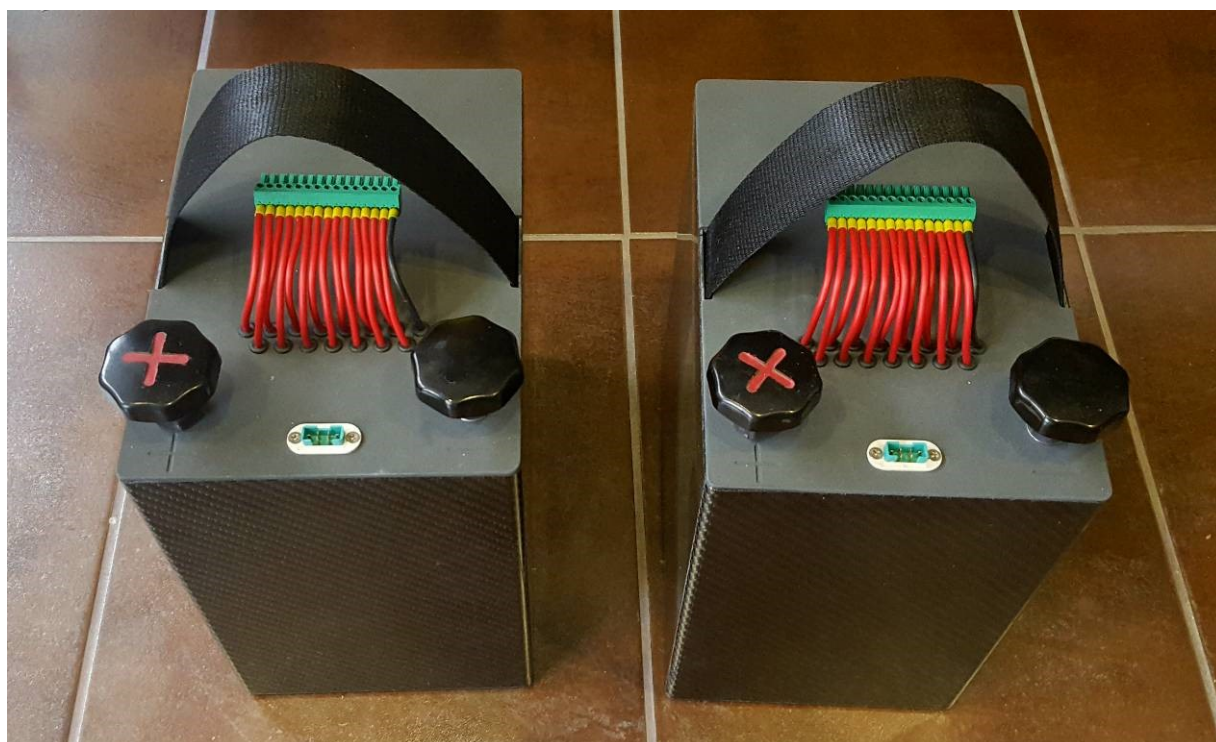




FES BATTERY PACK GEN1 14S 40Ah

With external BMS

User Manual, Version 1.15



LZ design d.o.o., • Brod 3D, 1370 Logatec, Slovenia • tel +386 59 948 898
info@lzdesign.si • www.front-electric-sustainer.com

Table of content

1. Important notices	3
1.1 Limited Warranty	3
2. General info	4
2.1 Technical data	4
2.2 General layout of the pack with connected BMS	5
2.3 External FES BMS 7R	5
2.4 External BMS firmware update	6
3. Battery pack charging	7
3.1 Available chargers	7
3.2 Charger to Battery pack connection and charging	10
3.3 FES BMS Control software	13
4. Before flight	14
4.1 Installation of the FES Battery packs into the sailplane	15
4.2 Pre-flight test run	16
5. After landing	17
5.1 Removing the batteries	17
6. Maintenance	18
7. Transport	19
7.1 Car transport	19
7.2 In glider trailer	20
7.3 Transport by ship or train	20
8. Discharging and storage	21
8.1 FES discharging assistant	21
8.2 FES Discharger 2	21
8.3 Warning sticker	22
9. Used packs	22
10. Revision history	23

1. Important notices

It is important to read this manual carefully before using the FES battery pack! It contains important information about FES propulsion system, having a vital importance to the flight safety. If you need more information, please contact the manufacturer of your glider or FES manufacturer LZ design.

Information in this document is subject to change without notice. LZ design reserves the right to change or improve their products and to make changes in the content of this material without obligation to notify any person or organization of such changes or improvements.



WARNING means that the non-observation of the corresponding procedure leads to an immediate or important degradation of the flight safety.



CAUTION means that the non-observation of the corresponding procedures leads to a minor or to a longterm degradation of the flight safety.



NOTE draws the attention on any special item not directly related to safety, but which is important or unusual.

1.1 Limited Warranty

This product is warranted to be free from defects in materials or workmanship for one year from the date of purchase. Within this period, LZ design will, at its sole option, repair or replace any components that fail in normal use. Such repairs or replacement will be made at no charge to the customer for parts and labour. The customer shall be responsible for any transportation cost. This warranty does not cover failures due to abuse, misuse, accident, or unauthorised alterations or repairs.

