FES MAINTENANCE MANUAL

Version 1.17

For sailplane types:

LAK17A FES, LAK17B FES, MiniLAK FES,
LAK17C FES
Silent 2 Electro
AS13.5m FES, AS15m FES, Apis 15m FES
HPH 304ES
Discus-2c FES, Ventus-2cxa FES, Ventus 3 FES,
Duo Discus FES
Diana 2 FES, Diana 3 FES
LS8-e, DG1001-e
Antares FES

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

Table of Contents

1. Important notices

Please read this manual thoroughly. It contains important information about the FES system and its maintenance, having vital importance to flight safety.

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.

The following definitions apply to warnings, cautions, and notes used in this manual.

WARNING: Notes with a red triangle describe procedures that are critical and may result in reduced safety or may lead to a critical situation.

CAUTION: A Yellow triangle is shown for parts of the manual, which should be read carefully and are important.

NOTE: A bulb icon is shown when a useful hint is provided to the reader.

1.1 Limited Warranty

This FES system is warranted to be free from defects in materials or workmanship for two years from the date of purchase when installed by LZ design. 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 labor; however, the customer shall be responsible for any transportation cost. This warranty does not cover failures due to abuse, misuse, accident, or unauthorized alterations or repairs.

If the FES system is installed into the sailplane by authorized company, warranty for installation and failure of components (as a result of improper installation) is this company's responsibility. LZ design will not cover failures due to unauthorized installation, alterations or repairs, abuse, misuse, or accidents.

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. This warranty gives you specific legal rights, which may vary from state to state.

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. Some states do not allow the exclusion of incidental or consequential damages, so the above limitations may not apply to you.

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. Such remedy shall be your sole and exclusive remedy for any breach of warranty.

To obtain warranty service, contact your local LZ design dealer or LZ design directly.

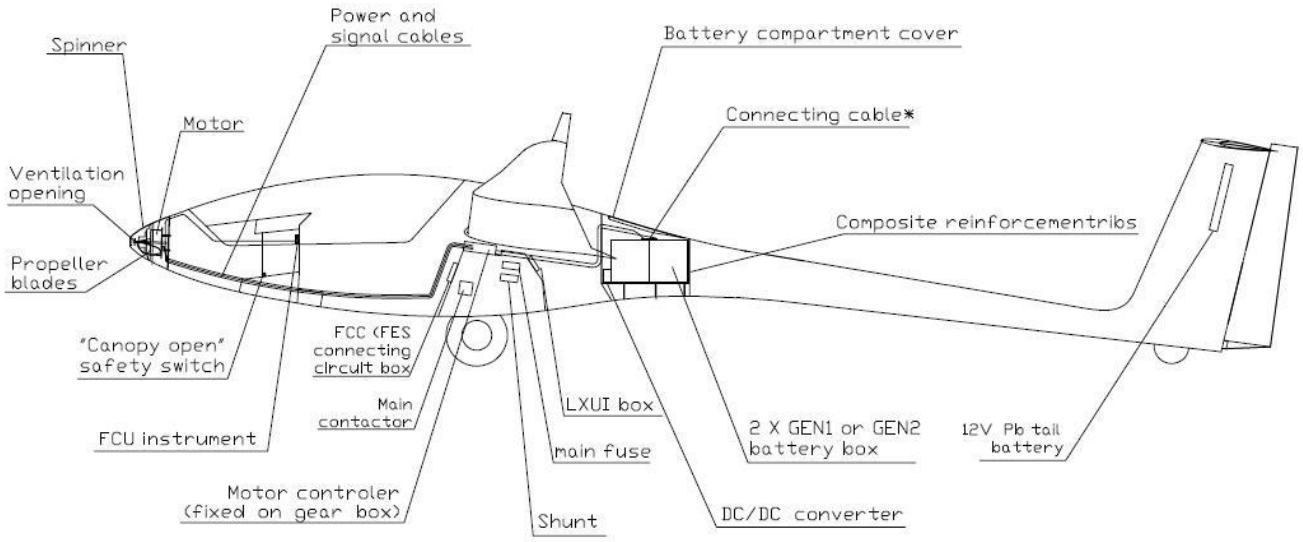
2. Introduction

The FES Maintenance manual contains information for pilots, technicians, and mechanics about safe and proper maintenance of the sailplanes equipped with FES (Front Electric Selflaunch/Sustainer) system. This information is given following the requirements of EASA CS 22.1529 for sailplane maintenance.

