



***Rudman Regulator  
Mark 3x8 Digital  
Lithium Ion BMS***



***Owner's Manual***  
***Rev 1.8***

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## **ATTENTION! ELECTROSTATIC SENSITIVE DEVICES OBSERVE PRECAUTIONS FOR HANDLING**

Don't ship, or store near electrostatic, magnetic, electromagnetic, or radioactive fields!

Static electricity can produce high voltages which can damage sensitive electronics in this product. Damage due to negligent handling and static ***may not be covered under your warranty.***

### ***TIPS TO PREVENT ESD DAMAGE:***

Avoid contact with any of the components on the product circuit boards. It is best to hold the PCB only by the edges much like you might handle a record or compact disc. When working with the PCB it is best to have an appropriate anti-static mat and wear a properly grounded wrist strap. In the absence of proper equipment the risk is much higher but other precautions may be helpful. Keep your work area clean and especially be cautious of static inducing objects such as plastic desk accessories, wastebaskets, telephones and computers. Avoid shuffling or rubbing against things and avoid using rolling chairs.

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## **Mk3x8 Digital Lithium BMS For up to 8 cells**

### **General Overview**

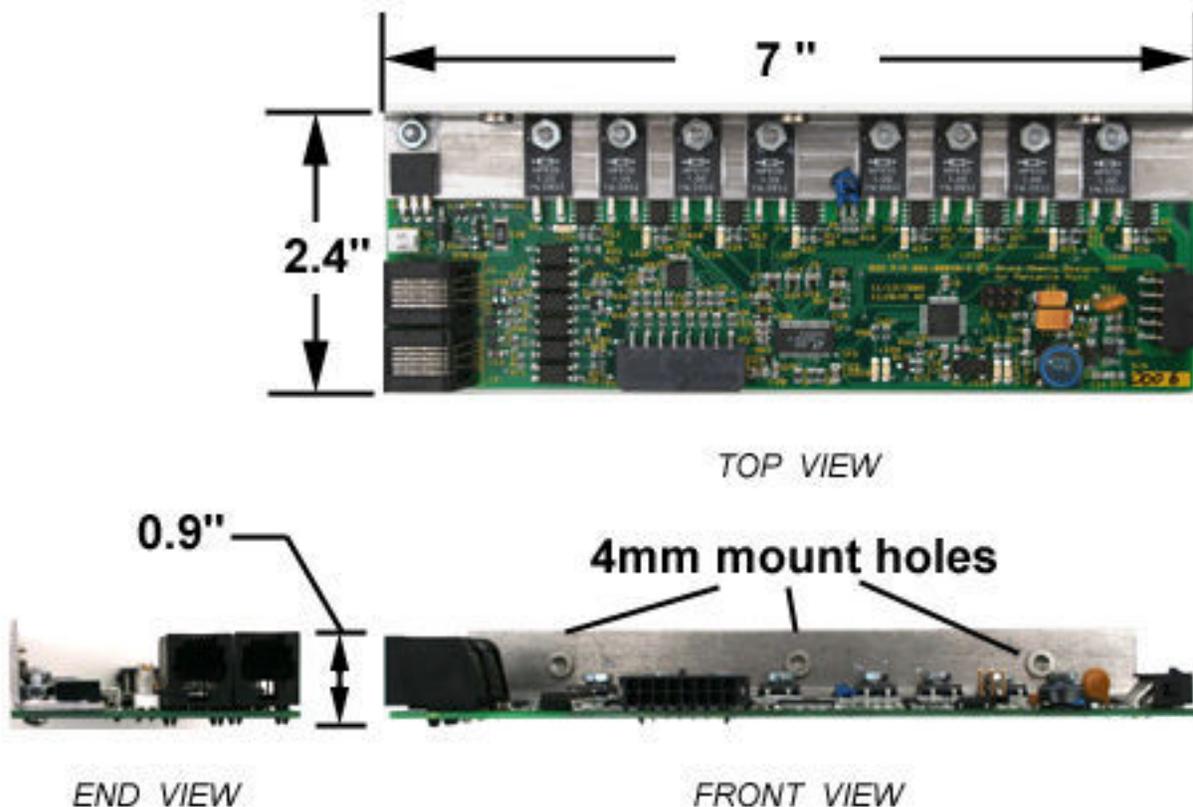
The Mk3x8 Digital Lithium Regulator is a feature rich battery management board capable of individual voltage and temperature monitoring and equalization of up to 8 cells. Each Mk3x8 is less than 1 inch tall and has a footprint of only 7 x 2.4 inches yet they have incredible dissipation capacity for quick equalization. Furthermore, they have simple RJ reg bus ports for quick and simple communication back to any Manzanita Micro Charger.

When lithium cells are connected in series, even if they are closely matched when new, over time their exact capacities and voltages will drift apart. With the many varieties of sealed lithium ion batteries permanent capacity loss can result if cells are overcharged to the point of venting. Furthermore, with some lithium polymer batteries as well as certain other chemistries, thermal runaway or explosion can occur if there is no intelligent BMS to keep the cells in their safe operational range. The intent of the Mk3x8 regulator is to bypass current around a fully charged lithium cell so that all the other cells in a long series string can get fully charged without any one becoming overcharged. This is accomplished with individual Mk3x8 circuit boards attached to each group of 8 cells. These boards are able to sense the voltage across the cell and turn on a bypass resistor to bypass current around the cell instead of going through it. Each of the 8 circuits has a blink feature that changes duty cycle in response to the needs of the individual cell allowing the user to see what is happening.

When using the regulators in conjunction with an appropriate charger, it is possible to charge and equalize the batteries very quickly without worrying about damaging them. Fast, full charges coupled with individual cell equalization means less down time, more range per charge, better battery health and longer lifespan.

The digital communication bus allows detailed continuously updating graphical battery and BMS data display using the Manzanita Micro Mk3 Reg Scanner Software. Additionally, anyone with a PC, a USB port and the included software can view text based important battery and regulator information. This information includes up to 8 individual cell voltages (or the total block voltage for that unit using "Querytot" command), individual cell temperatures (with up to 8 user installed temp sensors), regulator internal (heatsink) temperature and other information. The rest of this manual details these features as well as how to change settings.

### Dimensions and Specifications



The Mk3x8 Digital Lithium BMS units weigh in at approximately 3.6 ounces (102 grams) Approximate dimensions are: 2.37 in x 7 in x 0.938 inches (60mm x 175mm x 23mm)

The Mk3x8 name signifies Mark 3 edition BMS (digital) with 8 channels (for 8 cells). All Mk3x8 systems are calibrated and fully tested before leaving Manzanita Micro.

