AVR491: Quick start guide for SB200

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1 Introduction

This document gives an introduction to the use of the SB200. It explains how the SB200 hardware and PC software is used and how it can be used to demonstrate and evaluate the SB201 features and performance.

Figure 1-1 SB201 mounted in the SB200 in a 2-cell configuration.
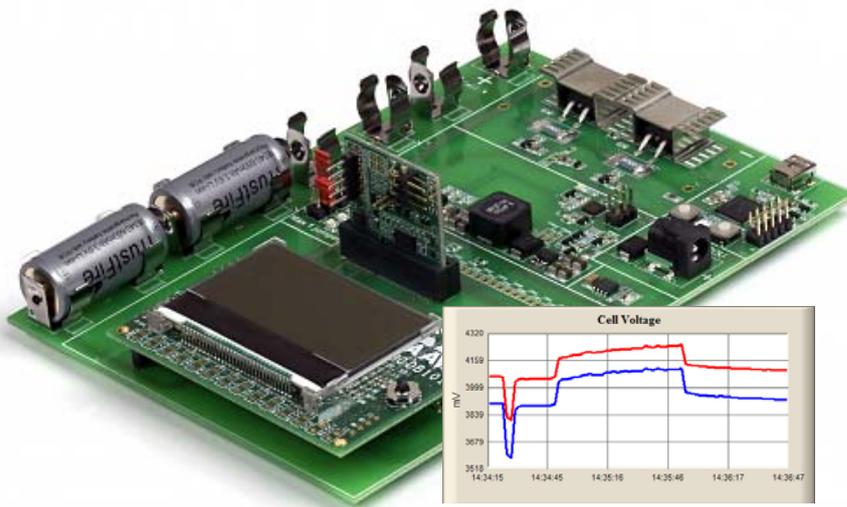
2 Safe use of the SB200 and Li-Ion battery cells

Four Li-Ion battery cells are provided with the SB200. These batteries have built-in protection to ensure that misuse does not expose the user to any danger – after all Li-Ion are explosive. When using the unmodified code example provided by Atmel there should be no danger regardless of using a battery with or without protection. However, during the development phase, it is nice to know that bugs and incomplete development does not put the developer in any danger.

A consequence of using protected battery cells is that there will be a certain energy loss caused by the built-in protection electronics. Further, it will be difficult to test extremes, such as deep under-voltage, over-current and so on, as the built-in protection will affect the result. It can also happen that the protection disables the battery if (dis)charged too much. Therefore, be aware that strange behavior can be due to the battery protection.

Caution: A jumper is used to select which battery cell that is the top cell. If the jumper is place incorrectly it may short a battery cell (refer to section 3.8 "Quick Start Guide - Step by step").

Figure 2-1 Unprotected battery exploding (Not a SB200).

3 Examples of use

The SB200 is designed to be a demonstration platform and an easy-to-use development environment for varies AVR® based smart battery applications. The SB200 does however introduce more resistance than what would normally be found in a battery pack, which will introduce slight errors e.g. when reading the battery cell voltage. Nevertheless, the SB200 is an excellent platform for demonstration, evaluation and application development for AVR based smart battery application.

The following sections describe the main features of the SB200 kit.

3.1 Charging the batteries

The built-in charger of the SB200 can be controlled from the PC application to run for a given period of time, after which it stops charging. Note that the charger is autonomous and will stop charging when the period has expired, even if the PC software is shut down or the USB cable is disconnected.

The charging is limited by its voltage and current limits: For a two cell Li-Ion battery pack the typical recommended charge voltage is 8.4V and the charge current is typically 1C. For a 880 mAh battery the charger is therefore set to 8400 mV and 880 mA for 120 minutes (max 255 minutes). This means that the maximum charging voltage is 8.4V and the maximum current is 880mA, which ever is limiting the charging.

Pushing the SET button will start/restart the charger with these parameters. While the charger is active a green LED on the top-middle of the SB200 will light up.

The charging voltage and current of a nearly full battery can be seen in Figure 3-1.

