DYNAMIC ENGINEERING

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Est. 1988

User Manual

LiFePO4 11.6 KWH
Battery Manual

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Manual Revision 1p1

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LiFePO4 11.6 KWH

The electronic equipment described herein generates, uses, and can radiate radio frequency energy. Operation of this equipment in a residential area is likely to cause radio interference, in which case the user, at his own expense, will be required to take whatever measures may be required to correct the interference.

Dynamic Engineering's products are not authorized for use as critical components in life support devices or systems without the express written approval of the president of Dynamic Engineering.

Connection of incompatible hardware is likely to cause serious damage.

Manual Revised 02/23/22

Table of Contents

List of Figures

Product Description

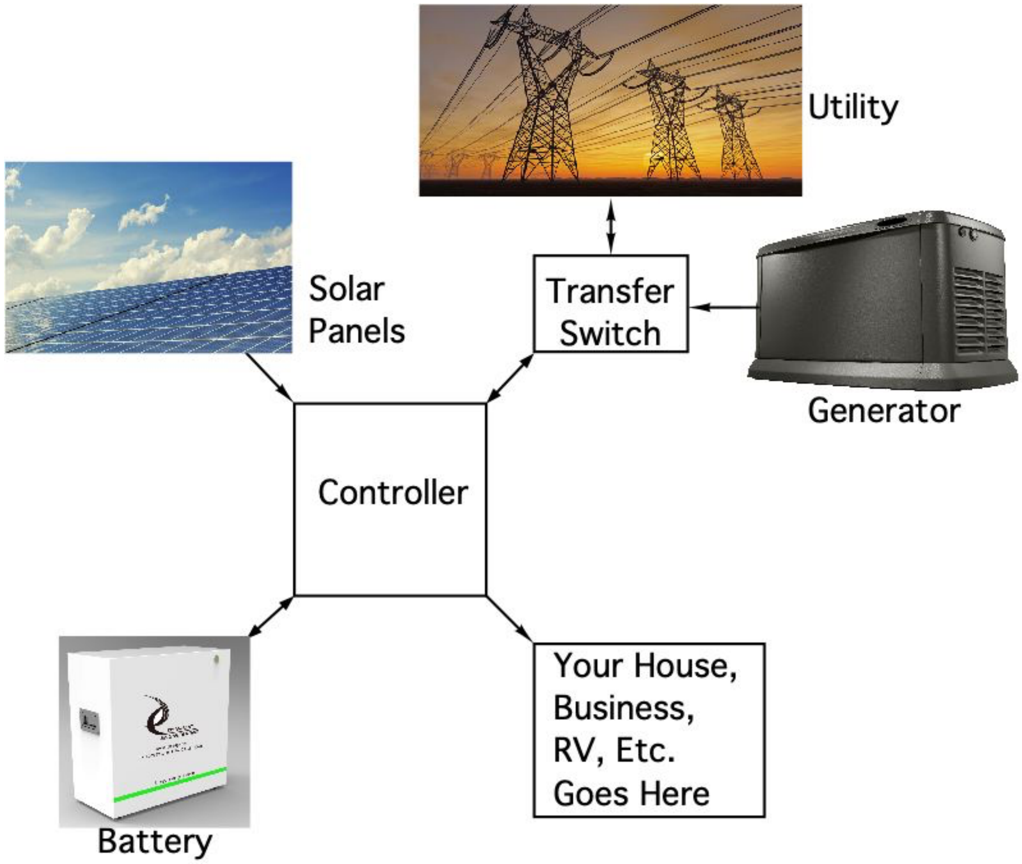


FIGURE 1 SYSTEM BLOCK DIAGRAM

The battery function shown in the diagram is key to having the system provide near instant power continuation. In an "on-grid" application when the Utility suffers an interruption the battery coupled with the controller will fill the gap and prevent the load from seeing the brownout or blackout. When using and offgrid system the battery bank will supply power whenever the PV panels are not able to provide all of the load requirement. When the PV is providing excess power the batteries can store it for future use.

$LiFePO_4$ 11.6KWH is a modular battery design with 11.6 KWH of storage per unit. Up to 16 units can be connected in parallel. Each unit supports up to 100A when discharging. With units in parallel the current and storage is additive.