## **MARK 3X8 DIGITAL LITHIUM ION BMS KEY FEATURES**

- Real time voltage monitoring of 5 to 8 lithium cells
- Real time temperature sensing of up to 8 external temp sensors
- Additional temperature sensor included on BMS module's heat sink
- Small size is less than 1 inch thick and 7 inches long by 2.4 inches wide
- Quick automatic cell equalization and balancing with high and low voltage on board indicators and outputs to the charger
- Two high speed real-time warning lines which can be relay buffered for external use
- All BMS modules connect together using readily available RJ cable
- BMS easily connects to a PC using the included USB adapter
- Includes free Windows based scanner and command software
- All commands are easily entered and read in simple ASCII text
- Easy user adjustable min and max voltage parameters allow flexibility for various types of lithium cells from 1.75 to 5.5 volts per cell
- Each BMS board can bypass up to 2.5 amps per cell channel (20A total) equating to fast charging and equalization of unbalanced cells
- Dual RJ reg bus ports for easy connection to the charger or other BMS units in a simple daisy chain fashion
- Self regulating thermal protection and feedback to Manzanita Micro Chargers
- Built-in active variable speed 12V DC fan control output on each BMS unit. The fan settings can be viewed and changed using the included software
- Large heat spreader is totally isolated from the cells and is already threaded for easy mounting to a larger heat sink.
- Each unit can dissipate up to 110 watts

## Mark 3x8 Lithium BMS Operation

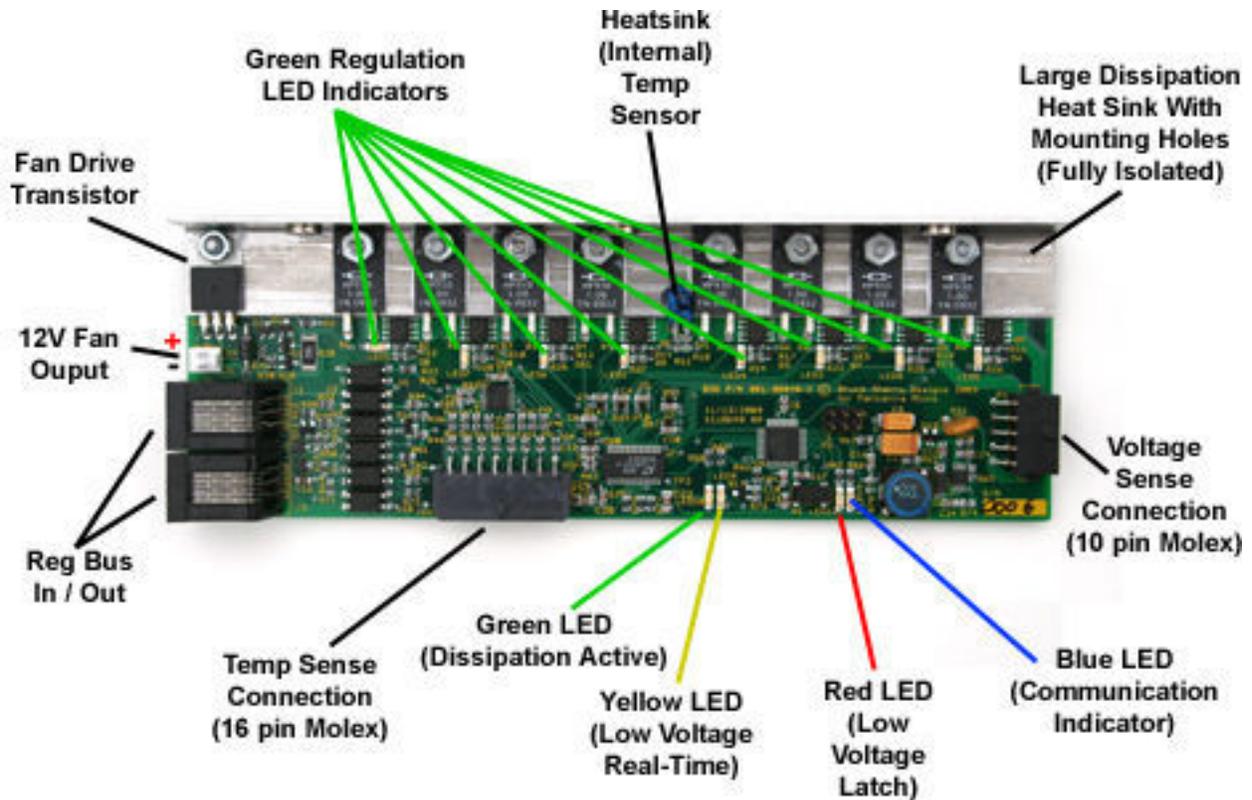


figure 02

### Indicators:

There are twelve LED indicators on a fully populated Mk3x8 regulator. When the regulator is first connected to at least 4 cells, the green, yellow, red and blue LEDs will illuminate briefly to let the user know that they are all functioning.

### 8 Green LEDs – “Regulation Indicators”

The eight green LEDs indicate that the BMS unit is regulating. Each of the eight LEDs in the middle of the board correspond to their own independent dissipation channels. They come on when the cell they are attached to is above the regulation set point and the reg load is activated. The green LED next to the yellow LED, blinks any time any of the eight cells are at their upper regulation voltage limit. This is a brief transient event at first with a brief blink followed by a much longer off time. As the cell becomes more fully charged, the on time increases and the off time decreases, thereby increasing the bypass current through the regulator and preventing the battery from being overcharged. So, the faster the individual green LED blinks, the more fully charged that

cell is. The set point voltage controls the voltage level when this regulation occurs. On a Mk3x8 reg, this set point high voltage limit is preset to 3.8 Volts per cell before leaving Manzanita Micro. This set point can be adjusted by communicating with the regulator from a computer via a USB cable and the DT box or the Manzanita Micro Regscanner. The high and low set points can be adjusted in 0.024 volt increments. For more information on this procedure, see the “Adjustments” section later in this manual.

**NOTICE!** If any green LED stays on steady this means that at least one of the channels in the BMS unit is regulating at full bore. If this happens frequently the charger should be turned down or the regs need more cooling. When the reg bus is connected to a Manzanita Micro battery charger and a green LED remains steady on one or more regs, the charger should cut back or shut down automatically as necessary. In this case the blue “Timer” LED on the charger will be lit.

#### Yellow LED – “Undervoltage Real-time”

The yellow LED indicates that one or more of the cells in the string is/are currently below the undervoltage set point. This can indicate a discharged cell, a bad cell or a damaged BMS unit.

The undervoltage set point on a Mk3x8 BMS unit is preset to 2.5 Volts per cell before leaving Manzanita Micro. This set point can be adjusted by communicating with the unit from a computer. For more information on this procedure refer to the “Adjustments” section later in this manual.

**NOTICE!** When many BMS units are connected together to monitor a pack of batteries if one unit detects an undervoltage condition with any one of its cells and illuminates its yellow LED, this will trigger all of the regulators to illuminate their yellow LEDs. In this case, one must look for the regulator with the red LED to find the offending battery.

#### Red LED – “Undervoltage Latch”

The red LED indicates that one or more of the cells attached to that reg has/have gone below the undervoltage set point at some point since it was last brought to a full charge. The red LED will remain lit until either the power is disconnected from the regulator or the battery is fully charged and all eight green LEDs blink. This feature lets the user quickly spot the weakest batteries in the pack even if some of the individual cells are currently not below the undervoltage set point.

#### Blue LED– “Communication Indicator”

The blue LED indicates when the regulator is communicating on the Rudman Bus. All of the blue LEDs should blink in sequence whenever an external device is communicating with a string of regulators and going through each valid bus address. The blue LED will illuminate whenever the unit is being communicated with.