3. Description of the FES system

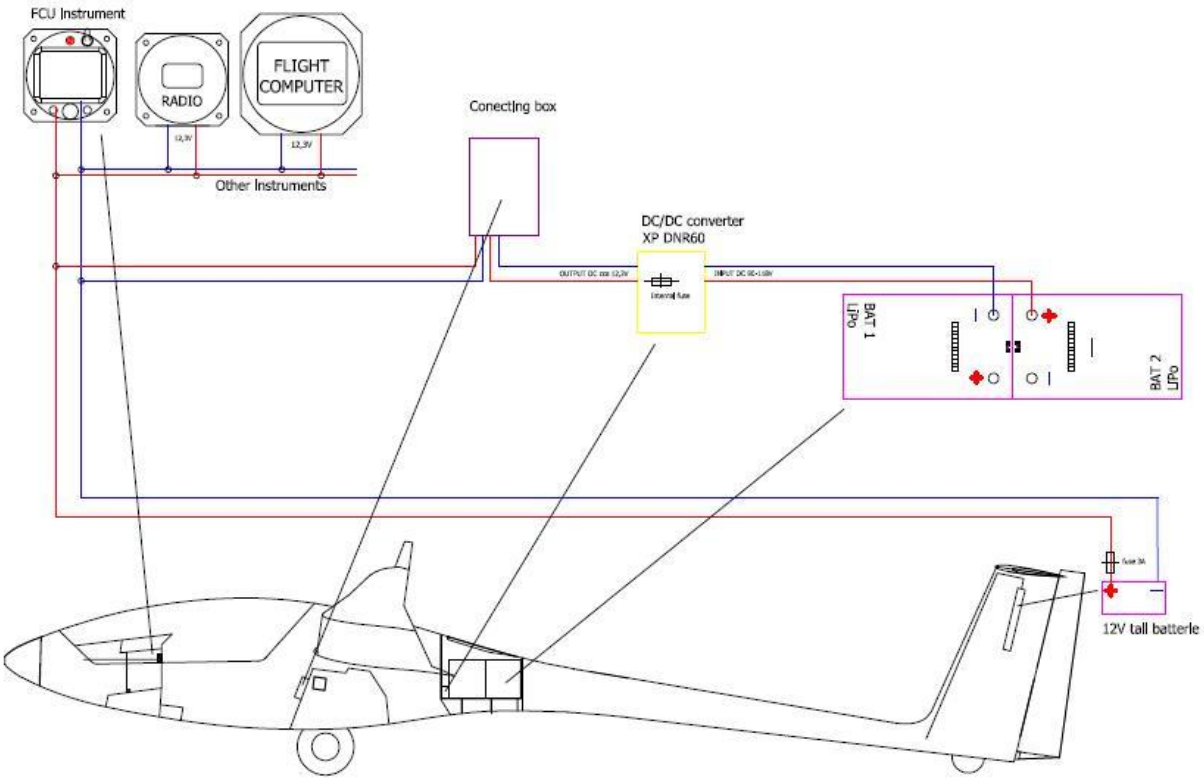
We developed the FES system to be reliable and straightforward to use. It requires minimal maintenance. You must familiarize yourself with the position of all the FES components and their function to conduct maintenance on an FES system.

3.1 General layout



* At GEN1 battery pack here is located main fuse

The general layout of the FES system.



Connection of the instruments to the FES 12V power supply circuit.

3.2 Description of main FES components

3.2.1 Electric motor

The FES system uses an outrunner type motor with brushless synchronous permanent magnet and an electronically controlled 3 phase commutation system. The rotor position is measured using three hall sensors, with an additional fourth hall sensor used for automatic propeller positioning.

This motor can work only in combination with a suitable electronic motor controller. It transforms the direct current supplied by the battery packs into a 3phase current required by the motor.

The following table contains typical electrical motor power ratings (type: FES-LAK-M100) with 116V on the motor controller and loaded with a propeller (type: FES-LAK-P10-100).

FES M100 MOTOR*	
Maximum torque	75 Nm**
Maximum current	200 A**
Maximum Voltage	116 V**
Motor velocity constant	45 RPM/V
RPM without load (116V DC on the controller)	5300 RPM
Motor current without load at 5300 RPM	16 - 18 A
Max. RPM with FES-LAK-P10-100 propeller (1m diameter)	4500 - 4700 RPM
Battery current loaded (4500 rpm, 116V) with FES-LAK-P10-100	up to 200 A
Rotor rink diameter	177 mm
Motor length	100 mm
Motor weight	cca. 7,3 kg
Motor efficiency	82 – 95 %
Maximum allowed temperature	90 °C
Minimum allowed starting temperature	-20 °C

*Please refer to the FES Motor manual for a detailed description.
**Note that some heavier FES gliders use higher 133V system.

3.2.2 Propeller

The FES system uses a foldable fixed-pitch carbon fibre composite propeller. It is designed and tested according to EASA CS 22 Subpart J.

