MANZANITA MICRO

Rudman Regulator
Mark 3 Digi-Reg
PCB version 3
Owner's Manual
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MK3 DIGITAL LEAD-ACID BATTERY REGULATORS

Introduction:

The Mk3 Digital Rudman Regulator is a modern version of the original BATREG Rudman charging regulator. When batteries are connected in series, even if they are closely matched when new, over time their exact capacities and voltages will drift apart. With flooded batteries one can charge them until the most full batteries start gassing and then keep going until all of them equalize. The ones which gassed can simply have more water added. With sealed lead acid batteries like AGM or Gel types if they are overcharged they can lose water and therefore have permanent capacity loss. The intent of the Rudman Regulator is to bypass current around a fully charged sealed lead acid battery so that all the other batteries in a long series string can get fully charged without any one becoming overcharged. This is accomplished with individual circuit boards attached to each individual 12 volt module. 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. The circuit has an LED blink feature that changes duty cycle in response to the dissipation needs of the battery and which allows the user to visually see what is happening. The faster the green LED blinks, the more charged the battery is.

What all this means to the end user is that when using the regulators in conjunction with an appropriate charger, one can charge and equalize the batteries very quickly without worrying about damaging them. Fast, full charges coupled with equalization means less down time, more range per charge, better battery health and longer life.

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 battery voltage, battery temperature (with user installed temp sensor), regulator heatsink temperature and other information. The rest of this manual details these features as well as others and how to change settings.

Dimensions and Specifications

The Mk3 Digital Regulator BMS units weigh in at approximately 2.3 ounces (66 grams) Approximate dimensions are: W=3.125 in x L=4.375 in x H=0.812 inches (79mm x 111mm x 20mm)

The Mk3 name signifies Mark 3 edition digital BMS (as opposed to the Mk2 series of analog regulators). All Mk3 systems are calibrated and fully tested before leaving Manzanita Micro.

The Mk3 BMS units are intended for use only with 12 volt AGM or gel style lead-acid batteries. Each Mk3 BMS unit will arrive from Manzanita Micro programmed to monitor one 12V lead acid battery.

Mk3 Key Features

- Real time voltage monitoring of a single 12V lead-acid battery
- Real time single channel external temperature sensor input plug
- Additional temperature sensor included on BMS module's heat sink
- Small size is only about 4 inches long by 3 inches wide and less than an inch thick
- Quick automatic cell equalization and balancing with high and low voltage on board indicators and outputs to the battery 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 (D/T Box)
- Free Windows based scanner and command software available from the "Downloads" section of www.manzanitamicro.com
- 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 lead-acid batteries
- Each BMS board can bypass up to 2.5 amps per battery equating to fast charging and equalization of unbalanced batteries
- 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