Figure 3-1 Charging parameters and charging voltage and current
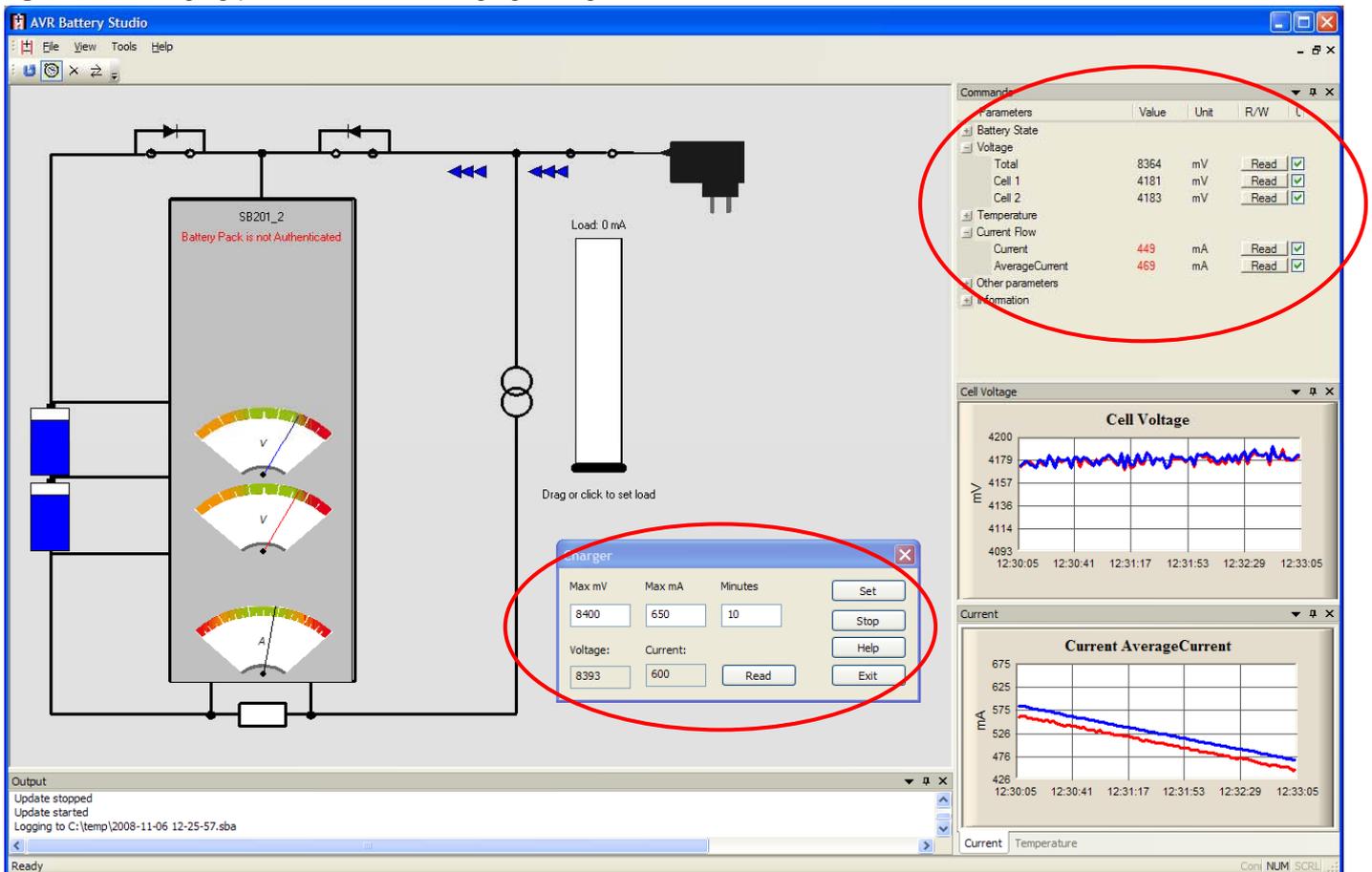
3.2 Discharging the batteries

To be able to evaluate the behavior of the smart battery during discharging, an electronically controlled load is available on the SB200. This is, like the charger, controlled from the SB200 PC software. The load can draw up to 5000mA from the

battery by dragging the slider fully to the top. Right-clicking the load and selecting the "Set Load" menu item and typing the current level directly in the edit box is however not limited to 5000mA, which allows very high current to be drawn from the battery. This allows for short circuit/over-current testing.

Dragging the slider will enable the load, while right-clicking and selecting "Clear load" will turn off the load.