The propeller blades are made from glass and carbon fibre composite in metal moulds, which are CNC machined. This manufacturing technique improves the geometrical accuracy of the moulds and enables us to manufacture blades with the best geometry tolerance currently possible.

A quality acrylic white paint is used to protect the solid composite body against the moisture and erosion. Each pair of propeller blades is sanded and polished to reduce the mass difference between them to less than 0,2 g. The paint is resistant to fuel, oil, and other chemical products and has excellent flexibility.

Propeller technical data and limitations:

FES Propeller*	
Number of propeller blades	2
Maximum power on a propeller shaft	23 kW
Maximum rotational speed	4500 RPM + 5 %
Propeller blade mass excluding attachment bolts	Approx. 260 g
Propeller diameter	1000 mm
Service time between inspections	50 hours or 12 months
Service time between detailed inspections	200 hours
Type of propeller	Tractor
Direction of rotation	Clockwise looking at the direction of flight.
Operating conditions	Any normal environmental conditions.

*Please see the FES Propeller manual of specific glider type for a detailed description.

3.2.3 FCU instrument

FCU instrument was developed for the FES system by LXNAV – known in the gliding community for their excellent flight computers (LX80XX, LX90XX) and electronic variometers. LXNAV manufactures FCU instruments exclusively for the FES system.

Technical specification:

- ON/OFF switch
- sunlight readable QVGA LCD (320*240 display)
- consumption ca. 100 mA
- audio signal
- rotary encoder with pushbutton
- RPM input
- 2x LED inputs
- digital output for BRAKE
- analogue output for POWER (adjustable with rotary knob)
- temperature inputs (Controller, Motor, and two battery packs)
- digital input for measuring current
- digital input for measuring voltage
- RS232 input for firmware update
- analogue input for open canopy switch
- CAN bus
- RS485 bus
- analogue input for 12V power supply voltage measurements
- SD card internal socket

Please see the FES FCU Instrument manual for a detailed description.

3.2.4 Battery packs

The battery packs have been developed specifically for the FES system. Usually there are 14 cells, all wired in serial (14S) in each battery pack. Some FES systems are equipped with 16 cells wired in serial (16S) All FES systems require a pair of battery packs. The first pack is marked as "A" and second pack as "B". Battery packs provide power to the whole FES system, including 12V accessories and instruments.

We are using high power SLPB (Superior Lithium Polymer Battery) cells produced by the global leader of the Lithium polymer battery industry - Kokam Co. Please see the cell technical specifications for detailed information about the cells.

- **GEN1** battery packs have an **external BMS** (Battery Management System).
- **GEN2** battery packs have an **internal BMS** (Battery Management System).
- **GEN3** battery packs are additionally equipped with e-ink display and G-sensor.

For the + and - terminals, we chose to use Amphenol Radsok hyperbolic high-power contact technology. High current sockets are hidden inside of the pack. Different sizes of the terminals are used to prevent incorrect polarity connections. The minus pole (-) uses an 8mm and the plus pole (+) a 10,3mm socket.

Technical data of typical FES battery packs

Battery pack type	FES GEN2 14S 40Ah
Weight per pack	15,7 kg
Box dimensions (W x L x H), without terminals and ventilators	154 x 220 x 260 mm
Cells producer	Kokam, South Korea
Electrochemical system	NMC (LiMnNiCoO2)
Cells type	SLPB100216216H
Cell average capacity	40 Ah
Number of cells	14
Energy storage capacity	2,1 kWh
Maximum allowed total voltage	58,3 V
Minimum allowed total voltage	42 V
Maximum allowed current	250 A
Max balancing current per cell	1 A
Internal BMS type	FES-BMS-9R
Standard 1200 W charger	FES KOP1001
Standard 600 W charger	FES KOP602
Optional 2000 W charger	FES KOP2300
Optional 2000 W charger	FES R2300
Optional travel 350W charger	FES Satiator

For a detailed description of the battery packs, please refer to the following manuals:

- FES GEN1 Battery pack manual
- FES GEN2 Battery pack manual
- FES GEN3 Battery pack manual

3.2.5 Wiring

FES wiring consists of:

1. POWER CABLES
- For power cables, we use high-quality Betatherm 155 wires with a cross-section of 35 sqmm.
- On the end of power wires, suitable cable shoes and Radsok power connectors are pressed with special tool.

2. SIGNAL CABLES
- We use high quality tinned and shielded wires in signal cables.
- Signal wires are crimped to pins of multipole connectors and directly soldered to the circuit board inside the FCC box.

3. 12V WIRES
- We use aviation grade Spec 55 wires for all 12V circuits.