THE WARRANTIES AND REMEDIES CONTAINED HEREIN ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED OR STATUTORY, INCLUDING ANY LIABILITY ARISING UNDER ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, STATUTORY OR OTHERWISE.

IN NO EVENT SHALL LZ DESIGN BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES, WHETHER RESULTING FROM THE USE, MISUSE, OR INABILITY TO USE THIS PRODUCT OR FROM DEFECTS IN THE PRODUCT.

LZ design retains the exclusive right to repair or replace the unit or software, or to offer a full refund of the purchase price, at its sole discretion. To obtain warranty service, contact your local LZ design dealer or contact LZ design directly.

2. General info

This is a standard FES Battery developed especially for FES application. There are 14 cells, all wired in serial (14S) in each battery pack. A pair of battery packs is required in a standard FES system. First pack is marked as A and second pack as B.

We are using high power SLPB (Superior Lithium Polymer Battery) cells, produced by global leader of Lithium polymer battery industry – Kokam Co.

To avoid possible wrong connections there is 8mm threaded contact for – pole and 10mm threaded contact for +pole.



Never ever shortcut terminals with a metal conductor! This is very dangerous!

Handle with care!



Do not try to open Battery pack

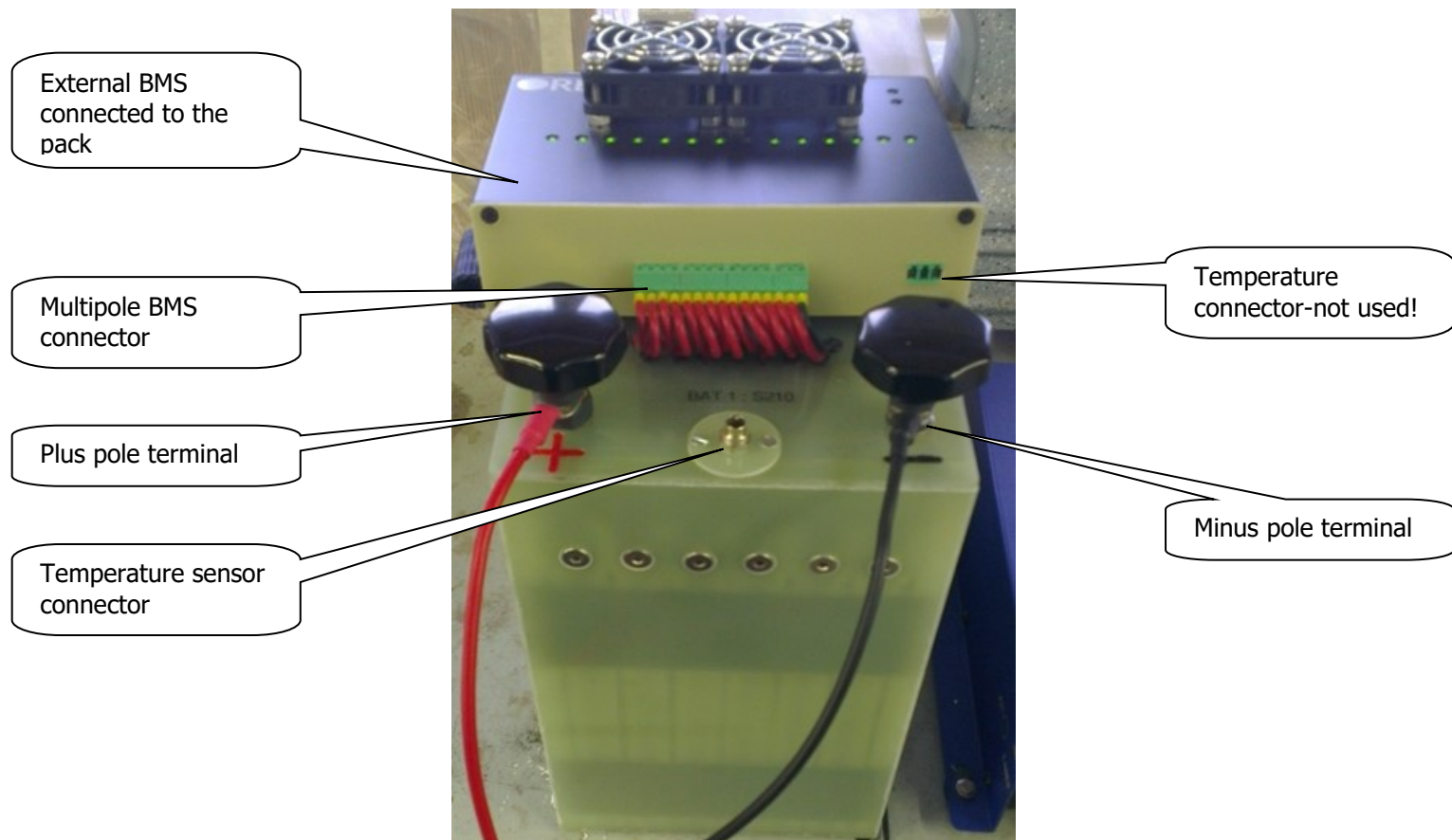
Do not touch terminals with both hands!

Keep battery packs away from children!

