MATRIX | ELECTRICAL MACHINES

BATTERY SIMULATOR MANUAL

CP4483

Inspiring The Next Generation Of Engineers

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Contents

Introduction

Description

The battery simulator product is part of the Matrix Electrical Machines range. It simulates the operation of a network of rechargeable batteries. It outputs a DC voltage appropriate to the type and number of cells being simulated. Over time, the drop in voltage due to the discharge of the batteries is simulated. The chemistry and capacity of the cells can be selected. Numbers of cells in series and parallel can be changed and the device can operate either in real time or with an accelerated time simulating a faster discharge.

Three different cell chemistries are available; lithium-ion, lithium-iron-phosphate and lead-acid. Up to 32 cells in parallel can be simulated. The number of cells in series is different for each chemistry and is limited by the output voltage range of the device. Cells placed in series increase the final output voltage. Cells placed in parallel increase the total capacity.

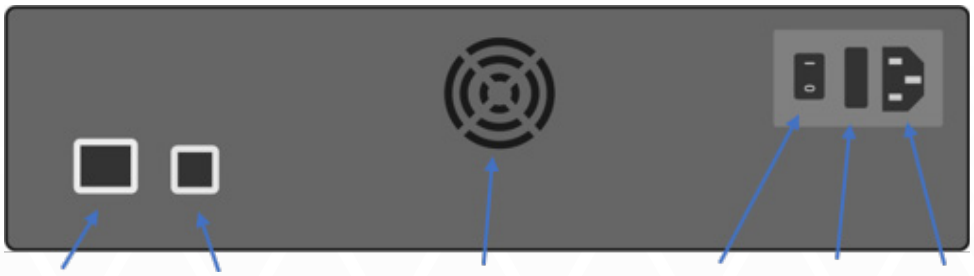
The device can be controlled using the built-in touch screen interface. All functions can also be controlled using the USB interface. A FlowCode App Developer program is provided for this and additionally, an API is provided to allow users to create programs in the development environment of their choice. An Ethernet interface provides the means for the device to push data to an MQTT sever.

Panel Layout

Front Panel

3.5 inch Touch screen Shrouded 4mm connectors for V+ and 0V.

Rear Panel



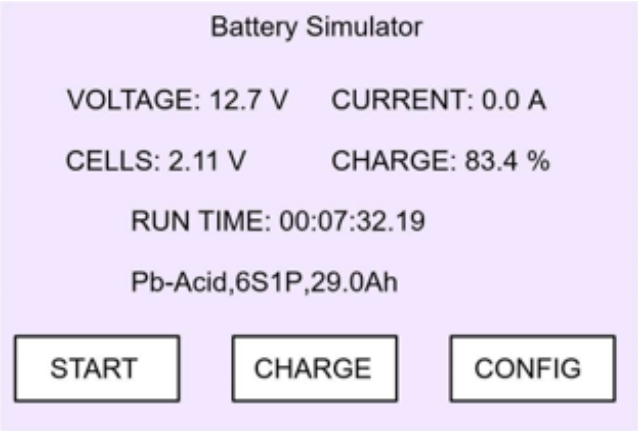
Ethernet USB Fan Power Switch Fuse Mains inlet

Touchscreen Control

Touchscreen Control

The device can be configured and monitored via the built in touchscreen. The simulated battery chemistry, capacity and topology of cells can be set. The simulation can be started and stopped from the touch screen and a simulation of charging the battery can be run. The simulation time can be multiplied so that long experiment times are compressed.

Front Screen



The screen that appears when the device is switched on shows the status and configuration of the simulated battery. The voltage is the voltage of the whole battery. When the simulation is not running, this will be the open circuit voltage of the battery.

Once the simulation begins running, this will show actual output voltage of the battery under load. The current is the measured output current of the device. This will be zero when the simulation is not running.

The voltage of an individual cell is shown. Only one cell voltage is shown because the system simulates all cells in balance. The state of charge is expressed as a percentage with 100% being fully charged and 0% being completely discharged. The run time display shows the amount of time that the simulation has been running. The simulation time may run faster than real time if a time multiplier has been applied in the configuration of the battery. The bottom line of the screen gives a short overview of the battery type; chemistry, series and parallel cell and capacity.

