Do not mix and match different models or brands. Doing so will result in the batteries unexpectedly shutting down and possibly cause damage.

3.1.4. Disable Your Chargers Equalizing Cycle

	Caution: Disable charge equalizing to prevent damage to your system.

If equipped, charge equalizing must be disabled in your charge controller(s), including the one in your inverter, if it has one.

3.1.5. Do Not Use a Battery Temperature Sensor (BTS)

	Caution:

	Battery Temperature Sensors are not compatible with lithium batteries and will cause damage to your system.

A BTS is often used by battery chargers in lead acid batteries because the “full” voltage changes with temperature. This technology is not compatible with lithium batteries and must not be used. Using a BTS is likely to cause the charge controller to over-charge the KiloVault® battery and damage it.

3.1.6. Temperature and Battery Physical Spacing

Because the batteries warm up while in use, you will want to consider your local average and seasonal temperature when positioning your battery bank. If they will be in a warmer environment you may want to leave a minimum of one inch between each of the batteries. If they will possibly be subject to cold temperatures you may want to place them as closely as possible to each other. Please note that the batteries can discharge several degrees below freezing but they will not charge.

3.1.7. Insulating Battery Enclosure in Cold Temperatures

Insulation around the batteries should also be considered for winter time if the batteries will be exposed to temperatures that approach 32°F (0°C). Below freezing the BMS will not allow charging to prevent damage to the cells.

	**Note:** The battery capacity reduces by 20% between room temperature and just above freezing. Lead acid based batteries reduce capacity by 50% over the same temperature range.

Using an insulated enclosure during these cold periods will maintain more of the heat generated during normal charging and reduce the chances of the BMS shutting down the batteries in cold temperatures. However, please make sure to remove the insulation in the hot months, as overheating the batteries will shorten their life and the BMS will shut down the battery in temperatures above 149°F (65°C).

3.1.8. Battery Interconnect Cabling

Refer to published electrical wiring specifications and ratings for all interconnecting cables. All wire must be the appropriate gauge and construction to handle the loads that will be placed upon it. Heavy gauge, fine stranded copper wire is the industry standard. A minimum of 2/0 or 4/0 AWG copper cable is recommended for battery interconnect cables.

Cables connecting parallel rows of batteries together must be the same length. Cables of differing lengths will cause voltage differences between the rows. Recall that the parallel rows must be kept within 0.2V of each other to ensure they work correctly and large currents do not occur between rows. If your battery bank suddenly shuts down as one or more rows approach fully charged or fully discharged then it’s likely either the batteries are not all at the same state of charge or, if they are measured to be all the same, the voltage drop across the cables connecting the rows is not equal. Using a voltmeter or a multimeter, the measured difference between any parallel rows of batteries

must not be greater than 0.2V (see **Error! Reference source not found.**). Also use the voltmeter to make sure that the voltage drops across each battery interconnect is very close.

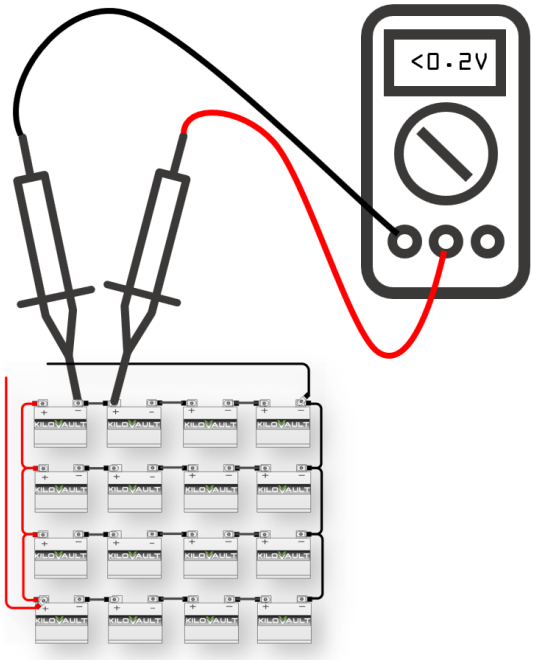

Figure 2: Interconnect Cabling

3.1.9. Digital Voltmeters

Use any standard digital voltmeter with a 0.1V accuracy tolerance to verify battery polarity before making any connections. Also use the voltmeter to measure the voltages of the batteries after the initial charge to ensure they are all within 0.2V (or less) of each other.

