

Instructions for charging FES battery pack

(last update: 26.11.2011)

GENERAL INFO

It is important to read these instructions carefully before charging the FES battery pack! If you need more information please contact the FES manufacturer.

1. To charge FES battery pack you need a CHARGER and a BMS as they must be connected together. To most people a CHARGER is a well known device, but what is a BMS?

During charging and discharging LiPo battery cells differ in voltage levels, due to capacity of cells. Cells with lower capacity charge and discharge faster than cells with higher capacity. LiPo cells have nearly linear voltage to capacity dependence. Battery management system (BMS) controls the voltage of each cell in the battery pack. Cells which have higher voltage than others are discharged through resistor inside of BMS – the energy dissipates through heat. Balancing of each cell is indicated by green light emitting diode (LED).

BMS can also balance cells without the presence of a CHARGER (above pre-set balancing voltage start).

FES system is available with:

- 12 cells/pack wired in serial (named 12S)
- 14 cells/pack wired in serial (named 14S)

We used one of the best cells currently available on the market:

produced by Kokam, type SLPB100216216H, high power, with capacity of 40Ah.

You can find more technical data about these cells in [Technical Specifications](#).

- for 12S pack BMS with 12 cells balancing LED indicators is used
- for 14S pack BMS with 14 cells balancing LED indicators is used

FES approved chargers are:

- KOP1001 BMS version (1000 W), which is our FES standard charger
- KOP602 BMS version (500 W), optionally available as on-board charger due to its dimensions and weight (2 kg only) - charging time is 2x longer.

FES manufacturer has pre-set the charger differently for 12S and 14S packs.

2. CHARGER **will not start charging** without signal from the BMS!
3. Each battery pack should be charged separately.
(Optionally, an additional CHARGER and BMS are available, which you can use if you have min 16 A fuses on the grid).
4. Both battery packs **must have** the same cell voltage levels (close to 4.16 V), before usage. Using two packs with different voltage levels is not allowed!

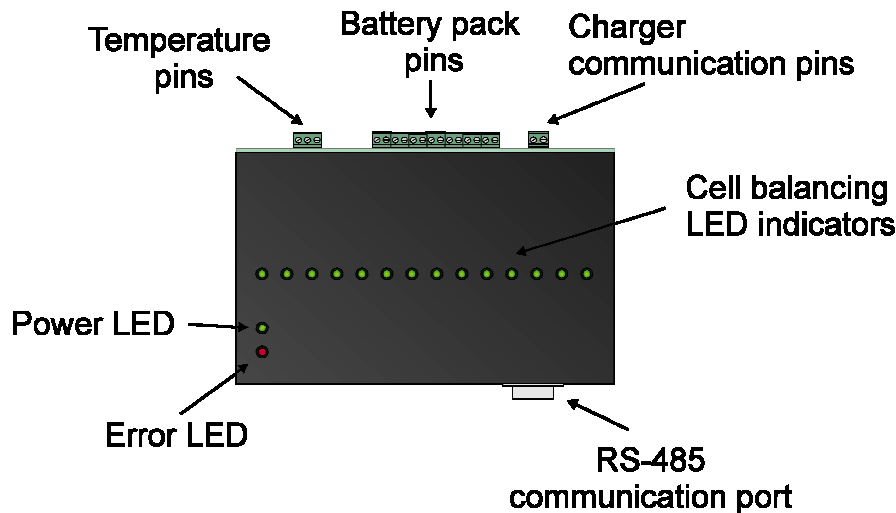


Figure 1: BMS function overview.

CHARGER (KOP1001 or KOP602) – BMS – BATTERY PACK CONNECTION

1. Connect BMS to battery pack. **All cells should be connected simultaneously!** Immediately after BMS connection to battery pack is established, the BMS starts the test procedure. Red »Error LED« turns on to signal the system's test procedure.

2. If the test procedure is OK then »Error LED« turns OFF and BMS starts working in normal mode. BMS sends signal to the CHARGER to start charging and »Orange LED« on CHARGER indicates the start of charging. It is also possible to hear the contactor "click" inside of the CHARGER.

If the CHARGER does not start charging, please check the following:

- CHARGER must be connected to the wall outlet (AC 220 V, 50 Hz)
- two DC charging wires from the CHARGER (+ plus (red) and – minus (black)) must be properly connected to battery terminals (**Mind the polarity!** - red wire goes to positive + red marked terminal on battery pack and black wire goes to negative - black marked terminal on battery pack. Reverse protection is implemented into the CHARGER).
- communication cable from CHARGER must be connected to BMS.

Charging current rises slowly to the final value of 18 A, and cooling fans in CHARGER start working.