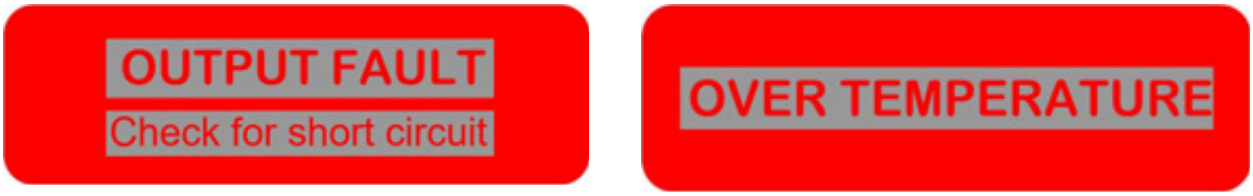
Touching the START button sets the simulation running. This will cause the battery voltage to appear at the output terminals and the timer to start running. While running, the only button visible is the STOP button which will pause the simulation. When stopped, the simulation will continue to show a frozen time display. Touching the START button again will restart the simulation from whatever time and state of charge it stopped at.

Understanding Settings

Fault Conditions

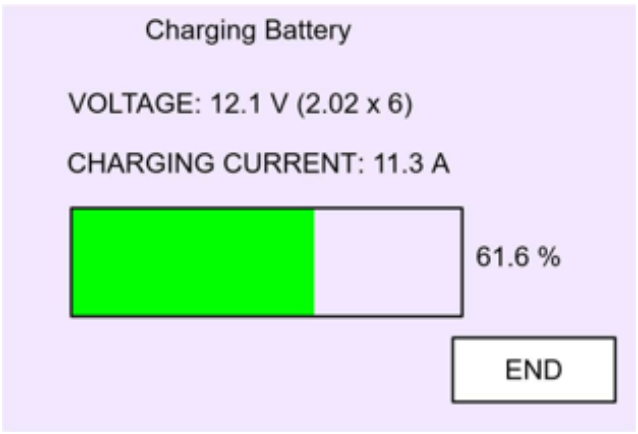
If the output terminals of the device are shorted together when the output is on then a warning message will appear on the LCD screen. The device will protect itself by shutting down the power stage until the fault is removed. Once the short circuit is removed, the output will automatically recover.

Under high load, a cooling fan may come on to protect the internal electronics. The fan will remain on until the internal temperature drops. It is safe to continue using the device while the fan is running. If the internal temperature becomes too high then the power stage will switch off and a warning message will appear on the screen.



On-screen Warning Messages

Charging Screen

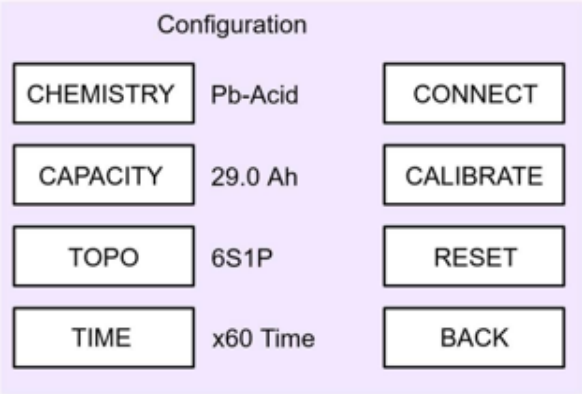


The CHARGE button starts a simulated charging cycle. The charger begins at whatever state of charge the simulation stopped at. This will be zero if the simulation has been run to completion. The terminal voltage of the battery is shown with the individual cell voltage and number of series cells shown in brackets. The charging current shown is a function of the chemistry and capacity of the battery and the progress of the charging cycle.

The END button will stop charging and return to the front screen. If the charger is stopped before completion then the battery will not be fully charged and the subsequent discharge simulation will begin with a part full battery. The charging process can be paused and resumed and is also affected by the time multiplier so that hours of charge time can be simulated in minutes of real time.

