REV1.0

2012/10/07

LiFePO4 Battery Management System

User's Guide

BMS-HV

BMS-LV

End-User Documentation

Copyright© 2012 Shenzhen Lith Battery

Al rights reserved.

IMPORTANT!

BMS (Battery Management System) should only be attached to a LiFePo4 Power System from Shenzhen Lith Battery.

Read all installation instructions prior to installation of the LITH-BMS.

1. SAFETY INFORMATION

The BMS (Battery Management System) must be used in accordance with the manufacturer's specifications and guidelines for recommended use. Remove all jewelry or other metallic objects from your hands and body during the installation of the battery packs and peripherals.

2. BMS FEATURES AND MODES OF OPERATION

The BMS performs the following functions:

- OV(Over Voltage), UV(Under Voltage), OT(Over Temperature) protection
- Interact with vehicle management unit (VMU) or system controller
- Charge control
- Inter-module balance
- Data collecting

a) OV (Over Voltage), UV (Under Voltage), OT (Over Temperature) protection: In case any one of battery cells has a voltage or temperature out of the operational range, the system will issue first a warning, then an alarm. An alarm usually requests that a contactor be opened to stop the discharge or charge condition.

b) Interact with Vehicle Management Unit (VMU): BMS will communicate with VMU by CANbus, RS-485, or a combination of analog and digital signals to make the system work under the control of a VMU.

c) Charge control: The charge process is carried out under the control of BMS. The BMS communicates with the charger via CANbus, RS-485, or an analog output to achieve real-time control purpose.

d) Inter-module balance: When the BMS detects there is SOC (State Of Charge) difference between battery packs, it will engage the inter-module balance circuit of the pack with higher SOC.

e) Data collecting: the BMS will poll all of the modules for the battery information. The information is sent from the BMS via a Controller Area Network bus line (CANbus).

The BMS functions in the following modes:

- Drive Mode: The BMS will enter the drive mode if the charger is not powered on before powering on the BMS. In drive mode, the BMS will perform the function of data collecting, OV (Over Voltage), UV (Under Voltage), OT (Over Temperature) protection, and interact with VMU. All the protections are implemented by communicating with the VMU to provide a soft shut down first or by opening the main contactor so that no more current will flow out of the battery.
- Charge Mode: If the charger is powered on before powering the BMS, BMS will detect the message from the charger when initializing and then enter charger mode. In charge mode, BMS will perform all the 5 functions listed above.

Feature	Comments
RS-485 Communication	RS-485 Communications is used to communicate with the battery modules.
CAN interface	CAN interface will be used to communicate with the host or the charge.
Charge Disconnect	When the battery modules are fully charged, they will communicate with the BMS and the BMS has the ability to turn off the charger or open the charger main contactor, interrupting current flow.
Analog/Digital Communications	In case the host controller doesn't have a CAN interface, the BMS communicates with the host via analog/digital signals. These signals include: Outputs – SOC (A), disable regen(D), early warning(D), BMS fault(D) Inputs- 12V ignition (D), vehicle fault (D),
Discharge Interrupt	When the batteries are discharged to the under-voltage protection point, BMS will attempt to alert the host to inhibit discharge. If discharge continues beyond this warning, the BMS will request that the main contactor open or can open it itself.
Insulation measurement	The BMS will check to make sure the battery pack is sufficiently isolated from the chassis before and after the main contractor is closed.
Pre-charge circuit	To limit the inrush current into the systems capacitors, a pre-charge resistor is connected to B+ before the main contactor is closed. This also prevents arcing and pitting across the contact tips. The BMS will close an auxiliary contactor to place a resistor in line with B+. After 2 seconds, the main line contactor will close.
Inter-module Balancing	Compensates slight capacity imbalance between different batteries when charging.
Intra-module Balancing	Compensates slight capacity imbalance between different cell banks within one module while charging.
Size	188 mm x 160 mm x 38 mm 7.4 in x 6.3 in x 1.5 in
Weight	Approximately 550g or 1.2 lbs

Table 1. Functionality of BMS

Charge Control

Charge control is usually implemented by a CAN message from BMS or VMU. During the bulk stage of charge, the BMS will ask for constant charge current output (usually at a rate below 1C). In the second stage, when any one of the battery modules is nearly full, the output of the charger will be decreased to allow balancing of battery modules. The charger output will be set to zero when charge process is terminated. In case there is a voltage difference between battery modules, the BMS will engage the inter-module balance circuit of the module that shows a greater SOC. If any cell reaches 3.9V while charging, the BMS will issue an Over Voltage Warning signal. If the cell continues to reach 4.0V, the BMS will issue an Over Voltage Alarm and open the charger contactor, halting charging.

