



FES BATTERY PACK GEN2 14S 53Ah

With integrated BMS

User Manual, Version 1.2



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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.

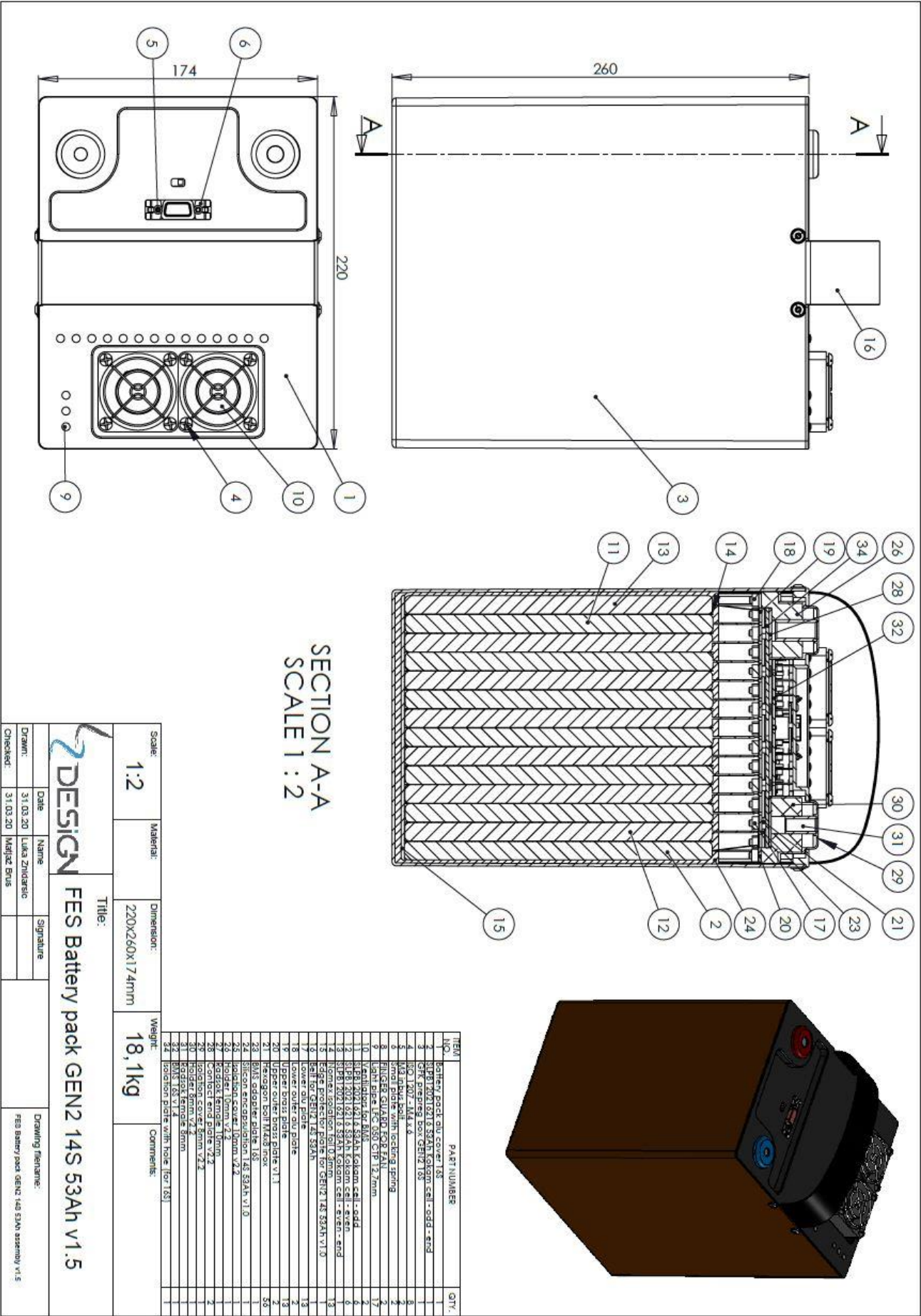
Each Battery pack is equipped with an internal BMS (Battery Management System) circuit board, which is fixed above the cells and is equipped with 14+2 LEDs to monitor its operation.

For + and – terminals we chose to use Amphenol Radsok hyperbolic high-power contact technology. High current female contacts are hidden inside of the pack. To prevent incorrect polarity connections, an 8 mm contact for the minus pole (-) and a 10,3 mm contact for the plus pole (+) are used.