Battery Simulator

Configuration Screen



The CONFIG button on the front screen will cause the configuration screen to be shown. This screen presents a menu that enables the parameters of the battery simulation to be set.

The BACK button returns to the front screen.

The RESET button sets the state of the battery to fully charged and returns to the front screen.

The other buttons all show further configuration screens which are individually described below.

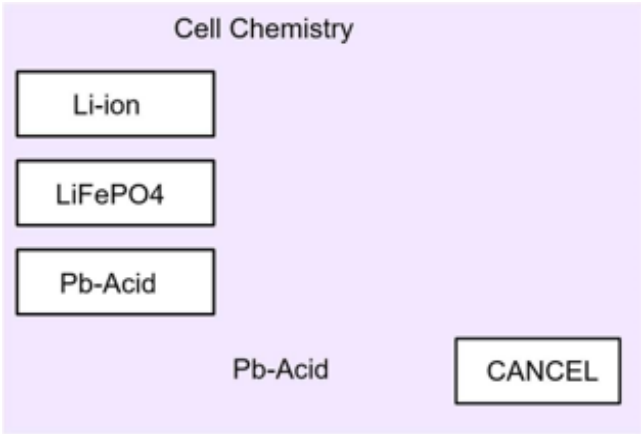
Chemistry

The chemistry screen presents a list of the available battery chemistries. These are: -

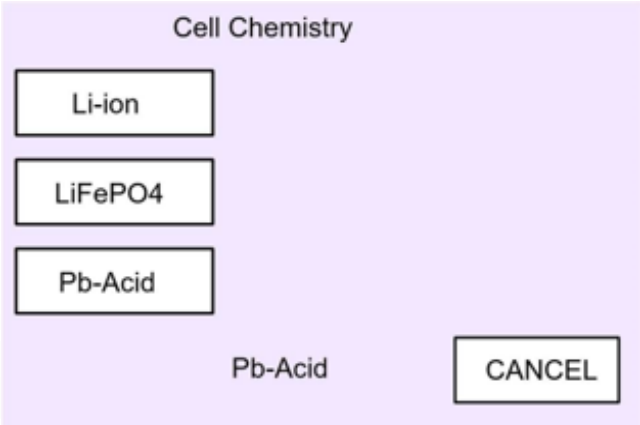
Lithium ion (Li-ion)

Lithium Iron Phosphate (LiFePO4) Lead Acid (Pb-Acid)

The selected chemistry is shown at the bottom of the screen. The CANCEL button returns to the configuration screen without changing the selected chemistry.



Capacity



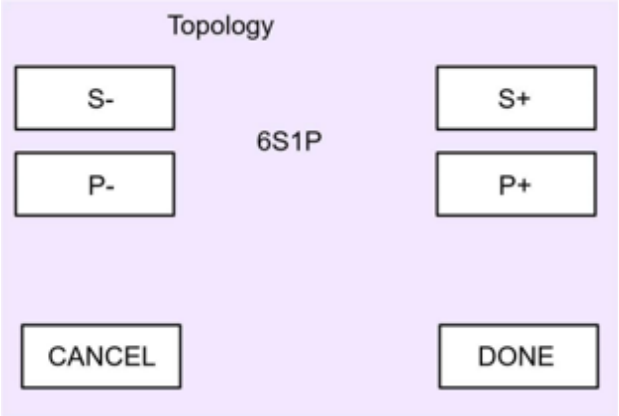
The capacity screen enables the capacity of the simulated battery to be adjusted.

Coarse adjustments can be made using the slider and fine adjustments by touching the + and – buttons. The buttons beneath the slider set the range of the slider to 0 – 50 or 0 – 500 ampere-hours.

When the desired capacity is selected, touch DONE to return to the configuration screen or CANCEL to return without accepting the new value of capacity. If the new capacity is accepted, the state of charge will be reset to 100%.