SB200 will shut down the load if the load temperature (PCB at the FETs) exceeds 125°C. CAUTION: 125°C is very hot, so do not touch the cooling fins!

The load is designed to draw fairly high load, but not to be very accurate. The actual current will typically be lower than that specified in the PC software. The discharging of a close to full battery is shown in Figure 3-2.

Figure 3-2 Discharging parameters and discharging voltage and current
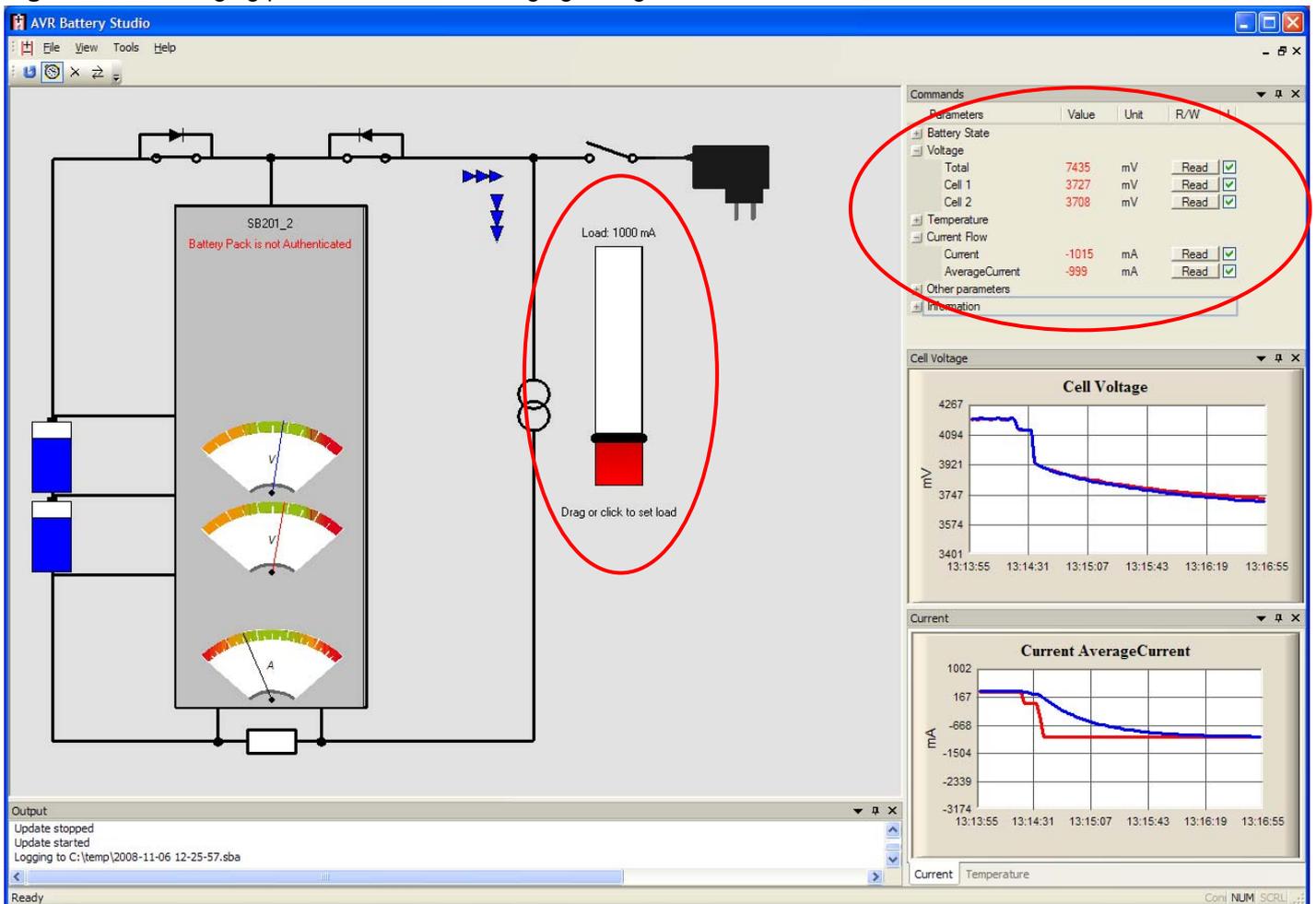
3.3 Reading values from SB201 smart battery.