Discharge Interrupt

When the battery modules are discharged to the under-voltage protection point, meaning at least one of the battery cells is discharged to 2.8V, the microprocessor in the module will communicate with the BMS, and the BMS will send a Critically Discharged Warning signal to VMU. In the event the voltage continues to fall and is below 2.3V, the BMS will send the Critically Discharged Alarm signal and request the opening the main contactor to VMU, which will lead to open the main contactor, or BMS will open main contactor directly. The main contactor will remain open until the signal is cleared. This is done by charging the batteries with greater than 1A for at least 1 minute.

Temperature Monitoring

When the cell surface temperature in each battery module is above 60ºC, the BMS will generate a “warning” battery pack signal. When the temperature is above 65 ºC, the BMS will generate an “alarm” battery pack signal.

There is an additional temperature sensor on the circuit board of the battery module monitoring the temperature of the circuit board. When the board temperature is above 80ºC, the BMS will generate a “warning” signal. When the temperature is above 85ºC, the BMS will generate an “alarm” signal. The system should either reduce or stop current to allow the system to cool. If the BMS controls the charge and discharge contactors, it will open both to allow the temperature to cool.

Isolation Measurement

The BMS has the option of checking for sufficient isolation between the battery pack and chassis ground. If this option is selected, the BMS will perform the test before

the main contactor is closed and also periodically during operation of the pack. If the isolation measurements fall below and acceptable value, the BMS will not allow the contactor to close, restricting the operation of the pack.

Using a laptop to talk to the BMS

Software and hardware is available from LITH to allow the BMS to send its information to a laptop via a USB-CAN adapter. All of the data listed in **CAN Communications** can be seen.

Resetting the BMS

The BMS can be cleared of errors by either a command via a laptop computer running the cycle monitoring software or by cycling the 12V key ignition input off and on.

CAN Communication

The BMS communicates with the system via CAN bus 2.0B. Also, the BMS collects a variety of data from each battery. The BMS sends the following information over CAN interface.