Battery Simulator

Topology

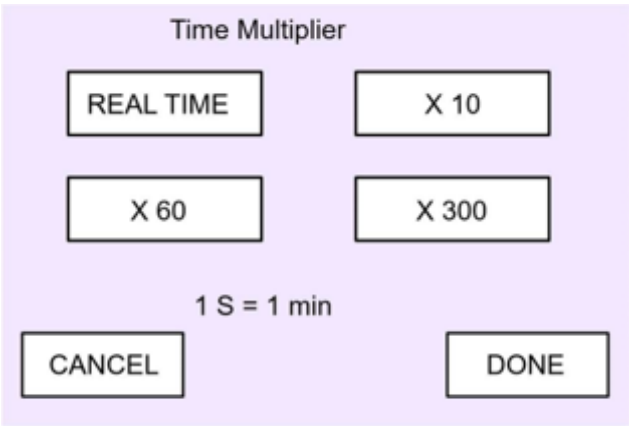


The topology screen configures the arrangement of cells in the battery. The S+ and S- buttons alter the number of cells in series and the P+ and P- buttons alter the number of cells in parallel. The voltage of an individual cell is set by the choice of chemistry and the output voltage of the complete battery will be the cell voltage multiplied by the number of series cells.

The maximum output voltage of the device is 36 volts and the maximum number of series cells is limited by this constraint. This means that the maximum number of cells in series is different for each chemistry.

Time Multiplier

Experiments involving the discharge and recharging of batteries can take some considerable time. Rather than waiting for hours, experiments can be speeded up by setting the simulation time to run faster than real time. The simulation time can be the same as real time or ten, sixty or three-hundred times faster. The simulation will calculate the discharge of the battery based on the simulation time.



Thus, a one amp-hour battery would ordinarily provide an amp of current for one hour. If the time multiplier is set to x60, the same battery would discharge in one minute. Changing the time multiplier will not reset the simulation. It is possible to stop the simulation, change the time multiplier and then continue the simulation at the new rate.

Battery Simulator

Connection
The connection screen shows a QR code that can be scanned to access an MQTT server that the device is pushing data to. The IP address of the device is also shown. The Ethernet connection parameters are set using the USB interface described later in this manual.

Calibration
The CALIBRATE button enters calibration mode. The procedure for calibrating the device is described later in this manual.

USB Control
A FlowCode App Developer program is provided that controls the device using the USB interface. The device is automatically detected when plugged into the computer. Plug the device in an start the application to begin controlling the device. The panel shows the battery output voltage and current. On the line below, it shows the voltage of an individual cell and the state of charge of the whole battery. These are the same values that are shown on the LCD screen.

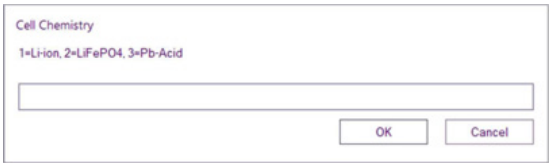
Below the voltage and current displays are ‘Start’ and ‘Charge’ buttons. Clicking these buttons will start the simulation or re-charging running. The LCD display will reflect this command. When either button is clicked, the other button will disappear and the button clicked will change to a ‘Stop’ button. Between the buttons is the simulation time display which shows how long the simulation has been running. Both the discharge and the charge process can be started or stopped from either the app or the touchscreen.

Battery Simulator

At the bottom of the screen are the configuration buttons which are used to control the parameters of the battery and the simulation.

From left to right, the buttons set chemistry, capacity, cell configuration and time multiplier. The right hand button resets the simulation, setting time to zero and charge to 100%.

The first button displays the currently selected cell chemistry. When this button is clicked, a dialog appears prompting the user to select a number from 1 to 3 corresponding to the available chemistries. If a valid number is selected then the chemistry will be changed on the connected device and the button will display the name of the new chemistry. In an invalid number is entered or the cancel button is clicked then the chemistry remains unchanged.

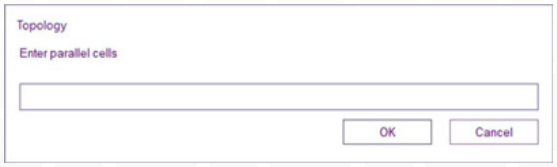


The next button displays the battery capacity. When clicked, the user is prompted to enter a new value. If the value is between zero and 500 then the new capacity will be sent to the device and shown on the button. If the dialog is canceled or an invalid number is entered then the capacity will be left unchanged.

