GENASUN

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Genasun Battery Management System Master Board

Manual rev. August 2009

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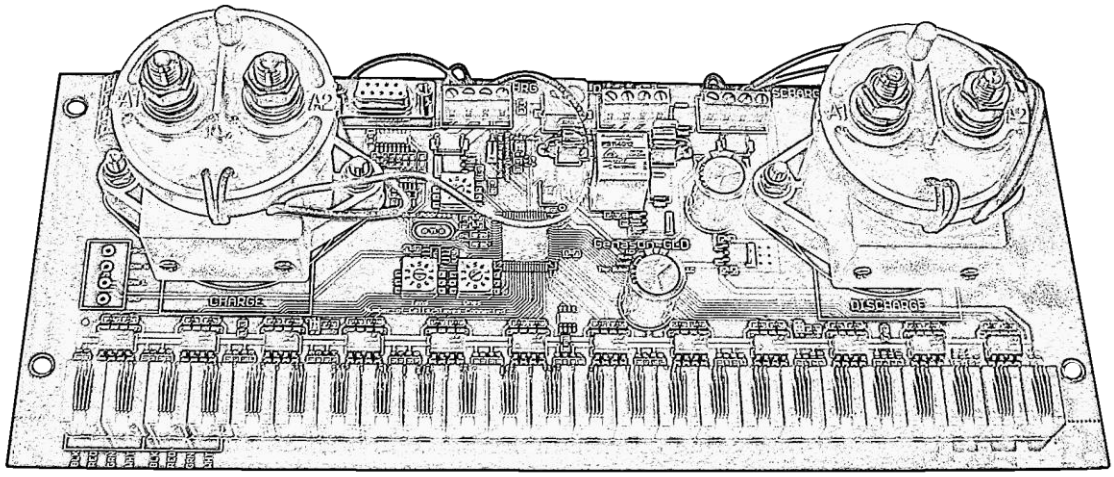