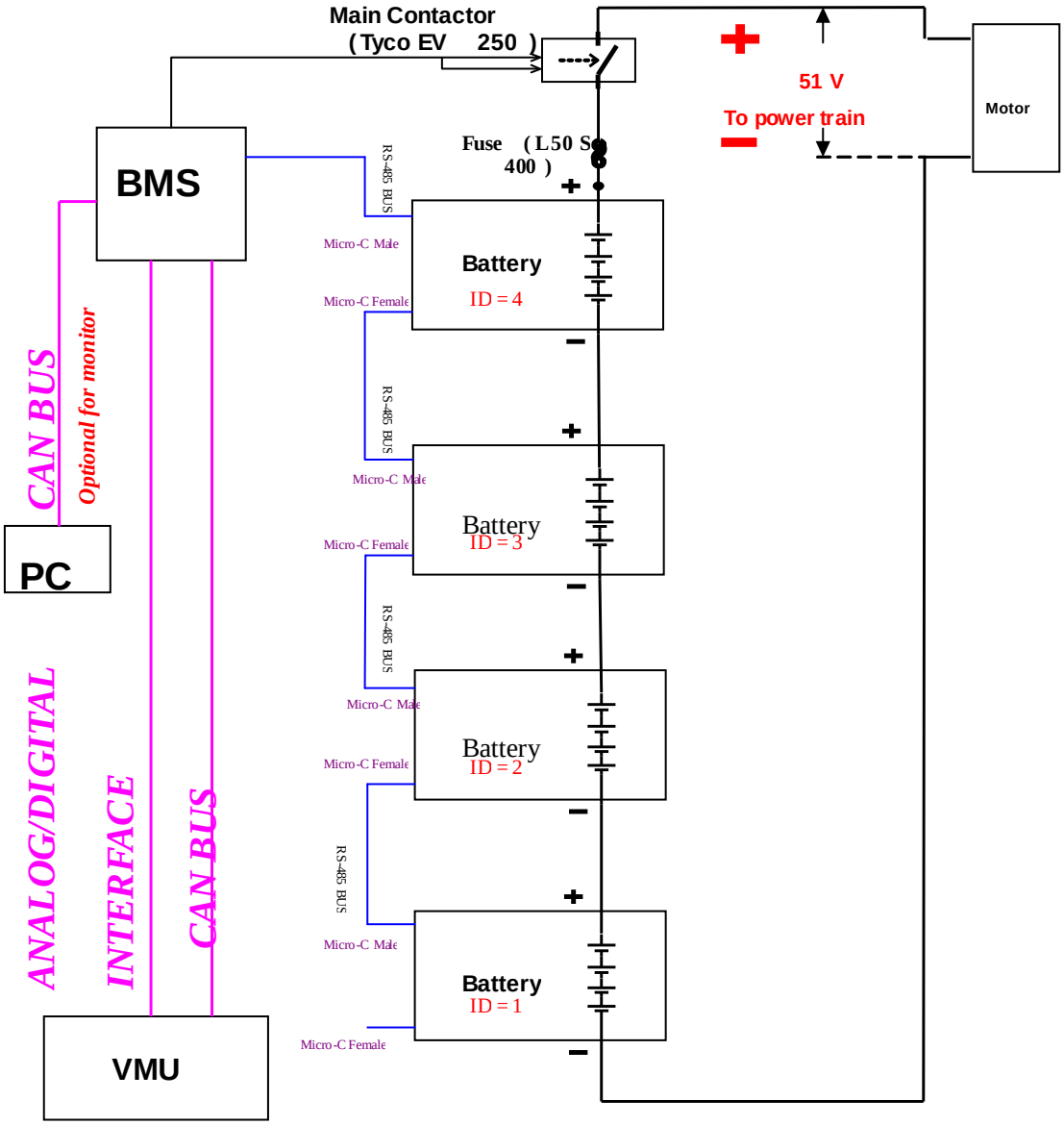
- State of Charge (SOC)
- BMS mode (standby, charge, or discharge)
- Charge State (main, equalize, or float)
- Charge Balancing (occurring or no activity)
- Battery Faults
- Lost Communication with Module
- Over Temperature Warning / Alarm
- Low Capacity / Early Warning
- Critically Discharged Warning /Alarm
- Over voltage alarm
- MAX discharge over 120A warning and then alarm
- MAX discharge over 150A warning and then alarm
- MAX discharge over 200A warning and then alarm
- MAX discharge over 250A warning and then alarm
- MAX discharge over 300A warning and then alarm
- Temp sensor failure
- Volt sensor failure
- Current sensor failure
- SOC mismatch between modules
- Over Voltage Shut Down
- Critically discharged shut down
- Pre-charge contactor failure to close
- Battery Voltage
- Battery Current
- Open contactor request
- Main contactor state
- Insulation measurement state
- Charge contactor state
- End of Charge
- Battery Max temperature
- Battery Min temperature
- Cell Min and Max voltage
- Temperature of PCBA in each module

Mechanical

The BMS is made from durable ABS Plastic. The connectors for CAN, RS-485, 12V rail etc. in the BMS meet the requirement of IP56.

3. INSTALLATION

Ensure that the batteries are installed properly. Check the stack voltage to make sure it is within the operational range (10V-150V DC for LV model or 100V~450V DC for HV model). Make sure all the communication cables have been connected between battery modules.



4 Battery modules in series

Figure 1. Example of 4 batteries hooked up in series.

For best results, mount the BMS in an area that is easy to access, yet protected from the elements. The unit can be mounted in any orientation.

