Battery emulator guide

# MCU

The MCU emulator is a single unit that is connected to the BMS MCU. The figure below shows the MCU emulator.

Super awesome picture

## Power

The emulator board has two options for a power source:

* Using banana cables and a lab power supply
  + Red connector is P+
  + Black connector is P-
* A DC jack connector for a dedicated power supply

The banana cables make the board more versatile, as the input power must satisfy the following voltage and current conditions:

* A voltage range of 6V to 35V
* A current range from 1A to 2.5A

The DC jack connector is useful for when a set voltage and current that reflects actual system behavior is known, which saves time with configuration of the power supply.

### Fuse

A fuse socket is installed on the board, which makes it easy to exchange a fuse, should it be blown during operation. The fuses used by the author are 6.3A 125VAC/VDC, [045106.3MRL](https://www.digikey.dk/en/products/detail/littelfuse-inc/045106-3MRL/700829), from Littelfuse.

## Connectors

Below the connectors on the MCU emulator board is listed as well as their respective signal names referenced to the BMS MCU documentation. Note, the connections on the emulator board are not 1-1 with the BMS MCU wire harness. One therefore finds that e.g. the BMS MCU connectors J4a and J4b have signal connections to multiple emulator board connectors. This choice was made to simplify emulator design.

### Top

* The pin connector on the left is used for General-Purpose Input and Outputs (GPIO) for the BMS MCU. The BMS Creator software can be used to configure which GPIOs should be used for inputs and outputs. Furthermore, this connector provides the emulator with BMS CAN signals. The signals that are associated with this connector are:
  + GPIOX (1 to 16)
  + iCAN HI
  + iCAN GND
  + sCAN HI
  + sCAN LO
  + sCAN GND
* The pin connector on the right is used for the BMS MCU auxillary temperature sensors, controlled by the potentiometers on the far right side of the MCU emulator board. The signals associated with this connector are:
  + T-AUX-X (1 to 11)
  + T-AUX-GND-X (1 to 11)

### Bottom

* The twelve pin connector in the bottom serves several functions: it provides Hall effect current sensing (Hall high and low, denoted as CSENSEX), as opposed to shunt sensing used for the BCU interface, power to the BMS MCU and an ignition switch. The connector also has an output signal from the MCU board, HVIL out. The signals that are connected to this connector are:
  + GND (2x)
  + Power (6V – 35V)
  + Ignition
  + HVIL IN
  + HVIL OUT
  + CSENSEX (HI and LO)
  + CSENSEX GND (HI and LO)
  + CSENSEX 5V (HI and LO)
* The six pin connector in the bottom is used for the BCU high voltage interface cable. The signals that are connected to this connector are:
  + SH+
  + SH-
  + HV+
  + HV-
  + HV+ Load side
  + HV+ Charger side
* The four pin connector in the bottom is used for providing the MCU with battery pack voltage terminals. This can either be supplied from the actual CMU emulator boards, or from a power supply if it is desired to only test MCU functionality.
* A CAN BUS connector used with the switch next to the connector. The BMS MCU provides the emulator board with an isolated and non-isolated CAN signals (iCAN and sCAN). iCAN is isolated from battery and BMS supply voltage and GND, while sCAN is isolated from the battery alone, referenced to BMS supply voltage GND. The switch is used to easily toggle between these two modes. The CAN connector must be used with a PEAK PCAN-USB adapter in order to communicate properly with software.

## Auxiliary temperature sensors

The emulator board has 11 temperature emulators using potentiometers for setting the temperature. Each temperature has two potentiometers, a 500kΩ for emulating cold temperatures and a 10kΩ for emulating hot temperatures. With these two potentiometers, it possible to emulate a temperature range from -40°C (high resistance) to +85°C (low resistance). The large potentiometer can be used as a coarse setting, while the small potentiometer is used for fine tuning.  
If necessary, it is possible to make a multimeter reading of the total and individual resistance of the potentiometers, by using the orange test points.

Insert picture of potentiometers, marking test points, 10k and 500k

## Pack current

The switch and potentiometer on the far left is used for emulating either a load current or a charging current. The switch determines whether the BMS MCU sees a load current or a charging current, and the potentiometer is used for setting the amplitude of the observed current. The orange test point is connected to the output of the potentiometer. Since the current seen by the BMS is measured with a shunt resistor, it is possible to predict what the current amplitude should be based on the test point.

## GPIO

There are 16 GPIOs on the emulator board. Through the BMS Creator configuration software, each of these can be configured as either an input or an output.

If configured as an input, the switch is used for toggling the signal on and off. When the signal is on, the green LED next to the switch lights up as a visual indicator. Note, the BMS Creator software includes a GUI that shows the same functionality.  
If configured as an output, the switch must be in the on-position to have correct functionality. The LED will be lit if there is a signal coming from the BMS MCU, which means the LED can still serve as a visual indicator even in this scenario.

Indsæt billed

### HV and Ignition switches

Located close to the GPIO switches is 5 switches related to a different functionality. The switch to the left labeled “Ignition” is used for a functionality on the BMS that turns the system on from sleep mode. The remaining switches are used for toggling their respective HV signals related to the BCU interface on and off.

## Hall effect

The Hall effect is controlled by two potentiometers. Currently, Hall effect is not used for the DTU Roadrunners Solar Team project, however, it was deemed important in the design to include the functionality for future projects.

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## Connectors

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* The connector to the left is for the cell voltage connector. It carries the signals:
  + Cell1- (x2)
  + Cell12+ (x2)
  + CellX+ (2 to 11)
* The connector to the right is the temperature connector. It carries the signals:
  + NTC X (1 to 12)
  + GND (NTC X) (1 to 12 in pairs of two)
* There are two one pin connectors, located on each side of the board. The purpose of these connectors is to provide the functionality to place multiple emulator boards in series. This makes it possible to emulate battery modules with up to 12 cells inside, and then connect this modules in to a pack.

## Cell temperature emulator

The emulator board has 12 temperature emulators using potentiometers for setting the temperature. Each temperature has two potentiometers, a 100kΩ for emulating cold temperatures and a 10kΩ for emulating hot temperatures. With these two potentiometers, it possible to emulate a temperature range from -24°C (high resistance) to +85°C (low resistance). The large potentiometer can be used as a coarse setting, while the small potentiometer is used for fine tuning.  
If necessary, it is possible to make a multimeter reading of the total and individual resistance of the potentiometers, by using the orange test points.

Insert picture of potentiometers, marking test points, 10k and 100k

## Cell voltage emulator

The emulator board has 12 isolated voltage emulators. The isolation makes each voltage output independent, which can be used for setting set cell voltages. The voltage range of the voltages are from 0V to 5V controlled by two potentiometers a 1kΩ and a 100kΩ.

Two orange test points are associated with each emulator row. Close to the connectors are two additional test points, which will show the total voltage of the emulated battery pack.

In addition, two pin rows are located at each emulator row. The pin row the far left is connects the isolated 5V voltage of each row in series, which makes it possible to quickly assemble a large voltage should this be desired. The next pin row is used for battery packs that are smaller than 12 cells/modules. If you wish to only emulate a pack of 6 cells/modules, the rows from cell 12 to cell 6 should be connected by placing a shunt connector on these pin rows.