The series and parallel arrangement of cells in the battery is shown on the button in the short hand form: -

[Number of series cells] S [Number of parallel cells] P

For example, 4S2P indicates eight cells arranged as two parallel strings of four cells each. When clicked, two dialogs are presented one after the other. The first prompts the user to enter the number of series cells, the second prompts for the number of parallel cells.

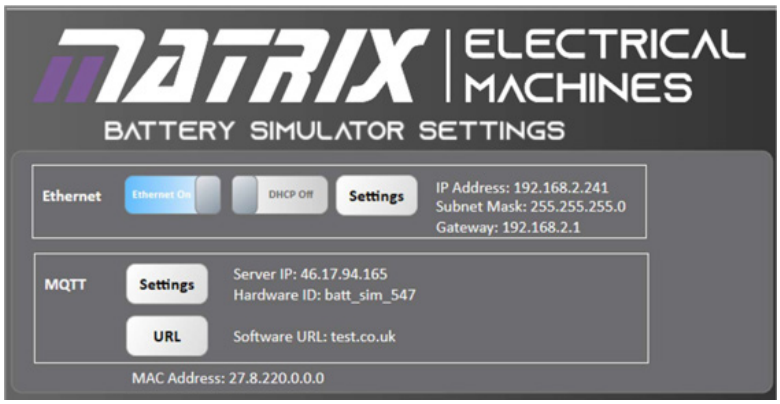


Battery Simulator

The time multiplier button show the relationship between simulation time and actual time. It will display “Real Time” when no time multiplier is set and the simulation is running in real time. When clicked, a dialog prompts the user to enter a new time multiplier. Valid inputs are 1, 10, 60 or 300. All other values are ignored.

Ethernet Connection Configuration

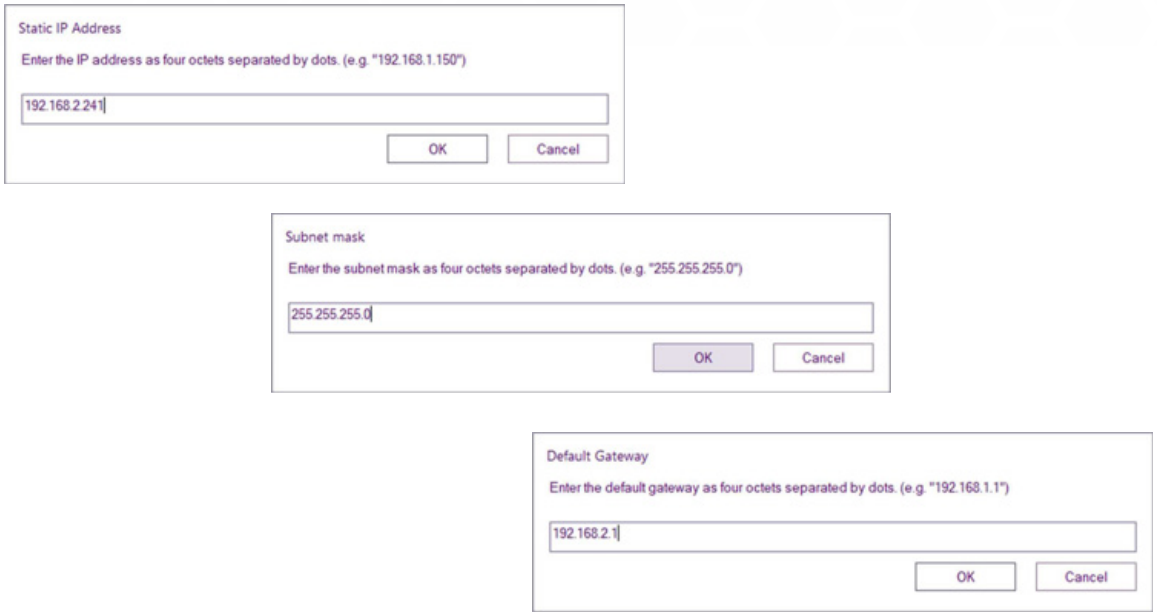
To configure the Ethernet interface, connect to the device by USB and run the Battery Sim Settings application. Once successfully connected the application will show the current settings.