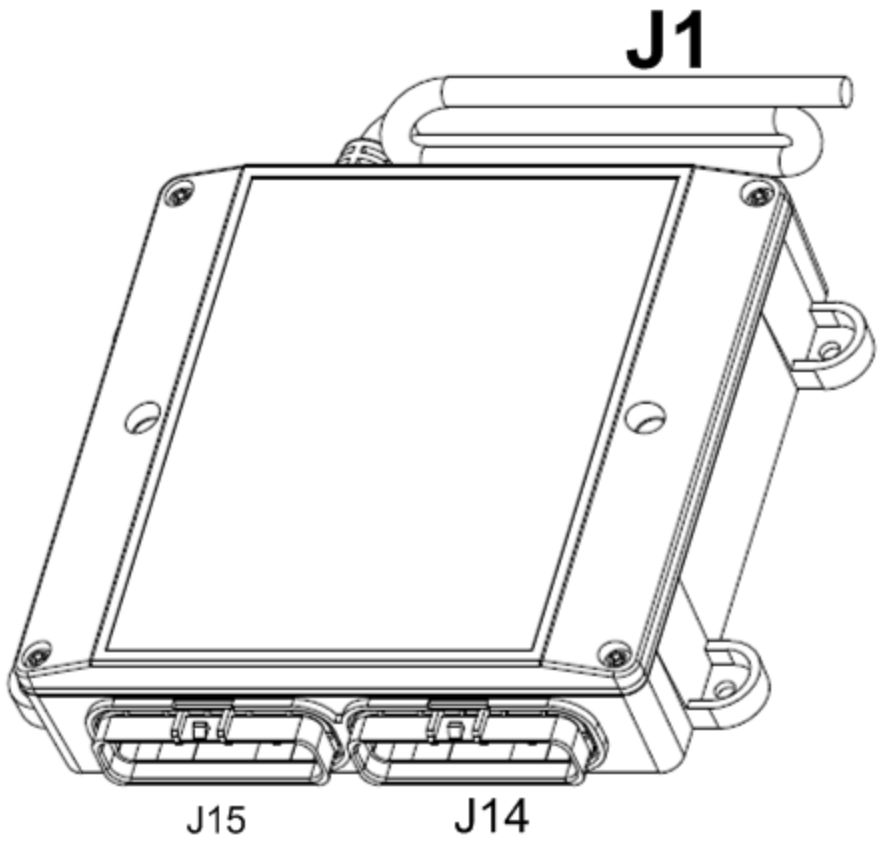


Figure 2. BMS illustration

Both J14 and J15 are 26 pin connectors, as seen in Table1, Table2.
Connect J14 pin18, pin4, pin17, pin3, pin16 of BMS to the communication connector of a battery. The signals are described below in Table1.
The connector J14, for pin24 to pin 19, pin10 to pin5, used to connect the analog and digital signals between the BMS and the device. Refer to Table 1 for location and function of each pin.

If the vehicle management unit (VMU), or system controller, communicates by CANbus, connect J14 pin13, pin26, pin12, pin25, pin511 (CAN Interface) of the BMS to the VMU interface. It can also be connected to an USB-CAN adapter (available from your LITH sales staff) to see or log the battery information on a laptop computer.

J14 CAN interface is used as the electric interface between BMS and the management unit for CAN communication.

J14 Connector Detail

Pin	Signal Name	Description	Maximum Rating(V)
13	CANH	HIGH-level CAN bus line	40
26	CANL	LOW-level CAN bus line	40

12	CAN VCC	Power supply of CAN bus	5
25	GROUND	GND of CAN transceiver, also BMS GND	0
11	Shield	Shielded layer of CANbus cable	0
24	WAKEUP	Input, Wake up the BMS(9~14,nominal 12V)	14
10	12_SYS	12V+ external power supply (9~14, nominal 12V)	14
23	CHG_ENABLE	MCU distinguish charge mode or driver mode	12
9	GND	Ground to chassis of vehicle	0
22	CHGCUR	Analog Charger Current control (0~5V) 5VDC- 100% current 0VDC- 0% current	5
8	SOC	Output Signal (0-5V) State Of Charge (Analog). 5VDC-100% SOC; 0VDC-0% SOC.	5
21	CHGREQ	No use	
7	FAULT	Output signal to indicate open contactor request. (0-12V, nominal 12V) 12VDC-fault condition; 0VDC-no fault.	12
20	EARLY_WARNING	Output signal to indicate Low capacity warning. 12VDC-Early warning light (3W) is turned on/reduced performance is requested; 0VDC- Warning light is off / Normal operation.	12
6	DISABLE_REGEN	Output signal to disable regen 12VDC-Disable the regen functionality of the Motor Controller; 0VDC- Enable the regen functionality of the Motor Controller.	12
19	VEHICLE_FAULT	Input from Vehicle/Device or Motor Controller indicating something is wrong. 12VDC-Fault condition, open the contactor. 0VDC-Normal	12
5	12V_IGNITION	Input from key switch, turns on BMS (9-14)	14
18	VCC	Power supply for the RS-485 transceiver	7
4	B(+)	B signal from the RS-485 transceiver	12
17	A (-)	A signal from the RS-485 transceiver	12
3	GROUND	Ground for the RS-485 transceiver	0

16	Shield	Shielded layer of RS-485 cable	0
2	VCC	Power supply for the RS-485 transceiver	7
15	B(+)	B signal from the RS-485 transceiver	12
1	A (-)	A signal from the RS-485 transceiver	12
14	GROUND	Ground for the RS-485 transceiver	0

Table 1. J14 connector

The connector on the top, J1, is a 4 pin connector used to connect power up to the BMS. Refer to Table 2 for location and function of each pin.