Mk3 Digital BMS Operation

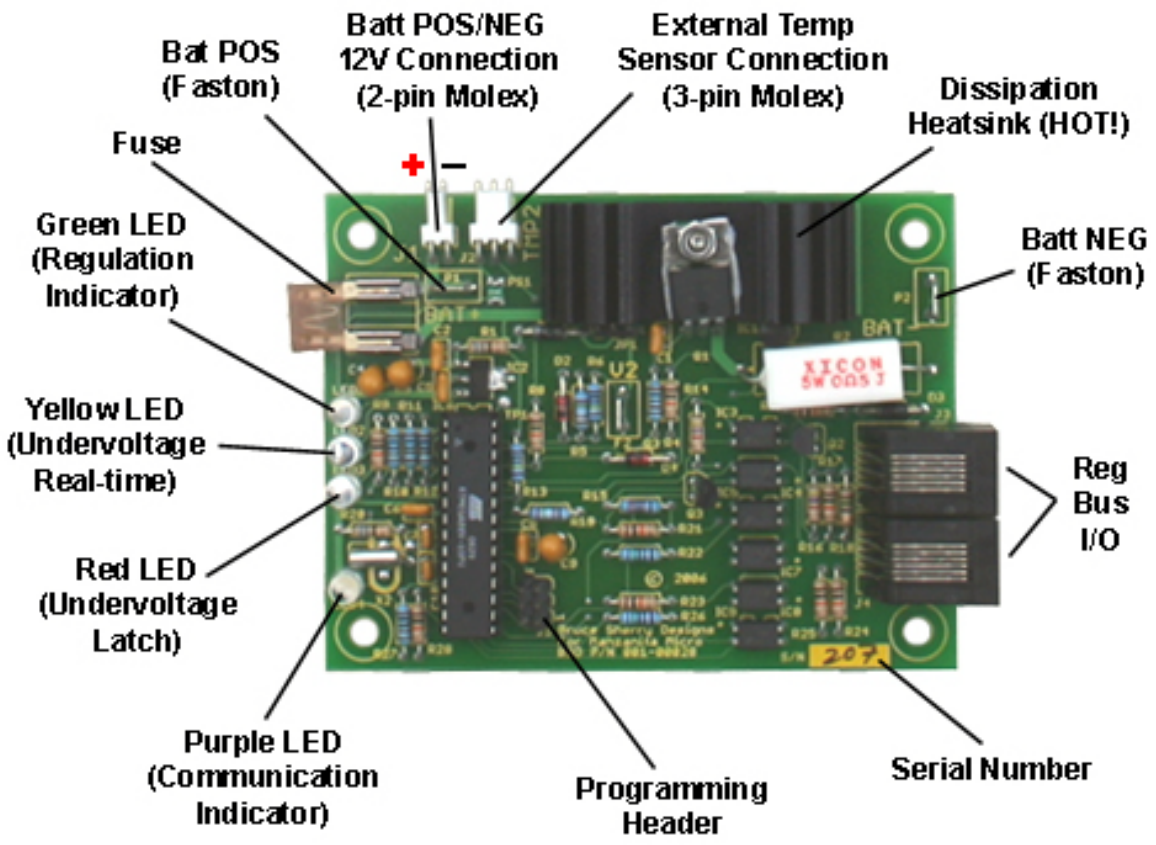

figure 01

Indicators:

There are four LED indicators on a fully populated Mk3 regulator. When the regulator is first connected to a 12 volt battery, each of the lights will illuminate briefly to let the user know that they are all functioning. At this time, the regulator also sends out identification information over the reg bus.

Green LED – "Regulation Indicator"

The green LED indicates that the regulator is regulating. This LED comes on when the battery it is attached to is above the regulation set point and the reg load is activated. This is a brief transient event at first with a brief blink followed by a much longer off time. As the battery 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 green LED blinks, the more fully charged the battery is. The set point voltage controls the voltage level when this occurs. On a Mk3 reg, this set point is preset to 14.8 Volts before leaving Manzanita Micro. This set point can be adjusted by communicating with the regulator from a computer or the Manzanita Micro Regscanner. For more information on this procedure, see the "Regulator Adjustment and Commands" section later in this manual.

NOTICE! If the green LED stays on steady this means that it is either regulating at full bore or it has reached its thermal limits (if it has reached its thermal limits, the red LED will also be on). In either case if this is happening 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 will shut down automatically. In this case the purple LED will also be lit on the offending regulator(s).

Yellow LED – "Undervoltage Real-time"

The yellow LED indicates that a battery in the string is currently below the undervoltage set point. This can indicate a discharged battery, a bad cell or a damaged reg.

The undervoltage set point on a MK3 Reg is preset to 10.0 Volts before leaving Manzanita Micro. This set point can be adjusted by communicating with the regulator from a computer. For more information on this procedure refer to the "Adjustments" section later in this manual.

NOTICE! When many regulators are connected together to monitor a pack of batteries if one unit detects an undervoltage condition 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 the battery which that reg is attached to has gone below the undervoltage set point at some time since it was last brought to a full charge. This feature lets the user quickly spot the weakest batteries in the pack even if the battery is currently not below the undervoltage set point.

The red LED will remain lit until either the power is disconnected from the regulator or the battery is charged until the green LED blinks. The red LED can also be cleared using the clear history command from a computer (see the Mk3 Reg Scanner Software Manual for more information).

Purple LED– “Communication Indicator”

The purple LED indicates when the regulator is communicating on the RudmanBus. All of the purple LEDs should blink in sequence whenever an external device is communicating with the regulators and going through each valid bus address. The purple LED will also illuminate when the regulator is telling the charger to back off.

Dissipation Heatsink:

The black finned heatsink is the area on the regulator where energy is bypassed around the battery and dissipated as heat . This is what sets the Rudman Regulators apart from the competition and allows for maximum battery balancing in a short amount of time. When the regulator’s heatsink temperature becomes too high, the reg automatically tells the charger to cut back so that it can cool.