3.1.10. Environmental Conditions for Batteries

Ensure the location of the battery bank is dry and as well protected from extreme temperatures as possible. No ventilation is required as these do not off-gas like lead-acid batteries do.

3.2. Installation

Once all Pre-Installation conditions have been met, proceed with installation according the following instructions.

3.2.1. Configurations

The KiloVault® HLX series of batteries can be used 12V, 24V, 36V, and 48V configurations where one, two, three and four batteries, respectively, are connected in a row (plus to minus).

The maximum number of batteries in a bank is limited to sixteen (4 in parallel and 4 in series). Each row of batteries must be kept within 0.2V of each other or the battery bank may prematurely shutdown during charging and discharging.

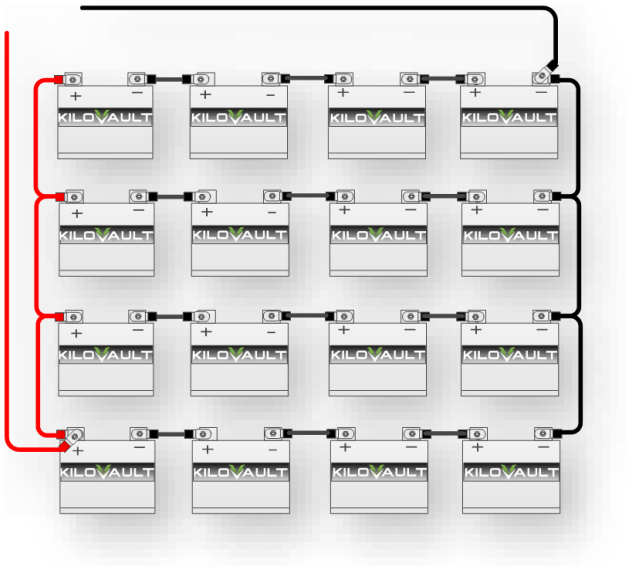

Figure 3: Maximum Configuration

3.2.2. Bolt Tightening

Torque all bolts and battery terminals to 110 In-lb. +/- 10%. Terminals left insufficiently tightened will lead to overheating, melting the battery and potentially causing a fire.

4. Operation

4.1.1. Configuring Charge Controller & Inverter Voltage Set-points

It is very important that your battery charger (solar, inverter or AC) is set to stop charging at a maximum voltage and your inverter should be set to shut down at a certain voltage according to the table below.

Inverter and Charge Controller Set Points

	12V System	24V System	48V System
Inverter Low Voltage Disconnect	12.0V	24.0V	48.0V
Charge Controller Bulk/Absorption Voltage			
<40A Chargers	14.1V	28.2V	56.4V
40-60A Chargers	14.0V	28.0V	56.0V
60-150A Chargers	13.9V	27.8V	55.6V
Charge Controller Float Voltage*			
<40A Chargers	13.8V	27.6V	55.2V
40-60A Chargers	13.8V	27.6V	55.2V
60-150A Chargers	13.8V	27.6V	55.2V

* At full charge rate of 150A we recommend allowing the Absorb charge to last 2 minutes or less to avoid overcharging the batteries. 40-60A chargers are recommended to allow the bulk/absorption charge to last 4 minutes or less, while chargers under 40A should use 6 minutes or less. When the batteries are being overcharged the BMS will turn the battery off, making the battery effectively an open circuit in your battery bank.