2.1 Technical data:

FES Battery pack GEN1 14S 40Ah	
Battery pack type	FES GEN1 14S 40Ah
Weight of single battery pack	15.5 kg
Box dimensions (WxLxH), without terminals	154 x 220 x 240 mm
Cells producer	Kokam, South Korea
Electrochemical system	NMC (LiMnNiCoO ₂)
Cells type	SLPB100216216H
Average capacity of each cell	40 Ah
Number of cells	14
Energy storage capacity	2.1 kWh
Maximum total voltage	58.3 V
Minimum total voltage	42 V
Maximum current	250 A
Max balancing current per cell	1 A
Approved external BMS type	FES BMS 7R
Standard charger	FES KOP1001
Optional charger	FES KOP602

2.2 General layout of the Battery pack with connected BMS



2.3 External FES BMS 7R

With Battery packs is delivered usually one or optionally two external BMS (Battery Management System – type FES BMS 7R) which needs to be inserted into multipole green connector above the cells during charging process. BMS is equipped with 14+2 LEDs to monitor its operation.

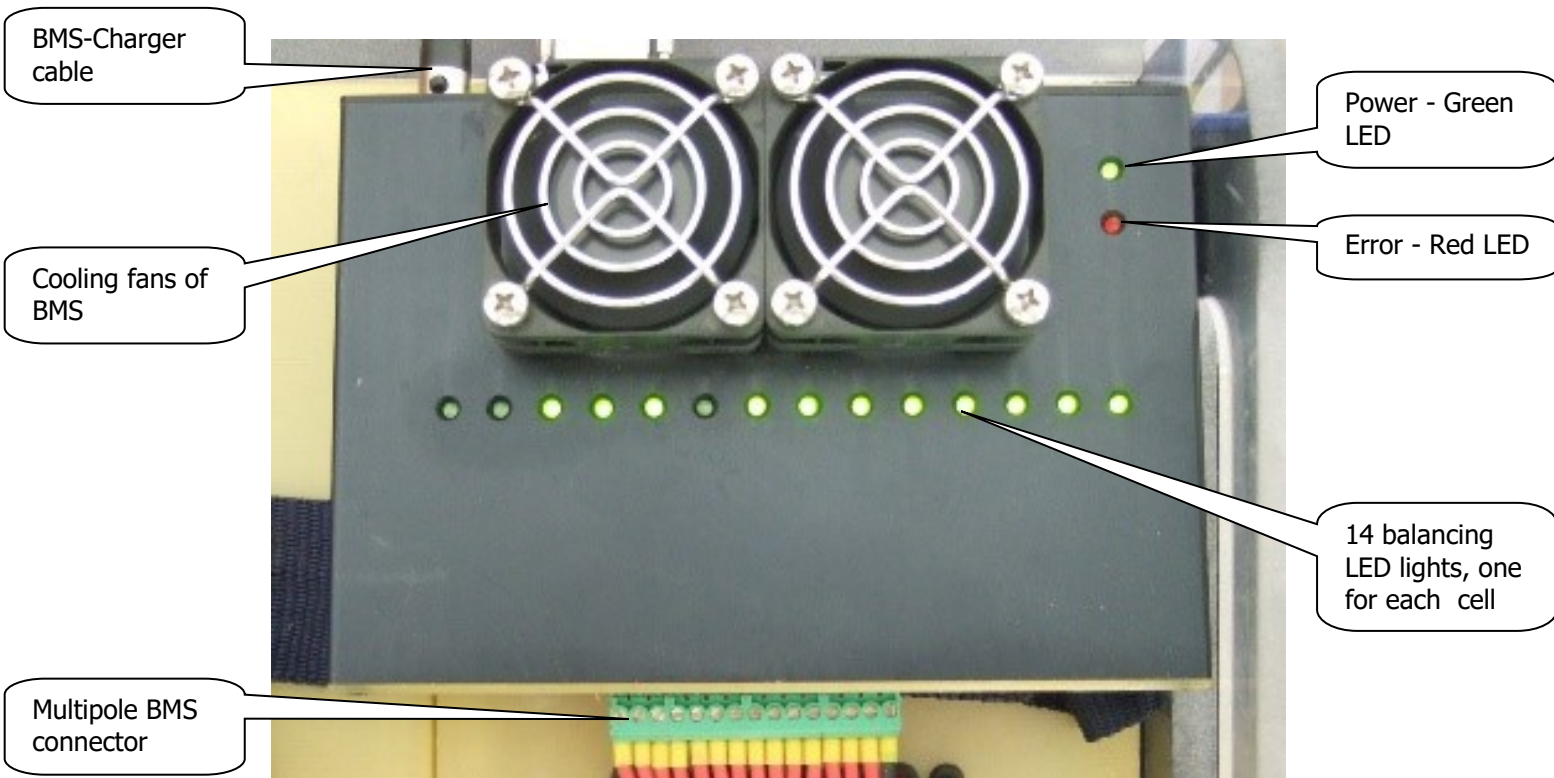
Why BMS is required and how it works?

During charging and discharging LiPo battery cells differ in voltage levels, due to slightly different 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. 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 heating of the BMS aluminum housing box. To improve dissipation of the heat there are two small ventilators on top of the BMS which starts when temperature of the box reach preset temperature.

Balancing of each cell is indicated by 14 green light emitting diode (LED).