4. DIFFERENT TYPES OF CONNECTORS

3.2.6 Other components

DC/DC converter converts high voltage from FES battery packs to 12 V, which supplies the instruments and the main contactor. It also charges 12 V battery if installed.

The main contactor connects and disconnects the FES battery packs to the motor controller. A pre-charge resistor is also installed.

The motor controller converts high voltage DC to three-phase AC voltage, which it feeds to the motor. It also sends RPM and controller temperature by the CAN bus to the Flight Control Unit (FCU) instrument.

Ventilators provide cooling to the motor controller.

The power switch provides 12V power to the main contactor and the motor controller electronic circuit board.

The BMS in each battery pack controls charging and cell balancing. It can be connected to a PC with a special cable to monitor the charging process with the BMS Control software. During the flight, BMS sends temperature and individual cell voltage data to the FCU instrument.

A shunt measures current from Battery packs.

The LXUI box converts analogue current and voltage measurement signals to a digital signal, which is sent over the CAN bus to the FCU instrument.

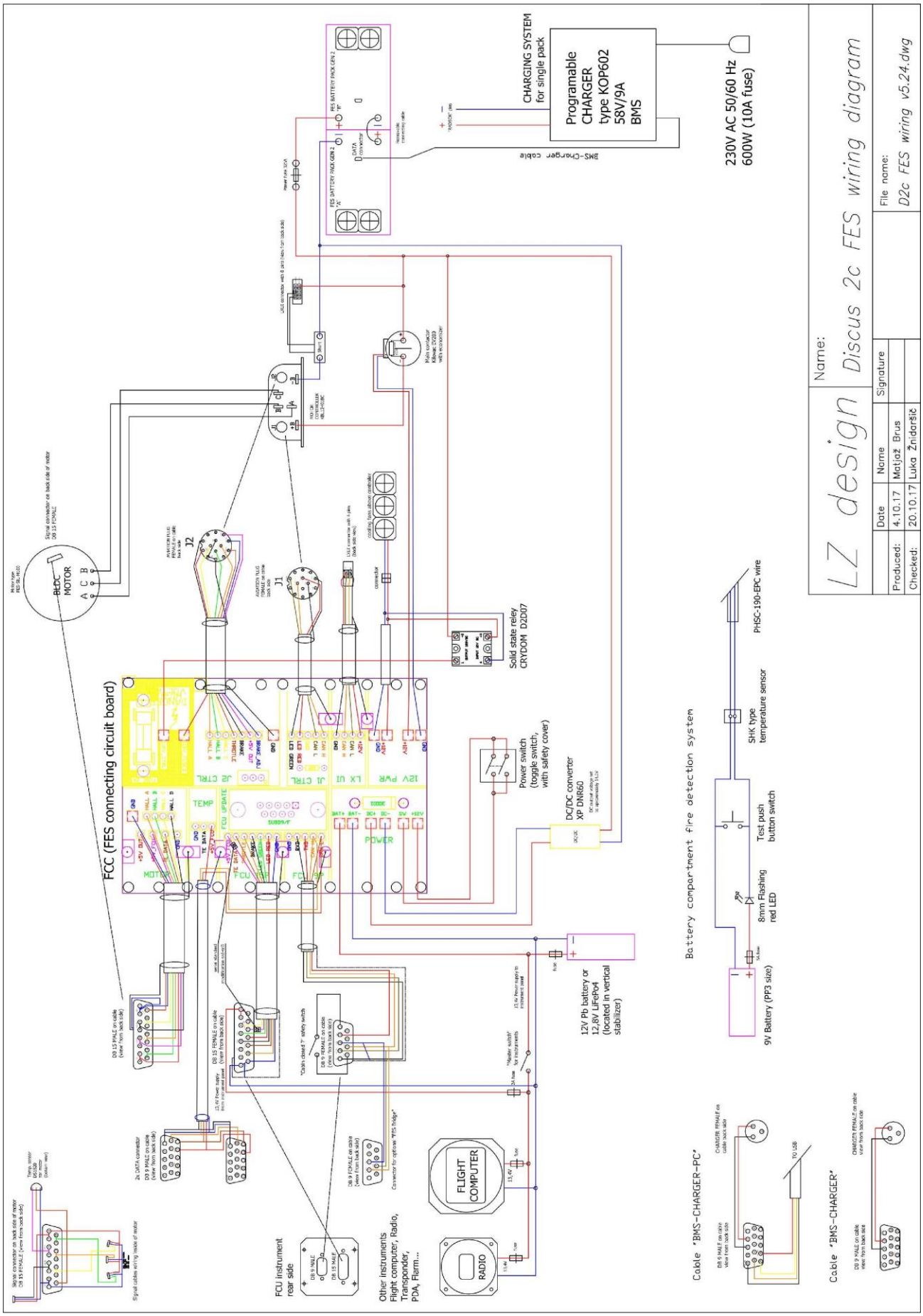
FCC box is where all signal and 12V wires meet and are distributed to the right consumers. It houses a microprocessor for automatic propeller positioning, a 2A fuse, a potentiometer for adjusting the electronic brake, and a female DB9 connector used when updating the FCU.