The thermal threshold temperature for the heatsink is normally set to 150 -180 degrees farenheit upon leaving Manzanita Micro. This threshold can be changed in order to push the regulators harder, but be aware that higher heatsink temperatures it may shorten the life of the regulator. For more information see the “Adjustments” section later in this manual.

WARNING! ***NEVER touch the heatsink while the vehicle is charging!*** As the the name implies, this heatsink gets HOT. Temperatures can be as high as 270°F and it can cause burns if touched while it is hot. It is also important to **never touch anything conductive across the heatsink as it is not isolated and can cause a shock to you or damage the regulator.**

Fuse:

Each MK3 Regulator has an individual fuse designed to prevent damage to the reg. It is a standard 5 amp automotive style mini blade fuse and is designed to be easily replaced if the user makes a mistake such as accidentally connecting the reg across more than one 12 volt battery. The fuse will also blow if the reg is hooked up to the battery backwards (polarity reversal).

NOTICE! If the reg continues to blow fuse after fuse figure out the problem or contact a qualified service technician or Manzanita Micro.

Connections:

P1 – Battery Positive Connection

P1 is the ¼ inch fast-on spade style connector which is used to attach a wire from the positive terminal of the battery to the regulator.

P2 – Battery Negative Connection

P2 is the fast-on spade style connector which is used to attach a wire from the negative terminal of the battery to the regulator using a ¼ inch fast-on connection.

J1 – Battery POS/NEG 2-pin Molex Connection

J1 is an alternative battery connection to the aforementioned P1 and P2 faston connections. This option allows the user to connect both the battery positive and negative terminals to the regulator using one 2 pin molex plug. The Molex part number for the female 2-pin plug is: 22-01-3027. It is recommended to use 22 awg hook up wire and crimp or solder the proper pins to the end. The Molex part number for the pins is: 08-50-0114. See figure 01 for proper pin polarity.

J2 – External Temp Sensor 3-pin Molex Connection

J2 is a 3-pin Molex header allowing a connection point for an additional temperature sensor. A common use for this connection would be to monitor the temperature of the 12V battery that the regulator is attached to. Some of the regulators are shipped with a small black jumper fastened to two of the pins on J2. In this case, if the user wishes to connect a temp sensor they must first remove and discard the jumper. The Molex part number for the female 3-pin plug is: 22-01-3037. It is recommended to use 22 awg hook up wire and crimp or solder the proper pins to the end. The Molex part number for the correct pins is: 08-50-0114. Manzanita Micro recommends the LM34DZ temperature sensor available from many electronics suppliers. The sensor should be connected exactly as shown in figure 02.

NOTICE: Make sure the temperature sensor never sees temperatures greater than 212 degrees Farenheit (100 degrees Celsius). Additionally, heatshrink or some other sufficient type of insulation should be used to prevent the three leads on the temperature sensor from shorting out against each other. It is also important to make sure that the temperature sensor does not get contaminated with acid residue from the battery or left over flux from soldering.

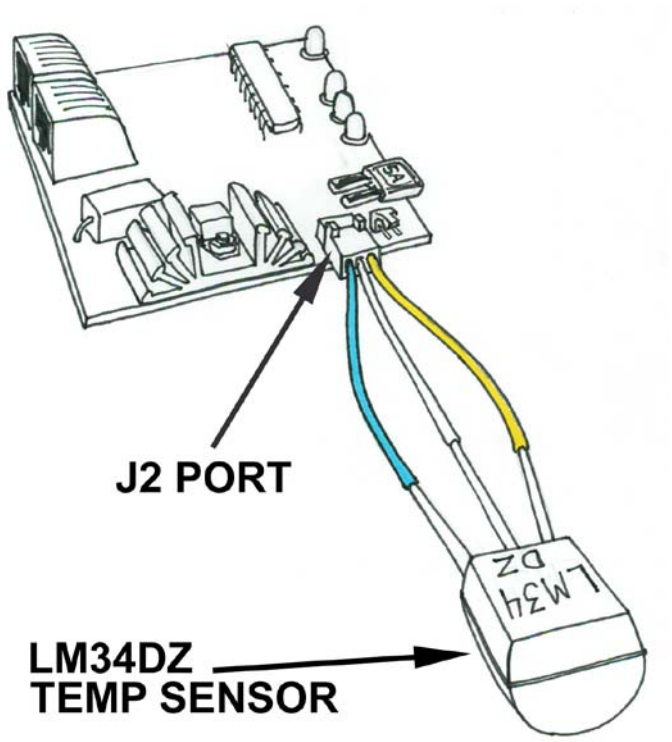

figure 02

J5 – Programming Header

J5 is the 6 pin programming header. This is where the Atmel programmer is attached when the regulator is initially programmed at Manzanita Micro.