### **Dissipation Heat sink:**

The long 'L' shaped aluminum heat sink is the area on the BMS unit where energy is bypassed around a cell and dissipated as heat . This sets the Manzanita Micro BMS apart from the competition and allows for maximum battery balancing in a short amount of time. When the unit's heat sink temperature becomes too high, the unit automatically tells the charger to cut back via the reg bus data cable system. Bolting the BMS unit to a larger heat sink and/or adding a cooling fan will allow for even higher performance and faster equalization. Mounting fasteners should be 4mm hardware.

The thermal threshold temperature for the heat sink is normally set to 180 degrees Fahrenheit upon leaving Manzanita Micro. This threshold can be changed in order to push the regulators harder, but be aware that higher heat sink temperatures may shorten the life of the regulator. For more information see the "Adjustments" section later in this manual.

### **WARNING! NEVER touch any of the heat sinks while the cells are being charged!**

As the name implies, the heat sinks get HOT. Temperatures can be as high as 180°F (82.2°C) and they can cause burns if touched while they are hot.

### **Built In Fuse:**

Each MK3x8 BMS unit has a built-in individual poly fuse designed to prevent damage to the reg in certain circumstances. The poly fuse is rated to 50 milliamps. Damage will occur if there is ever more than 70 volts placed across the BMS unit.

**NOTICE! THE POLY FUSE WILL NOT PROTECT THE UNIT AGAINST REVERSE POLARITY OR INCORRECT VOLTAGE SENSE WIRING!** If a unit frequently trips the poly fuse, contact a qualified service technician or Manzanita Micro.

### **Connections:**

#### P2 – Voltage Sense/ Cells Connection

P2 is the Molex 10-pin voltage sense connection which connects each individual cell to its respective BMS channel. The Molex part number for the standard required female connector plug is: 43025-1600 and the pins are p/n: 43030-0008. For further instructions refer to "Wiring the Mk3x8 BMS" in the Installation section of this manual. If you happen to have one of the custom bottom mounted voltage sense connections then refer to the Appendix at the end of this manual for a specific diagram of the bottom mount connection.



*figure 03: Standard Voltage Sense Plug*

### J1 – External Fan Connection

J1 is the 2-pin molex plug right next to the RJ ports. This provides power to drive an external 12 volt fan. The part number for this connector plug is: 22-01-3027 Red and black 22 awg stranded hook up wire is recommended. Crimp on the Molex end pins (p/n: 08-50-0114) and insert them into the connector plug until they latch. The red positive wire should be inserted into the RIGHT side of the Molex connector so that it is on the side nearest to the heat sink on the BMS unit.

**CAUTION: Do not short out these pins as they can have 12 volts potential between them at any time. Also when an external fan or fans are hooked up to this connection be aware that it/they may turn on and off at any time.**

The external fan uses PWM control allowing 8 different fan speeds (1-9) and an automatic mode (O). For more information on controlling an external fan, refer to the 'Fan' command description on page 21 of this manual.

### P3 – Eight Channel 16-pin Molex Temperature Sense Connection

P3 is a 16-pin Molex connection which allows up to 8 individual temperature sensors to be connected to the regulator. These external temperatures can then be displayed on any laptop or computer running the supporting software. These external temperature sensors will be in addition to the unit's own internal heat sink temperature readout. The Molex part number for the required 16-pin female connector plug is: 43025-1600 and the pins are p/n: 43030-0008. For proper temperature sensor wiring order the sensors from Manzanita Micro or refer to "Wiring the Mk3x8 Regulators" in the Installation section of this manual. Figure 04 below shows a properly constructed temperature sense harness and figure 10 shows another illustration of the BMS connection.



*figure 04 (see also figure 10)*

#### P1 – Programming Header

P1 is the 6 pin JTAG programming header. This is where the chip programmer is attached in order to load the firmware when the regulator is initially programmed at Manzanita Micro. Users should never attempt to attach anything to this header.

#### J2 and J3 – Regbus I/O RJ Connections

J2 and J3 are the In/Out ports for the reg bus communication line. These are standard 6 pin RJ data connections. The Mk3x8 units are to be connected to each other in a daisy chain fashion. The precise order does not matter as long as each unit is individually programmed with a unique bus address identification number that does not change. The dongle terminator (DT) for the Manzanita Micro Regscanner or a laptop can be plugged into the same RJ connection at either end of the chain to read information and send commands to the BMS units over the Rudman Bus. More information on that is contained in the next section.

#### **The REGBUS interface:**

The REGBUS communicates important information back to the charger such as whether any regs are regulating or not and whether any heat sink channels are too hot. The charger uses this information to determine when to turn down the charge current and when to turn off the charger. In addition, the REGBUS also transmits the digital information to the terminator and dongle where an external digital device can be hooked up in order to view and/or change the regulator information.

The REGBUS interface contains five wires connected as follows:

1. Power supply (+5 volt DC)
2. Reg overvoltage condition (reg ON or reg hot) – +5V on this line when active
3. Undervoltage condition – 0V on this line means undervoltage active
4. Power supply return Ground (GND)

**CAUTION:** The GND return is NOT isolated on older Manzanita Charger models.

5. Rudman bus negative
6. Rudman bus positive



*figure 05*

Note: The pin count reads from left to right when looking straight on into the RJ receptacle (refer to figure 05). Or, when looking at the bottom of the board, pin #1 is the square pin.

All of these wires are isolated from the battery being monitored to prevent faults. The opto-isolator components keep local Batt POS and Batt NEG isolated from the charger's Batt POS and Batt NEG. The +5 and GND are powered from a 150 mA DC/DC converter. All measurements are made relative to the GND wire. It is important to verify all six of the wires are continuous throughout the system. On older PFC charger models, the GND on REGBUS is not isolated from battery negative.

The primary functions of the REGBUS are:

1. Supply power to the charger side of the BMS units
2. Support analog data exchange from BMS to charger and real-time analog control
3. Support digital data transfer and control of BMS via the Rudman Bus (modified EVILbus)

Optimally, the charger will run at full current until the first regulator gets hot, then it will cut back to save that regulator and also start the countdown timer. With new sets of cells, it can take several hours for the pack to go from the first one to top off until the last one tops off this is especially true if the cells were manufactured at different times.

As more charge and discharge cycles are performed, the cells in a pack will become more closely synchronized and the equalization time will be much quicker. As the cells near the end of their useful life, the time to equalize usually gets longer and longer as some cells perform more poorly than others.

How hot to run the regulators during the absorption phase is a function of the ambient temperature and how fast the vehicle needs to get back into service. Higher temperatures will make the absorption phase take less time but is more risky to the regulators. When the upper thermal threshold on a regulator has been reached, the blue and red LEDs will illuminate and the reg will pull the hot reg line to +5 volts. This will tell the charger to stop charging until the temperature of the heat sink drops below the thermal limit. Adding airflow across the regulators will dramatically help cooling the regs and speed up charge equalization.

### **BMS Installation:**

The Mk3x8 BMS units have 3 mounting holes with threaded inserts. These mounting points are spaced evenly on the back side of the long angled aluminum heat spreader. More precisely the mounting holes are at 25mm, 87.5mm and 150mm from the left edge. It is recommended that the units are mounted to a larger heat sink or piece of aluminum or copper. The dissipation resistors and the fan drive transistor are isolated from the heat sinks.

