FES MAINTENANCE MANUAL

Version 1.12

For sailplane types: LAK17A FES, LAK17B FES, MiniLAK FES
Silent 2 Electro FES, AS 13,5m FES
HPH 304ES FES
Discus-2c FES, Ventus-2cxa FES

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1. Important notices

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

Information's in this document are 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.

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.

I case that FES is installed to the sailplane by authorized Company, the Company carries also responsibility and warranty for installation and failures of components, which could be result of improper installation even if they occur later during normal use (if the cause of a failure is with wrong installation). 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 contact LZ design directly.

October 2013

2. Introduction

This FES Maintenance manual is part of FES System manual, and it 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 in accordance with requirements of CS 22.1529 for sailplane maintenance.

2.1 Warnings, cautions and notes

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

Warning: *Means that the non-observation of the corresponding procedure leads to an immediate or important degradation of the flight safety.*

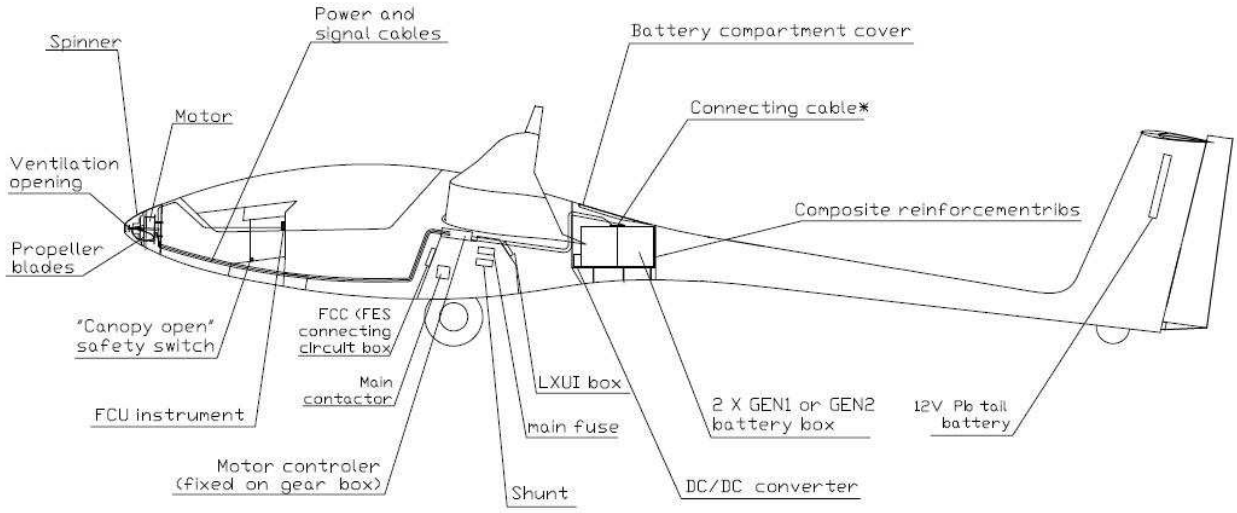
Caution: *Means that the non-observation of the corresponding procedure leads to a minor or to a more or less long term degradation of the flight safety.*

Note: *Draws the attention to any special item not directly related to safety but which is important or unusual.*