J3 and J4 – Regbus I/O RJ Connections

J3 and J4 are the In/Out ports for the regbus communication line. These are standard 6 pin RJ data connections. The regulators are to be connected to each other in a daisy chain fashion. The precise order does not matter as the regulators are each individually programmed with a specific bus address identification number that does not change. 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 regulators over the RudmanBus. More information 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! In fact, the REGBUS return line is actually connected to main battery pack negative through the charger! It is important to always remember that the partially exposed metal conductors on the regulator's RJ terminals can be a potential electrical shock hazard. AVOID TOUCHING THE TOPS OF THE REGULATORS WHEN THE REGBUS IS PLUGGED INTO THE CHARGER.

5. Rudman bus negative
6. Rudman bus positive

figure 03

Note: The pin count reads from left to right when looking straight on into the RJ receptacle (refer to figure 03). 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. All measurements are made relative to the GND wire. It is important to verify all six of the wires are continuous throughout the system. **CAUTION: 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 batteries, 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 batteries 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 batteries 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 improve performance by keeping the units cooler and allowing for meaningful equalization capability.

Installation:

Regbus wiring is described later. The following paragraphs only consider the battery and sensor wiring.

The regulators have 4 mounting holes at the outer corners of the PCB. It is recommended that the reg be mounted to a non-conductive surface since the underside of the PCB contains conductive component leads. Some users simply stick double sided tape under the regs but ideally they are to be mounted using insulated studs. Number 6 plastic standoffs with plastic acorn cap nuts are a fine solution (see figure 04)

figure 04

The MK3 regulators can be installed with 3 different wiring techniques

1. Directly on top of each individual battery
2. Dispersed around the vehicle
3. On a back plane at a central location in the vehicle

Wiring the Rudman Regulators:

Voltage sensing wires (battery connections) to the regulators should be kept as short as possible. Connect the BAT + (P1) reg terminal to the positive terminal of the battery which that reg is to monitor. Connect the BAT - (P2) reg terminal to the negative terminal of the battery which that reg is to monitor. Or, if using the Molex battery connection, then make sure polarity is correct (positive pin to the right/ negative to the left) and plug that plug into the J1 (2-pin Molex) header. See figure 01 for pin polarity.

NOTICE! Do not share wires between regulators! Each regulator must be connected to its battery with a separate pair of wires. This will solve cross-talk issues and minimize voltage ripple errors.

For temperature sensor wiring refer to the “J2” portion of the “CONNECTIONS” section of this manual.

Regbus Wiring:

All MK3 regulators are connected with a 6 pin RJ data cable allowing them to communicate back to the charger. These communication lines connect the regs in a daisy chain fashion. For more information on the battery and sensor wiring, see “The Regbus Interface” section earlier in this manual.

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 any electronics store. 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 4)

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 04)