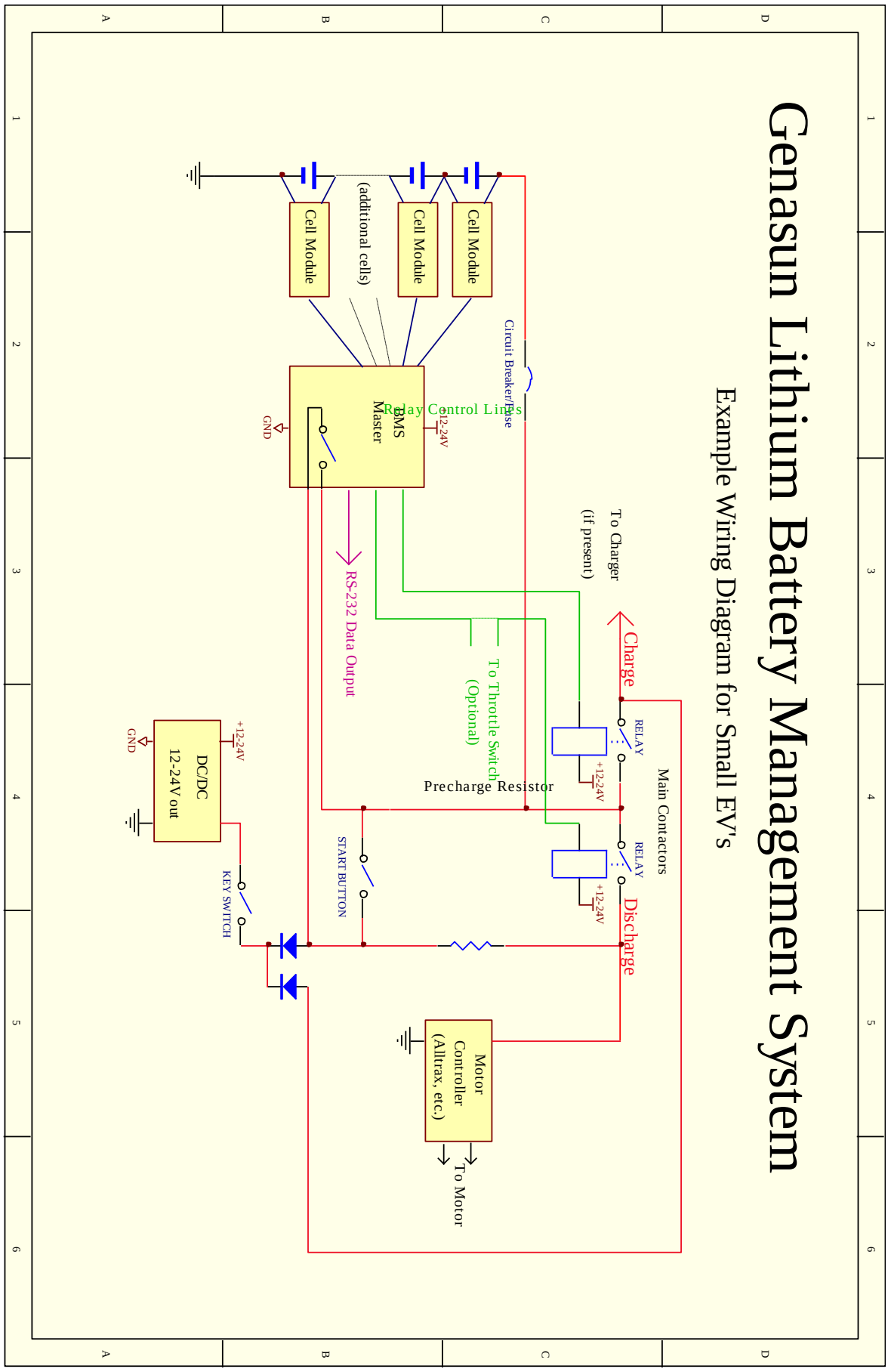
BMS OVERVIEW

Genasun's Battery Management system (BMS) is a key component for the safe and reliable operation of lithium battery banks in many applications, including electric vehicles, aircraft, and boats. The BMS monitors individual cell temperatures and voltages. Using this information, the BMS performs cell balancing, and protects the cells from voltage and temperature extremes. This BMS is only one component of a safe lithium battery system, and should be complemented by chargers adjusted for the correct float voltage, loads with appropriate low-voltage cutoffs, fuses or circuit breakers for overcurrent protection, and appropriate cell cooling and mechanical support.

Genasun's BMS consists of a BMS Master circuit board and cell modules, one per cell (or group of paralleled cells). The cell modules monitor voltage and temperature, and transmit this data to the BMS master via an optically isolated link. The BMS Master aggregates all of the cell data, and controls up to three contactors. These contactors remain closed during normal operation, but will open during fault conditions. One contactor controls loads, or devices like drive motors that may be capable of regeneration, but are primarily loads. A second contactor controls charging sources, such as AC chargers, alternators, solar charging systems, etc. A third relay, located on the BMS Master circuit board, can be configured for auxiliary charge or discharge control. This may be useful in situations where, for example, the alternator field must be disabled before the alternator is disconnected, in order to avoid a voltage spike. The BMS Master includes a plain text serial output (9600 8N1) with cell voltages and temperatures, and BMS status. The following diagrams show typical applications of the Genasun's Battery Management System in an electric vehicle. A single contactor may be used, as in the second diagram, although the battery pack will have to be recharged manually if it becomes over-discharged.