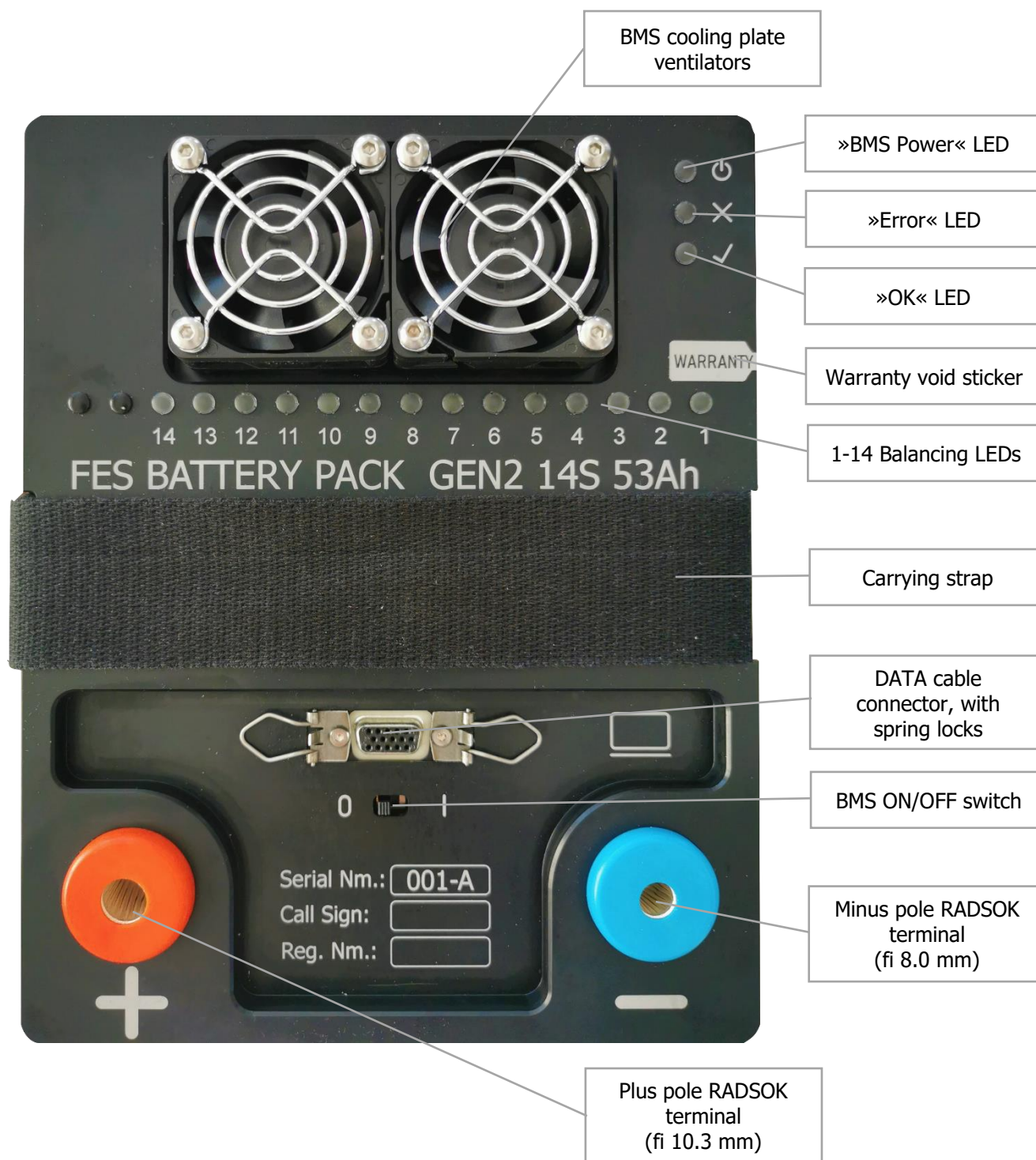
2.1 Technical data

FES Battery pack GEN2 14S 53Ah	
Battery pack type	FES GEN2 14S 53Ah
Weight of single battery pack	18,1 kg
Box dimensions (WxLxH), without terminals and ventilators	174 x 220 x 256 mm
Cells manufacturer	Kokam, South Korea
Electrochemical system	NMC (LiMnNiCoO ₂)
Cells type	SLPB120216216
Average capacity of each cell	53 Ah
Number of cells	14
Energy storage capacity	2,75 kWh
Maximum total voltage	58,3 V
Minimum total voltage	42 V
Maximum current	250 A
Max balancing current per cell	1 A
Internal BMS type	FES-BMS-9R
Standard 600W small power charger	FES KOP602
Optional 1200W middle power charger	FES KOP1001
Optional 2000W high power charger (also supports US 110V~)	FES KOP2300