The SB201 support most commands specified in the SBS data specification. In addition it can provide "extended commands", which provide information about the voltage and temperature of the individual battery cells. It also supports AES based authentication of the battery.

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All supported SBS and extended commands are listed on the right hand side of the PC software. All commands can be invoked individually, and through a check box selection: the "Update" button will refresh all commands for which the check-box is checked.

The most used way of refreshing the commands is most likely to set the auto-update timer button. This will refresh the checked commands with fixed intervals as set in the "Tools->Options" menu.

Figure 3-3 SBS commands and extended commands – some auto refreshed.
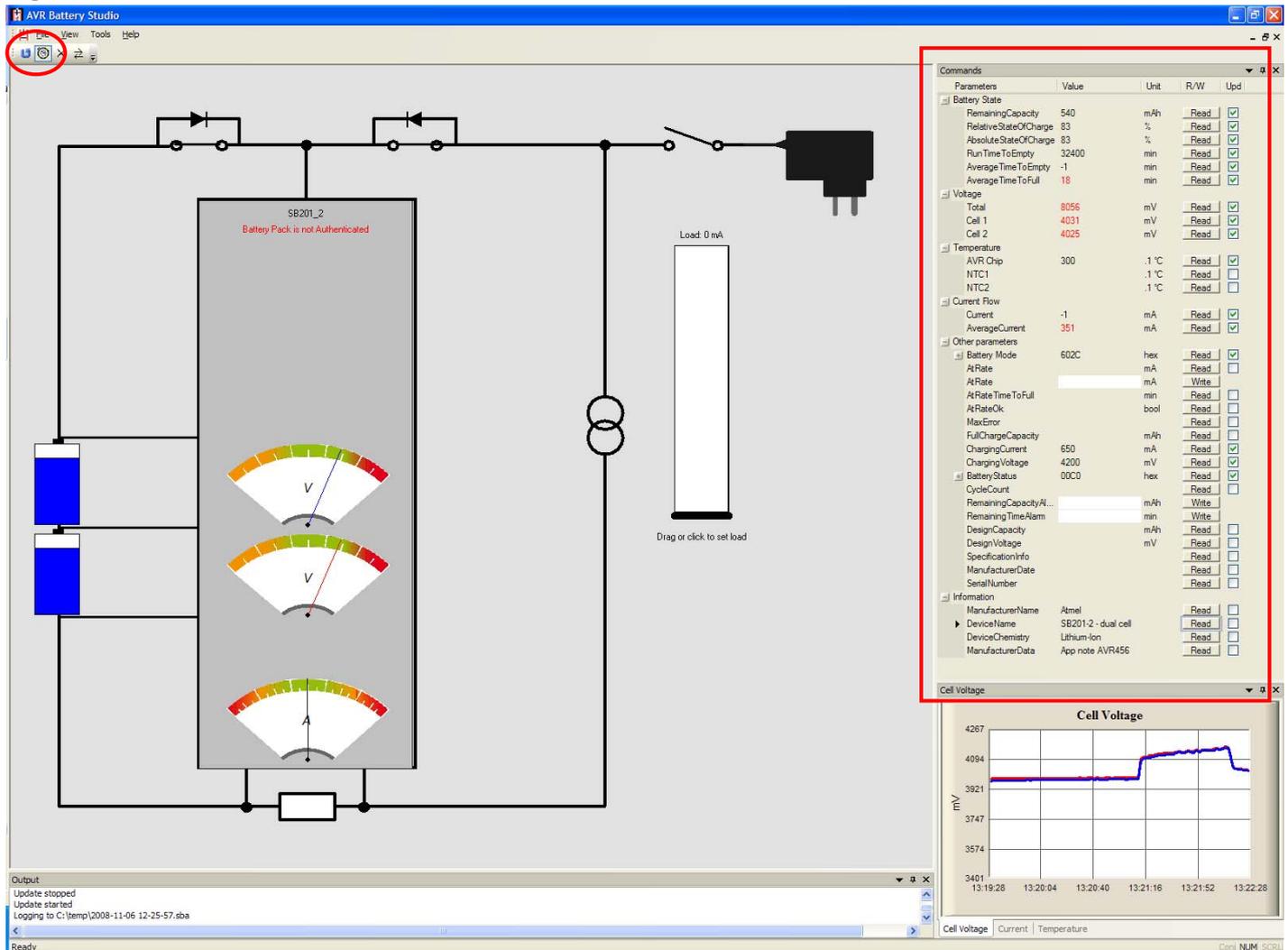
3.4 Shunt calibration

The shunt resistor on SB201 has ±1% accuracy and can therefore cause inaccurate measurements if not SB201 is calibrated for the real resistance. The shunt resistance is calibrated in factory, but if a recalibration is needed due to e.g. reprogramming the following procedure can be used.