Genasun Lithium Battery Management System

Example Wiring Diagram for Small EV's



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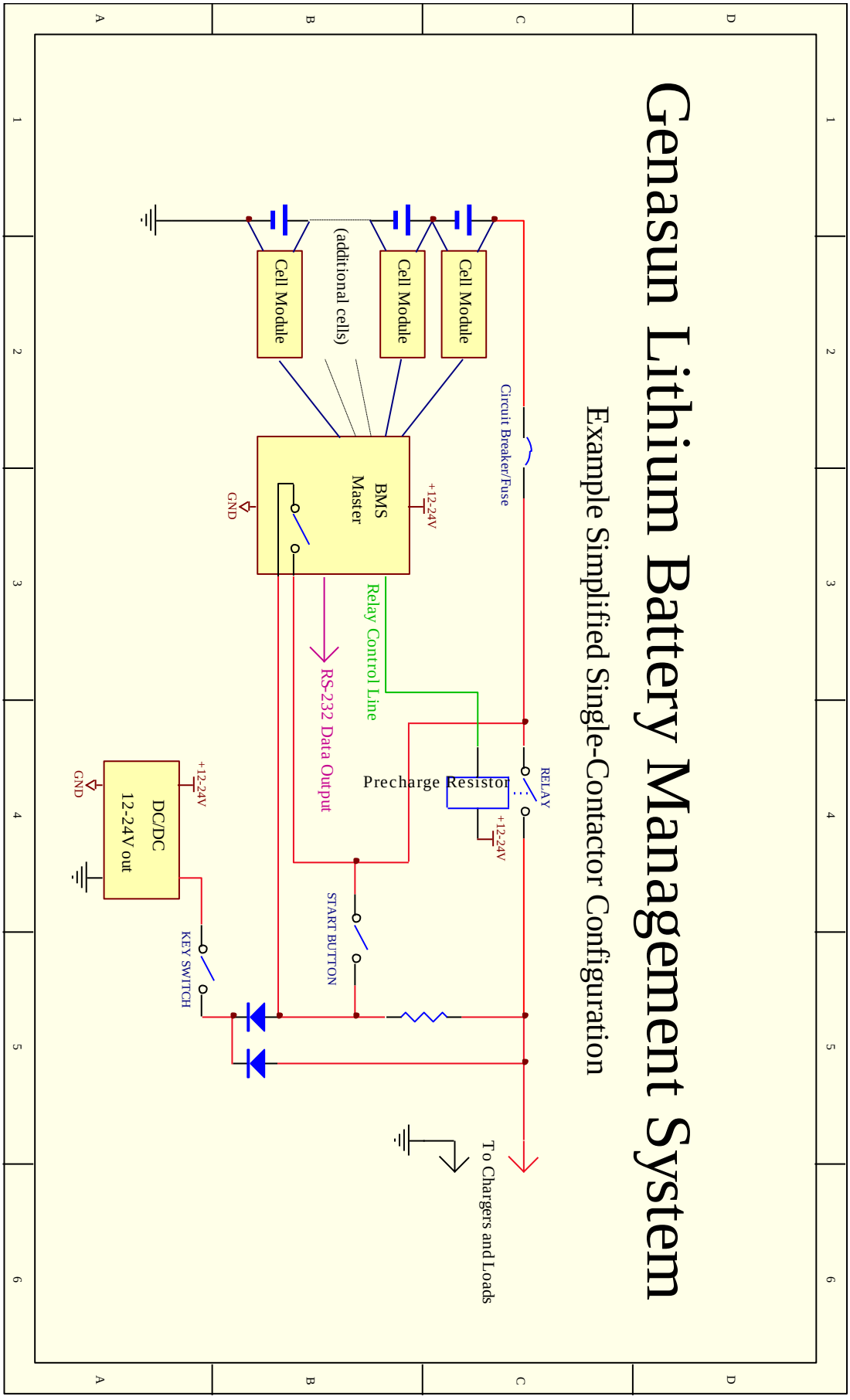

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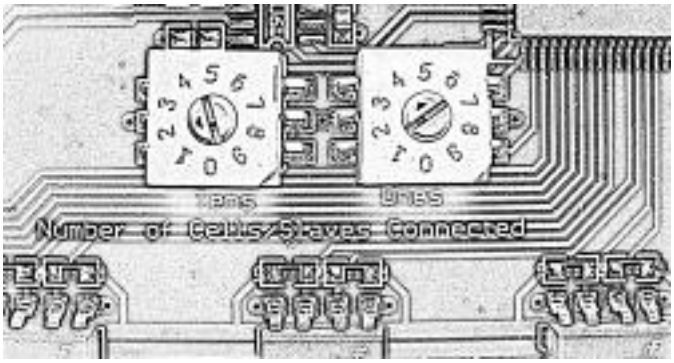
BMS MASTER INSTALLATION

The BMS master should be installed in a protected environment, free from excessive moisture and mechanical stresses. Spaces for EV-200 relays are provided on the PCB. These may be used if the BMS will not be subject to vibration, but the relays should be mounted separately for vehicle applications, to avoid excessive stress on the circuit board.