4.1.2. Disable Equalization

	**Caution:** Disable charge equalizing to prevent damage to your system.

Equalization mode in your charge controller absolutely must be turned off/disabled or the batteries will be permanently damaged. Equalization charge mode is applicable to flooded lead acid batteries. An indication that equalization was left on is that the battery will show a high voltage (HV) event in the Bluetooth App.

4.1.3. "Gel/Sealed Battery" Settings

If your charger has only limited options for charge settings and Lithium is not an option, select battery type "Gel" or "Sealed Battery". These settings will not be optimal but will work in most cases.

4.1.4. Energize Your Inverter First

Due to the special pre-charging function in the KiloVault® BMS, it is necessary to first connect and energize the equipment that draws the largest capacitive load, such as your inverter. If a smaller device is powered up first, the pre-charge loop in the BMS will be lost and unable to handle the greater in-rush from the larger device.

Power up other devices connected to your battery, like solar charge controllers, battery monitors, etc. one at a time after the inverter, waiting 60 seconds before powering each one up.

Alternatively, in most cases, if everything is powered up all at the same time (or less than 60 seconds of each other) the surge protection circuitry will kick in, shut down the batteries but in less than 1 minute the batteries will restart. If the batteries continue to shut down repeatedly, then the devices should be started only one at a time, waiting 60 seconds between each one.

4.1.5. Self-Protection Mode by the KiloVault® BMS

In the event that one of the batteries reaches an extreme condition the internal BMS will put the battery into protection mode (creating an open circuit). When this occurs the batteries will go off-line until they recover back into operational range. Most often this can take anywhere from just a couple of minutes up to several hours depending on the fault condition. If an *Under-Voltage Protection* event caused the shutdown, it will sometimes recover on its own or, if the battery has been completely depleted it may need to be re-charged at least a few amp-hours for it to recover. Some fault conditions are logged and visible using the smartphone Bluetooth app.

4.1.6. Charge Rate

Charging rates below the battery's maximum capacity will extend battery life. A charge rate of 100A is recommended, although up to 150A is allowed. After 3000 cycles at 100% depth-of-discharge the battery's capacity will be approximately 75% of when it was new. If charging above 60A, ensure the bulk/absorption voltage is set to no higher than 13.8V.

4.1.7. Temperature & BMS Self-Protection

We strongly recommend staying within a temperature range 32-113°F (0-45°C) for both charging and discharging to prevent damage, extend battery life, and ensure expected performance.

The battery will protect itself and not allow charging below 32°F (0°C). However, it will continue to discharge down to -4°F (-20°C). As a result, it is possible to completely discharge the batteries in cold conditions and not be able to charge them until they are placed into warmer conditions.

4.1.8. Temperature & Effects on Battery Capacity

Although extreme low temperatures will not reduce the batteries capacity, their current output will be reduced. At 14°F (-10°C) the available current is reduced by 10 to 20% and decreases further to 60% as it approaches the Low Temperature protection value of -4°F (-20°C).

4.1.9. Charge Slower in Very Cold Conditions

If ambient temperature is below 39°F (4°C), reducing the initial charge current to no greater than 60A until the batteries have had a chance to warm up is recommended before introducing the nominal charge rate of 100A.

4.1.10. Ensure Batteries Are at the Exact Same Resting Voltage Prior to Operation

When returning batteries into operation ensure they are at the exact same resting voltage (ideally wait an hour or two to observe the resting voltage). They should all be at exactly the same low voltage (all within 0.05V of each other) between 11.5V to 12.5V prior to initiating charging. Alternatively, they can all be charged to exactly the same full voltage of 14.1 to 14.2V (batteries must be within 0.05V of each other). Refer to 3.1 for more information.

4.1.11. Ensure Parallel Rows of Batteries are Within 0.2V of Each Other

Where there are multiple strings of batteries in parallel, verify the voltage of each string of batteries to ensure they are all within 0.2V of each other. If not, you will need to re-perform the charging step found in 3.1. If the strings of batteries have too high of a voltage difference there is a risk that too much current will flow from one string to the other and cause the BMS to shut the batteries down.