A 12V battery acts as a redundant power supply for the instruments when the main battery packs are not installed. The battery must be equipped at least with a 3A fuse (7,5-10A when installed electric bugwipers).

A 325A power fuse protects the entire system in case of a high power short-circuit.

FCU instrument displays battery and propulsion system information to the pilot via the screen and three status LEDs and houses the throttle rotary control knob.

3.3 General FES wiring scheme



4. FES maintenance

4.1 Maintenance of main FES components

4.1.1 Motor maintenance

We designed the FES motor such that it does not require any special maintenance.

Warning: *Opening or disassembling the motor can void the warranty! It is very dangerous due to powerful magnets installed on the rotor!*

To ensure proper operation of the motor, please consider the following:

- Make sure the **motor compartment is clean and completely free of all foreign objects** that could enter the interior of the drive.
- It is necessary to **protect the motor from humidity, dirt, paint, glue,** etc. Proper functioning of the motor cannot be guaranteed, and irreparable damage is possible if you ignore this.
- In **case of damage**, ship the motor back to the manufacturer for repair. Unintended handling leads to secondary damage.

Note: Strong magnetic field of the magnets in the rotor can erase the data on magnetic memory cards or electronic devices and interfere with sensitive medical devices (e.g., pacemakers). *Keep them away from the rotor's close-up range!*

The gap between the stator and the rotor magnet's function-boundary is only a few tenths of a millimeter thick. The danger of foreign objects accumulating in this gap exists and makes itself noticeable by scratching-sounds. In this case, remove the spinner, and blow out the motor with compressed air. Stop using the system and prevent the motor from running until you have cleaned it. Be especially aware of metal shavings, which can firmly stick to the magnets. If this is the case, the drive needs to be disassembled by the manufacturer.

4.1.2 Propeller maintenance

Please refer to the FES Propeller manual.

4.1.3 Battery packs maintenance

Please refer to the FES Battery pack manual.

4.1.4 FCU instrument maintenance

Please refer to the FES FCU Instrument manual.

4.2 Normal procedures and inspections

4.2.1 Rigging and de-rigging of an FES equipped sailplane

Please refer to the sailplane's manual.

Warning: *Remove the cable connecting the battery packs during rigging and de-rigging if the batteries are installed in the fuselage.*

4.2.2 Daily inspection

It is essential to inspect the glider after rigging. As a minimum, check the following:

- Check the sailplane as required for the specific type of sailplane.
- Check the FES system visually, especially the condition of the propeller blades.

If you find any issues, repair them before the flight!

4.2.3 Pre-flight inspection

Perform a pre-flight inspection each day before the first take off.

- Check the sailplane itself as required before a flight
- Perform FES test run on the ground as described below

4.2.4 FES test run on the ground

1. Remove propeller covers and a tail dolly.
2. Open the battery compartment cover.
3. Check that the Power switch is OFF.
4. Insert the connecting cable between the battery packs.
5. Seal the battery compartment cover with glider tape.
6. Take a seat in the glider and close the canopy.
7. Check that the propeller area and the space in front of the glider are free of people and obstacles.
8. Switch on the FCU.
9. Switch on the Power switch and rotate a throttle knob gently clockwise.
10. Wait about 8 seconds, for FCU to show all battery symbols.
11. Start the motor but use only low power to check the proper operation.

Caution: *If you want to test the system at its maximum power, a helper must press the fuselage down and prevent the glider from moving.*

12. Check if propeller braking and automatic positioning are working fine.
13. Switch OFF the power switch.
14. Switch OFF the FCU.

4.2.5 After flight inspection

Caution: *Always remove the connecting cable between the battery packs after landing. (Older packs with external BMS: Always remove the Power fuse after landing and put safety covers on the exposed terminals.)*

Warning: *Make sure that the Power switch is OFF before removing the connecting cable (or the Power fuse).*

If you used the system during flight, remove both batteries from the glider and recharge them according to the charging instructions in the FES Battery pack manual.

4.2.6 Ground handling

Use the protective propeller covers on the ground that prevent propeller blades from opening. Do not forget to remove the covers before the flight!

Caution: *Make sure that the propeller is in a horizontal position when lifting the tail of the fuselage, i.e., when attaching the tail dolly.*

Warning: *Do not push on the propeller or spinner for pushing or pulling the glider or lifting the tail!*

When opening and closing the canopy, propeller blades must always be positioned horizontally.