External BMS can balance cells also without presence of a CHARGER if voltage of cells is above pre-set balancing voltage



Different LEDs are blinking during balancing process

BMS data and initial settings

Parameter	Value	Unit
Maximum charging current**	9 or 18	A
Maximum balancing current	1	A
Single cell end of charge voltage*	4.16	V
Single cell balance start voltage*	4.1	V
Single cell under-voltage protection*	3.24	V
Single cell over-voltage protection*	4.20	V
Cooling fans start temperature*	50	°C
Max. BMS temperature*	55	°C

* Initial settings may be changed with BMS Control software.

** Maximum charging current depends on the type of charger.

2.4 External BMS firmware update

Update of external BMS firmware, is possible only by FES manufacturer!

3. Battery pack charging

Charging of FES battery packs is permitted only with special FES chargers, that are listed below. A suitable voltage step-up transformer must be used for chargers that require 230 V~ 50/60 Hz input, in countries with 110 V~ grid.



Note: All chargers come pre-set with suitable settings for FES GEN1 14S from factory and work only if a communication with the BMS connected to battery pack can be established.

3.1 Available chargers

1. FES KOP1001 – standard equipment

- Maximum power consumption: **1200 W**
- Maximum charging current: 18 A
- Required input voltage: 230 V~ 50/60 Hz
- Weight: 3.9 kg



FES KOP1001 Charger

2. FES KOP602 – optional charger

- Maximum power consumption: **600 W**
- Maximum charging current: 9 A
- Required input voltage: 230 V~ 50/60 Hz
- Weight: 2.2 kg



KOP602 Charger

Battery chargers FES KOP1001 and FES KOP602 are modern programmable fully automatic devices. They are programmed so, that they work only in combination with provided BMS. BMS needs to be connected to battery pack multipole connector, and with a signal cable to the charger.

Charger is programmed with suitable settings for FES GEN1 14S battery packs. Do not extend or shorten + and – charging cables as this would affect on charging, due to voltage drop on cables!

The charger stores data about charging times and Ah charged. This data may be accessed for further analysis by manufacturer.

Required input voltage is 230V~ 50/60 Hz. Unfortunately is not available 110V version of charger. If your country is using 110V grid, then you should use suitable voltage step up transformer.



Before using the charger, check that the fuse on the grid is suitable. For 1200W charger it should be minimum 10A fuse. Always try to connect charger directly to inlet, without extension cables and splitters if possible



Each Battery pack must be charged separately.



If you ordered another pair of Battery packs, make sure that you do not mix battery packs between the sets. The same two battery packs of one set must be always used in pair!



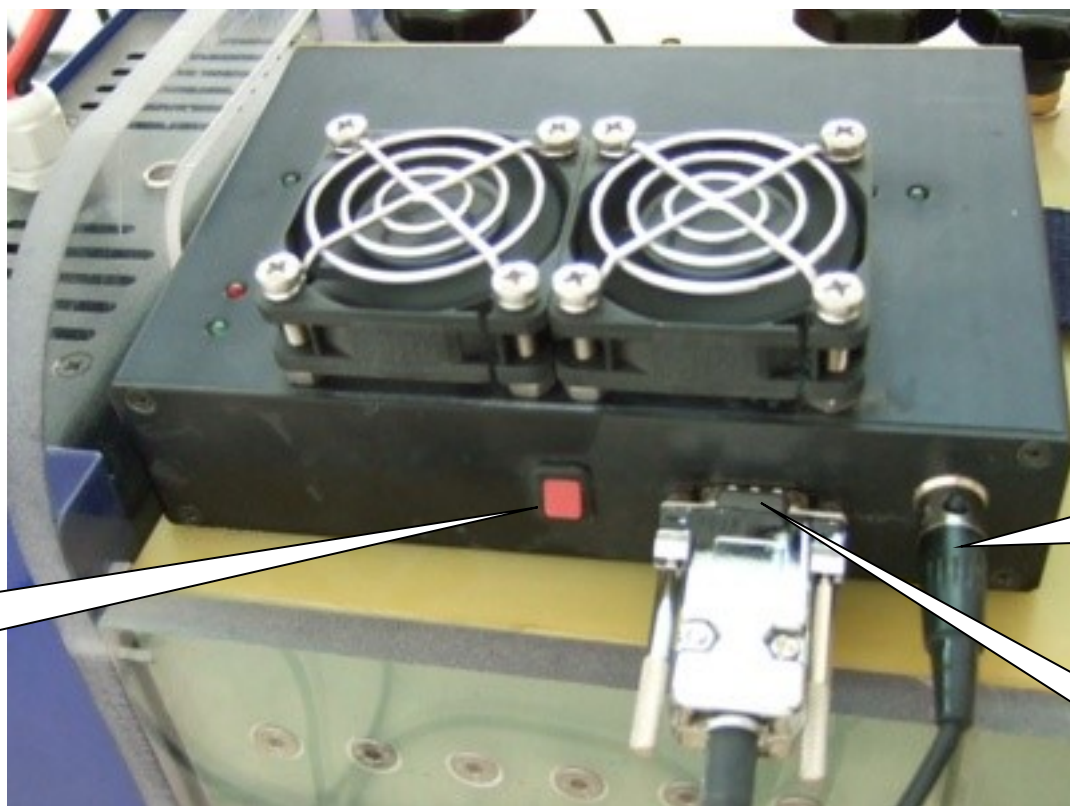
Optionally, an additional charger could be ordered, so that you could charge both packs simultaneously. However, in this case, you should check that you have a suitable fuse (16 A) on the grid.