IMPORTANT! Connect the J1 wires to the BMS first before connecting the other end to the battery terminals.

J1 Connector Detail

Wire Color	Description	Nominal Rating (V)	Range (V)
Blue	Battery Negative	B-	
Brown	Battery Positive	100-450 for HV 10-150 for LV	80-450 for HV 8-200 for LV

Table 2. J1 BMS Power Supply

The connector J15 is a 26 pin connector which is used to connect wires from the BMS to the coils of the contactors and sense relays. Refer to Table 3 for location and function of each pin. No external coil diodes are needed as they are already built into the BMS.

Contactor 1: Charge Path main contactor
Contactor 2: Charge Path auxiliary contactor (Pre-charge)
Contactor 3: Discharge Path main contactor (LINE)
Contactor 4: Discharge Path auxiliary contactor (Pre-charge)

J15 Connector Detail

pin	Signal Name	Description	Nominal Rating (V)
13	GND		0
26	Positive	To Contactor 1 coil positive terminal Charger Main Contactor	12
12	Negative	To Contactor 1 coil negative terminal Charger Main Contactor	0
25	Sense	When contactor 1 is closed, Sense and Sense_Gnd are shorted together.	

11	Sense_Gnd	When contactor 1 is closed, Sense and Sense_Gnd are shorted together.	
24	Positive	To Contactor 2 coil positive terminal Charger Pre-charge aux contactor	12
10	Negative	To Contactor 2 coil negative terminal Charger Pre-charge aux contactor	0
23	Sense	When contactor 2 is closed, Sense and Sense_Gnd are shorted together.	
9	Sense_Gnd	When contactor 2 is closed, Sense and Sense_Gnd are shorted together.	
22	Positive	To Contactor 3 coil positive terminal Main Contactor	12
8	Negative	To Contactor 3 coil negative terminal Main Contactor	0
21	Sense	When contactor 3 is closed, Sense and Sense_Gnd are shorted together.	
7	Sense_Gnd	When contactor 3 is closed, Sense and Sense_Gnd are shorted together.	
20	Positive	To Contactor 4 coil positive terminal Pre-charge aux contactor	12
6	Negative	To Contactor 4 coil negative terminal Pre-charge aux contactor	0
19	Sense	When contactor 4 is closed, Sense and Sense_Gnd are shorted together.	
5	Sense_Gnd	When contactor 4 is closed, Sense and Sense_Gnd are shorted together.	
18-14 4-1	GND		0