4.2.7 Tie-down and ground-towing

Do not leave a FES equipped sailplane outside in the rain, unless it is fully covered with high quality all weather covers.

Protect the motor and battery compartment from water. Remove the battery packs from the glider and store them in a dry place, without direct sunlight, to prevent to be overheating.

Towing on the ground should always be performed with the battery packs appropriately secured with the propeller in a horizontal position. We recommend using tow gear or at least a towing rope to tow the glider to the start.

4.2.8 Storing and transportation

A FES sailplane should be transported and stored in a high-quality enclosed trailer constructed of metal or fiberglass reinforced plastics with adequate insulation and ventilation characteristics.

- **Lighter fuselages** can be secured against forward and jumping motions with a nose cone support in the shape of the spinner with a recess for propeller blades in the horizontal position, covered with a soft and thick material.

- We recommend securing **heavier fuselages** with the support that holds fuselage behind the spinner. Otherwise, the loads on motor and propeller blades could be too high and damage them during transportation on bad roads.

We recommend using soft cotton canopy cover, which covers the nose of the sailplane and prevents the opening of propeller blades.

If you are not using a canopy cover, use **FES propeller blade fabric covers** to prevent the propeller blades from opening when pulling the fuselage out of the trailer.

The fuselage dolly should be positioned just forward of the main landing gear opening. Forward stop or a belt must be provided for the fuselage dolly to prevent the fuselage dolly from slipping forward and leaving fuselage without support.

4.2.9 Cleaning

Avoid cleaning with water around the FES motor and battery compartment area. Clean the spinner and propeller blades with a wet sponge or soft cotton towel. Tape adhesives are best removed using anti-silicone cleaner, nano cleaner or nitro thinner.

4.2.10 Inspection at the end of flight season

At the end of the flying season or before long storage of the glider in a hangar or a trailer, store the FES Battery packs in a dry, warm place (room temperature). The battery packs are best to be stored when cells have a voltage of 3.7 V per cell, which is equal to ca. 52 V per pack or ca. 104 V total system voltage (valid for 14S battery packs) - displayed by the FCU instrument.

4.3 Adjustments

The following FES system items have to be checked and adjusted if they are out of the allowable range:

1. **Early LAK FES aircraft only:** The gap between spinner and fuselage should be around 0,5 – 1,0 mm. You can change the gap with tightening or un-tightening of 4 nuts on the backside of the mounting wall.
2. Closing and opening of the ventilation: When the ventilation knob is in the full rearward position, the ventilation should be fully closed. If not, adjust it with two M3 bolts that hold the wire inside of the instrument panel.

4.4 De-rigging and rigging of FES components

4.4.1 Removing battery packs from the sailplane

1. Check power switch (key) is OFF
2. Check that FCU and all other instruments are OFF - i.e., Flight computer, Flarm, Radio, Transponder, PDA, etc
3. Open cover of the battery compartment
4. Unplug the connecting cable between the packs
5. Unplug the RED + and BLACK - power connectors
6. Secure the power supply cables to the side of the battery compartment box
7. Remove both temperature sensor connectors (DATA) from each battery pack
8. Secure the temperature sensor cable to the side of the battery compartment box
9. Un-tighten battery pack fixation knobs
10. Remove the fixation plate
11. Tightly grip the front battery by a carrier strap
12. Lift it out of the fuselage and lay it down in a safe spot
13. Tightly grip the rear battery by a carrier strap and slide it forward along the bottom of the battery compartment
14. Lift the battery pack out of the fuselage and lay it down in a safe spot
15. Close the cover of the compartment

Caution: *Make sure to store battery packs in a dry and safe place. Read the FES Battery pack manual.*

4.4.2 Installing the battery packs into the sailplane

Warning: *Make sure that you fully charge both battery packs before installation into the sailplane. Both battery packs **must have** an approximately equal voltage of cells (approx. 4.16 V per cell). The total voltage difference of each battery pack **must be less** than 1 V!*

1. Open the battery compartment cover.
2. Check that the power switch (key) is OFF.
3. Check that FCU and all other instruments are OFF – i.e., Flight computer, Flarm, Radio, Transponder, PDA, etc.
4. Insert the first pack into the fuselage with contacts facing forward.
5. Slide it back against the rear bulkhead.
6. Insert the second pack into the fuselage with contacts facing rearward.
7. Place the fixation plates.
8. Tighten the battery pack fixation knobs.
9. Insert and secure the temperature sensor connectors (DATA) to each battery pack.
10. Insert the RED (+) contact pin into the front pack.
11. Insert the BLACK (–) contact pin into the rear pack.
12. Close the battery compartment cover.