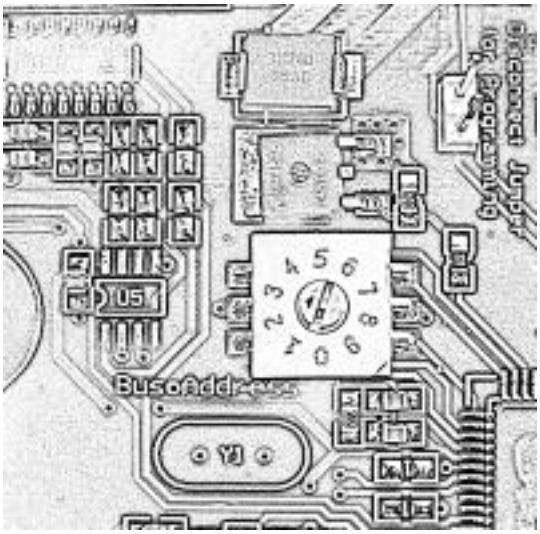
BMS MASTER CONFIGURATION

Genasun's BMS is factory programmed for a particular cell chemistry, so there are only a few additional user settings needed, controlled through the settings of three rotary switches. These switches are only read when the BMS is powered up, so the BMS must have the power switched off and on for the new switch settings to be applied.

First, use the two rotary switches labeled "Number of Slaves" to set the number of cells modules that will be connected to the BMS. One switch is for the tens decimal place, and one for the ones. Valid settings are 02 through 24.



Rotary switches for setting the number of cells connected to the BMS Master.



Rotary switch for setting BMS mode.

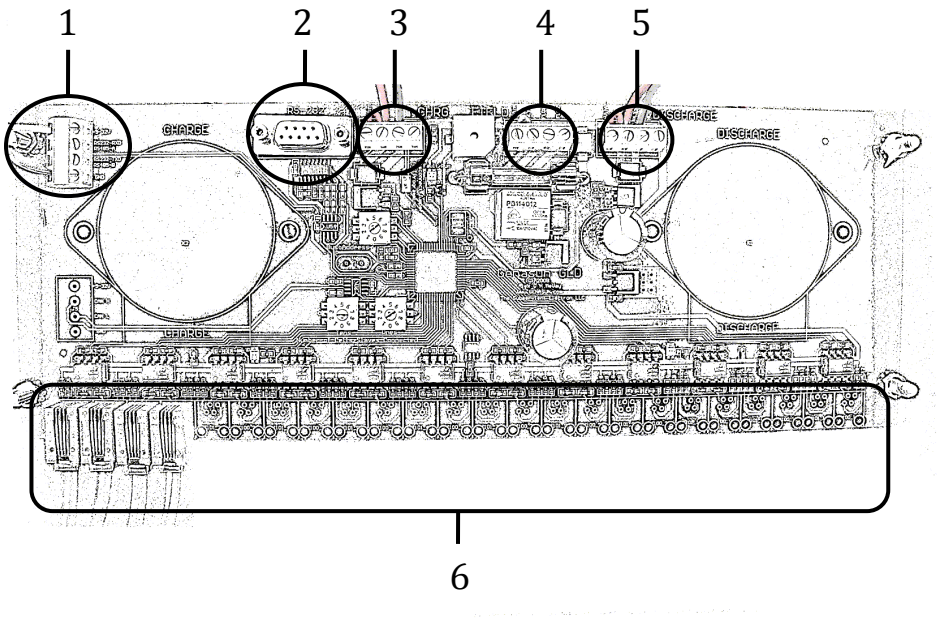
The remaining rotary switch sets the mode of operation of the BMS as follows:

0: BMS Disabled
3: BMS Active, On-Board Relay for Additional Charge Control
4: BMS Active, On-Board Relay for Additional Discharge Control
1,2,5-9:Factory and Test use only

In modes 3 and 4, the on-board relay can be used to control chargers and loads for more graceful operation near the protection limits. In mode 3, the on-board relay will open just before the main Charge relay as the cells reach the upper voltage limit. This mode can be used to disconnect the field of an alternator before open-circuiting the output, thus preventing a voltage spike. In mode 4, the on-board relay will open just after the main Discharge relay as the cells reach their lower voltage limit. This can be useful to preserve power to low-current loads after the main loads (such as a motor controller) have been disconnected. If the on-board relay is not used, modes 3 and 4 are identical.

BMS MASTER CONNECTIONS

The BMS Master requires connections for the cell modules, DC power, and the relays. The diagram below shows the connection points, which are detailed in the following sections by connector and terminal label.