BMS-Charger signal cable plugged into the Charger; yellow LED light is ON-Charger is working



BMS-Charger signal cable with round connectors on each side



Back side of BMS with ON-OFF switch, BMS-PC cable with DB9 connector, BMS-Charger signal cable with round connector connected

3.2 Charger to Battery pack connection and charging



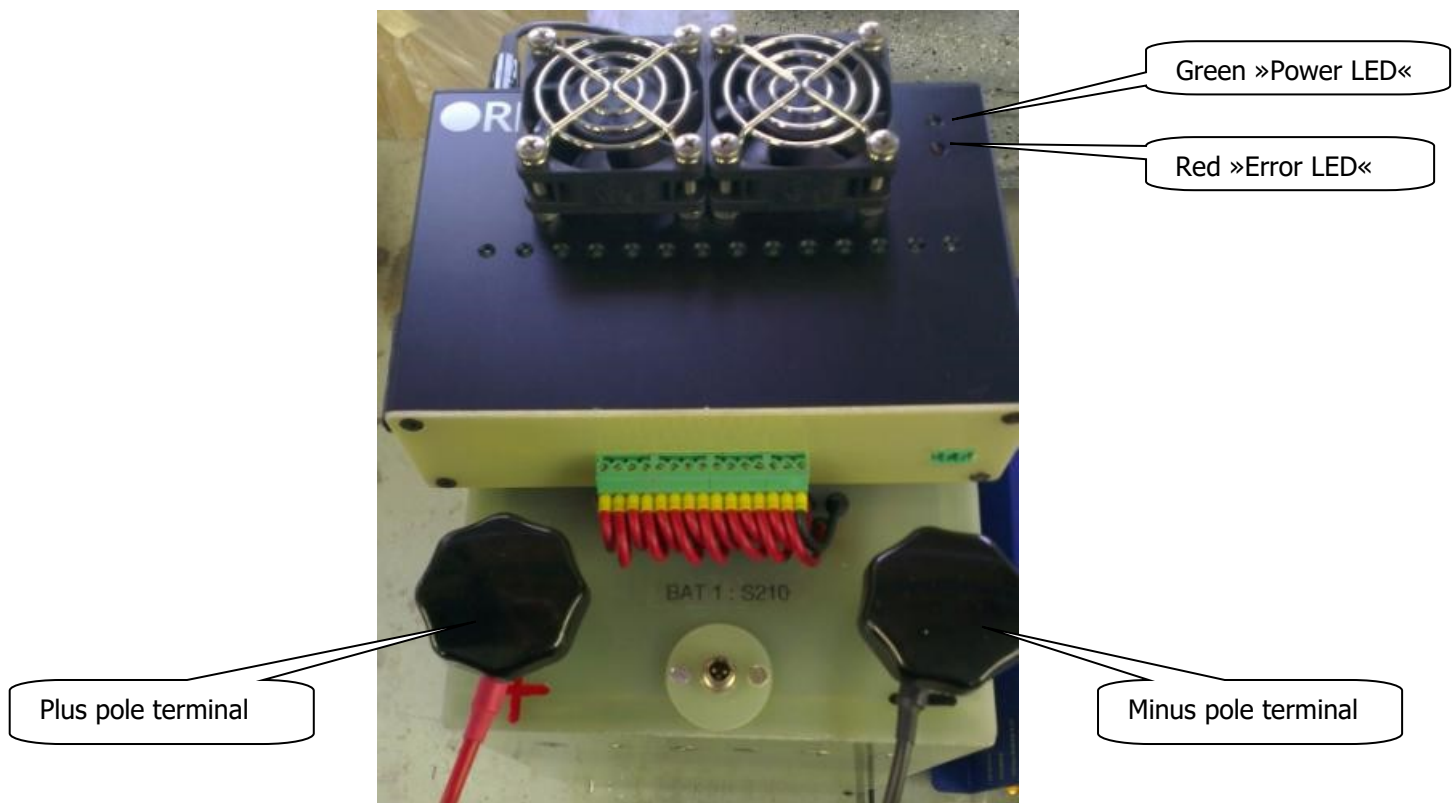
Caution: Place Charger on a safe, secure position. Keep away from dust, direct sunlight, fire, smoke, children and any unattended person!



Warning: Before charging an inspection for physical condition of battery packs should be done. Any sign of physical damage such as punctures, dents, scratches, must be evaluated and reported to manufacturer before charging.

1. Connect BMS to first battery pack
2. Connect RED + and BLACK – cables from charger to first battery pack
3. Connect charger and battery pack with Charger-BMS signal cable
4. Plug in Charger to 220V 50hz outlet
5. Turn ON switch on back side of BMS

Immediately after BMS switching ON, the BMS starts test procedure. Red »Error LED« turns ON to signal the system's test procedure.



6. 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.

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

7. In normal mode green »Power LED« of BMS is flashing. This means that the BMS is turned ON, but not necessary balancing. Normally balancing starts when one cell reaches pre-set value, usually 4,1V (could be changed by BMS Control Software). If

any of 14 green LED cell balancing indicators are ON, it means that those cells have slightly higher voltage compared to the lowest one.