No	KWH	Max Current	Run Time
1	11.6	100	4.43
2	23.20	200	8.86
3	34.80	300	13.29
4	46.40	400	17.72
5	58.00	500	22.16
6	69.60	600	26.59
7	81.20	700	31.02
8	92.80	800	35.45
9	104.40	900	39.88
10	116.00	1000	44.31
11	127.60	1100	48.74
12	139.20	1200	53.17
13	150.80	1300	57.61
14	162.40	1400	62.04
15	174.00	1500	66.47
16	185.60	1600	70.90

The run time calculation assume 95.5% conversion from DC to AC efficiency and a load of 2.5 KW average. Run Time is in hours.

Features:

1. 100A max sustained.
2. 11.6 KWH storage capacity [228 AH]
3. >6000 cycles with 80% retention DOD
4. Battery Management System [BMS] with thermal and current shutoff features
5. Heavy Duty case with epoxy sheet shielding around the battery cells
6. 4 position switch with 16 settings for unique addressing of batteries.
7. Dimensions: 600 x 302 x 550mm ⇔ 23.62 x 11.89 x 21.65”
8. Operating temperature: -30C ~ 60C [-22F - 140F]
9. Charging Temperature: 0C ~45C [32F - 113F]
10. Charge current ⇔ up to 40A per battery
11. Battery efficiency – .165-.315 W consumer by battery [.0014 % of capacity]

System

The batteries operate between 49V and 54V for a majority of the stored charge. We will select 52V as a typical value for calculations and discussion purposes.

At the max current with 1 battery 52V * 100A = 5200W or 5.2 KW. The battery power delivered is DC. The system being operated is probably AC meaning the battery power is converted to power the load. Also the voltage for the load side is probably 120 or 240 Vrms. The current delivered is the battery power delivered minus the conversion inefficiency. For example the Sol-Ark-12K model has a listed efficiency of 95.5V for battery to AC conversion. 5200W * (1-.955) = 234W lost in conversion leaving 4966 available for use within your system. Dividing by 120Vrms we have 4966W/120V => 41.38A to the load. Adding batteries in parallel will increase the current / wattage available to the load. See the table above for parallel combinations.
In addition one should considered the PV to battery path to see how much stored energy you can achieve. Again using the Sol-Ark-12 example we have 97.5% efficiency. If you add together [the inefficiencies] there is a loss of 7% going from PV to battery to AC [load]. The battery is very important to your system and as you can see the controller / inverter / charger system is too.

LiFePO4 11.6KWH is compatible with the Sol-Ark series and other agnostic controllers [ones not strictly tied to a particular battery]. If you can program the settings on the controller and if the expected battery is “48V” LiFePO4 can be used with your system.

How many batteries should you use? The answer to this depends on your system. If your system is a typical house and if you have gone electric then you can have some impressive loads with Washer, Dryer, Oven, Water Heater, heat pump, blow dryer, microwave and if you are on a well a potential for well pump start up current. In addition, most houses are set-up with 240 AC with two 120 circuits used thoughout the house and combined for appliances that need the 240. Some of your appliances may use natural gas or propane and not affect the load as much [furnace still has a fan] or completely [water heater]. You may need two 12K units in parallel to meet the worst case load or you may be able to use a smaller unit. With the controller sized you can select the battery to support that capability. With 2 LiFePO4 11.6 KWH batteries in parallel we have a max of 9.9 KW delivered. With 4, 19.864KW delivered. The KWH of storagew also increases. The max power your system is not the same as the average power or minimum power. Your max may be 9.9 KW but the average could be closer to 2.5KW. Dividing the stored power by the average power you can see how long the system can run off battery power. Using 11.6 and 2.5 we have 4 - 5 hours. Adding a second battery would increase the max power to match the worst case 9.9KW and double the run time to the 9-10 hour time frame.

The following table has data from the web. Replace with your own appliance data for any calculations on your system.

Appliance	Wattage	Time	KWH
Washer	350-500	1 Hr	.35-.5
Dryer	1800-5000	1 Hr	1.8-5
Hair Dryer	1200-1875	10 min	.2-.3
Hot Water Heater	4500-5500	20 min	1.49-1.83
Heat Pump	0-5000	24 hr	0-120
Refrigerator	1200-1400/day		1.2 – 1.4
Well Pump	250-1100	3 hr	.75-3.3
Dish Washer	1200-2400	1 hr	1.2-2.4
LED 60W equiv	7	8 hr	.056

For a more complete table try googling Appliance Consumption.   Note: the refrigerator item is shown for the full day and is an efficient model. Your unit will likely draw more when running. In standby all modern models are close to "zero".   For the HeatPump it will depend on the weather, what your settings are etc.   The point of the table is to demonstrate the instantaneous load can be fairly high. 10.9 – 20 KW for the load if everything on all at once.   The average load would be much lower.