3. Description of FES system

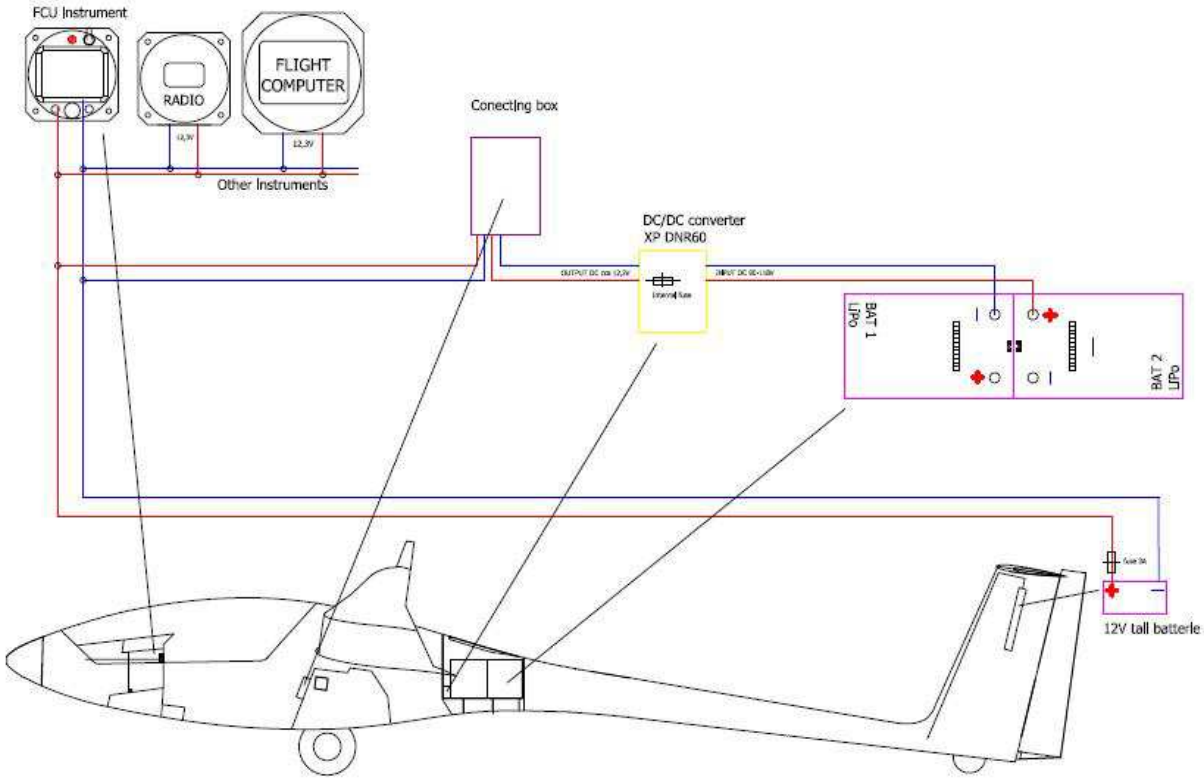
We spent a lot of effort to develop FES system to be simple and reliable, but also that it would need as little as possible of maintenance. However some minimal maintenance is still required. In order to be able to perform maintenance it is first required to know locations of installed FES components and to understand how it works.

3.1 General layout



* At GEN1 battery pack here is located main fuse

General layout of the FES system



Wiring of instruments to FES 12V power supply circuit

3.2 Description of main FES components

3.2.1 Electric motor

Motor construction is outrunner brushless synchronous permanent magnet motor with electronically controlled commutation system 3 phase. Rotor position is determined by 3 hall sensors and additional 4th hall sensor for automatic propeller positioning.

This motor can work only in combination with suitable electronic motor Controller which transform DC current from Battery packs to 3 phase current which supply motor.

Electrical motor power ratings (type FES-LAK-M100) at 116V on motor controller and loaded with propeller (type FES-LAK-P10-100):

Maximum torque	75 Nm
Maximum current	200A
Maximum Voltage	180V
Rpm non loaded	45 rpm/V
Rpm non loaded (at 116V DC on Controller)	5300 rpm
Non loaded motor current (at 5300 rpm)	16-18 A
Rpm loaded with FES-LAK-P10-100 propeller (1m diameter)	4500 rpm
Battery current loaded (4500 rpm, 116V) with FES-LAK-P10-100	up to 200 A
Rotor rink diameter	177mm
Motor length	100mm
Motor weight cca.	7,3 kg
Motor efficiency	82-95 %
Maximum allowed temperature	90 °C
Minimum allowed starting temperature	-20 °C

More detailed description of motor is provided in FES Motor manual.

3.2.2 Propeller

The foldable fixed pitch carbon fibre composite propeller is high quality product.

Technical data and limitations of the propeller:

Number of propeller blades:	2
Maximum power on a propeller shaft:	23 kW;
Maximum rotational speed:	4500 RPM +5%;
Propeller blade mass excluding attaching bolts:	approximately 245 g each blade;
Diameter of the propeller:	d = 1000 mm;
Service time between main overhauls:	50 hours;
Total service time:	200 hours;
Type of propeller:	tractor;
Sense of rotation:	clockwise looking at direction of flight.
Operating conditions:	the propeller can be operated in any normal environment conditions except hail, sand storm or similar

FES propellers as described herein is designed and tested according to CS 22 Subpart J. It is made of GFC and CFC from accurate metal molds, which were manufactured using modern CNC technology. This made it possible to have very accurate propeller geometry. Inside is solid and not hollow.

Quality acrylic white paint is used to protect the composite body against moisture and erosion. Each blade pair is sanded and polished so that mass difference tolerance is only 0,2g. Paint is resistant against fuel, oil and other chemical products. This type of paint has also an excellent flexibility.

More detailed propeller description is provided at FES Propeller manual.