2.2 Drawing



2.3 General layout of the pack:



Top view of FES GEN2 14S 53Ah Battery pack

2.4 Internal BMS

FES GEN2 battery pack is equipped with BMS (Battery Management System) electronic circuit.

How does the BMS work?

The BMS electronic measures and controls the voltage level of each cell in the battery pack. During charging and discharging, battery cells differ in voltage levels, due to slightly different capacity of the cells. Cells with lower capacity charge faster than cells with higher capacity. Cells that reach maximum pre-set voltage faster than the others, are discharged through resistors inside of the BMS. The redundant energy is dissipated as heat through the upper cover plate, which is milled from Aluminium and anodized in black. To improve dissipation of the heat, two fans are installed on top of the cover plate. They are started when a pre-set heat sink temperature of 50°C is reached.

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



Note: BMS starts balancing cells only during charging, and above a pre-set balancing start voltage (4.10 V).

BMS data and initial settings

Parameter	Value	Unit
Maximum charging current**	9, 18 or 30	A
Maximum balancing current	1	A
Single cell end of charge voltage *	4.16	V
Single cell balancing start voltage *	4.10	V
Single cell balancing end voltage *	4.16	V
Single cell under-voltage protection*	3.1	V
Single cell over-voltage protection*	4.18	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.

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 GEN2 14S from factory and work only if a communication with the BMS circuit board inside of the battery pack can be established.

3.1 Available chargers

1. FES KOP602 – standard equipment

- Maximum power consumption: **600 W**
- Maximum charging current: 9 A
- Required input voltage: 230 V~ 50/60 Hz
- Weight: 2.2 kg
- Two FES KOP602 chargers are included with each FES System so both battery packs can be charged at the same time.
- Modern, fully automatic charger.
- Logging of charging times and capacity.



FES KOP602 Charger

2. FES KOP1001 – optional charger

- Maximum power consumption: **1200 W**
- Maximum charging current: 18 A
- Required input voltage: 230 V~ 50/60 Hz
- Weight: 3.9 kg
- Modern, fully automatic charger.
- Logging of charging times and capacity.



FES KOP1001 Charger

3. FES KOP2300 High Power – optional charger

- Maximum power consumption: **2000 W**
- Charging current: 30 A
- Required input voltage: 80 V – 265V~ 47/63 Hz
- Weight: 5.6 kg
- **Suitable for US customers** as input voltage can be also 110 V~



FES KOP2300 High power charger



Note: Before plugging in the charger, check if a suitable fuse on the grid side is installed. Recommended minimum rated fuses are:

- 10 A rated fuse for the 1200 W charger,
- 16 A rated fuse for the 2000 W charger.

High power chargers must be connected directly to the socket, without extension cables and/or splitters.



Warning: If you have another pair of Battery pack, make sure that you do not mix packs between the two sets. The same two packs of one set (first marked as A, second marked as B) must be always used in pair!

3.2 Standard 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, physical condition of the battery packs should be inspected. Any signs of mechanical damage, such as punctures, dents, scratches or similar must be evaluated and reported to manufacturer before charging.

Battery to charger connection procedure:

1. Connect **RED +** and **BLUE -** cables from charger to first battery pack.
2. Connect charger and Battery pack with BMS-Charger communication cable.



BMS-Charger communication cable (FES KOP601, FES KOP1001)

3. Plug in the charger to the outlet (220 V AC, 50-60 hz).
4. Turn on the BMS switch on top of the battery pack cover.

Immediately after BMS is switched ON, the BMS starts a test procedure - a check of all 14 cells, one by one. Red »Error LED« turns ON during system's test procedure and turns OFF again when the test is completed without error.