Table 3. J15 Contactor Connections

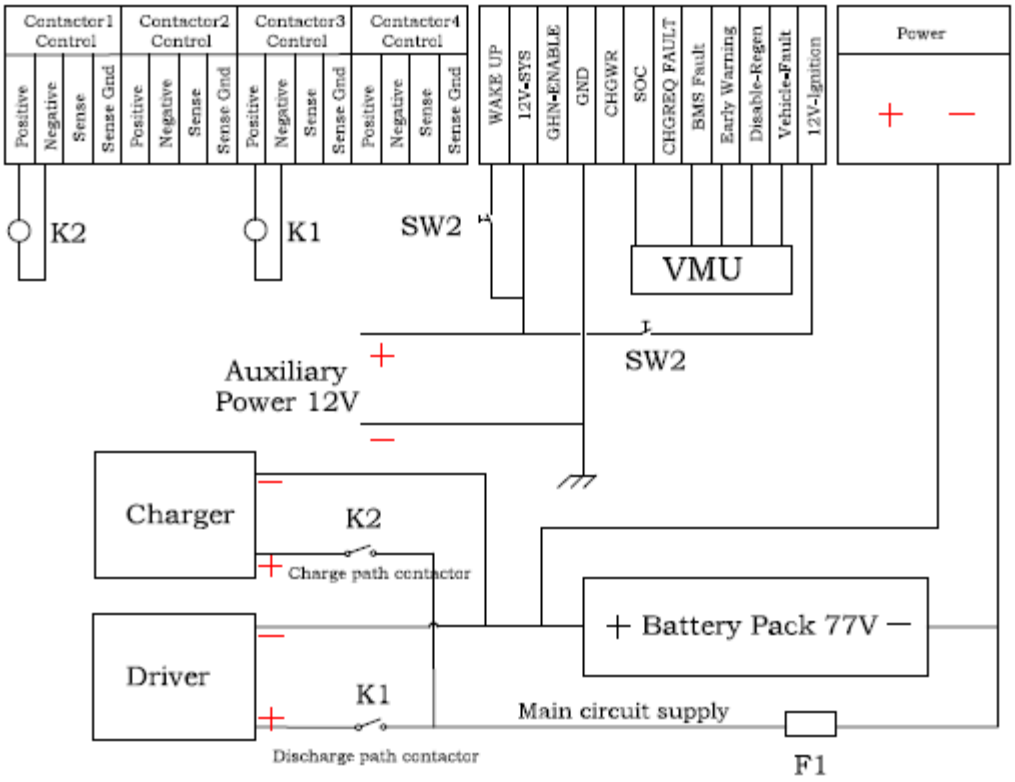


Figure 3. Example of wiring up 6 Batteries in series to BMS

K1= Line contactor
K2= Aux contactor (if applicable)
SW1= Key switch (normally open)
SW2= Storage switch (normally closed)

4. LIMITED WARRANTY

LITH BMS Limited Warranty

Shenzhen Lith Battery Co., Ltd warrants the BMS and its components (“Product”) as free from defects in materials or workmanship under normal use for a period (“Warranty Period”) of two (2) year from the date of original retail purchase. This warranty applies to the original purchaser (the “Customer”) only and is non-transferable.

During the Warranty Period, should the Product, in LITH's opinion, malfunction, LITH's sole liability shall be, at LITH's sole discretion and at no charge to the customer, to either repair or replace the malfunctioning products if returned within the Warranty Period, freight prepaid, to the place of purchase. Each returned Product must include a written statement detailing the nature of the claimed defect, as well as the Customer's name, address, phone number and a copy of the original sales receipt showing the date of purchase.

Warranty is avoided if LITH determines the Product has been:

1. Serviced by anyone other than LITH;
2. Modified by improper installation of third-party products;
3. Damaged from accident, misuse, misapplication or abuse;
4. Damaged by improper transportation or packing when returned by the Customer to LITH;
5. Damage by unusual physical stress or interference, failure or fluctuation of electrical Power, lightning, static electricity, fire, or other acts of God; or
6. Operated outside of the parameters of the Manual.

THIS WARRANTY IS MADE IN LINE OF ALL OTHER WARRANTIES, WHETHER EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A SPECIFIC PURPOSE. THE REMEDY SET FORTH HEREIN SHALL BE SOLE, EXCLUSIVE REMEDY WITH RESPECT TO THE PRODUCT.

No person is authorized to make any other warranty or representation concerning the performance of the Product. Some jurisdictions do not allow exclusion of implied warranties, so the above exclusions may not apply to you. Any limited warranties that cannot be disclaimed are hereby limited to a term of one (1) year from the date of original retail purchase or, in the event relevant state law requires an implied warranty term exceeding one (1) year, for the briefest term allowable under relevant state law. Some states do not allow limitation on how long an implied warranty lasts, so the above limitation may not apply to you.

Under no circumstances will LITH be liable for any indirect, special, incidental, or consequential damages, including any loss of revenue, loss of profit, or loss of data whether based on warranty ,contract, tort, or any other legal theory, even if LITH has

been advised of the possibility of such damages. LITH shall not be liable for any claims made by any third party or made by the Customer directly or indirectly on behalf of any third party. Some jurisdictions do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or seclusion may not apply to you.

LITH reserves the right to change Product specifications or to discontinue the Product or other LITH products without prior notice.

This warranty supersedes all previous LITH product warranties.

LITH BATTERY SUPPORT
www.lithbattery.com

©2012 Shenzhen Lith Battery Co., Ltd
The information contained herein is subject to change without notice. LITH shall not liable for technical or editorial errors or omissions contained herein.