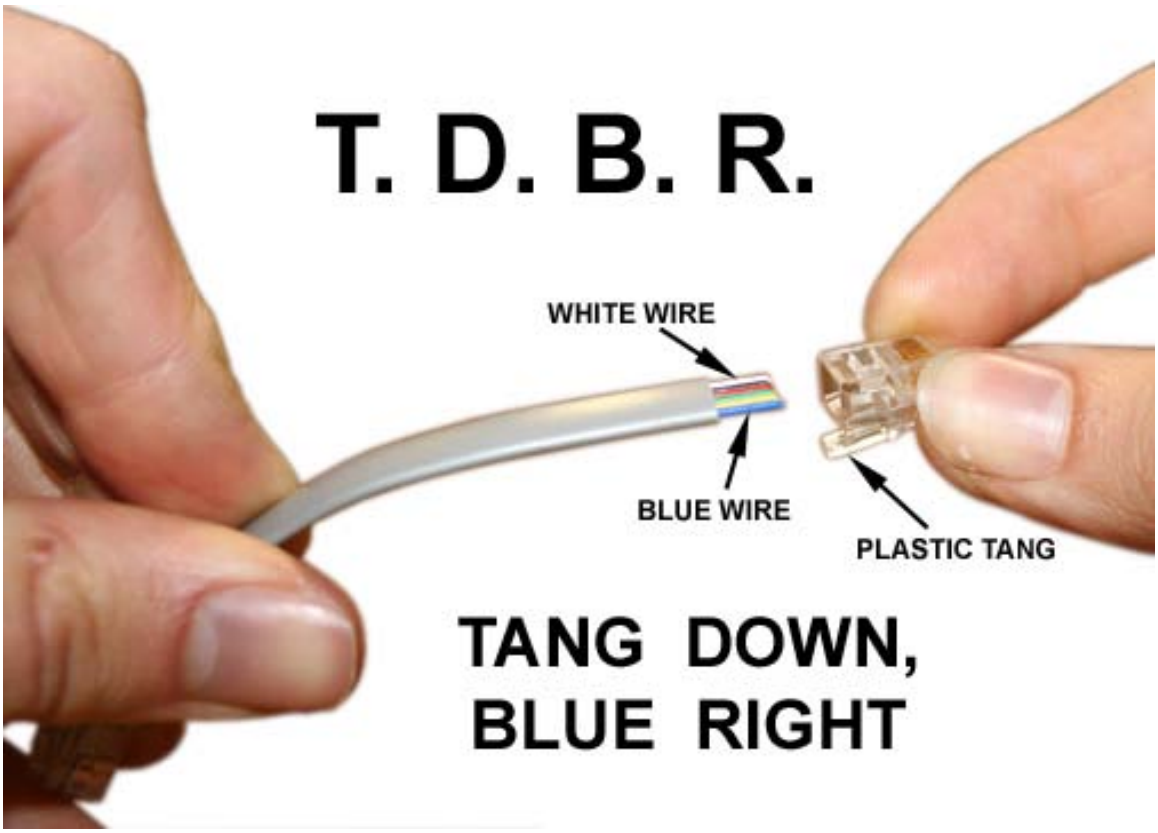

figure 04

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 05)

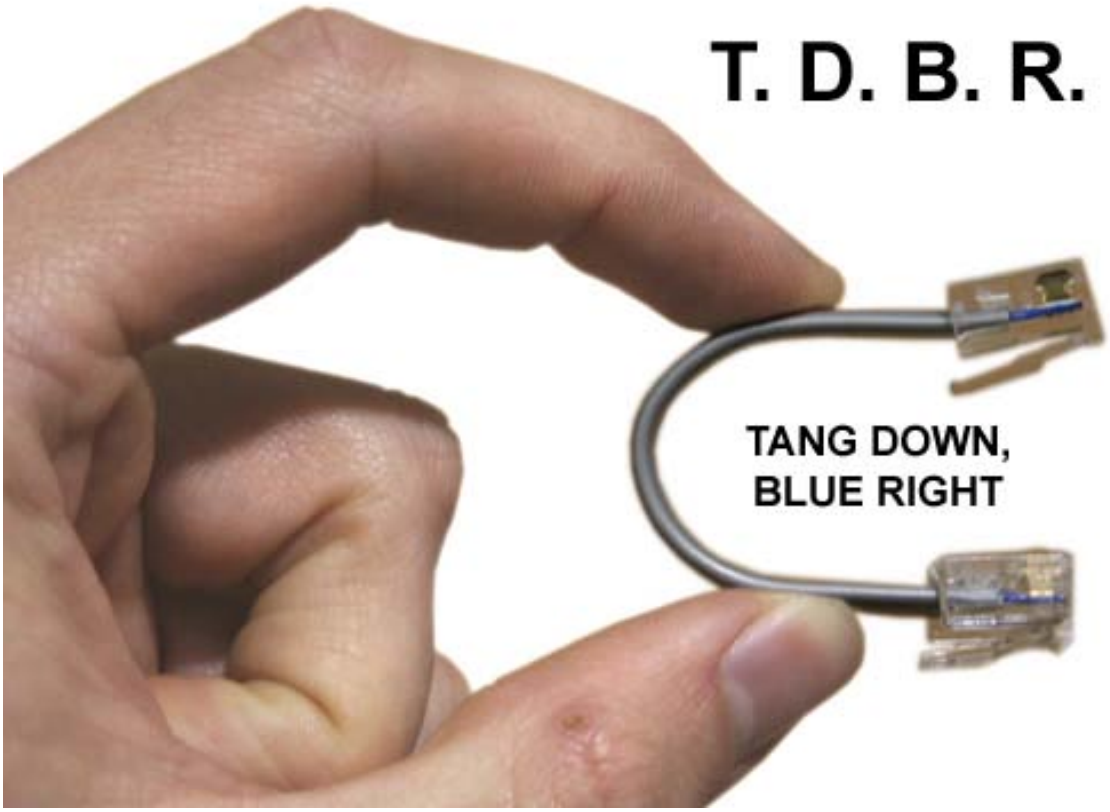

figure 05

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 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 and also in the full Manzanita Micro BMS software manuals. Details on hooking up the dongle / terminator (DT box) is in the section below

figure 09 – Older Style Non-USB Powered D/T Box

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 port itself. On older models there is actually a separate 12 volt power jack (as in figure 09). On the older models, 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.