This application sets the basic configuration of the Ethernet interface and the details of the MQTT connection. The top section of the window shows the current settings of the Ethernet interface. The switch on the left hand side of this section configures the interface to be on or off. If the interface is on then a switch next to it selects DCHP on or off. If DHCP is on then the rest of the section is blank. The device will automatically configure the Ethernet interface by negotiation with a DHCP server on the network. If the DHCP option is switched off then a ‘Settings’ button will be visible and the current settings will be shown.

Clicking the settings button will prompt the user to enter a new IP address followed by the subnet mask and default gateway. If all three are valid then they will be sent to the device. The new settings will take effect next time the device is powered on.

Battery Simulator



The bottom section of the application shows the MQTT client settings. Clicking the settings button will prompt the user to enter a new server IP address followed by the hardware ID.

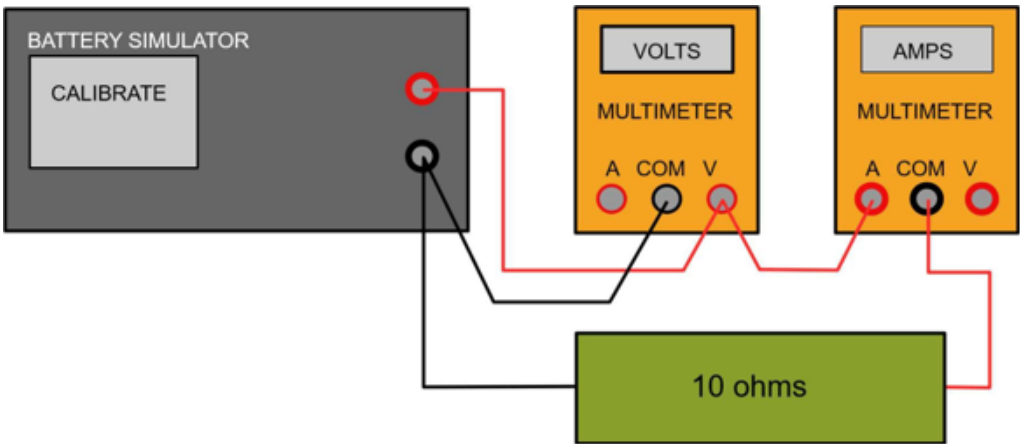
Clicking the URL button will prompt the user to enter a new URL.

Battery Simulator

Calibration Procedure
The battery simulator firmware includes a procedure to calibrate the voltage and current sensing components. To complete the procedure, the user will require two calibrated digital multimeters

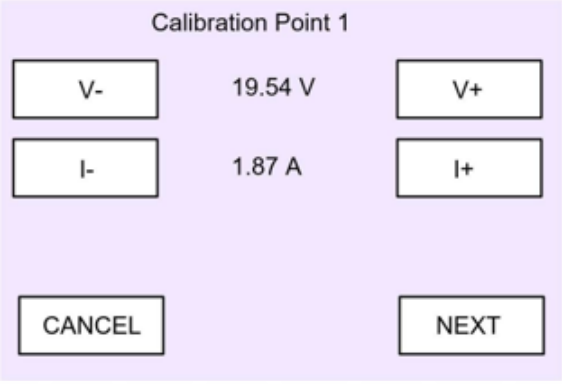
(one voltmeter and one ammeter) and a 10 Ω resistor with a power rating of at least 50 W. The resistor does not need to be a high precision type, it is the meters that determine the accuracy of the calibration.

To begin calibrating, connect the 10 Ω resistor across the output of the battery simulator. Connect one DMM in 10A current mode, in series with the resistor. Connect the other multimeter in voltage mode, across the output.



Connection of Test Load and Meters

Touch the 'CONFIG' button on the LCD to enter the configuration screen and then touch 'CALIBRATE' to start the calibration procedure.