5. Specifications

HLX Series	1800 HLX	3600 HLX
Rated Capacity	1800Wh	3600Wh
Rated Voltage	12.8VDC	
Nominal Amp-Hour Capacity	150Ah	300Ah
Optimal Charger/Inverter Settings		
Bulk/Absorption Voltage	14.0V recommended* (13.8 - 14.1V acceptable)	
Float Voltage	13.8V recommended (13.3 – 13.8V acceptable)	
Low Voltage Inverter Cut-Off	12.0V	
Equalization	*Disable*. Do not use. Battery will enter protection mode.	
Over Voltage Shutoff Protection	14.6 ±0.2V	
Under Voltage Shutoff Protection	11.5V	
Continuous Discharge Current	150A	
Maximum Discharge Current	150A (continuous)	200A for 30 mins, 150A (continuous)
Peak Discharge Current (<3 secs)	500A	
Standard Charge Current	100A	
Maximum Charge Current	150A	
Standby Mode Activated	Current Draw from Load < 0.25A (250mA)	
Dimensions	19.1in x 6.7in x 9.4in (485mm x 170mm x 240mm)	20.5in x 10.6in x 8.7in (520mm x 269mm x 220mm)
Battery Weight	41.7 lbs (18.9kg)	84.4 lbs (38.3 kg)
Shipping Weight	45.2 lbs (20.5kg)	103.4 lbs (46.9 kg)
Terminals	Stainless Steel M8-1.25 x 12 mm Bolts	
Operating Temperature Range	Charging: 32 - 113°F (0 - 45°C) Discharging: -4 - 140°F (-20 – 60°C)	
Optimal Temperature Range	59 – 95°F (15 – 35°C)	

Temperature Protection	
Low Temp. Charge Protection	32°F (0°C) with protection release at 39°F (4°C)
Low Temp. Discharge Protection	-4°F (-20°C) with protection release at 14°F (4°C))
High Temp. Charge Protection	149°F (65°C) with protection release at 122°F (50°C)
High Temp. Discharge Protection	149°F (65°C) with protection release at 122°F (50°C)
Over Current Protection	
Delay until cutoff @255A	4-6 minutes
Delay until cutoff @400A	5-6 seconds
Time until protection is released	8 seconds after load is disconnected
Self-Discharge Rate	≤2% per month
Normal Self-Discharge Current	≤20mA
Estimated # of Cycles Until 80% of Rated Watt-Hour Capacity Remains	2000 cycles @ 100% Depth of Discharge 5000 cycles @ 80% Depth of Discharge
Voltage Configurations	12V, 24V, 36V, or 48V
Maximum Configuration	Up to 4 parallel strings of 4 series batteries (16)
Battery Management System	Monitors and optimizes charge/discharge for each cell, provides overcharge, over discharge, temperature, and short circuit protection
Maximum Time Between Charges	6 months
Warranty	7.5 Year Limited Warranty
Monitoring	Wireless on-site battery status monitoring (optional)

*Note: Bulk/Absorption voltage settings are dependent upon the charge rate of the AC or solar charger. For chargers less than 40A, 14.1V is acceptable, for 40-60A chargers, 14.0V is acceptable, and for chargers >60A use 13.8V.

6. Storage and Re-Commissioning

6.1. Disconnect Batteries for Long Term Storage

For long term storage (i.e. 6 months or more) simply disconnect all sources of charge and discharging from the battery bank.

6.2. Self-Discharge & Maximum Period Between Charging

Although the batteries have a very low self discharge rate (≤2%/month, ≤12%/year) they should be charged a minimum of every six months.