You can deal with this by having a partially enabled system – essentially only certain circuits on the system.   No laundry when the power goes out sort of thing. You can accomplish this by doing it manually – make sure not to turn on the oven when the dryer is running. Or you can size the system to handle all of the needs. You can program things like the well pump to run when unlikely to be doing laundry to spread that load.

For my own [personal] installation we started with two Sunny Boy, Sunny Island units and early last year updated to two of the Sol-Ark-12 units. The original implementation had 4 lead acid deep cycle batteries.   I wanted to update to the LiFePO4 battery design which led to investigating controllers etc.   Currently we have 2 of the LiFePO4 batteries in parallel. Each controller is assigned 100A.   This provides the 4.966 KW per side of our 240. We run in TOU mode from 4pm-9pm each day to reduce our power bill as our solar power is pretty much off-line by 4pm.   We do push running the washer / dryer outside of the TOU to reduce this load on our batteries.   Other than the BBQ and stove top everything is electric. The system works very well.

Our house is in a somewhat rural area and subject to frequent power outages.   We have our controller programmed to run from Solar, Utility, Battery, and Generator in that order other than for TOU. The generator is automatically started and stopped based on the battery charge available. I am planning to increase to 4 batteries to allow more time between generator charging cycles. The extra batteries will also double our available KW rating. With 2 more batteries our system would be quiet all night. We will also be able to remove the washer / dryer restriction during TOU.

With the modular approach you can add more batteries at any time. Be cafeful when adding uncharged batteries to a system with charged batteries already in place. Refer to the controller manual for this procedure. If no procedure is available, our recommendation is to disconnect the batteries in use [charged], add the new uncharged batteries, bring them up to the same voltage level as the original set, add them in. The LiFePO4 batteries have a power switch built in. The batteries should be turned off when connecting and disconnecting. Once reconnected and the batteries enabled, the BMS will communicate between the units to balance.

Connections

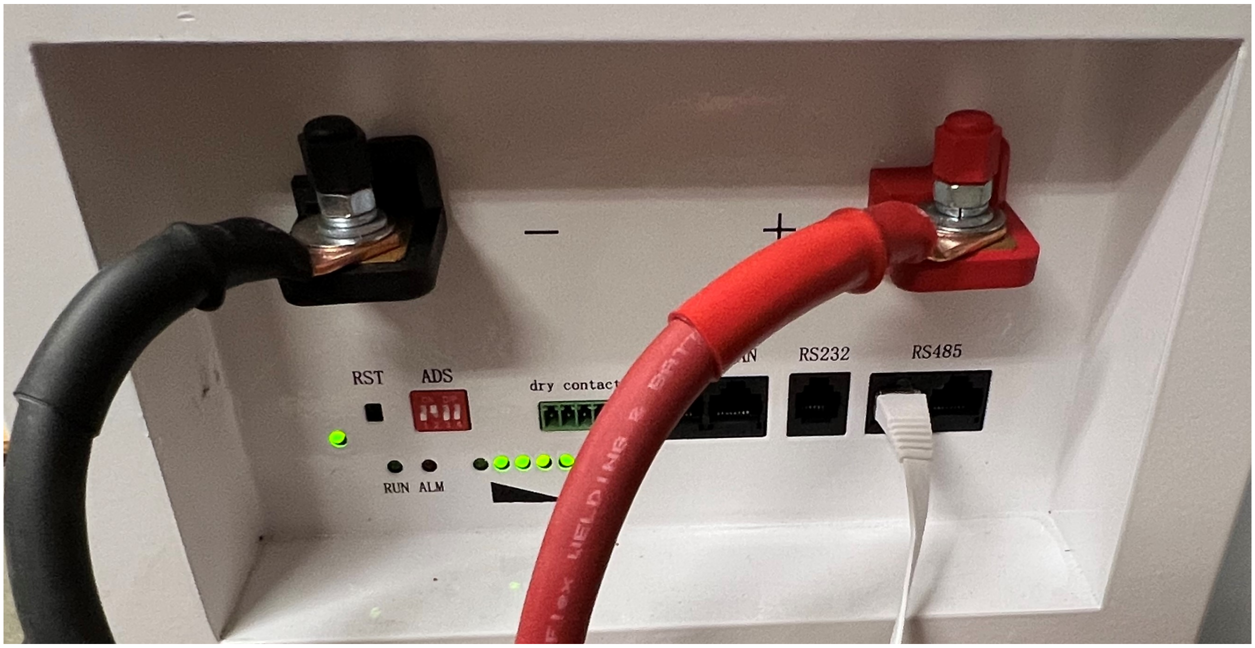


FIGURE 2 CONNECTION VIEW

In ther view above the power, communications, and addressing features of LiFePO4 11.6 KWH are shown.