If the computer has trouble connecting with the D/T box it may need to have the "DT USB Driver" which is available for download from www.manzanitamicro.com

If you are attempting to communicate through a serial type connection or you have one of the older DB9 (RS232) serial dongles you can use a simple program like Hyperterm or Putty. The baud rade must be set to 9600-n-8-1

If you have one of the older Mk3 models with the separate dongle and terminator boxes you can contact Manzanita Micro at 360-297-1660 for further support.

Regulator Adjustment and Commands

Using Commands

Unlike the old analog Rudman Regulators, the Mk3 regs do not require adjusting potentiometers in order to change voltage settings. Instead, the Mk3s can be calibrated, asked to feedback information or have settings 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 the peak voltage limit. All commands must be entered in lowercase letters only.

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

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

The commands can also be abbreviated as shown in the commands list in order to reduce typing. Type in the bus address followed by the abbreviation and ended with a period. For example, to ask for the voltage reading from regulator number 5, the abbreviated command would be: “5v.” The fewer the characters, the faster the response time will be.

Commands List

ASCII numbers from 00 to 98 are valid device bus addresses. Address 99 is reserved for an all device broadcast, which is only valid for settings such as sethigh, setlow, hstclear, etc. The table on the next page lists all valid commands. If there is a “yes” in the “B” column of the table, then it means that the command is able to be used as a broadcast command. The shorter command abbreviations are listed in bold in the first letter of letters of the commands in the list.

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

B?	command	result	comments
no	**v**oltage	' 01V 12.34V '	Voltage query, returns voltage in ascii
yes	**seth**igh 15.55		Set Unit regulation voltage to 15.55V
yes	**setl**ow 10.00		Set Unit undervoltage warning level to 10.00V
no	**mi**nvolts		Read unit minimum voltage recorded
no	**ma**xvolts		Read unit maximum voltage recorded
yes	**h**stclear		Clear unit recorded min and max voltages
no	**s**tatus		Read status of unit, Returns a hexadecimal value as the sum of: • Disabled 0x80 • Shunting 0x40 • Under Voltage 0x20 • Over Voltage 0x10 • Has Been Low 0x08 • Over Temp 0x04 • Normal Oper. 0x00
no	**g**ethighv		Read regulation voltage on unit
no	**r**eadlowv		Read low voltage warning limit on unit
no	**x**trntemp		Read from external temp sensor if connected
yes	**d**isable		Disable Shunt on unit
yes	**e**nable		Enable shunt on unit
no	**t**emperat		Read unit's onboard heatsink temperature
yes	**l**ights		Blink the lights and display the sign-on message
yes	**bte**nable xxx		Enable battery temperature charge disable at xxxF This is the temperature point at which the unit will command the charger to stop charging. This is factory preset to 120 degrees F. NEVER ENABLE THIS WITHOUT FIRST PROPERLY CONNECTING A TEMPERATURE SENSOR!
yes	**btd**isabl		Disable battery temperature temp sensing
yes	**sto**rvolt		Store current voltage
no	**r**etrvolt		Retrieve voltage stored with "storvolt"
yes	enblhist		Enable histogram collection
yes	dsblhist		Disable histogram collection
no	prnthist		Print histogram
no	commands		Print list of commands (without arguments)
no	vcal1 xx.xx		CALIBRATION PURPOSES ONLY, DO NOT USE! Store internal voltage for later calibration
no	vcal2 xx.xx		CALIBRATION PURPOSES ONLY, DO NOT USE! Provide 2nd voltage, triggering calibration

NOTICE! When using any Manzanita Micro Battery Management System, ensure that the reg bus 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 reg bus, the charger cannot communicate with the regs and this could lead to potentially damaging situation if there is an un-matched battery 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

Or for technical questions or other inquiries:

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PO Box 1774
Kingston, WA 98346

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