### **Wiring the Mk3x8 BMS:**

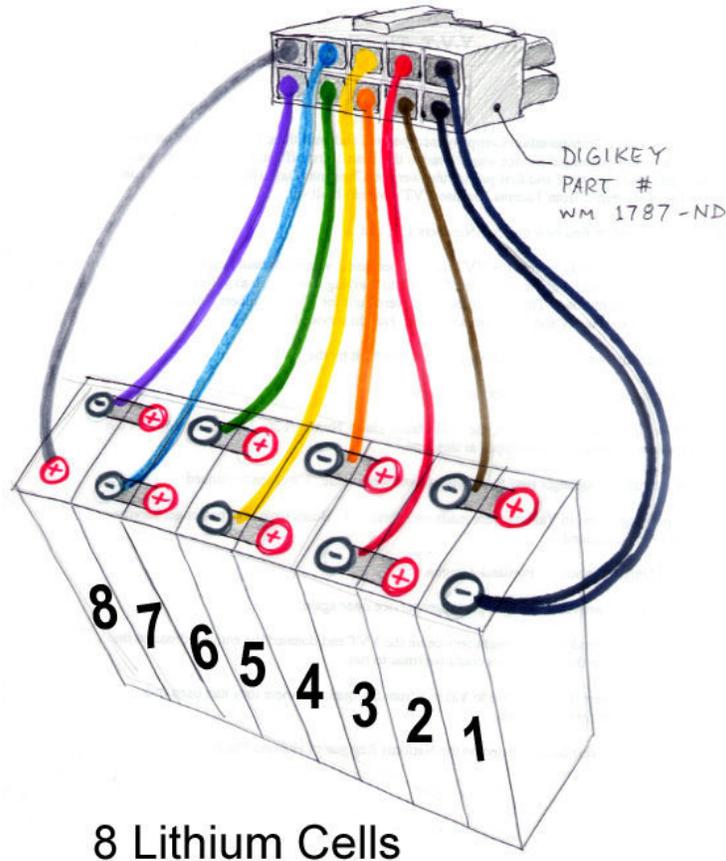
#### Voltage Sense Wiring:

Battery wires to the BMS units should be kept as short as possible. Each Mk3x8 BMS unit needs only 9 cell connection wires to monitor a block of 8 cells (actually 10 wires since there are 2 black ground wires). Refer to the wiring illustration shown in figure 03 in order to assure proper wiring. Nine different colors of wire are recommended in order to color code for ease and accuracy of cell wiring.

Manzanita Micro recommends using 22 gauge stranded hookup wire in black, brown, red, orange, yellow, green, blue, violet and gray. Be sure to check that each wire goes into the 10-pin Molex connector exactly as shown in the wiring diagram (figure 03) and that each wire goes to the appropriate connection between cells. When wired as shown in the diagram, the cell voltages will be in the correct order.

The Digikey part number for the Molex connector pins is: WM 1125 CT-ND. Crimp the Molex connector pins and insert them into the connector plug until they latch. The other ends of the wires connect to the cells. Simply attach an appropriately sized ring terminal and bolt the terminal onto the cells placing it on top of the lug or bus bar. The two black wires are both attached to the negative terminal of the 1<sup>st</sup> cell in the group of 8 cells. The gray wire is the most positive wire so it is connected to the positive terminal of the 8<sup>th</sup> cell in the group of 8 cells. The other wires connect in order at each interconnect point between the cells as shown in figure 06.

**NOTE:** In some cases the number of cells in a battery pack may not be divisible by eight. If this is the situation, please continue to use all 9 cell voltage sense wires when wiring the cells. When the last cell in the group is reached, simply place all the extra ring terminal connections on the last (most positive) terminal of the group.



*figure 06 : Standard Voltage Sense Connector Diagram*

### Temperature Sense Wiring:

Temperature sensor wires must be twisted pairs and should be kept to 18 inches or less. The Mk3x8 regulators use 8 pairs of wires to monitor up to 8 external temperature sensors. Manzanita Micro recommends using 22 gauge stranded hookup wire. Be sure to check that each wire goes into the 16-pin Molex connector exactly as shown in the photo in figure 04. Crimp the Molex end pins onto the wires and insert them into the connector plug until they latch. Each pair should be placed exactly like the photo so that there are 8 vertical rows. In order to easily distinguish the sensors from each other it is recommended to use pairs of similar colors. Solder a wire to each temperature sensor lead and cover the exposed joint with heat shrink. The temperature sensors are not polarity sensitive so it does not matter which side the wires go to. The temp sensors

are available from Manzanita Micro as well as pre-built harnesses.

### Reg bus Wiring:

All MK3x8 BMS units are connected with a 6 pin RJ data cable allowing them to communicate back to the charger. These communication lines connect all of the BMS units in a daisy chain fashion.

### Regbus Cable Construction:

The 6-wire RJ cable which is used to connect the regulators is a common data transfer cable and is available at most electronics stores. The 6-pin connector plugs are usually clear and it is easy to crimp them using an appropriate crimping tool with a 6-pin die. These are also readily available.

**NOTICE!** RJ cable is quite rugged but take care not to cut or sharply bend (and fatigue) the cable in order to avoid errors from broken internal wires. Additionally, follow the proper cable construction techniques listed below and make sure that all the wires are installed in the correct orientation. (See figure 07)

Proper Regbus cable construction is not difficult but it requires keen attention to detail on the part of the person installing the plug ends onto the RJ cable. The following steps tell how to correctly make a regbus cable suitable for use with any 6-Pin Manzanita Micro product.