6.3. Temperature & Humidity

Recommended: 15°C to 35°C, 45% to 75％Relative Humidity
Less than 1 month: -4°F to 113°F (-20°C to 45°C), 45% to 75％Relative Humidity
Less than 3 months: 14°F to 95°F (-10°C to 35°C), 45% to 75％Relative Humidity

6.4. Avoid Using Trickle Chargers

Connecting a trickle charger is not recommended, unless the charger can be configured to stop charging at 14.2V or below. Most trickle chargers are not sufficiently sophisticated to provide this charge voltage ability. Over-charging the battery triggers the over-charge protection which shuts the battery down until the voltage goes down enough by itself. Once that happens the trickle charger would quickly raise the voltage up too high once again. As a result, the constant cycling of this circuitry will shorten the life of the entire battery.

6.5. Re-Commissioning

Prior to re-commissioning:

- Ensure batteries are at 11.5-12.5V or 14.0 – 14.2V
  When returning batteries to operation, be sure that the batteries are within operational range prior to initiating charging and all exactly the same voltage. The exact same voltage must be chosen between 11.5-12.5V and 14.0-14.2V (but not in the 12.6-13.9V range because the levels of actual state of charge can vary with minute voltage differences). See the Pre-Installation instructions above.
- Ensure all batteries are within 0.2V tolerance
  Verify the voltage of each individual battery to ensure they are still all within 0.2V of each other (or less). If not, you will need to re-perform the charging step found in Pre-Installation.
  Because of the nature of the voltage versus state of charge curve of the Lithium battery, the voltage differences will be most pronounced with any of the batteries is nearly full or nearly discharged (i.e. 14.0-14.3V or 11.5-12.5V). It is recommended to check that all voltages are within 0.2V of each other at these nearly full or discharged levels.
  Checking voltage differences in the 12.6-13.9V region is not useful to ensuring all of the batteries are really at the same state of charge (see Figure 1).

- Charge slowly in very cold conditions
  If ambient temperature is below 39°F (4°C), reducing the initial charge current to no greater than 60A until the batteries have had a chance to warm up is recommended before introducing the nominal charge rate of 100A.

7. Certifications

- UN DOT
- IP55 Rated

8. Disposal

- Do Not Incinerate
- Recycle in accordance with local laws and services

9. Troubleshooting and Q&A

1. *Why is the battery bank suddenly shutting off?*

- **Possible Cause 1:**
  It is likely that one or more of your batteries are not truly at the same state of charge as the others. Those batteries are hitting the upper or lower voltage limits ahead of the others and the BMS is shutting them down. To ensure that the batteries don't unexpectedly shutdown they all must be charged to (or discharged) to the exact same voltage. That voltage must lie either on the upper end of the charge curve where it flares up (green circle – upper right) or the lower end (yellow circle – lower left) as shown in Figure 3.