After the test procedure, several LEDs turn ON for about 1 second. The number of the LEDs that light up, represent a state of charge (SOC) of the battery pack. Each LED represents around 7% SOC, for example:

- 2 LEDs are lit: SOC is approximately 14 %
- 7 LEDs are lit: SOC is approximately 50 %
- 14 LEDs are lit: SOC is approximately 100 %

5. When the test procedure is completed the green »Power LED« starts blinking indicating that the BMS is working in the normal mode. At this time, BMS sends a signal to the charger to start charging. Orange LED on front panel of the charger lights up, which indicates charging. It is also possible to hear the contactor "click" inside of the charger. Charging current increases slowly to the maximum value of 9 A (or 18 A at 1200 W, 30 A at 2000 W) and charger cooling fans turn on after a while.
6. In normal mode, the green »BMS Power« LED is flashing. This means that the BMS is turned ON, but not necessary balancing. Balancing starts when one cell reaches a pre-set balancing voltage value, usually 4.1 (this can be changed using BMS Control Software). If any of 14 green LED cell balancing indicators is ON, this means that the corresponding cell has a slightly higher voltage compared to the cell with the lowest voltage.
 - If one or more cells have higher voltage than the others, they will be discharged and the BMS temperature rise will be minimal.
 - In case that one cell has lower voltage than the others, all cells with higher voltage will need to be discharged to reach a balanced stat. This leads to higher BMS temperature rise, even if the voltage difference is only 0.010 V (10 mV).

The cooling fans turn on when the BMS cooling plate reaches 50°C.



Caution: Cooling fans may not be able to cool down the BMS sufficiently in hot conditions and the temperature of the BMS cooling plate can continue rising. In this case, charging is interrupted automatically when the BMS cooling plate reaches 55°C, until it drops to 45°C and charging resumes.

7. The red »Error LED« is ON only during the initial test procedure. After the test is finished it turns OFF. If a system error is detected the LED blinks a certain number of times followed by a pause. The number of blinks identifies the error as per table on page 12.
8. When the first cell reaches 4.160 V, charging current is reduced. If there is a big difference between the cells (more than 50 mV), it can take long for all of them to reach 4,16 V, as charging current is reduced to 1 A.
9. When all cells reach 4.160 V (+/- 2mV), **BMS sends a signal to the charger to stop charging.**

The **Green** "Power LED" stops flashing and starts **glowing Green**.

This indicates that the charging cycle was completed properly.

10. Switch OFF BMS on top of the Battery pack. Unplug charger from the outlet. Unplug charging cables and signal cable from the battery pack.

11. Charge second FES GEN2 battery pack!



Warning: 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 is not allowed!

Maximum 1 V difference between total voltages of both packs is acceptable. For instance, Pack 1: 58,1 V (average 4.150 per cell), Pack 2: 57,1 V (4,080 V per cell), this is just acceptable! Bigger voltage difference is not acceptable!



Caution: If there is a risk of a lightning strike by an approaching thunderstorm, stop charging immediately and disconnect the charger from the outlet.

3.3 List of red error codes

Number of red blinks	Error description
1	Voltage of s single or multiple cells is too high (4.2 V) *
2	Voltage of one or multiple cells is too low (3.24 V) *
3	Cell voltages differ more than pre-set allowed value (0.5 V) *
4	Temperature of the cells is too high (>55 °C) *
5	BMS temperature is too high (>50 °C) *
6	Number of cells is not set correctly
7	Temperature is too low for charging < -1 °C
8	BMS does not detect the temperature sensor
9	Communication error
10	Measurement of cell voltage out of range. Below 0,1 V or above 4,8 V
13	Wrong chemistry set by BMS control software