If there is more than 30mV (preset value) difference between highest and lowest cell, then balancing start even before one cells reach 4,1V.

Possible scenarios:



1. If one or more cells have higher voltage levels than the others, it will discharge them, the temperature rise of BMS will be minimal.

2. If only one cell has lower voltage level than all the others, all higher cells need to be balanced. This leads to higher BMS temperature, even if voltage difference is only 0.010 V (10mV).

If BMS gets hot despite of working ventilators (more than 55 °C) during charging, this means that it has a lot of work with balancing (scenario 2). In such case CHARGER will switch off automatically until temperature of BMS will drop for about 10 degrees.

8. Red »Error LED« is ON only during the initial test procedure. After the test is completed, it turns OFF. Some system errors are also 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 blinks	Error description
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
9	Wrong chemistry settings in BMS

*Initial settings may be changed with BMS Control Software.

9. When first cell reaches 4.160V, charging current is reduced. If there is a big difference between cells (more than 50mV) then it can take quite long time until they all reach 4,16V, as charging current is only 1A.
10. When finally, all cells reach 4.160V (+/- 2mV) then **BMS send a signal to CHARGER to stop charging**. Green "Power LED" stop flashing and **is turned ON**

When this happened charging and balancing is properly **completed!**



When green Power LED is continuously ON, this clear sign that charging process is properly completed!

- 11.** Switch OFF BMS and disconnect it from Battery pack. Unplug charger from outlet. Remove charging cables and signal cable from Battery pack.
- 12.** Charge second Battery pack!



Both battery packs **must have** approximately the same cell voltage levels (close to 4.16 V per cell), before usage. Using two packs with too much difference in voltage levels is not allowed!

Maximum 0,4V difference between total voltages of both packs is acceptable.

If there is bigger voltage difference it is **not acceptable!**

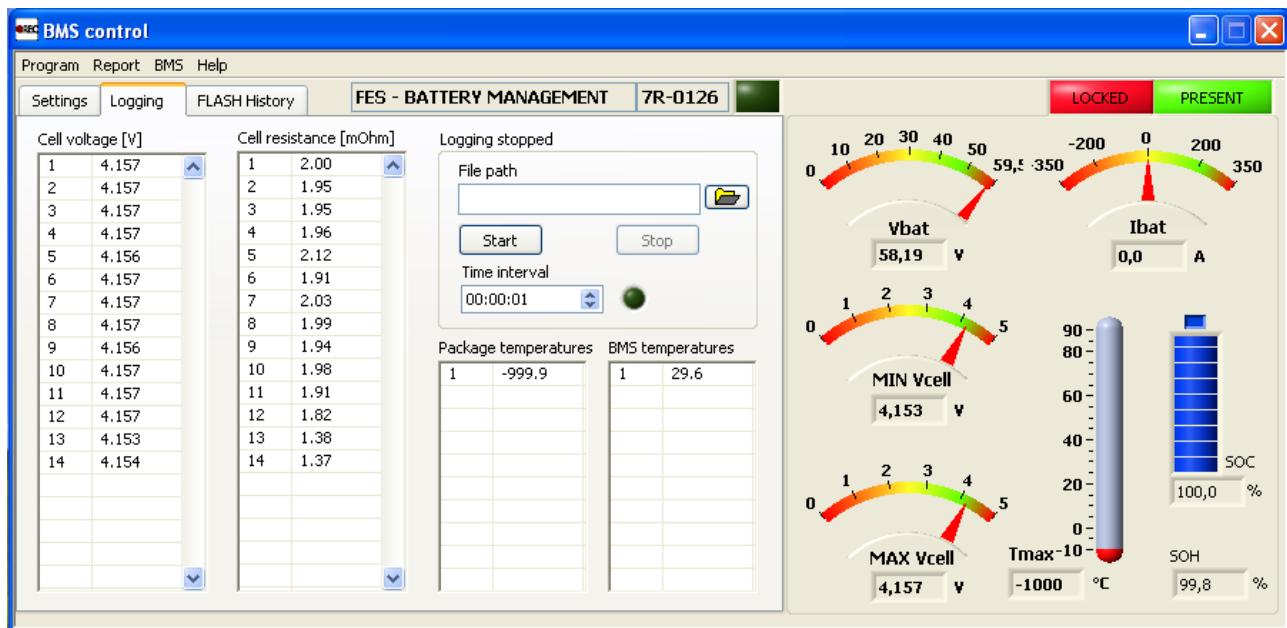
For instance, Pack 1: 58,24V (4.160 per cell), Pack 2: 57,82V (4,130V per cell), this is just acceptable!

3.3 FES BMS Control software

If you want to monitor and log how voltage level of each cell in battery pack is rising during charging, you can use dedicated BMS Control software on PC (or via optional FES LCD display).

In case that some problems are discovered during charging, log file can be created and sent by email. It can help to discover the problem and find a suitable solution.

Installation and setup of the FES BMS Control Software is described step by step in a dedicated FES BMS Control manual, which can be downloaded from our website.