The battery simulator will output roughly 20 volts at 2 amps and the LCD will show the calibration screen. Touch the + and – buttons on the screen until the voltage and current shown on the screen match the multimeter readings.

When the numbers are set, touch NEXT to move to the next calibration point. This time the simulator will output roughly 8 volts at 0.8 amps

Again, adjust the numbers on the screen until they match the readings on the multimeters. Touch FINISH to complete the calibration. Touching the CANCEL button at either of the calibration points will abandon the calibration procedure. The device will continue using its existing calibration.

Specifications and Commands

Specifications

Settings	
Battery chemistry	Li-ion, LiFePO4 or Lead Acid
Battery discharge curves	Fixed for selected chemistry
Parallel Cell Configuration	Up to 32 cells in parallel
Series Cell Configuration	Limited by output voltage divided by cell voltage for selected chemistry
Battery capacity	Up to 500 Ah
Time multiplier	Discharge in real time, x10, x60 or x300 (1 second = 1 second, 10 seconds, 1 minute or 5 minutes)
Discharge time	Determined by capacity and time multiplier

Mains Input	
Connector	IEC60320 type C14, includes earth connection to case.
Voltage	100 to 264 VAC
Frequency	47 to 63 Hz
Current	Typically 4A @ 115VAC, 2A @ 230 VAC
Fuse	5A

DC Output	
Max Output Voltage	36 Volts
Max Output Current	10A
Short Circuit Protection	Full protection. Warning message on screen and automatic recovery when short is removed.
Series Cell Configuration	Limited by output voltage divided by cell voltage for selected chemistry
Voltage Monitor Resolution	0.1 Volts
Current Monitor Resolution	0.1 Amps

API Commands

When the device is connect to USB it enumerates as a COM port. Each command begins with a colon and end with a semicolon followed by a new line character.

Example; host sends four bytes to request the output voltage: -

ASCII	:	A	;	<LF>
Hex	3A	41	3B	0A

Device responds with three bytes, ‘A’ to echo the command and then two bytes to represent a 16-bit number sent least significant byte first: -

ASCII	A	.	.
Hex	41	F1	04

The hexadecimal number 04F1 is 1265 in decimal. This represents a voltage of 12.65 volts.

API Command List

Command	Parameters	Return	Function
A		2 bytes	Read output voltage x 0.01V
B		2 bytes	Read output current x 0.01A
C		2 bytes	Read cell voltage
D		2 bytes	Read state of charge x0.1%
E	2 bytes		Set state of charge x 0.1%
F		4 bytes	Read run time 1st byte = hundredths, then seconds, minutes, hours
G		1 byte	Read battery chemistry
H	1 byte		Set battery chemistry 1 = Li-ion, 2 = LiFePO4, 3 = Pb-Acid
I		2 bytes	Read battery capacity x 0.1 Ah
J	2 bytes		Set battery capacity x 0.1 Ah
K		2 bytes	Read battery topography 1st Byte = Series, 2nd Byte = Parallel
L	2 bytes		Set battery topography 1st Byte = Series, 2nd Byte = Parallel
M		2 bytes	Read time multiplier
N	2 bytes		Set time multiplier
O			Reset timer to zero and state of charge to 100%
P			Start the simulation
Q			Stop the simulation
S		1 byte	Reads whether the simulation is active. 0 = inactive, 1 = active, 2 = Charging.
T		13 bytes: - 1 byte 2 bytes 2 bytes 2 bytes 2 bytes 4 bytes	Read Whole Simulation Condition: - Active: 0=inactive, 1=active. Output voltage x 0.01V Output current x 0.01A Cell voltage x 0.01V State of charge x0.1% Run time 1st byte = hundredths, then seconds, minutes, hours
U		7 bytes: - 1 byte 2 bytes 1 Byte 1 byte 2 bytes	Read Whole Configuration: - Battery chemistry Battery capacity x 0.1 Ah Series topography Parallel topography Read time multiplier
Z			Start simulation of charging the battery.

Notes

BATTERY SIMULATOR MANUAL

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