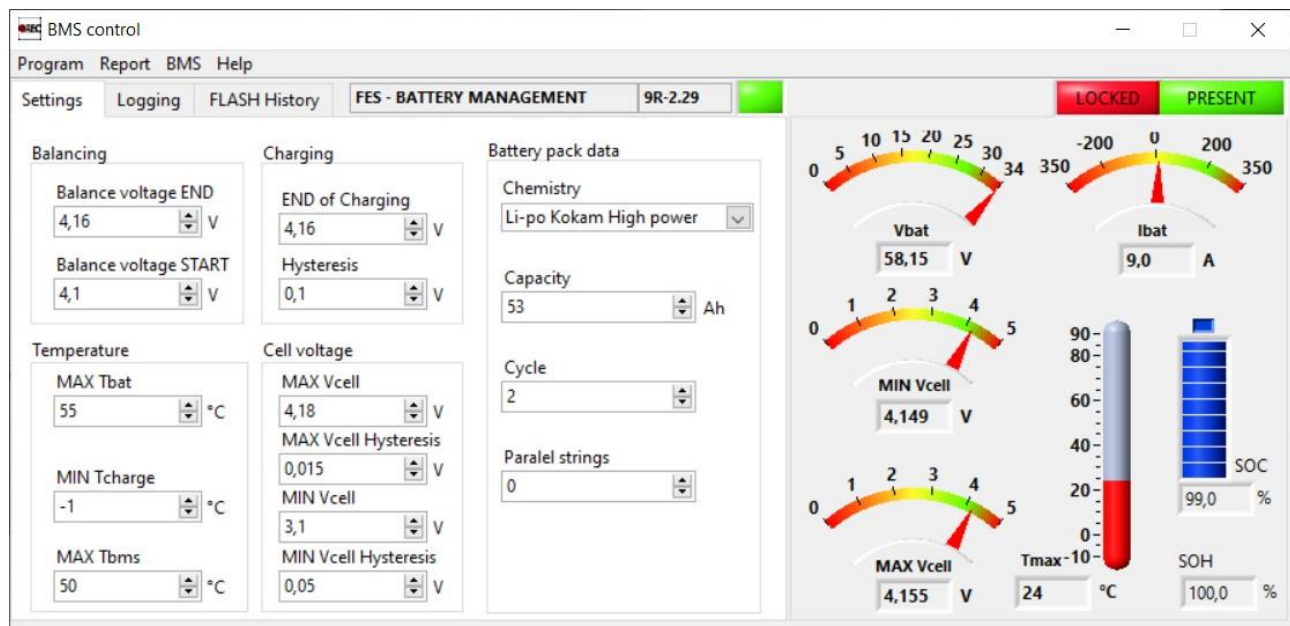
*Initial settings may be changed with BMS Control Software.

3.4 FES BMS Control software

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

In case there are problems detected during charging, a log file can be created and sent to us it by email. This can help us 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 for self-launching, so that maximum power is available to obtain a good climb rate. This is especially important when:

- 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 Installing the batteries



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: "Power switch" 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. Both battery packs should be correctly secured with the fixation plates and the fastening knob – **please see chapter 4.1.1!**
8. Lift power cables from side support.
9. Plug in the shorter cable, with 8 mm pin in the BLUE (or BLACK) housing, into a minus marked 8 mm socket of the front battery pack.
10. Plug in the longer cable with 10 mm pin in the RED housing, into a plus marked 10 mm socket of rear battery pack.
11. Insert DATA cable connectors, into each battery pack DATA connector.



Caution: Before inserting the DATA cable connector, make sure that the orientation is correct. Connector should be plugged in straight, otherwise pins could be damaged.

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.

4.1.1 FES battery packs fixation



When you put the batteries in the battery compartment, evenly align the strap for holding – it should be equally folded over the edge of the battery pack on both sides!



Lay the lower fixation plate on the holding strap.



Lay the upper fixation plate on the lower fixation plate. Put the pin (fi 4 mm) of the knob in the centering hole on the bottom plate and fasten the knob.



The strap is evenly aligned.



Lower fixation plate and the centering hole.

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 and tail dolly.
2. Open battery compartment cover.
3. Check: Power switch OFF.
4. Switch ON the BMS on each battery pack and wait until initial check is completed.
5. Insert the connecting cable between the front pack + terminal and rear pack – terminal.
6. Close the battery compartment cover and seal it with tape.
7. Seat into the cockpit of the glider and close the canopy.
8. Check that nobody is in the line of the propeller disk or in front of the sailplane.
9. Switch ON the FCU and wait a few seconds until a normal screen appears.
10. Switch ON the Power switch.
- 11. Wait about 5 seconds so that the charge level (indicated as bottles) reaches 100 % (this happens only if total voltage is above 114 V).**
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 automatic positioning is working properly.
14. Switch OFF the Power switch.



Standard type of "Connecting cable", as used on most FES systems.



Top and bottom view of right-angle type of "Connecting cable", as used on LAK gliders.

5. After landing



Warning: After last landing of the flying day (or if you decided not to fly), it is mandatory to unplug the "Connecting cable", from the battery packs! At the same time, also both BMS's on top of the battery packs, must be switched OFF.