4.5 Removing and installing the motor

Note: *Removal of the motor from the sailplane is only allowed with **written permission** by the manufacturer. Unauthorized removal voids the warranty!*

Warning: *Flights without the motor are not allowed due to a significant change in the centre of gravity (C.G.)!*

To remove the motor from the glider (with spinner and propeller attached):

1. Open the ventilation fully – push the ventilation lever forward.
2. Remove the round composite cover on the front motor mounting rib from inside of the cockpit (usually 5-6 M4 bolts).
3. Unlock the spring locks which secures the DB15 multipole cable connector. Carefully unplug multipole connector from the motor.
4. Machen Sie ein Foto von drei Stromkabeln und notieren Sie die Reihenfolge ihrer Farben oder schreiben Sie ihre jeweilige Position auf Papier (wird später für eine ordnungsgemäße Installation benötigt).
5. Lösen und entfernen Sie drei selbstsichernde Metallmuttern von den Motoranschlüssen. Entfernen Sie die Abstandshalter unten - achten Sie darauf, dass sie nicht hineinfallen.
6. Trennen Sie drei Stromkabel.
7. Sechs M8-Schrauben lösen und entfernen. Beachten Sie, dass eine M8-Schraube, die sich unter den Stromkabeln befindet, einen dünneren Kopf hat. Halten Sie die Motorbaugruppe fest und entfernen Sie sie vorsichtig vom Rumpf.

Installing the motor into the glider

To install the motor back into the aircraft, follow the steps above in the reverse order with the following additional steps:

1. Open ventilation fully – push the ventilation lever forward.
2. Fix motor with six M8x20 hex head inox bolts. Below each head must be placed new bolt locking plate to secure them. One bolt below power cables should have lower head, for more safety clearance to cable shoes on the end of power cables.
3. Connect the power cables in the same order as before (take a look on photo you took during disassembly). Use new M6 metal self-locking nuts, and put M6 inox spacers below. Make sure there is sufficient safety distance between the cable shoes and aluminum mounting plate or to the M8 hex head fastening bolts. Install the M8 bolt with the thinner head below the power cables.
4. Carefully plug-in the signal cable multipole plug into the connector socket on the motor's rear wall. Secure the connector with the spring-locks.

After reinstalling the motor, check the following:

- Spinner is in the centre of the fuselage
- The gap between spinner and fuselage is equal - 1 mm
- All bolted connections are assembled correctly and secured properly

Perfom a test run of the motor on the ground and check:

- Motor rotating direction
- Motor running smoothly
- Propeller brake works OK
- FCU instrument is functioning correctly

4.6 Mounting and removal of the propeller

For mounting and removal of the propeller blades, refer to the FES propeller manual.

4.7 Lubrication instructions

There are only three parts in the FES system which require lubrication:

- Two pins that attach the propeller blades
- The ventilation valve pin, which goes through the shaft of the motor

Use a small amount of lubricant, creating a thin grease film. If there is an excess of grease, the centrifugal force will spread it along the inside of the spinner and the bottom surfaces of the propeller blades, making them dirty. The excess lubricant may appear like a crack.

5. Periodical inspections

5.1 Introduction

This section introduces a list of inspections designed to ensure the safe operation of the FES system during its lifetime.

Qualified personnel, authorized to do sailplane inspections, should perform these inspections at the time of regular sailplane inspections.

5.2 Sailplane inspection periods

The FES inspections are carried out in parallel to the regular aircraft maintenance and inspections required for the specific type of the sailplane. These occur usually:

- After every 100 flight hours
- At annual inspection
- After rough landings or ground loops
- At the end of the flight season or before the aircraft is stored for an extended period in a hangar or trailer

5.3 Inspection after every 100 flight hours

It is mandatory to check the FES system thoroughly, according to the following checklist:

	Inspection after every 100 flight hours	Date of inspection: ……	
No.	**Checking**	**Conformity** Yes / No	**Signature**
1	FCU instrument wiring and functioning		
2	Inspect ventilation opening - closing		
3	Inspect propeller as per propeller manual		
4	Inspect motor as per the motor manual		
5	Check the motor mount on the motor frame		
6	Check the gap between spinner and fuselage		
7	Check all bolted connections		
8	Check power cables for damage		
9	Check battery packs		
10	Check 12V battery condition - if installed		
11	Inspect controller and main contactor		
12	Perform a ground test run of the motor		
13	Check operation of the propeller brake		
14	Check operation of the propeller positioning		

5.4 Annual inspection

It is necessary to check the sailplane every 12 months following the 100 flight hours inspection.

Additionally, please check if we published any updates to FES manuals on the FES website under the download section!