1: BMS POWER

+9-32V:	Connect to Power Source for BMS, +8-32V (9-32V if EV200 relays are used)
RS232-RXD:	No Connection
RS232-TXD:	Serial Data Output, 9600 Baud 8N1
GND:	BMS Ground (galvanically isolated from cells)

2: SERIAL OUTPUT

RS-232:	Serial Data Output, 9600 Baud 8N1

3: CHRG

+Vint:	Internal Power Supply Output (typically jumpered to RLY+)
RLY+	Connect to Positive CHARGE Relay Coil Terminal, and Relay Supply Voltage (typically +Vint)
RLY-	Connect to Negative CHARGE Relay Coil Terminal
NC	No Connection

4: FIELD (On-Board Accessory Relay)

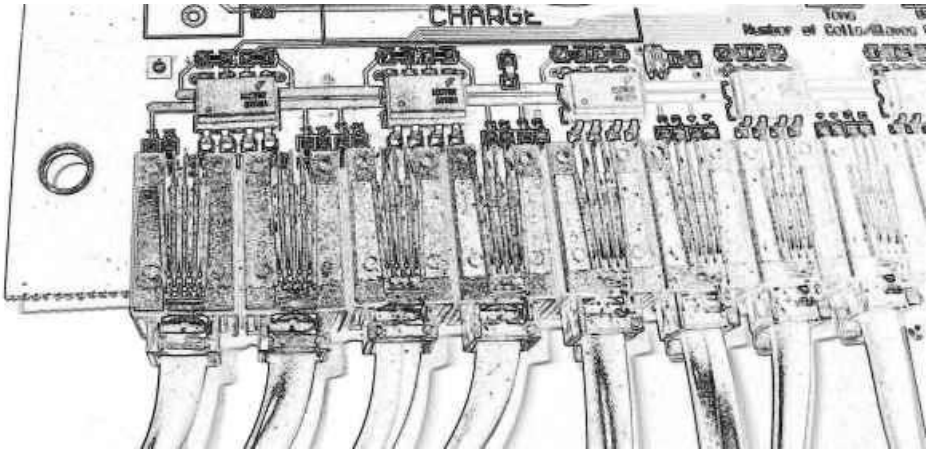
+Vint:	Internal Power Supply Output (typically jumpered to RLY+)
RLY+	If Used, Connect to +12V Field Relay Supply (Can Jumper to +Vint if BMS Supply is 12V)
FLD1	FLD1 and FLD2 are Normally Open 10A Contacts,
FLD2	See **BMS MASTER CONFIGURATION** for Details

5: DISCHARGE

+Vint:	Internal Power Supply Output (typically jumpered to RLY+)
RLY+	Connect to Positive DISCHARGE Relay Coil Terminal, and Relay Supply Voltage (typically +Vint)
RLY-	Connect to Negative DISCHARGE Relay Coil Terminal
NC	No Connection

6: CELL MODULE CONNECTIONS

Plug Cell modules into these connectors, starting from the left and working to the right. The BMS will not operate if this guideline is not observed. The cell modules may be connected in any order.

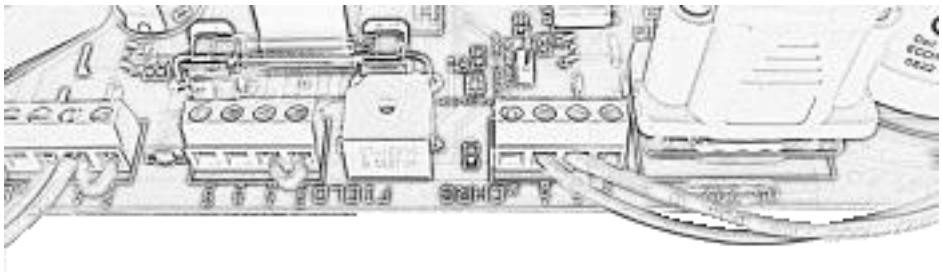


Connection of the Cell Modules to the BMS Master.

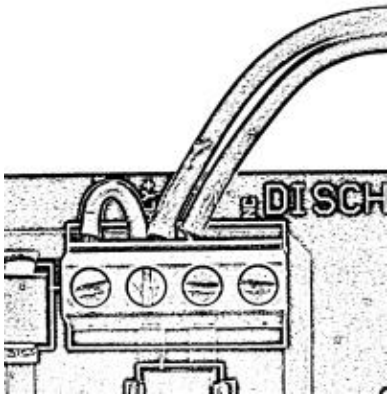
DC power should be applied to the labeled terminal block, located on the right side of the BMS Master if you are facing the main row of green terminal blocks. Please follow the voltage limits in the specifications. If you are using EV-200 relays, please note that there is a large inrush current when the relays switch on, and power connections to the BMS Master should be relatively short and stout.