Cells voltage levels and calculated internal resistance values on fully charged battery pack

4. Before flight

Valid for FES Self-launchers:

FES battery packs must be always recharged to 100% SOC for self-launching, so that maximum power is available to obtain a good climb rate. This is especially important if:

- batteries are cold and voltage drop under high load is increased,
- taking off from a short runway,
- taking off at high altitude or
- in hot summer conditions

Valid for FES Self-sustainers:

Battery packs should be recharged before each flying day, especially if the motor was used significantly during previous flights, and/or a long cross-country flight is planned. This ensures maximum energy will be available when needed.



Note: *It is recommended to recharge the battery packs just a day or two before flight is planned. However, enough time must be planned in for charging process to complete fully.*

4.1 Installation of the FES Battery packs into the sailplane



Warning: Make sure that both battery packs are fully charged before installation into the sailplane. Both battery packs **must have** approximately the same voltage level of cells (close to 4.16 V per cell). The difference between the total voltage levels of the packs should be **less** than 1V.

1. Check batteries for any visual damage.



Warning: Even small, visually detectable damage implies, that the affected battery is not airworthy.

2. Open battery compartment cover.
3. Check that "Power switch" is OFF.
4. Check: Sailplane main switch (fuse) OFF.
5. Insert the first pack (terminals facing forward) and slide it backwards.
6. Insert the second pack (terminals are facing rearward).
7. Correctly secure both battery packs with the fixation plates and the fastening knobs.
8. Lift power cables from side support.
9. Connect + red power cable to M10 threaded + terminal of front battery pack and tighten it well with a knob.
10. Connect – black power cable to M8 threaded - terminal of rear battery pack, and tighten it well with a knob.
11. Insert and secure both temperature sensor connectors, to each battery pack.
12. Close battery compartment cover.



Warning: The battery compartment cover must be sealed with tape in flight. If there is a possibility of water entering the battery compartment on the ground (e.g. rain shower or during cleaning), the battery compartment cover must be kept sealed. Water could damage the batteries even in small quantities.

4.2 Pre-flight test run

After the battery packs were recharged, it is always required to perform short motor run, so that FCU instrument can recognize and store the new charge level to the FCU memory.

Short motor run is also recommended before the first flight of a flying day.

1. Remove propeller cover.
2. Remove tail dolly to achieve safe propeller clearance.
3. Open battery compartment cover.
4. Check: Power switch OFF.
5. Insert "Power fuse" between free + and – terminals of the packs, and tighten both knobs
6. Close cover of battery compartment and seal it with tape.
7. Seat into the cockpit of the glider and close the canopy.
8. Check that nobody is in line of propeller disk or in front of the sailplane
9. Switch ON FCU and wait a few seconds until a normal screen appears.
10. Switch ON the Power switch.
- 11. Wait about 5 seconds so that charge level (indicated as bottles) reaches 100% value (this will happen only if total voltage is above 114V).**
12. Gently rotate throttle knob clockwise to start the motor. Use only small RPM, just to check if the system works normally.



Caution: *New battery charge level will be stored to the FCU memory, only if the motor is started and it ran a short while.*

13. Check if propeller braking and automatic positioning is working properly.
14. Switch OFF the Power switch.

5. After landing



Warning: After last landing of the flying day (or if you decided not to fly), it is mandatory to remove "Power fuse", from the battery packs!



Caution: Make sure that "Power switch" is OFF before removing connecting cable.



Note: Only when "Power fuse" is removed, FES system is completely shut down. Otherwise, there is still some current consumption, which could result in discharge of battery packs, below critical level of 90 V, if "Power fuse" is not removed for a week or two. After such scenario, a new battery packs would be required.

5.1 Removing the batteries

When the total voltage of the battery packs drops below 110 V, it is sensible to remove them from of the glider and recharge them shortly before next flight is planned.

To remove batteries the procedure below should be followed:

1. Check: Power switch is OFF
2. Check: Sailplane main switch (fuse) OFF.
3. Open battery compartment cover.
4. Untighten knobs above Power fuse and remove Power fuse away.
5. Untighten knobs above power cables and disconnect them from terminals. Fix power cables to the side of battery compartment box
6. Remove temperature sensor connector, from each battery pack
7. Fix temperature sensor cable to the side of battery compartment box
8. Unscrew battery pack fastening knobs.
9. Take all retaining plates out.
10. Firmly grip the front battery by a carrier strap
11. Lift the battery pack out of the fuselage and put it in a safe place.
12. Firmly grip the rear battery pack by the carrier strap und slide it forward along the bottom of the compartment.
13. Lift the battery pack out of the fuselage and put it in a safe place.
14. Close battery compartment cover.



Caution: Always use a transport box or similar for transport and storage of the batteries to protect them from mechanical damage. Make sure you store battery packs in a dry and safe place. Read FES Battery pack manual section 7 and 8 for further instructions.

6. Maintenance

With proper and careful use of FES battery packs, there is practically no maintenance required. FES battery packs are designed with the best cells available, so that they can provide high power, good endurance and will serve you for many years and charging cycles.



Note: Unfortunately, some capacity deterioration will occur due to aging of the cells whether the battery packs are in use or not. The useful life of a lithium cells is based on several factors which can prevent the battery from providing sufficient current draw due to increased internal resistance.