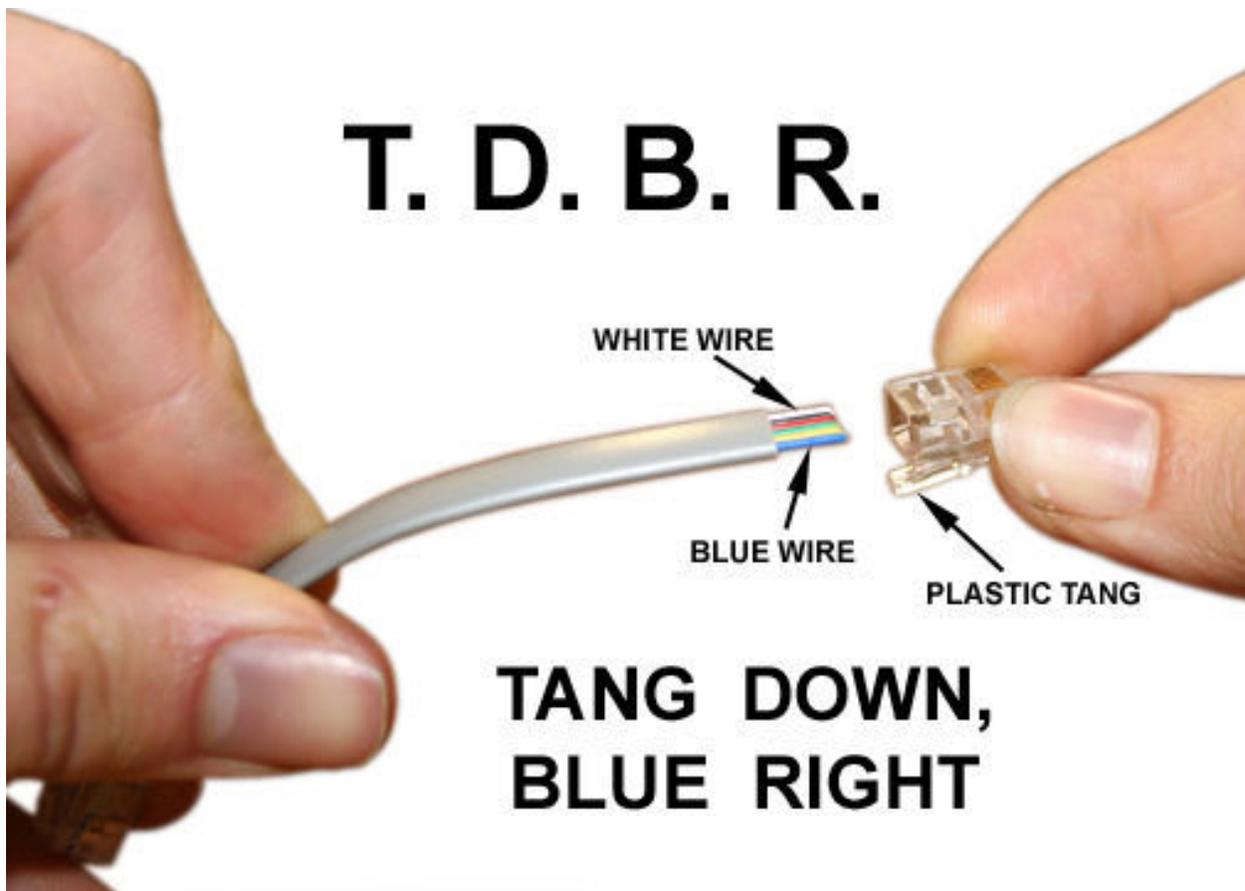
Step 1: Cut the RJ cable to the desired length. (It is advisable to err on the long side because each of the cable's ends will be pushed to the back of their respective RJ receptacles.

Step 2: Strip about a quarter inch of the thick "flat" outer jacket off of each end of the cable in order to expose the 6 colored wires inside. Most RJ crimping tools will have a special wire stripping section with a guide which will allow you to quickly strip the correct length of cable jacket off.

Step 3: Hold the flat RJ cable in front of you in your left hand with one end pointing towards you and one away from you.

Step 4: Looking down at the cable in your hand make sure that the end facing away from your body has the **blue wire to the right** side.

Step 5: Now take an un-crimped plug-end in your right hand and with the tang oriented on the bottom side, slide the outward facing end of the flat RJ cable into the slot in the un-crimped plug. Make sure it is not crooked and push it all the way into the un-crimped plug. (see figure 07)



*figure 07*

Step 6: Double check that the **blue wire is to the right** side with the tang down and then take the RJ crimping tool in your right hand. With your left hand push the cable with un-crimped plug into the 6-pin die on the crimping tool.

Step 7: While using your left hand to make sure that the RJ cable is firmly held all the way into the connector, squeeze the crimping tool with your right hand and complete the crimp.

If you have a clear plug-end, you can look in and make sure that each of the 6 metal pins sunk all the way down into their respective wires. Give the connector a slight tug to make sure that it is adequately fastened and now you have created a proper RJ cable end.

Follow the same steps on the other end of the cable and you are done. **NOTE!** When crimping the second end of the cable, notice that you'll have to flip it over in order to **again orient the blue wire to the right when the connector tang is facing down.** (see figure 08 )



*figure 08*

## **Connecting With the Digital Interface**

### Connecting With a Laptop or Other Windows Based Computer

Any computer with a USB port and running Windows can plug into the regbus using a dongle / terminator box which is available from Manzanita Micro. These items in conjunction with the free software, will allow you to view regulator data and send commands using a text based program. The files are available from [www.manzanitamicro.com](http://www.manzanitamicro.com) and they are located in the "Downloads" section.

Simply open the file and follow the simple setup wizard to install the program on your computer. Once installed, open the program and if the regs are properly connected through dongle / terminator and you should be able to read information from them. More specific instructions for the application can be found in the README file included with the software itself. Details on hooking up the dongle / terminator (DT box) is in the section below



*figure 09*

### Dongle Terminator Box (DT Box)

The dongle / terminator box is a black adapter box with a USB plug which plugs into the computer that will be used to communicate with the Mk3 regulators using the Rudmanbus system

The other end of the dongle has two RJ jacks which allow it to be connected with cables to the reg bus system. The reg bus alone will not function correctly without a supply of 12v power. The new DT box receives its power from the USB plug itself. On older models there is actually a separate 12 volt power jack (as in figure 09). The center pin requires +12 volts and is a 2.1mm post.

**NOTE!** Communication over the digital Rudmanbus will not be possible if the DT box is not receiving a solid 12 – 15 volts.