3. In normal mode green »Power LED« on BMS is flashing. This means that the BMS is working, but not necessary balancing. Balancing starts only when at least one cell reaches minimum 3.7 V (pre-set value, which could be changed by BMS Control Software and special code). If any of 12/14 green LED cell balancing indicators are ON, it means that those cells have slightly higher voltage compared to the lowest one.

4. Red »Error LED« is ON only during the test procedure, after the test is completed it turns OFF. System errors are indicated with red »Error LED« by the number of ON blinks, followed by a longer OFF state. Number of blinks identifies the error:

Number of ON blinks	Error
1	Single or multiple cell voltage is too high (4.2 V)*.
2	Single or multiple cell voltage is too low (3.24 V)*.
3	Cell voltages differs more than 20 mV (0.02 V).
5	BMS temperature is too high (50°C)*.
6	Number of cells is not set properly.

*Initial settings may be changed with BMS Control Software.

5. When first cell reaches 4.16 V, charging current is reduced from 18 A to about 3 A. When all cells reach 4.16 V the **BMS sends signal to CHARGER to stop charging**. When voltage level of CHARGER is very close to the end of charging, »Orange LED« might start blinking. This means that CHARGER itself goes to second charging mode with max charging current 5 A, maximum time 30 minutes.

6. CHARGER itself has programmed maximum charging time (about 3 h) and when this time is reached it will automatically stop charging. If charging was stopped due to maximum charging time (instead of signal from BMS), the red light on charger will start blinking periodically *2-times flashes / 2 s pause / 2-times flashes etc.*

7. If there is still any of LED balancing indicators active after charging is completed (»Orange LED« on CHARGER is OFF), we suggest to leave BMS connected to battery package, until all cells are perfectly balanced – when there is no green LED balancing indicators ON, green »Power LED« is blinking and BMS is cold.

BMS is set to balance the cells to 5 mV (0.005 V), meaning if there is difference of 0.01 V or even 0.02 V, it will try to balance them. If you measure the voltage of each cell (on small bolts on connector) by using the usual digital V-meter (with scale on 20 V), it should show only 0.01 V difference, as measurement precision of usual V-meter is lower than the balancing precision.

For more accurate voltage measurement of each cell in battery pack, we strongly suggest to use dedicated software. BMS Control Software enables to monitor and log all parameters of the battery pack and change the original settings. Connect the BMS to the computer USB port by special RS-485 cable and start the BMS Control Software. In case of troubleshooting logging file can be sent to FES manufacturer, who can easily discover the problem and find a suitable solution.

Possible scenarios:

- If one or more cells have higher voltage levels than the others, it will discharge them, the temperature rise of BMS should be minimum.
- If only one cell has lower voltage level than all the others, all cells need to be balanced. This leads to higher BMS temperature, even if voltage difference is only 0.01 V.

BMS over temperature switch-off is set to 50°C. When this temperature is reached the BMS stops balancing. If the BMS is connected to the CHARGER, it also sends a signal to the charger to stop charging or to reduce charging current. Red »Error LED« starts blinking with 5 blinks. When the BMS cools down to 40°C the balancing starts again – if connected to the CHARGER, it will start charging again or raises to maximum current!

If BMS gets very hot (more than 55 °C) during charging, this means that it has a lot of work with balancing (scenario 2). In such case we recommend to disconnect the CHARGER from power supply until cells are perfectly balanced and BMS cools down to a normal temperature.

CHARGER SETTINGS AND BMS CONTROL SOFTWARE

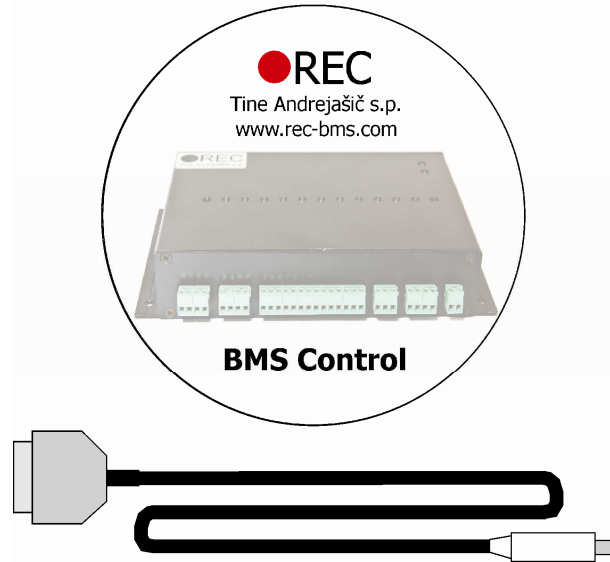


Figure 2: BMS Control Software setup CD with (RS-485 to USB) cable.