Suitable uses and treatment that will reduce deterioration include:

1. Use low power settings as much as possible and practical during flight.
2. Do not discharge cells below 3.4 V (95 V total voltage), if it is not necessary.
3. Store battery packs at suitable temperatures when they are not in use (see chapter 7. Storage)
4. Store battery packs at suitable charge levels (around 50% SOC, see chapter 7. Storage)

Good indication of the battery pack condition is SOH – State of Health % parameter, which can be read in lower right corner of BMS control software. It is calculated from average internal resistance of the cells, measured during charging, and number of charging cycles.

With poor treatment of the battery packs, their cells internal resistance will be increasing faster, and the calculated SOH % level will reduce. It would be prudent to think about the replacement of the battery packs when it reaches 50%.

Poor condition of the cells can also be recognized during powered flight by these symptoms:

- bigger voltage drops at max power settings than usual,
- significantly reduced maximum achievable power (with fully charged packs),
- significantly reduced usable capacity – lower altitude gain and range of level flight,
- steeper temperature rise gradient of the battery pack.



Note: We suggest replacing FES battery packs, when maximum available range of level flight (total 90 V or 55°C, whatever comes first), is reduced to one third of the range achieved when they were new. Probably there would be not much sense to utilize them further in such state.

Please handle FES battery packs very carefully to avoid mechanical damage of the housing. Only if battery packs are free of any damage it is allowed to charge them and use them in the glider. They must be always visually inspected before each charging and use in the glider. This is even more important when the glider is used by a syndicate of pilots or in aeroclubs. If the housing is found to be damaged, cells inside could also be damaged, which can be dangerous. In such case please contact the manufacturer, for evaluation of damage and further steps.

7. Transport

7.1 Car transport

FES battery packs must be protected against mechanical damage and moisture, during transport in the car. We strongly recommend using a pair of FES Stainless steel boxes for advanced protection.



During transportation of GEN1 battery packs always use terminal protection covers (or threaded knobs on some types)!



FES stainless steel storage box

For safety reasons, transport box should be placed into the luggage compartment, if possible, pushed forward up to the back of the back seats. Transportation box should be secured additionally, so that it can not move during acceleration or braking.



Warning: *For safety reasons it is not allowed to transport battery packs in the cabin of the car, behind driver's or co-driver's seat for instance, or in front of the co-driver seat. This could be very dangerous in case of an accident.*



Warning: *Do not leave battery packs in the parked car under the sun, as they can be exposed to high temperatures.*

7.2 In glider trailer



Warning: *It is not allowed to transport battery packs in the front area of glider trailer.*

When transporting the glider in a trailer, the FES battery packs must be placed in the battery compartment of the glider and properly secured using the retainer plates, the same as during flight.



Warning: *When glider is stored in trailer the "Power fuse" must always be removed.*

7.3 Transport by ship or train

When your glider is transported by RORO ship (or train) in its trailer, or in a shipping container, with or without its trailer, we suggest placing and fastening the FES battery packs into the battery compartment of the glider, so they are properly secured, the same as during flight.

Another possibility is to place the battery packs into the FES Stainless steel boxes and secure them in a corner of the container.

It is recommended that gliders are shipped using light coloured shipping containers, where internal temperature on hot days at the sea might be lower. It is also possible to paint the top of or the whole container in white to reduce the internal temperature.



Glider trailer placed in the container.

8. Discharging and storage

When you stop flying for a longer time, for instance during winter, **it is mandatory** to discharge FES battery packs to 50% of charge. This is to middle of the allowed total voltage range: 3,7 V per cell, approximately 52 V per pack, or 104 V total as indicated on the FCU instrument, when the motor is stopped.

Discharging of the packs can be done in two ways:

- you can discharge them during the last flight of the season, or
- you can use FES discharging assistant (standard equipment) or FES Discharger 2 (optionally available).

8.1 FES discharging assistant – not available anymore

- End of discharge (50% SOC): 52 V
- Only works in a combination with a suitable DC load (we recommend electric oil radiator).
- EU / USA / UK outlet type.



FES discharging assistant

8.2 FES Discharger 2 – standard equipment

- End of discharge (50% SOC): 52 V
- A standalone device – **no need to connect external DC load** (oil radiator).
- **A touch LCD display.**
- Higher discharging power, shorter total time of discharging.
- Delivered already properly adjusted for usage with 14S Battery packs.



FES Discharger 2

The most important environmental factor for slower aging, is the temperature at which the battery packs are stored. Store them between 10°C to 20°C and normal humidity. Do not store batteries at high or below freezing temperatures and/or in humid environments (like in an old all metal glider trailer).



Note: Always try to avoid exposing battery packs to high temperature, as this is the most significant to the longevity of cells.

8.3 Warning sticker



Note: Above warning sticker, with some basic information regarding storage and charging, is located on rear vertical wall of each FES GEN2 battery pack!

9. Used packs

Check document "Handling instruction for used battery"

10. Revision history

February 2013	Initial release of manual, Version 1.0
April 2013	Minor updates, Version 1.1
June 2013	Minor updates, Version 1.11
February 2014	Minor update, Version 1.12
August 2014	Some info about good practice added, Version 1.13
April 2017	Cover photo with new carbon fibre prepreg housing 1.14
September 2021	Major update, to be more in line with GEN2 packs Version 1.15