3.2.3 FCU instrument

FCU instrument was developed for LZ design's FES system by LXNAV company, who is otherwise well known in gliding community by their excellent flight computers (LX8000, LX9000) - electronic variometers.

LXNAV produce FCU instruments exclusively for FES system of LZ design.

Technical specification:

- 1* RPM input
- 2* LED INPUT
- 1* digital output for BRAKE
- 1* analog output for POWER (adjustable with rotary knob)
- 4* temperature (Controller/Motor/ 2* battery)
- Audio signal
- 1* analog input for measuring current
- 1* analog input for maesuring voltage
- 1* rs232 input for firmware update
- 1* input for canopy open switch
- 1* CAN bus
- 1* rotary and push button
- ON/OFF switch

Functions not supported by software, but supported in HW.
- 1* rs485
- 1* additional analog input

Sunlight readable QVGA LCD (320*240).
Consumption cca 100mA.

More detailed description is provided at FES FCU instrument manual.

3.2.4 Battery packs and its chargers

Standard FES battery pack contains 14 cells which are all wired in serial. For FES application you need two of them. They are marked with serial number and a letter first as A pack and second as B pack!

We are using one of the best high power SLPB (Superiol Lithium Polymer Battery) cells available on the market produced by world renowned manufacturer Kokam. You can find detailed technical data about these cells in Technical Specifications.

- Older "Battery packs GEN1" has external BMS (Battery Management System)
- Newer "Battery pack GEN2" are equipped with internal BMS (Battery Management System) which is fixed above the cells, and is equipped with 16 LEDs to monitor its operation.

For + and - terminals (GEN2 packs only) we chose to use Amphenol Radsok hyperbolic high power contact technology. High current female contacts are hidden inside of the pack.

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

Technical data

Battery pack type	FES GEN2 14S
Weight	16 kg
Box dimensions (WxLxH), without terminals and ventilators	154x220x257 mm
Cells producer	Kokam, South Korea
Cells type	SLPB100216216H
Average capacity of each cell	43 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	250A
Max balancing current per cell	1A
Internal BMS type	FES-BMS-9R
Standard big charger	KOP1001 BMS
Standard small charger	KOP602 BMS

More detailed description of suitable battery packs are provided in:

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

3.2.5 Wirings

FES wiring consists of power, signal and 12V wires, and different types of connectors.
For power cables we use high quality Betatherm 155 wires with cross section of 35 sqmm. For signal wires we use high quality tinned and shielded wires. For all 12V circuits we use aviation grade Spec 55 wires.

On the end of power wires are pressed and soldered suitable cable shoes and Radsok power connectors. Signal wires, are soldered to multipole DB9 or DB15 connectors, and on other side directly to FCC box electronic circuit board. 12V circuits are equipped with cables shoes.

-DC/DC converter is used to convert high voltage from FES battery packs, to 12V which is used to supply instruments, and main contactor. It also charge 12V battery if installed.

-Main contactor is used to connect and disconnect traction batteries (FES battery packs) to motor controller. There is installed also precharge resistor.

-Motor controller is used to convert high voltage DC to three phase AC voltage which goes to motor. It also send RPM and controller temperature by CAN bus to FCU instrument.

-Ventilators are used to cool down motor controller.

-Power switch (double pole) is used to give 12V power to main contactor, supply to electronic circuit board in motor controller.

-BMS inside of battery packs is used to balance and to control charging. It can be connected to PC with a special cable in order to monitor charging process with BMS Control software. During flight BMS is sending data to FCU instrument, about temperature of the pack and voltage levels of each cell.

-Shunt is used to measure current from Battery packs.

-LXUI box convert analog measurement of current and voltage to digital signal which is sent by CAN bus to FCU instrument.

-FCC box have electronic circuit board, where all signal and 12V wires came together and are spitted to right directions. It consist also a microprocessor for automatic propeller positioning. There is located also 2A fuse, potentiometer for adjusting of electronic braking and DB9 female connector for FCU update.

-12V battery is not really required for operation of FES system, but is there mainly to be able to set other instruments if main battery packs are still charging. Battery should be equipped with 3A fuse.