## Voltage Sense Wiring With Rare Bottom Mount Connection

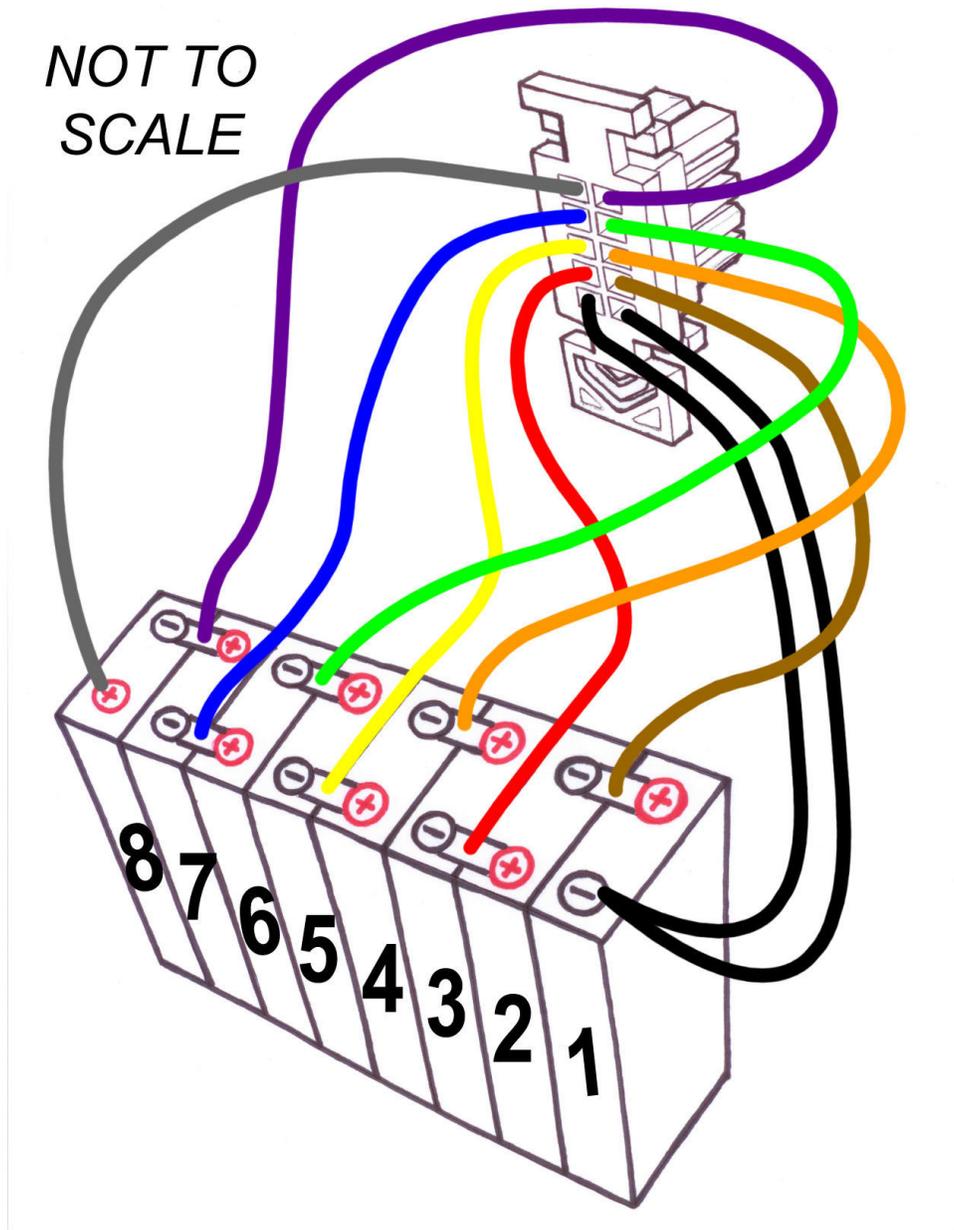


figure 10

Some custom Mk3x8 BMS units have been produced with special bottom mount connections. Figure 10 shows the correct wiring for the custom bottom mounted connector. The Molex part number for the 10-pin voltage sense connector in the picture is: 44133-1002. The Molex part number for the pins themselves is: 43030-0002.

NOTE! MOST UNITS USE THE STANDARD CONNECTOR SHOWN BACK IN FIG 06.

## Temp Sensor and Cell Indicator Numbering Guide

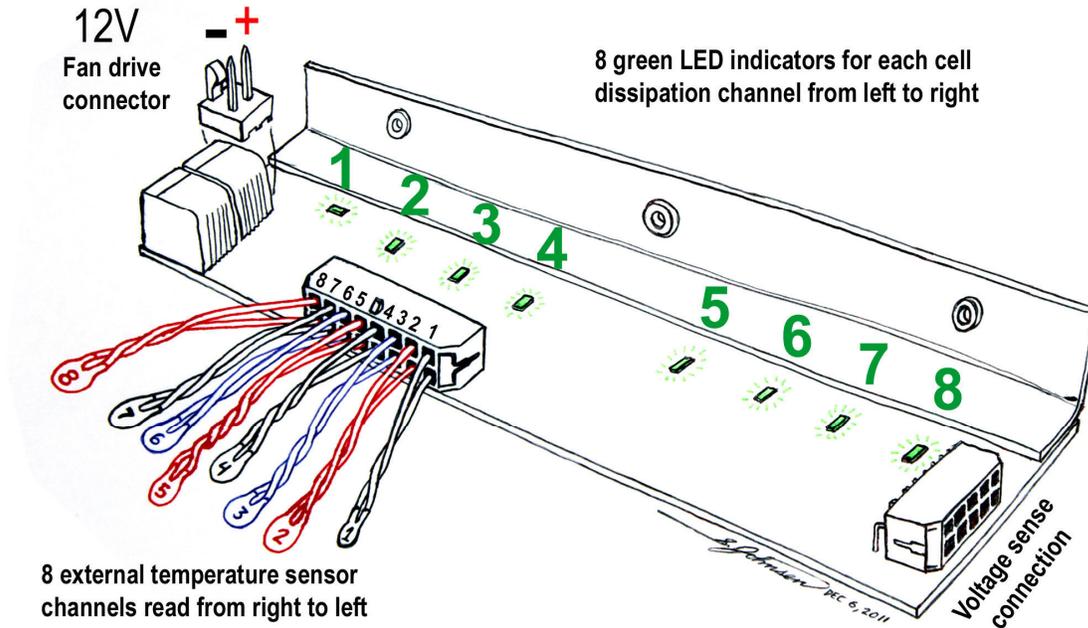
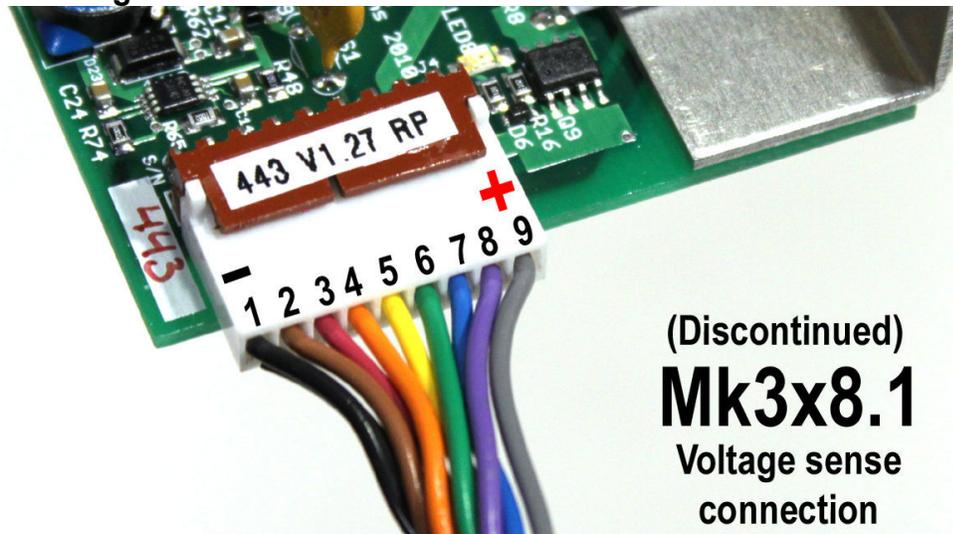


figure 11

The Mk3x8 was designed to monitor and equalize up to 8 lithium cells. There is also a means for connecting up to 8 individual external temperature sensors. Figure 11 shows how the temperature sensors are wired and which number each one corresponds to when viewing the sensors in the software. Also, there are eight green LEDs on the Mk3x8 and figure 11 shows which cells these LEDs correspond to.

## Voltage Sense Wiring for Discontinued Mk3x8.1 BMS



The image above shows the polarity of the 9 pin connector used on the very early Mk3x8.1 series 8-channel BMS units. Refer to figure 06 for the cell connections.

## Regulator Adjustment and Commands

### Using Commands

Unlike the old analog Rudman Regulators, the Mk3x8 regs do not require adjusting potentiometers in order to change voltage settings. Instead, the Mk3x8s can be calibrated, asked to feedback information or have settings (such as voltage limits) and changed using simple ASCII commands. Each reg can be talked to individually by using its specific bus address. Some commands can be sent to all regs at once by entering a bus address of 99. This is useful for commands like clearing history, or setting all of the voltage limits.