The power lugs are clearly marked. Part of our cable harness is shown. Note the heavy gage wiring. The wiring needs to support the expected maximum current with a voltage drop low enough to support safety and efficiency. We will offer a cable set to support the batteries. Built to order based on custom length specification. Separate documentation for this item available on our website.

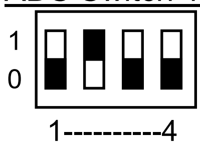
To connect batteries in parallel the + terminal is connected to the second + terminal. In parallel the – terminals are interconnected. We recommend running the pair of batteries to the controller. If a second set of batteries [4 total] run those separately to the controller. The reason is to reduce the cable size to something managable. Each battery can support 100A. Having 2 in parallel comes to 200 A. For safety added margin in wire capacity is highly recommended [likely code in your area]. In addition, the larger gage will result in lower impedance which equates to higher efficiency. Less resistive loss in the wire when charging or discharging.

If going beyond 4 batteries in parallel it may be necessary [depending on how connected to your controller] to combine with a bus bar or similar and to run a single heavy gage harness to your controller as the controller may have limited height to stack connectors from several battery banks.

For a dual controller system we recommend connecting the two controllers in parallel along with the batteries. Some models have the ability to shunt current between the units on the battery wiring. Also the controllers may not have equal loads and having the batteries in a pooled configuration rather than separated into a bank per unit will mean multiple unequal loads can be supported.

When programming the controller you may need to divide the total battery capability by the number of controllers. For example, with 4 batteries we have 400A available. If two controllers in use then allow each to use up to 200A when programming. *If the BMS is shutting the batteries down check this setting as you may have all of the current allocated to all of the batteries which means overload to the batteries as there is only the one pool.*[400 x2 vs 200x2]

<u>ADS Switch 1-4</u>:



The switches form a hex number with 0-15 valid. The numbering is opposite standard with the lsb on the left hand side. See the following table for positions and effective address.

Battery #	Addr(1)	Addr(2)	Addr(3)	Addr(4)
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
10	0	1	0	1
11	1	1	0	1
12	0	0	1	1
13	1	0	1	1
14	0	1	1	1
15	1	1	1	1
16	0	0	0	0

FIGURE 3 BATTERY ADDRESSING

When multiple batteries are connected in parallel forming a "bank" the first battery should be set to address 1. When using the serial communications port with the battery, you will connect your computer to battery number 1. All of the batteries are addressable from this port – do not need multiple cables or to move the cable from battery to battery.

The interconnection cable plugs into the RJ45 ports and a standard etherent cable can be used. There are two connectors – the photo shows the end of a two unit bank. The address is set to Battery 2 and the Left Hand input connector is used. The number 1 battery has the right hand [output] position utilized. The BMS in both batteries communicate over this cable to allow for the single port serial communication and to keep the batteries in synchronization for parallel installations.

The RS232 port is visible just to the left of the RJ45 communication ports. This port is supported with standard RS232 UART communication. See the separate SW section for more information. In addition to RS-232 the option for RS-422 and CAN are supported. Those connectors are somewhat hidden by the ground wire in the photo above.

The RS-232 port uses a phone jack RJ-11.

RJ-11	**RS232**
2	NC
3	RX
4	Tx
5	GND

The batteries are supplied with one cable set per bank ordered.

LED display. There are 6 LEDs to indicate the charge remaining in the Battery without needing to use the serial communications. Each LED indicates approximately 1/6 of full charge. The LEDs flash when being discharged showing which 1/6th is in use. In the photo the first 16.67% has been used as that LED is off and the battery is operating in the remaining part of the total charge.

Run and Alarm are additional LEDs to show additional status during operation.

RJ45	**RS485**
1,8	RS485-B1
2,7	RS485-A1
3,6	GND
4,5	NC

RJ45	**CAN**
1,2,3,6,8	NC
4	CANL
5	CANH
7	GND

The **Dry Contact** port supplies signals when certain conditions occur. When fully charged or when low [SOC].
Pin1-Pin2 open normally, closed when a cell drops below 3V.
Pin3-Pin4 open normally, closed when a cell is > 3.6V

RST is a recessed reset button for the BMS. Not normally used. If required, push the button for 3 seconds to reset the BMS.