The calibration is done by measuring the actual current that is drawn from the battery and compares this to what SB201 reports. The electronic load is not accurate

enough; instead an accurate ampere meter has to be connected on SB200 where the red jumper normally is placed.

Set the load to e.g. 500mA and check what the ampere meter measures and (push) READ the shunt resistor value and current from the SB200 PC software. If the ampere meter shows 490mA, SB200 reports 495mA and the shunt resistor value is set to 10000µΩ; the following equation can be used to calculate the real resistance of the shunt resistor:

$$Real\ shunt\ resistor\ value = 10000 * \frac{495}{490} \approx 10102 \mu \Omega$$

Type the calculated shunt resistor value in the Shunt Resistance edit box (click on the shunt resistance image to open) and then push the WRITE button. The current reported by SB201 should now be the same as the ampere meter. The SB201 firmware has thereby been calibrated to use the actual resistance of the shunt and tracks rather than the nominal value of the shunt itself.

Figure 3-4 Commands used for calibrating the shunt resistor value
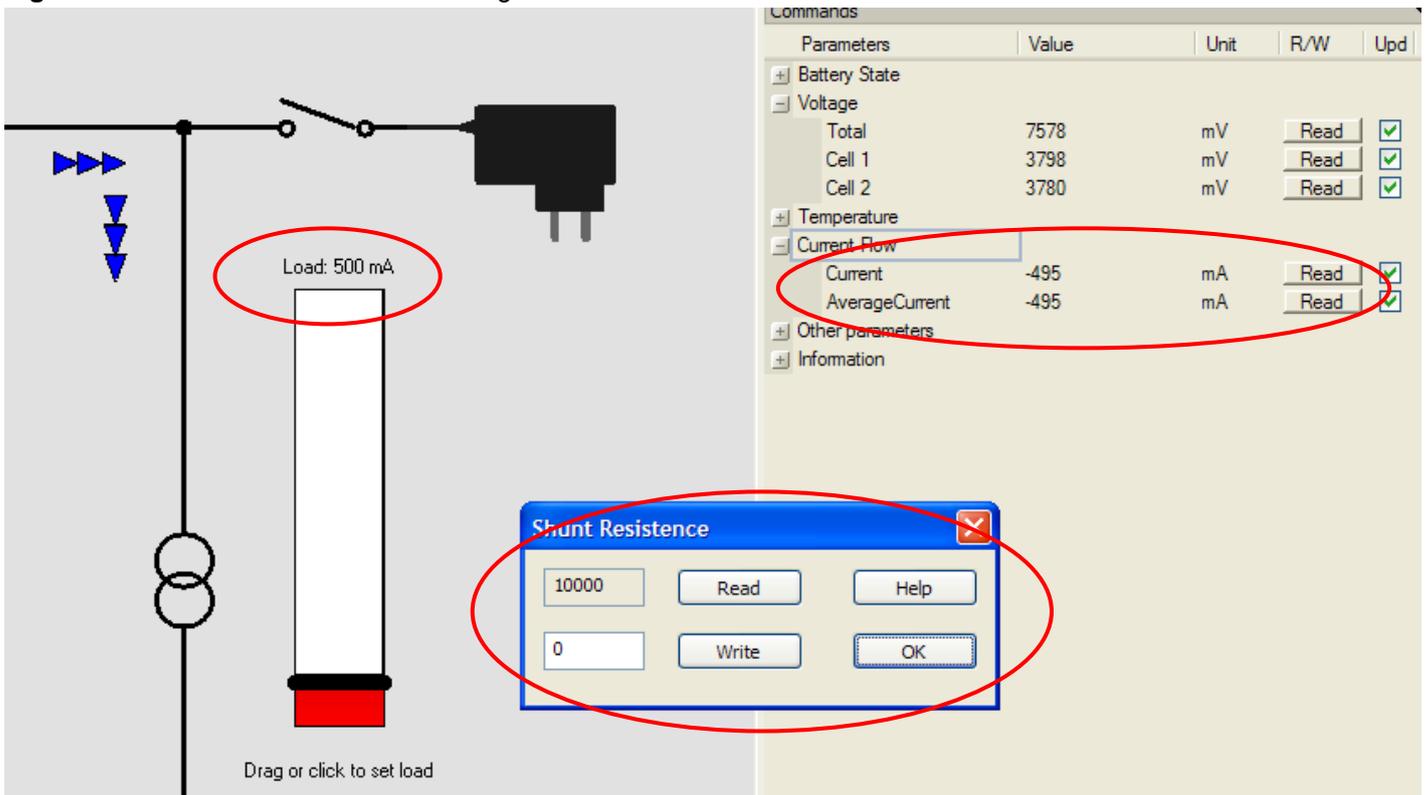
3.5 FET Disable and Storage Mode