The first two bytes are the devices bus address in ascii decimal (ie: 00 to 99). These are followed by the specific command to be executed.

To ask for regulator #1s battery voltage reading the command would be: "01voltage" and then hit the return key.

To ask for regulator #7s battery voltage reading the command would be: "07voltage" and then hit the return key.

**NOTICE! The commands *will not* work if there are any uppercase letters used. All letters must be entered in lowercase characters only!**

A complete commands list is included in the appendix at the end of this document.

**NOTICE!** Ensure that the REGBUS data cable is fully plugged into the charger whenever the vehicle is charging. The communication data cables are hooked to the regulators in a daisy chain fashion. Make sure that each of the smaller data cables are all plugged in where they should be before charging. If there is an unplugged portion of the REGBUS, the charger cannot communicate with the regs and this could lead to potentially damaging situation if there is an un-matched battery cell in the pack! The RJ connectors are similar to phone cord connectors and they are designed to snap into place and stay connected. If a cable is disconnected insure that it is fully reconnected. An audible \*click\* should be heard when the RJ plug is fully inserted and it should not be able to be pulled out without first pinching the small plastic tab underneath the plug.

For more information visit: [www.manzanitamicro.com](http://www.manzanitamicro.com)  
Or for technical questions or other inquiries:

Manzanita Micro  
Rich Rudman  
PO Box 1774  
Kingston, WA 98346  
Phone: 360-297-1660  
email: [bms.support@manzanitamicro.com](mailto:bms.support@manzanitamicro.com)

## APPENDIX A: Full Commands List with Descriptions

The list of Digital Regulator Commands is included in the following pages.

### Commands Document Conventions

Again, ASCII numbers from 000 to 999 are valid device bus addresses. Address 99 is reserved for an all device broadcast, which is only valid for settings such as minvolts, maxvolts, hstclear, etc.

The bus address is a string of decimal digits, and is always in the range 0 to 255 inclusive. Leading zeroes are allowed. When the regulator replies with a bus address, it will always send two or three digits. E.g.: 01, 099, or 200.

A broadcast command is one that responds to the broadcast address. The broadcast address is a single asterisk, i.e.: "\*" or "99".

**NOTE:** The latest version of the regulator supports the two digit bus address 99 as the broadcast address. To use 99 as a bus address that does not mean broadcast, but instead exactly one bus address, specify at least one leading zero. E.g.: 099.

A broadcast command will not reply with any report or status.

A descriptive word representing one field will be set off in <angle brackets>. The brackets are not included in the actual command. E.g. <addr> may be replaced by 1, 2, 99, etc. An optional field will be set of in [square brackets]. The brackets are not included in the actual command. E.g. [<voltage>] may be replaced by 2.500 or left empty. Commands may be specified using their full syntax, abbreviated to their minimum syntax, or anything in between. An abbreviated command ends with a period "." A command that takes an argument after the command must end with a single period, whether or not it is abbreviated. All commands must be in lower case letters. E.g. 1e. but not 1E.

Manzanita Micro MK3 Digital Regulator Command List

Command Name	Full Syntax	Minimum Syntax	Broadcast Command	Example Command	Example Reply
<b>btemp (bt.)</b>	<addr>btemp<temp>	<addr>bt.<temp>	YES	1bt.120	01BT 120F
	FUNCTION: Sets cell temperature that will activate the STOP CHARGE LINE when a cell is above this temperature. The temperature must be set between 32F and 180F. If <temp> is not present then the stored setting is displayed. If btdisable has been activated, btemp will reset the regulator to activate the STOP CHARGE LINE if a cell exceeds the designated temperature - Factory default is 120F.				
<b>btdisable (btd.)</b>	<addr>btdisable	<addr>btd.	YES	1btd.	01BT DISABLE
	FUNCTION: Disables the ability to activate the STOP CHARGE LINE if a cell is over temperature.				
<b>changead (ch.)</b>	<addr>changead.<newaddr>	<addr>ch.<newaddr>	NO	1ch.9	01 Now:09
	FUNCTION: Changes the current bus address <addr> to the new address <newaddr>. The other bus addresses on the same regulator are adjusted respectively. The new address must always be from 0 to 255. Additionally, the new address must not force any other bus address on the same regulator to exceed 0 to 255. Factory default is bus address 1, this will need to be changed if more than one regulator is in the series.				
<b>commandl (.)</b>	<addr>commandl	<addr>.	NO	1.	--Rudman MK3x8 Regulator --V0.17 Unit:01-08 S/N: 00001 commandl changead disable enable fan gethighv hstclear hmaclear hmiclear lights minvolts maxvolts querytot readlowv status sethigh setlow setover temperat tempwarm tempshot tempoff voltage xtrntemp commandl btemp btdisable
	FUNCTION: Lists regulator model, software version, bus address range, serial number and valid commands				
<b>disable (d.)</b>	<addr>disable	<addr>d.	YES	1d.	01Disable
	FUNCTION: Disables the regulators ability to shunt - Factory default has shunting enabled for cell protection and equalization				
<b>enable (e.)</b>	<addr>enable	<addr>e.	YES	1e.	01Enable
	FUNCTION: Enables the regulators ability to shunt - Factory default has shunting enabled for cell protection and equalization				
<b>fan (f.)</b>	<addr>fan[.<level>]	<addr>f.[<level>]	YES	1f.4	01F 4
	FUNCTION: Forces the fan to be ON at set <level> - Factory default automatically controls the fan by the heat sink temperature. The <level> must be 0 to 8. A fan <level> of 1 or more will force the fan to run, with 8 being at full power. Fan <level> 0 is the default automatic mode (controlled by the temperature.)				
<b>firstpos (fi.)</b>	<addr>firstpos[.<enable>]	<addr>fi.[<enable>]	YES	1fi.1	01FP 1
	FUNCTION: If <enable> is 1 it switches the cell # order in the EEPROM so that BMS will display the most positive cell as Cell #1. <enable> must be 0 or 1, if <enable> is not present, <addr>fi. reports the active mode - Factory default is 0 indicating the most negative cell is Cell #1.				
<b>gethighv (g.)</b>	<addr>gethighv	<addr>g.	NO	1g.	01G 3.792V
	FUNCTION: Replies with high voltage set point. There is only one set point per regulator, so all bus addresses on one regulator will give the same response. The high voltage set point can be adjusted with the sethigh command, this set point adjusts the cell voltage level at which shunting will turn on.				