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



Note: Only when connecting cable is unplugged, 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 connecting cable is left connected 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 OFF.
2. Check: Sailplane main switch (fuse) OFF.
3. Open battery compartment cover.
4. Remove the Connecting cable from terminals of battery packs.
5. Remove red and black power plugs from battery packs.
6. Fix both power cables on right side of battery compartment wall.
7. Remove DATA connectors from each battery pack.
8. Fix DATA cable to side of battery compartment.
9. Unscrew both battery pack fastening knobs.
10. Take all retaining plates out.
11. Firmly grip the front battery by a carrier strap.
12. Lift the battery pack out of the fuselage and put it in a safe place.
13. Firmly grip the rear battery pack by the carrier strap und slide it forward along the bottom of the compartment.
14. Lift the battery pack out of the fuselage and put it in a safe place.
15. 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%. Only cells might need replacement, as BMS electronics can be reused.

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.

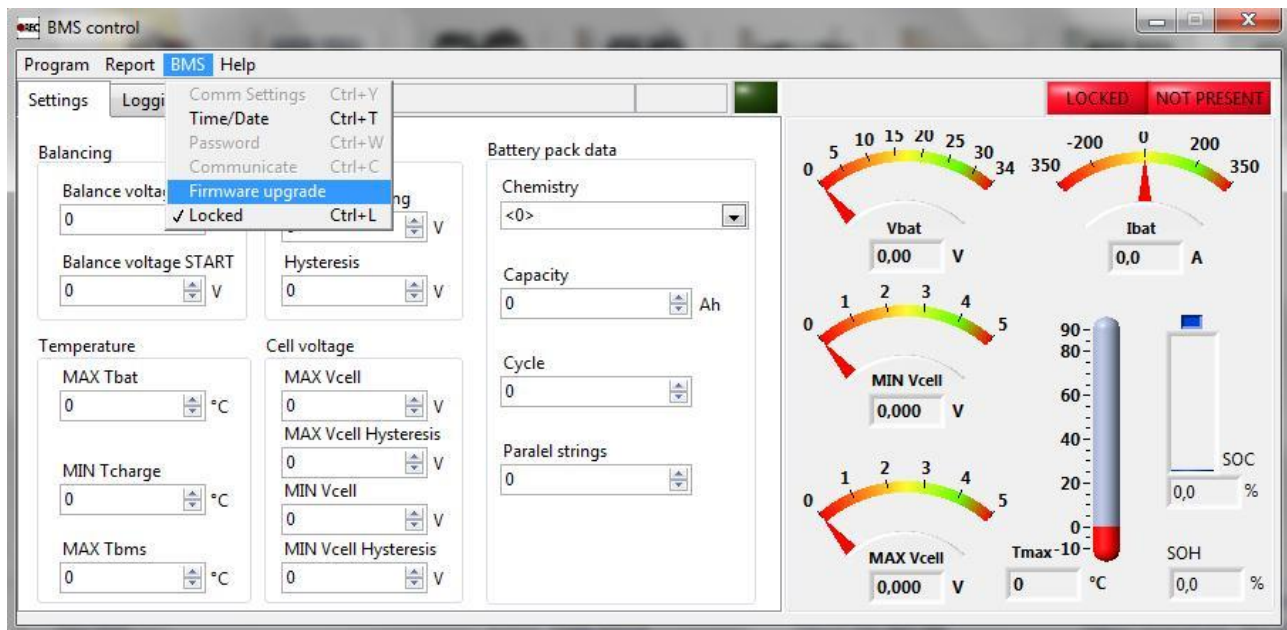
Please handle FES battery packs very carefully to avoid mechanical damage of the housing. Only if battery packs are free of any damage it is allowed to charge them and use them in the glider. They must be always visually inspected before each charging and use in the glider. This is even more important 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.

6.1 BMS firmware upgrade

If a new and improved version of BMS firmware is available, it is easy to perform an upgrade, by using the provided BMS-Charger-PC cable, and BMS Control software which is available for download from the FES website.

If there is any strange behaviour of BMS, upgrade usually resolves the problem.

To perform the upgrade, a suitable .bin file is required, which we can send to the customer by email. Please save it to the chosen location on PC disk.



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.



FES stainless steel storage box



FES GEN2 Battery pack placed into FES Stainless steel 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 care, 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 "Connecting cable" 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 – obsolete equipment

- 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

Please refer to the "Handling instruction for used battery" document.

10. Revision history

March 2020	The initial release of the manual, Version 1.0
July 2020	Chapter about battery packs fixation added, Version 1.1
October 2022	Removed optional R2300 charger, Version 1.2