The two switches in the Battery Studio main window can be used to enable and disable the charge and discharge FETs on the SB201. When toggled they will send a command to SB201, to set the desired state. This function is not intended for a finished product but can be convenient during development and evaluation. The BatteryMode Read command will also update the FET states.

Figure 3-5 Example of using FET Disable to disable the discharge FET
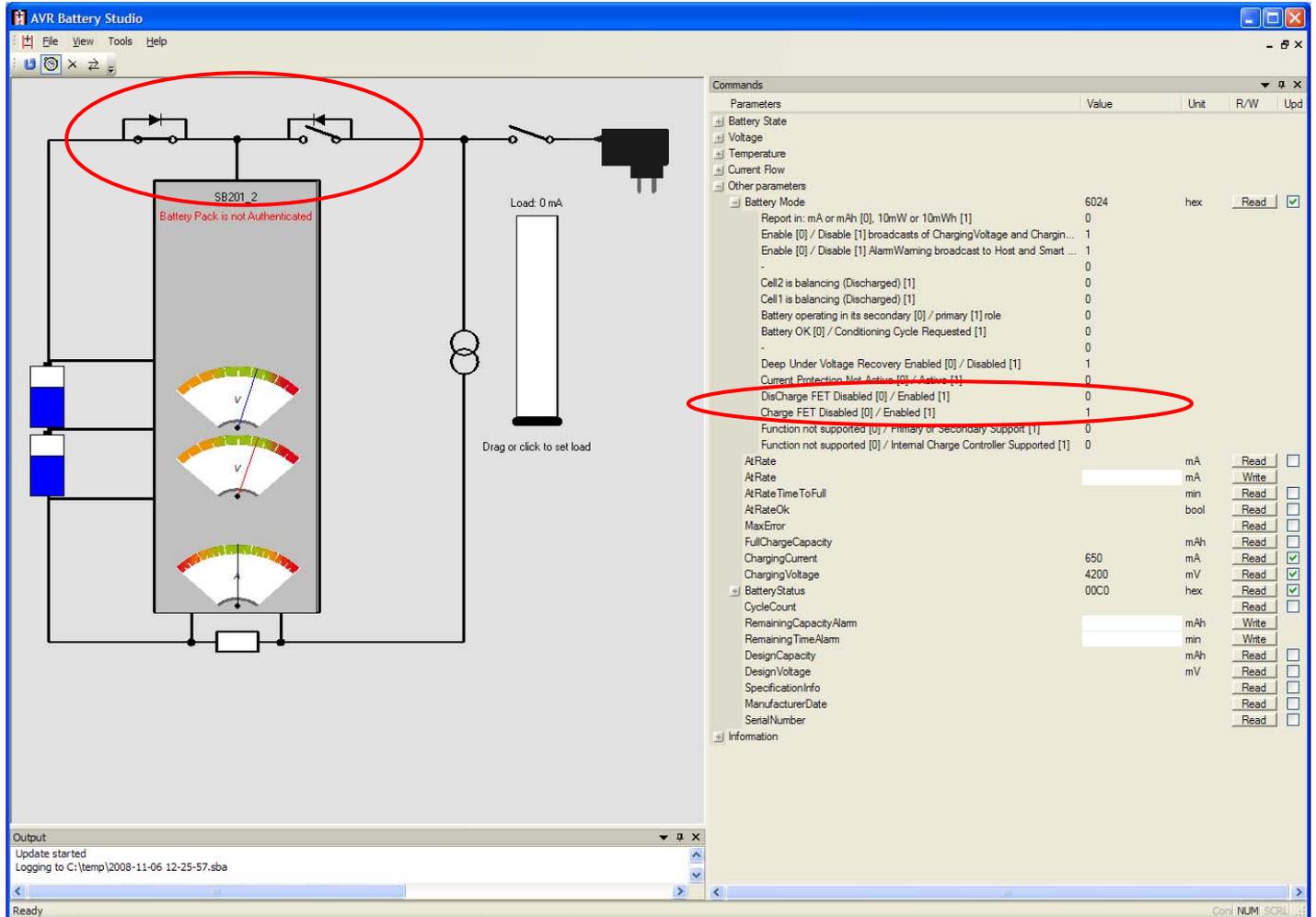
3.6 Logging data