Construction and Reliability

LiFePO4 11.6 KWH is constructed with a heavy duty chassis with separate battery cells mounted to an internal rail system. The design makes use of LiFePO4 – the safest version of Lithium and has epoxy sheet separation between the cells to help isolate the cells from each other. The BMS constantly monitors the operation of the battery and can shut the battery down if over temperature or too much current is being demanded from the unit.

The unit is about 207 lbs due to the materials. The design has passed UN38.3 testing.

Handles are built into the unit to support moving the unit. For most people this is a two person lift.

The calculated storage is 12KWH. This is based on the 228 AH cell and the cell voltage. The advertised value of 11.6 KWH provides some margin.

The battery is rated for more than 6000 cycles with 100% DoD with 80% of the storage retained. It is recommended to use 80-90% max discharge per cycle to increase effective battery life.

Thermal Considerations

Operating Temperature: -30C ~ 60C [-22F - 140F]
Charging Temperature: 0C ~45C [32F - 113F]

The minimum and maximum values represent the full use case for the battery and are the extremes. For longer battery life it is recommended to store and operate the batteries in a “cool, dry place”. The operating temperature range is wider than the charging temperature range. You can charge at home and use to run your RV in the cold.

Warranty and Repair

LiFePO4 is an unusual product for Dynamic Engineering. The batteries are manufactured in a large battery manufacturing facility for Dynamic Engineering. Our other Embedded Electronics products are manufactured at our Santa Cruz CA facility.

The warranty is passed through from our supplier. Dynamic Engineering will support any warranty claims by providing “know how” and in some cases replacement parts for the batteries. The warranty policy is reprinted here for reference, is subject to change and is based on the manufacturers policy. Their policy is copied below.

TEN YEARS FACTORY BACKED WARRANTY THAT COVERS MANUFACTURER DEFECTS WITHIN THE WARRANTY TIMEFRAME, WE WILL REPAIR OR REPLACE THE BATTERY.

COVERED CONDITIONS:

1) FOR PROBLEMS OF BMS OR OTHER SMALL ACCESSORIES, WE CAN SEND NEW BMS OR ACCESSORIES AND INSTRUCTIONS VIA PHONE OR VIDEO TO HELP CUSTOMER FIX THE PROBLEM.
2) FOR CELL DEFECT (VERY FEW PECENTAGE) WE CAN SEND REPLACEMENT BATTERY CELL OR NEW BATTERY DIRECTLY (ACCORDING TO SPECIFIC SITUATION NEGOTIATED AND DETERMINED)

NOT COVERED BY WARRANTY:

1) DAMAGED CAUSED BY ACCIDENTS OR ACTS OF GOD
2) LOOSE TERMINAL BOLTS AND CORROSION
3) FAILURE TO PROPERLY INSTALL THE BATTERY, MAINTAIN, AND CHARGE
4) FIRE, INTENSE HEAT, FREEZING
5) WATER DAMAGE AND MOISTURE
6) TAMPERING OF THE BATTERY PACK

Service Policy

Before returning a product for repair, verify as well as possible that the suspected unit is at fault. Then call the Customer Service Department for a RETURN MATERIAL AUTHORIZATION (RMA) number. Carefully package the unit, in the original shipping carton if this is available, and ship prepaid and insured with the RMA number clearly written on the outside of the package. Include a return address and the telephone number of a technical contact. For out-of-warranty repairs, a purchase order for repair charges must accompany the return. Dynamic Engineering will not be responsible for damages due to improper packaging of returned items. For service on Dynamic Engineering Products not purchased directly from Dynamic Engineering contact your reseller. Products returned to Dynamic Engineering for repair by other than the original customer will be treated as out-of-warranty.

Out of Warranty Repairs

Out of warranty repairs will be billed on a material and labor basis. Customer approval will be obtained before repairing any item if the repair charges will exceed one half of the quantity one list price for that unit. Return transportation and insurance will be billed as part of the repair and is in addition to the minimum charge.

For Service Contact:

Customer Service Department
Dynamic Engineering
150 Dubois Street, Suite B/C
Santa Cruz, CA 95060
831-457-8891
support@dyneng.com

Order Information

Please refer to our LiFePO4 webpage for the most up to date information: https://www.dyneng.com/Solar-Battery.html

LiFePO4 11.6 KWH	LiFePO4 type battery with 11.6 KWH storage, 100A current output per battery. Bankable upto 16 units. Comes as a floor standing unit with heavy duty case, LED display, ports for RS485, RS232, CAN bus connections. BMS provides constant monitoring of battery operation and safety shutdown. Separate power switch. Easy to connect power lugs for cabling. PN 60-2022-1160
LiFePO4 cable	Optional cable to interconnect battery to controller / inverter module. Orderable with custom lengths. Option for open ends at Controller side or lugs.