5.5 Inspection after a rough landing or ground loop

After a rough landing or ground loop, please do the following:

- check battery packs for visible damage,
- check the FCU instrument for proper operation,
- check if there is any damage on the propeller blades,
- check motor mounting points and spinner.

5.6 Inspection at the end of flight season

Remove the FES battery packs from the glider and store them in a dry place at room temperature. The capacity of the batteries is best preserved when you keep them at 50% for storage, which is about 3.7 V per cell, ca. 52 V per pack, or ca. 104 V total voltage displayed in the FCU instrument.

6. Parts with limited service life

The following FES system parts have a limited service life:

- 12V Pb or 12V LiFePo4 buffer battery (located in tail or central part of fuselage) should be replaced every 5 years (if installed in a glider)
- 9V fire detection battery, should be replaced every 5 years (if installed)

Replace other components of the FES system based on their condition.

7. Placards

Sailplanes equipped with the FES system require additional placards in the cockpit:

- Ventilation open and ventilation closed placards
- Maximum speed to fly with a motor running placard

8. Balancing of rotating parts

We balance the complete assembly of motor, spinner, and propeller blades to achieve vibration-free smooth operation of the FES. We use specialized equipment to reduce the oscillation of the rotating components to less than 0,06 IPS before installation.

During assembly, we mark the components with alignment dots, such that they match on all linked parts. These marks must be taken into account when assembling the spinner or propeller blades so that they oriented the same as before. If these marks are ignored, excessive vibration can occur during the motor run!

9. Repairs

9.1 List of potential problems

The charger does not start charging	Check if the power cord is plugged into a wall outlet
The charger does not start charging	Check if the connecting cable is connected between the battery pack (DATA) and charger
The charger does not start charging	Check electrical grid fuse
The capacity indicator is not showing full batteries in the FCU after the installation of fully charged batteries.	You must wait about 8 seconds after the power switch is turned ON. Additionally, the total voltage level of packs must be above 114V.
FCU is not showing remaining time	Enter code 00040 and then 00030
Voltage and current measurement are not available	Check connectors on LXUI box
The motor does not start, or it starts briefly and then stops unexpectedly	Check power switch, flip it OFF an ON a few times

Please use the following template when you are reporting a problem with the FES system:

FCU serial number	
FCU software version	
With power switch OFF *	
Are battery pack temperatures available?	
Is the motor temperature available?	
With power switch ON, and the motor stopped*	
Does the "OK" LED on the FCU light up?	
Does the FCU display the »CONTROLLER READY« message?	
Is the FCU "ERROR" LED glowing or blinking?	
Is the controller temperature available?	
Is voltage measurement data available?	
What is the voltage level?	
Does FCU display any messages? Which ones?	
With power switch ON and motor running *	
Does the "OK" LED on the FCU light up?	
Does the FCU display the »CONTROLLER READY« message?	
Is the FCU "ERROR" LED glowing or blinking?	
Is the current measurement data available?	
Is the power consumption calculation available?	
Is RPM displayed?	
Does FCU display any messages? Which ones?	

*If possible, take a photo of the FCU main screen and info page.

9.2 List of spare parts

- propeller blades
- propeller pins with spacer, crown nut, and safety pin
- propeller holder
- special propeller covers
- FCU instrument
- FCC box (FES Connection Circuit)
- main contactor
- power switch (or key switch)
- motor controller
- motor
- 2A fuse inside of FCC box
- 325A power fuse
- battery packs (GEN1, GEN2 or GEN3)
- Internal BMS electronic circuit
- External BMS box
- DC/DC converter (or DCPR box)

9.3 Soldering

In case that any soldering of wires is required, use only the correct equipment for the job. There is plenty of information available on the web about proper soldering techniques; here are just a few key tips:

- Use quality soldering iron, or soldering station (https://en.wikipedia.org/wiki/Soldering_iron)
- Keep the iron tip clean. A clean iron tip means better heat conduction and a better bond
- Use a wet sponge to clean the iron tip between the soldering of joints.
- Keep the iron tip well tinned.
- Make sure there are no cold joints!

9.4 Materials necessary for small repairs

Repair of minor damage on propeller blades:

- Use white polyester filler (or epoxy resin), for the repair of small scratches on the propeller blades

- Sand away excessive filler with fine sanding paper (initially granulation 360, later 600 and 800, 1000, 1500 and finally 2000)

10. Revision History

October 2013	The initial release of Maintenance manual, Version 1.0
November 2013	Minor updates, Version 1.1
June 2015	Minor updates, Version 1.11
September 2016	Minor updates, Version 1.12
October 2017	Minor updates, Version 1.13
March 2018	Minor updates, Version 1.14
May 2020	Proofreading, Version 1.16
January 2023	Minor updates, Version 1.17