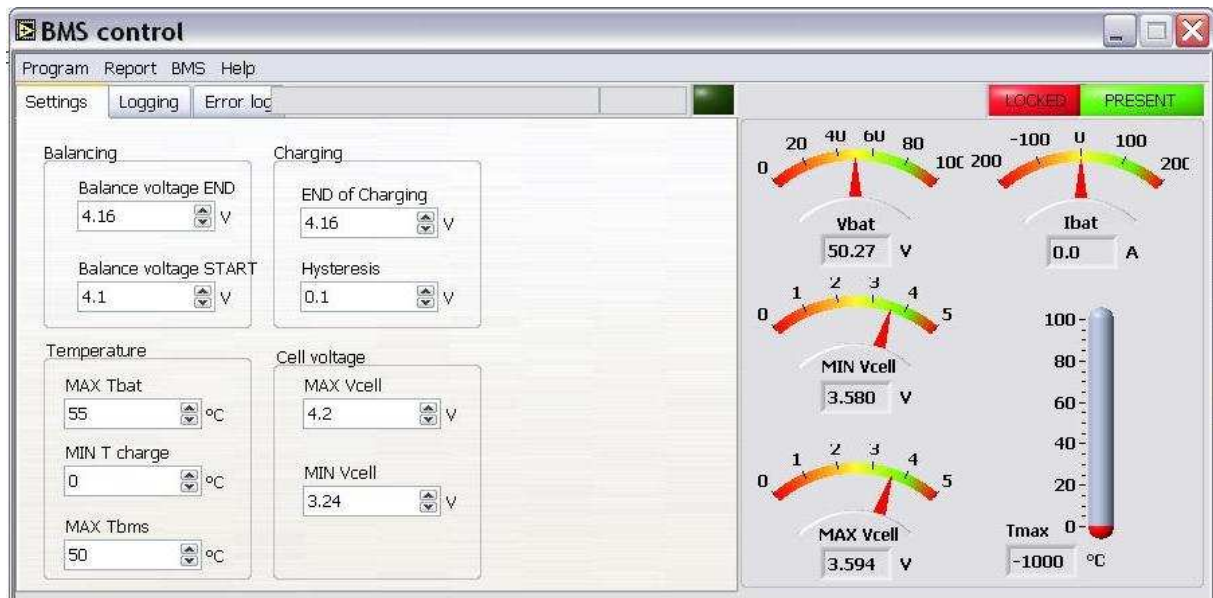


Figure 3: BMS Control Software settings.

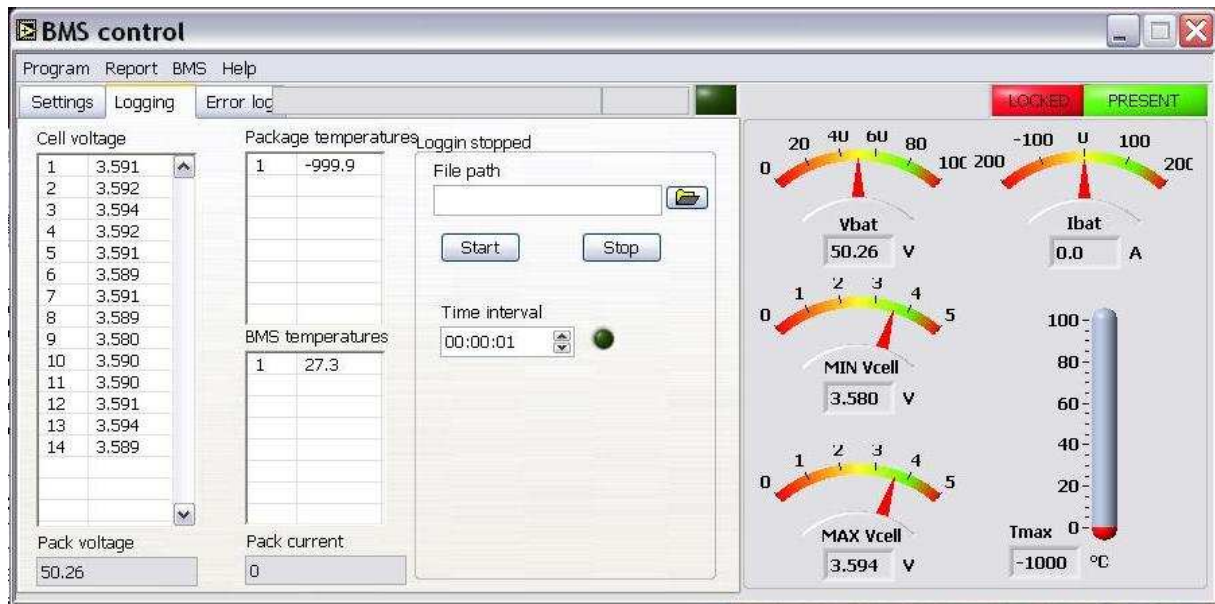


Figure 4: Voltage level of each cell, BMS temperature, pack voltage, minimal cell voltage, and maximum cell voltage.