Manzanita Micro MK3 Digital Regulator Command List

Command Name	Full Syntax	Minimum Syntax	Broadcast Command	Example Command	Example Reply
<b>hmaclear (hma.)</b>	<addr>hmaclear FUNCTION: Clears the history for the maximum sensed voltage for the given bus address.	<addr>hma.	YES	1hma.	NO RESPONSE
<b>hmiclear (hmi.)</b>	<addr>hmiclear FUNCTION: Clears the history for the minimum sensed voltage for the given bus address.	<addr>hmi.	YES	1hmi.	NO RESPONSE
<b>hstclear (h.)</b>	<addr>hstclear FUNCTION: Clears history for both minimum and maximum sensed voltages for the given bus address.	<addr>h.	YES	1h.	NO RESPONSE
<b>lights (l.)</b>	<addr>lights FUNCTION: LED indicators will flash on regulator with given bus address and reply with the sign on message including, model, software version, bus address range and serial number	<addr>l.	NO	1l.	--Rudman MK3x8 Regulator --V0.17 Unit:01 S/N: 00001
<b>maxvolts (ma.)</b>	<addr>maxvolts FUNCTION: Replies with maximum sensed voltage for given bus address	<addr>ma.	NO	1ma.	01MA 3.917V
<b>minvolts (mi.)</b>	<addr>minvolts FUNCTION: Replies with minimum sensed voltage for given bus address	<addr>mi.	NO	1mi.	01MA 1.510V
<b>phev (p.)</b>	<addr>phev[.<enable>] FUNCTION: Activates PHEV mode. The PHEV mode will be applied to all bus addresses per regulator. <enable> must be 0 or 1, 0 indicates PHEV is disabled, 1 indicates PHEV is enabled. If <enable> is not present, <addr>phev reports the active mode. If enabled (1), the STOP CHARGE LINE is activated whenever the UNDERVOLTAGE LINE is activated. The PHEV command can be used to trigger something to cut back when a cell gets below the low set point the same way the charger is normally notified when a cell gets too high. The low set point can be changed with the setlow command. The sethigh set point will still activate the STOP CHARGE LINE during charging.	<addr>p[.<enable>]	YES	1p.	01P 0
<b>querytot (q.)</b>	<addr>querytot FUNCTION: Replies with the total real time sensed voltage for the regulators with the given bus address	<addr>q.	NO	1q.	01Q 12.19V
<b>readlowv (r.)</b>	<addr>readlowv FUNCTION: Replies with the low voltage set point. There is only one low voltage set point per regulator, so all bus addresses on one regulator will give the same response. When a cell falls below the low voltage set point the UNDERVOLTAGE LINE is activated.	<addr>r.	NO	1r.	01R 2.496V
<b>sethigh (seth.)</b>	<addr>sethigh[.<voltage>] FUNCTION: Sets the high voltage set point. There is only one high voltage set point per regulator, so all bus addresses on one regulator are affected by the command. <voltage> must be from 0.000 to 9.999 and must contain exactly four digits. If <voltage> is not present, <addr>sethigh will give you the same result as the gethighv command. - Factory Default is 3.600V	<addr>seth.[<voltage>]	YES	01seth.3.792	01H 3.792V
<b>setlow (setl.)</b>	<addr>setlow[.<voltage>] FUNCTION: Sets the low voltage set point. There is only one low set point per regulator, so all bus addresses on one regulator are affected by the command. <voltage> must be from 0.000 to 9.999 and must contain exactly four digits. If <voltage> is not present, <addr>setlow will give you the same result as the readlowv command. If a cell falls below the low voltage set point the UNDERVOLTAGE LINE is activated. - Factory Default is 2.496	<addr>setl.[<voltage>]	YES	01setl.2.496	01L 2.496

Manzanita Micro MK3 Digital Regulator Command List

Command Name	Full Syntax	Minimum Syntax	Broadcast Command	Example Command	Example Reply
<b>setover (seto.)</b>	<addr>setover[.<voltage>]	<addr>seto.[<voltage>]	YES	01seto.3.984	01H 3.984V
	<p>FUNCTION: Sets the over voltage set point. This set point must be higher than the high voltage set point designated with the sethigh command. The sethigh voltage set point will enable dissipation where as the setover voltage set point is when the BMS will tell the charger to cut back. There is only one over voltage set point per regulator, so all bus addresses on one regulator are affected by the command. &lt;voltage&gt; must be from 0.000 to 9.999 and must contain exactly four digits. If &lt;voltage&gt; is not present, &lt;addr&gt;setover reports the current set point. - Factory Default is 3.648V</p> <p>&lt;addr&gt;status</p> <p>&lt;addr&gt;s.</p> <p>01S 28</p> <p>FUNCTION: Replies with real time status bits of the regulator with the given bus address as two hexadecimal digits. These digits are a sum of the hexadecimal digits from the immediate condition. For example if you have an over temp cell all of the bus addresses for that regulator will display a status bit of 01, but the bus address associated with the specific over temp cell will also have 02, therefore displays 03 because 01+02=03. Or if the shunt is disabled, status bit 80, and a cell is below the low voltage set point, status bit 20 then the reported status would be A0, following hexadecimal summation. Below is a table of the status bits and their meaning:</p>				
	<b>STATUS BIT</b>	<b>LED INDICATORS</b>	<b>MEANING</b>		
<b>status (s.)</b>	0x01	Blue ON, Yellow FLASHING	Regulator heat sink or a cell on the regulator is over temperature		
	0x02	Blue ON, Yellow FLASHING	Designates the exact bus address with an over temp cell		
	0x04	NONE	Reserved for future features		
	0x08	Red ON	The bus address has been below the low voltage set point		
	0x10	Green ON	The bus address is above the high voltage set point		
	0x20	Yellow ON, Red ON	The bus address is below the low voltage set point		
	0x40	Green ON, Cell Green ON	The shunt is enabled and the bus address is above the high voltage set point		
	0x80	NONE	The shunt is disabled		
	<addr>temperat	<addr>t.	NO	1t.	01T 064F
<b>temperat (t.)</b>	<p>FUNCTION: Replies with the real time temperature of the heat sink or unit if there is no heatsink like the MK3x12. There is only one heat sink temperature per regulator, so all bus addresses on one regulator will give the same response.</p>				
<b>tempphot (tempfh.)</b>	<addr>tempphot.<temp>	<addr>tempfh.<temp>	YES	1tempfh.151	01TH 151F
	<p>FUNCTION: Sets the heatsink temperature that will make the fan run at full speed. The fan speed scales up from tempwarm to tempphot. &lt;temp&gt; must be from 32 to 181 and between the tempwarm and tempoff set points.</p>				
<b>tempoff (tempo.)</b>	<addr>tempoff.<temp>	<addr>tempo.<temp>	YES	1tempo.171	01TO 171F
	<p>FUNCTION: Sets the heatsink temperature that forces the regulator to stop dissipating in order to avoid internal heat damage. &lt;temp&gt; must be from 32 to 181 and greater than tempphot.</p>				
<b>tempwarm (tempw.)</b>	<addr>tempwarm.<temp>	<addr>tempw.<temp>	YES	1tempw.120	01TW 120F
	<p>FUNCTION: Sets the heatsink temperature that starts the fan. The fan speed scales up from tempwarm to tempphot. tempwarm must be from 32 to 181 and less than tempphot.</p>				
<b>xtrntemp (x.)</b>	<addr>xtrntemp	<addr>x.	NO	1x.	01X Cold
	<p>FUNCTION: Replies with the real time temperature of the given bus address cell's external temperature sensor if the optional sensors have been installed. The MK3x12 has only 6 sensors so temp sensor 1 reports as bus address 1 &amp; 2, temp sensor 2 reports as 3 &amp; 4 etc.</p>				