The SB200 PC software can log data in two ways: battery current and average current can be shown on one "scope" plot and battery cell voltages can be shown in another.

Further, all commands read from the SB200/SB201 can be written to a log-file. This requires that a log file is specified and is done when auto-update is active. The log file uses a binary file format. All selected commands will be logged. Commands not selected will result in an empty value. The binary file can be exported to an Excel or CSV file to process the data.

3.7 Show status flags

Some of the SBS commands contain a series of status flags. To assist the user to translate the hex values into status flags, expand the BatteryStatus parameter and the status flags will show.

Figure 3-6 Expanded "BatteryStatus" command showing the state of the flags

3.8 Quick Start Guide - Step by step

The following procedure can be used to get started:

1. Insert the SB201-2 in the SB200.
2. Set the large red "Number of Cells" jumper in position "2" (or insert Amp-meter to measure current).
3. Insert battery cells in the CELL 1 and CELL 2 sockets – be aware of the polarity.
4. Connect 12V to the SB200
5. Either press the HWB button on SB200 or start the charger via the PC software to power up SB201. The HWB buttons starts a charge for maximum 1 minute or until you press it again. The charge voltage is set depending on which SB20x that is connected.
6. Start the AVR Battery Studio SB200 PC software from AVR Studio or directly.
7. Connect the USB cable between PC and SB200.
   a. Verify that the USB Status is "Connected" and that the Board is "SB201-2"

    b.   Wait for the SB201 to run through calibration (will take up to 30 sec the first time the SB201 is started).

8. Read the following commands

    a.   ManufacturerName ("Atmel").

    b.   DeviceName ("SB201-2 - dual cell").

    c.   DeviceChemistry ("Lithium-Ion").

    d.   ManufacturerData ("App note AVR456")

9. Test authentication by:

    a.   Open the authentication dialog by clicking the Battery Pack authentication text or from the menu.

    b.   Write "This will fail!!" in the Host Challenge edit box.

    c.   Push WRITE, hence READ (reads garbage)

    d.   AES Key says "Gandalf says?". Replace with "You cannot pass!".

    e.   Write "Authentic batt!!" in the Host Challenge edit box.

    f.   Push WRITE, hence READ (read back "Authentic batt!!")

    g.   Status should now say "Authentication Accepted".

10. Try the read commands from SB201. Check the following check boxes:

    a.   Voltage

    b.   Current

    c.   RelativeStateOfCharge

    d.   RemainingCapacity

    e.   VoltageCell2

    f.   VoltageCell1

    g.   Push the Update button on the menu to read all the values

11. Log data:

    a.   Open "Tools->Options" on the menu.

    b.   Specify a log file location.

    c.   Push the "Auto-generate filename" radio button and push "OK".

    d.   Notice how the graphs to the right display the battery current and cell voltages.

    e.   Set the load to 100 mA by dragging the slider. Notice the graphs.

    f.   Increase the current to higher levels and notice how the cell voltage drops.

    g.   Leave the load at 500 mA, and wait for the battery protection in the SB201 to disable discharging.

    h.   Disable the load, and enable the charger at 8400mV, 880mA, for 30 minutes and see how the charging voltage and currents develop.

    i.   Disable logging, and inspect the log file.

12. Explore the application - enjoy.

3.9 Trouble shooting

The most common problems experienced when working with the SB200 is listed below. All are to be considered normal and correct operation, even though it might require explanation to understand why the system (lack to) respond the way it does.