The coils for the main CHARGE and DISCHARGE relays should be connected to the labeled RLY+ and RLY– positions on their respective terminal blocks. These, and the on-board relay, are controlled by the BMS master by making or breaking the connection from RLY- to BMS ground with a MOSFET. An on-board diode protects the MOSFET from the inductive current spike when the relays are de-energized, but the RLY+ connection must be run to the terminal block for this protection to be active. The RLY+ connection must also be connected to a source of power for the relays. Typically, this is the same source of power as for the BMS Master, and a +Vint connection is provided on the relay terminal blocks adjacent the RLY+ connection, and these may be connected by a small wire jumper. If a separate voltage source is used for the relays, please respect the MOSFET voltage limits listed in the specifications, and make sure the supply shares the same ground as the BMS Master power supply.

If using the BMS in a single-contactor configuration, the main contactor may be connected to either the CHARGE or DISCHARGE relay control terminals. Using the CHARGE terminals allows the maximum delivered energy from the battery pack, while using the DISCHARGE terminals provides extra protection against over-discharge, and more conservative protection against high temperature. In the single-contactor configuration, manual intervention will be necessary to charge the pack if it becomes over discharge, therefore a dual contactor setup is generally recommended.



Relay Connector Overview, Showing +Vint Jumpers.



Closeup of Relay Connector, Showing +Vint Jumper.

The on-board relay (labeled FIELD) has a 12V nominal coil, and this RLY+ should only be connected to the +Vint if the BMS Master is used with a 12V nominal supply. The FLD1 and FLD2 connections are isolated from all other circuitry, and are closed during normal operation of the BMS, and open during fault conditions. Please respect the voltage and current limits for this relay listed in the specifications.

BMS OPERATION

When the BMS is switched on there may be some beeping as communications with the cell modules are established, and all relays will soon close if the cell modules report voltages and temperatures within the protection limits. This is the normal mode of operation.

If there is a communication fault, disconnected cell module, or internal fault, all relays will be turned off.

Operation at the voltage and temperature limits is described in the sections below.

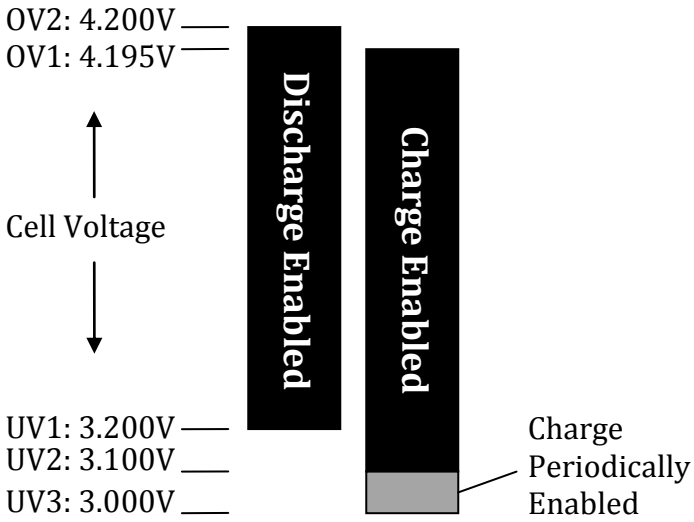
An on-board buzzer will sound if any cell is outside any protection limit or there is an internal or communication fault. Beeping may continue for a short time after faults are corrected due to the buzzer buffer. If the buzzer is too loud for the application, a small piece of adhesive tape may be placed over the buzzer aperture. The beep codes are listed in the table below. A "." represents a short beep, while a "_" represents a long beep. Due to the work load of the BMS microcontroller, beeps may be somewhat irregular.

Cell Undervoltage:	..
Cell Overvoltage:	...
Cell Overtemperature:	....
Cell Undertemperature:	_._.
Communication Error:	_ _..
Bad Switch Settings:	_..

If a cell module detects a voltage or temperature outside of the protection limits, the red LED on the cell module will light, allowing the cell to be identified and checked.