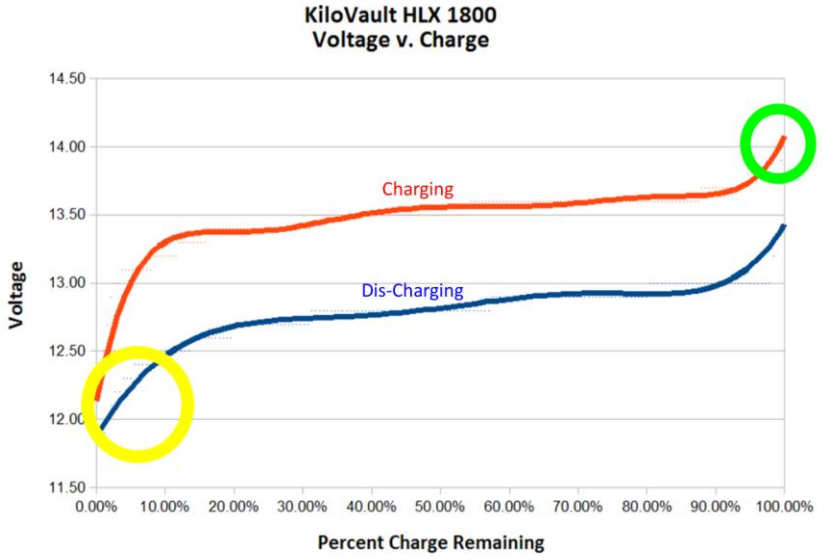

Figure 4: Voltage v. Charge Limits

- **Solution:**

  The batteries must be individually charged to the same voltage at the part of the LiFePO4 charging curve where either the voltage quickly swings up (between 13.8V-14.4V, circled in green in the graph below) or, less preferably, discharged to where the voltage quickly drops off (between 11.5-12.5V circled in yellow below). Consider using a simple 12V AC charger but it must be able to achieve 14.0-14.4V. Use a multimeter or voltmeter to ensure that once the batteries are fully charged they are all at the same voltage.

- **Possible Cause 2:**
  Your load (i.e. inverter or DC load) has exceeded the current capabilities of the batteries. KiloVault® batteries are capable of handling 150A continuous, and for a very brief moment handle up to 500A for a surge load. If your load is known to be close to 150A continuous or has a couple of very high surge loads (e.g. pumps, AC/HVAC systems, etc.) it is possible that the load is simply too high for the bank.

- **Solution:**

Adding an additional parallel row of KiloVault® batteries will increase the current capacity of the bank. Note that in the case that one battery shuts down or if the bank is not voltage balanced it is possible that despite having multiple parallel rows, a row shuts down and the current capacity is reduced to that of the remaining rows. This example is another good reason to make sure your batteries and the rows are all at exactly the same voltage.

2. *The battery Voltages do not remain equal over time. What's going on?*

- **Possible Cause 1:**

  Battery cables are not of equal length or damaged.

- **Solution:**

  Ensure all interconnects are of equal length, gauge, and are in good condition.

- **Possible Cause 2:**

  Cable terminal hardware is not tightened properly.

- **Solution:**

  Ensure all terminal hardware is properly tightened. Check the resistance using the Ohms setting on a standard voltmeter. Measure and record the resistance between the cable lugs on each of your battery cables to ensure proper contact between the wires and the terminal lugs.

3. *The battery has reversed polarity – what is happening?*

- **Possible Cause 1:**

  Battery voltage dropped below operating range and BMS protection has initiated

- **Solutions**

  Verify voltmeter probe orientation.
  Wait for battery to reset itself or introduce a charge to manually reset.

- **Possible Cause 2**

  Faulty BMS

- **Solution**

  Contact KiloVault® Support at KiloVault.com/support

4. *I have a small DC device/inverter connected to a battery and it seems the battery is turning off and on. Is something wrong?*

- **Possible Cause 1:**

  The KiloVault® batteries have an automatic standby mode where they will shut themselves down if they do not see a load of more than 200-250mA. That is about 3 Watts per series battery (i.e. 3 watts for a single 12V battery, 6 watts for 24V series, and 12 watts for 48V). In the standby mode the battery turns back on about every 15-20 seconds to search and see if

there is load connected to it. If your load is not larger than this minimum current then the battery will not stay on.

- **Solution:**

  Consider connecting an additional small DC load to the batteries to increase the current draw to over 250mA. If you are using an inverter, it is possible that it is going into its own standby mode and it is consuming less than the minimum current required to keep the batteries on. Also, for this case of the inverter, consider adding another small additional DC load to increase the current draw to over 250mA.

5. *Can you Charge your batteries with your RV Alternator?*

   As long as the alternator provides less than 150A of charging current and does not exceed 14.0V it can be used.

6. *What size is the terminal mounting hardware?*

   M8 x 1.25 x 16mm (Models shipped before 10/31/2018 will be M8 x 1.25 x 12mm)

7. *What voltage settings do you recommend for a generator?*

   We recommend a low-voltage start of 12.3V and a cut-off voltage of 13.9V (multiply those numbers by 2 for 24V and 4 for 48V systems).