If you encounter problems that are not covered by the list please report it to avr@atmel.com.

Table 3-1. Problems and solutions/explanations.

Problem	Solution/ explanation
The values does not update when I push a READ button.	Check that the "USB Status" in the lower left corner of the SB200 PC application is "Connected". If not ensure that the USB cable is connected, and that the SB200 is powered (green LED next to the DC jack should light up).
	Verify that the "Board" identification, also in the lower left corner, identifies the SB20x board correctly. If not, check that the SB20x smart battery board is correctly inserted.
	Ensure that the correct number of batteries are inserted in the battery sockets and that the "number of cells" jumper is mounted correctly (if the device board is identified correctly the LED will light up in the position where the jumper should be mounted.
	The smart battery AVR will not turn on after power off unless it get a "charger connect", which is a sufficiently high voltage from a charger. To do so, turn on the SB200 charger. This should turn on the Charger Active LED on the top-middle of the SB200. Try to read a command again.
	Check if the LED near the USB connector is constantly on (red or blue), if so, an unhandled error has occurred. The SB200 USB device must be reset, by pushing the left micro-switch on the SB200 – between the USB and the DC jack.
	Calibration of CC-ADC offset takes 20-30 seconds the first time the SB201 firmware runs. During the calibration the device board does not respond to any commands.
How can I test the AES Authentication? It just returns garbage when I push READ.	You need to specify the correct AES key on the PC side to decrypt the encrypted reply from SB20x correctly. The key is "You cannot pass!" (As Gandalf said when stopping the Balrog from passing the bridge of Khazad-dûm…). Specify the key, WRITE a 16 character string and now read back.
The SB20x responds to commands, but it is not possible to draw any current from it.	If the load is active when the SB20x starts (whenever the discharge FET has been off, and are turned on). The integrator in the electronically controlled load will saturate and cause a short circuit current to flow for a short while. The solution is to disable the load for a while, and not enable it until the SB20x has enabled its discharge FET. The expanded parameters on the BatteryStatus command will provide this information – as an extra service – for free.

Problem	Solution/ explanation
PROBLEM: Is it possible to change the auto-update refresh rate?	Use the "Tools->Options" and set the desired timer interval.
PROBLEM: I enabled the load to discharge the battery. It suddenly stopped discharging, and I cannot start the discharging again though the battery voltage of both cells is above 2.7V.	This is because one of the batteries has been below 2.7V while discharging. The SB20x has disabled further discharging to protect the battery. To enable discharging, the battery needs to be charged shortly. Turn on the charger for a while.
PROBLEM: The SB201 has "killed" on of my battery cells.	It did not – the battery cell killed itself! …This may occur if the battery cell's built-in protection is inaccurate – so that it triggers before the SB201 limits. Normally the battery can be brought back by turning on the charger. (During development you may load the battery too much, or (dis)charge more that the protection allows).
Set and clear buttons does not always respond.	The PC software is busy fetching data from the SB200 (waiting for response). Normal response will be observed if auto-update is disabled. Alternatively, push the button several times – until it responds.
Can I use the SB200 with unprotected cells?	At you own risk… Not recommended. (If you are a daredevil and remove the battery protection from the batteries shipped with the SB200, remember to wrap tape around the cells afterwards, so that the battery sockets does not short the cells)
The cell voltages are almost equal when the cells are fully charges, but are very different when close to fully discharges.	This is normal. The battery cells used have different resistance, which is more evident when discharged. By enabling cell balancing the battery cells will have close to the same voltage when charged, which is important to be able to charge the batteries to maximum capacity.
I am not able to erase, reprogram or start a debugging session on the SB20x daughter board.	If the firmware programmed in the smart battery AVR on the SB20x daughter board causes the device to enter power-off the programmer will not be able to reprogram the device. This can occur when the device enters power-off very shortly after starting up (assuming that power cycling has been attempted); In this case the device turned off the internal regulator and the internal logic required for the programming tool to take control is off. It can be required to force the device on to get around this. This is done by connecting V_{FET} to GND and V_{REG} to 3.3V. When this is done the device is powered regardless of the state of the regulator, and erase and programming is again possible.

4 EVALUATION BOARD/KIT IMPORTANT NOTICE

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