BMS INITIAL SETTINGS

Parameter	Unit	Value
Single cell end of charge voltage*	V	4.16
Single cell charging hysteresis*	V	0.1
Single cell balance start voltage*	V	3.7 or 4.1
Maximum charging current	A	18
Single cell balance 100 %*	V	4.16
Balance resistor	Ω	3.9
Single cell under-voltage protection*	V	3.24
Single cell over-voltage protection*	V	4.20
Single cell over and under-voltage protection hysteresis	V	0.01
BMS over-temperature protection*	$^{\circ}\text{C}$	50
BMS over-temperature hysteresis	$^{\circ}\text{C}$	10

*Initial settings may be changed with BMS Control software.

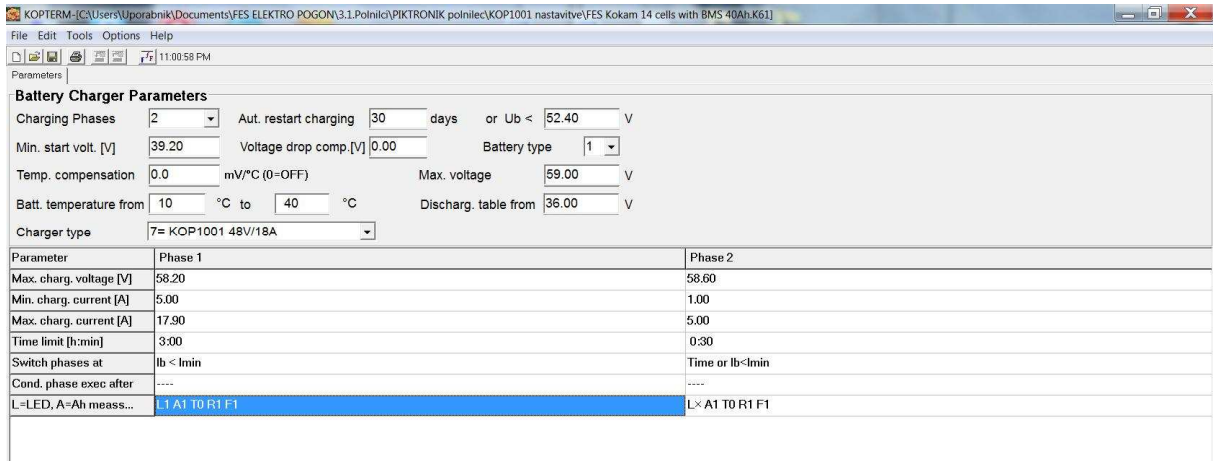


Figure 5: Charger settings for 14S packs.

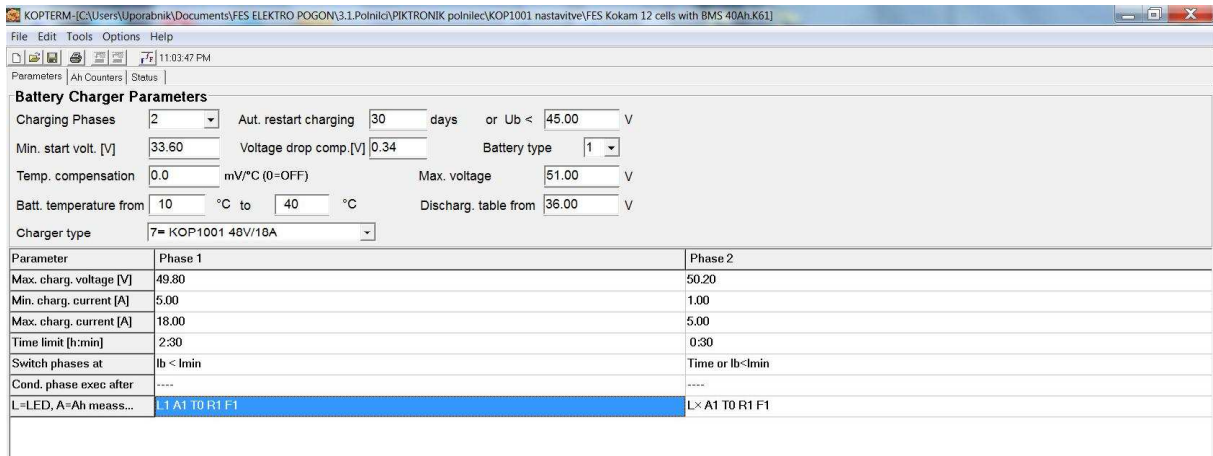


Figure 6: Charger settings for 12S packs.