Glossary

Acronyms and other specialized names and their meaning:

Watt	A watt abbreviated W = 1A * 1V. Note: Volts are in their DC equivalent. DC Volts = DC Volts but AC volts need to be stated as RMS.
KW	Kilo Watt – a measure of the power flow. 1 KW = 1000 Watts.
KWH	KWH is the integrated power based on an hour of usage. 5KWH is 5000 Watts for an hour.
RMS	Root Mean Square. When applied to the AC voltage max the RMS voltage is the equivalent DC voltage of the same power. Since DC is constant [or nearly so] and AC is sinusoidal the RMS number is lower. For example the RMS voltage measured with a standard hand held meter will show ~120V. The peak voltage when measured with an ocilloscope will show ~170V. The RMS factor is SQRT(2) / 2. If you really want to know, this is the equivalent factor from integration of the absolute value of the voltage of the sine wave.
PV Panel	Photovoltaic Panel or solar panel used to convert energy from the sun into DC current.
Controller Efficiency	or conversion factor. The controller in your system uses Solar or Battery power and coverts to Load power. The load can be the utility if selling back or your house / business /vehicle etc. Power from the Solar Array PV (photovoltaic) panels is DC. Power from the batteries is also DC. Power delivered to the load is generally AC. In addition, power from the utility is used to charge the batteries - AC to DC in this case. The conversion from DC to AC or AC to DC is not perfect meaning there are losses associated with the conversion. Lower losses are better for your system life, for your power bill, and for the amount of useful power delivered from the battery.

Transfer Time	is the time the controller takes to determine, and take action to switch sources when an event occurs - brown out, black out etc. Better controllers are faster. 4 mS and faster is a good target. Most appliances expect solid power. If the transfer time is very long the power in your installation will reduce in voltage [brown out] and you will see your lights flash and sometimes clocks and other items need to be reset. When the voltage is lower than expected the current used is increased. The increase in current can cause earlier failure of devices on the system, especially if the system is frequently correcting for Utility brown outs. With a faster unit the power switches quickly enough to act as a whole house UPS.
UPS	Uninterruptable Power Supply. A device which monitors and frequently filters the local power. When the power input is disrupted, the device uses local storage to supply power to the device. Great protection when using a generator and transfer switch to fill the gap while the generator is coming on-line.
DC	Direct Current. The voltage is at a level relative to ground. The voltage is relatively constant - for a battery the fully charged and fully utilized states will be different voltages. The rate of change is slow enough to be considered DC. The voltage decrease is relatively monotonic - not sinusoidal in nature. Power = Current * Voltage for DC applications.
AC	Alternating Current. The voltage is sinusoidal. The peak voltage and the commonly measured voltage are not the same values. The handheld meter will display the RMS [root mean square] value for the waveform. Using RMS voltage allows a constant to be applied to sinusoidal waveform. If you integrate the power under the Sine wave to take into account the zero crossing and peak power you end up with the RMS equivalent.
Parallel	when applied to controllers and batteries means connecting more than one together to create a

	increased supply. For example, use two controllers in parallel to double the power delivery, use two batteries in parallel to double the stored power. Sometimes referred to as a battery bank when operating in parallel. Parallel means + to + and - to - which keeps the voltage constant and increases the available storage and current. It is generally inadvisable to connect in series with Lithium batteries.
DoD	Depth of Discharge - what percentage of the rated capacity can be utilized [discharged] per cycle and not affect the battery operation [number of cycles] Exceeding the DOD can damage the battery and reduce life-span
Duration	The number of hours the battery can support the load. This figure is highly dependent on the load. See main body of manual for some example calculations.
Battery Efficiency	How much of the stored charge is used by the battery compared to how much can be delivered. This number depends on the test set-up as the BMS and other battery associated electronics will draw a fairly constant load while the time to discharge can vary greatly with the load applied. Shorter duration larger loads will appear to have a higher efficiency than a smaller load for a longer period. A better measure is the fraction of a KWH consumed by the battery. Usually, this number is small compared to the efficiency loss in the DC/AC conversion - in terms of absolute power consumed.

If you have suggestions for additions or clarifications please send them to engineering@dyneng,.com and be sure to indicate the name of this manual.