BMS OPERATION at VOLTAGE EXTREMES

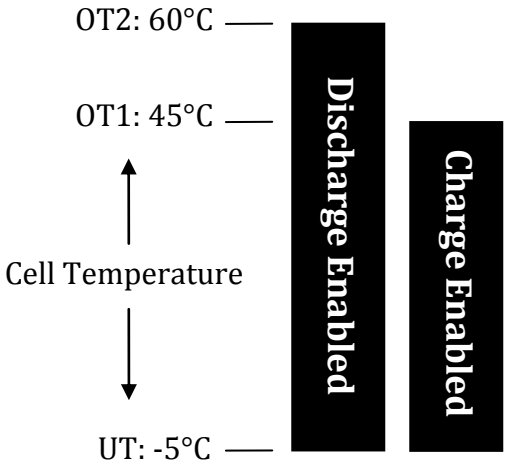
The figure below illustrates the operation of the CHARGE and DISCHARGE relays at the extremes of cell voltage. The upper voltage limits on the left of the diagram (OV1, OV2) apply to the highest cell in the pack, while the lower limits (UV1, UV2, UV3) apply to the lowest cell in the pack. As the cell voltage rises, CHARGE is disabled before DISCHARGE. As the cell voltage falls, DISCHARGE is disabled before CHARGE. This behavior ensures graceful operation at the voltage extremes. If any cell is discharged below UV2, the CHARGE relay will be enabled periodically. This allows the BMS to effectively check for the presence of a charger, while preventing over-discharge from the consumption of the CHARGE relay. If any cell is discharged below UV3, manual intervention will be necessary to charge the pack again, assuming no cell damage has occurred.



CHARGE and DISCHARGE Operation at Voltage Extremes
(Voltages given are for Li-ion/Li-Poly BMS Program)

BMS OPERATION at TEMPERATURE EXTREMES

The CHARGE and DISCHARGE relays will be disabled if any cell temperature goes outside of the respective protection limit. BMS operation at temperature extremes is shown in the diagram below.



CHARGE and DISCHARGE Operation at Temperature Extremes
(Temperatures given are for Li-ion/Li-Poly BMS Program)

BRINGING THE CELLS TO INITIAL BALANCE

For a battery pack to achieve its full potential, the cells must be in balance, which, roughly, means the cells should be at the same state of charge. The cell-balancing function of Genasun's BMS will bring cells into balance, but if the cells are at disparate states of charge when the pack is assembled, this can take a long time: several days or more. If a pack is unbalanced, the result could be early cutoff of charge or discharge as one cell reaches the protection limits, even though the overall pack voltage may be well within the normal limits. This effect is even more noticeable with lithium-iron-phosphate chemistries, which have a very steep charging curve (V vs. Ah) near full charge. If the cells are severely unbalanced, it is recommended to charge them in parallel or individually to their full-charge voltage (typically 3.8-4.25V depending on chemistry) until the current has tapered to a small value. Alternatively, if the cells are relatively well balanced, the Genasun BMS can perform the initial balancing if the assembled battery pack is charged slowly or held at a voltage near but below the full-charge voltage. The BMS may cycle the charge contactor on and off to avoid cell overcharge while pack balancing is underway.

BATTERY PACK CHECKLIST

Please follow these guidelines to help create a safe and reliable battery system:

- BMS installed according to instructions
- Cells supported and protected from mechanical damage
- Battery pack protected from water
- Adequate cooling for intended current levels
- Fuse, circuit breaker, etc., for overcurrent protection, located inside or close to pack
- Thermistor temperature sensors in close thermal proximity to cells
- All charging sources set for appropriate charging profile and maximum voltage
- All loads, if at all possible, set with appropriate low-voltage cutoff
- With bolt terminals, all cell connections cleaned before assembly and tightened securely
- All pack terminals protected from accidental short circuit (dropped tool, etc.)

BMS MASTER SPECIFICATIONS

Input Voltage:	8-32V (EV-200 relays require 9V minimum)
Internal Fuse:	5A Fast Acting, 1/4"x1 1/4"
Typical Supply Current:	15mA (excluding contactor consumption)
Size:	12.00x4.87x1.20"
Number of cells managed:	2-24 cells or paralleled cell groups

On-Board Relay:

Relay Type:	Tyco PB114012
Coil Voltage:	12V
Coil Current:	30mA
Contact Voltage:	300V
Contact Current:	10A

(breaking current reduced above 28Vdc, please consult relay datasheet)

Relay Control Outputs:

Type:	Open Drain MOSFET
Max Continuous Current:	2A
Max Voltage:	40V

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