8. *What voltage settings do you recommend for 80% depth-of-discharge?*

   We recommend an absorption voltage of 13.8V, float voltage of 13.4 and low voltage disconnect (for the inverter or DC load) of 12.2V. Multiply those values by 2 for a 24V system and 4 for a 48V system.

9. *Do I need a special 'app' to connect via Bluetooth to the batteries?*

   Yes. Currently there are apps only available for Android and iPhone and can be found on their respective stores by searching for 'KiloVault'. Your smartphone's Bluetooth must be turned on for the app to find the batteries. Android requires location services to be turned on for the app to work. The app has been found to not work on some models of Android phones. Please note that the app is provided as is to serve as a free troubleshooting tool. Be aware that a good voltmeter provides a more accurate voltage reading than the Bluetooth application.

10. *I understand that the batteries have to be **all** charged to the same voltage of a recommended 14.1V DC but my inverter does not have an AC charger. What can I do?*

    There are a couple of options for you:

    a) Use a 12V AC charger (capable of charging up to 14.1V) connected to a generator or the utility company's power to charge each battery. We recommend the Iota Engineering DLS series of 12V AC Chargers that are capable of being configured for this slightly higher voltage.

    b) Use a 12V solar charge controller (set to 14.1V or 'sealed battery' charging, as long as it gets to 14.1V) with a solar panel to charge up the batteries individually. This method will take

longer than an AC charger unless you are using a high amperage charge controller will sufficient solar panels.

c) This is the least recommended option! Carefully discharge the batteries all to a precise voltage (down to 1/10th of a volt) between 11.9 to 12.3V (e.g. select a voltage of 12.2V DC). You will need to carefully monitor the voltage with a voltmeter or multimeter to make sure you remove the load discharging the battery right when it hits that precise voltage. We recommend using a discharging load of no more than 50A (i.e. maximum of 600W) so they don't discharge so fast you miss the exact point when they hit the targeted low voltage.

Note:

In all of the cases above (whether you are charging or discharging) the voltage will either "relax" back down a few tenths of a volt when you remove the charger or go back up when you remove the DC load on the battery. Don't panic. That's ok. The important part is you stop the dis/charging at the same point in time when it reaches those target voltages.

11. *I have a simple battery monitor or a low power device connected to the battery and it seems the battery is cycling, turning off and on. What's going on?*

The KiloVault® batteries need a minimum of 250mA to be drawn or they will go into their power saving, standby mode. The simplest solution is to connect additional loads to reach at least 250mA (3 Watts).

12. *The voltage on the battery momentarily drops when a load is initially connected – what's going on?*

This is normal result of the battery switch from its pre-charge function to provide enough current when connected to devices that have input capacitors and, in turn, high current surges in an extremely short period of time. The battery will resume its normal voltage and function mode within a few short seconds afterwards.

13. *The battery is not working when it is connected to the inverter.*

Some inverters have higher input capacitors whose current draw overcomes that of the pre-charge function of the battery. To minimize the initial discharge when the batteries are initially connected to the inverter, make sure that the inverter is off while connecting. Then wait 45 seconds before powering up the inverter.

14. *The Bluetooth app shows a short circuit event in the log. What's happening?*

When the battery is connected to a DC load or a charging load the pre-charging function of the battery is disabled. That pre-charging function is used to compensate for the surge capacitors on the input side of inverters and other devices. This order of connecting devices may trigger the short circuit protection in the BMS once the high inrush device (usually an inverter) is connected. The solution here is to disconnect all devices from the battery (even battery monitors), first connect the inverter, wait 45 seconds and then connect the remaining devices.

	**Caution:** Repeated triggering of the short circuit protection may damage the BMS circuitry.

15. *Do high temperatures affect the performance of the batteries?*

    Yes. Similar to lead acid batteries, the battery cycle life will be reduced if they are regularly charged and discharged above temperatures of 100 degrees F.