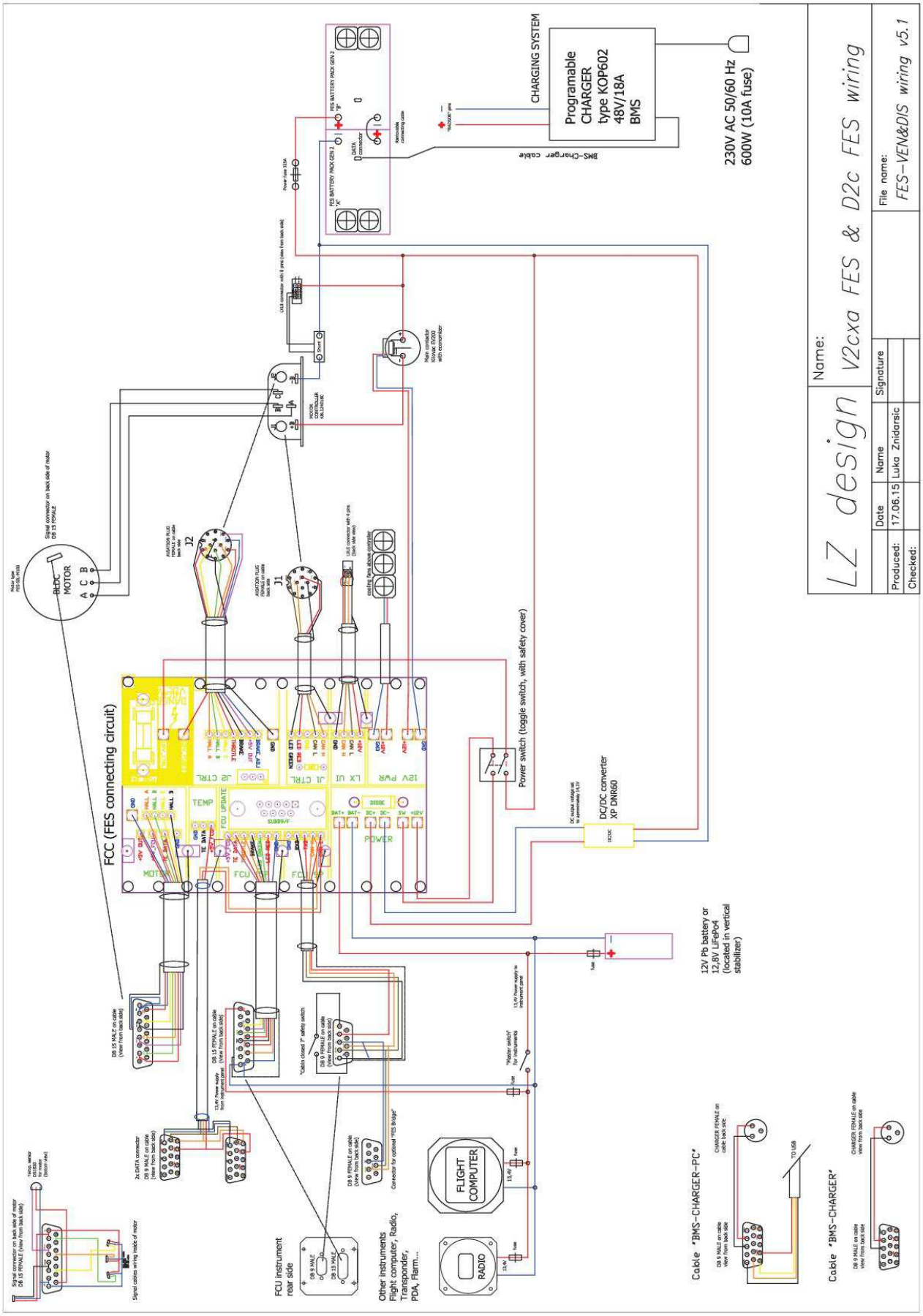
-325A power fuse protect the whole system in case of a high power short-circuit.

-Battery packs provide power to the whole FES system

-one 1,kW or optionally two 600W external chargers are used for charging of Battery packs, one by one or simultaneously in case of two chargers.

-FCU instrument gives information to the pilot about important parameters. There is also located throttle knob, and 3 bright LEDs in red and green color.

3.3 General FES wiring scheme:



4. FES maintenance

4.1 Maintenance of main FES components

4.1.1 Motor maintenance

FES motor is designed so that practically does not need any special maintenance.

Warning: *Opening or disassembling of the motor would cause a forfeit of warranty claims! It could be also very dangerous, due to very strong magnets on rotor!*

Though, it has to be considered that no foreign objects at all can enter the interior of the drive. Further, it is necessary to protect the motor from humidity, dirt, paint, glues etc. If this is ignored, a proper functionality of the motor can not be guaranteed and irreparable damages are possible. In case of damage, ship the motor back to the manufacturer for repairs. Unintended handling leads to secondary damages.

Note: *Keep magnetic memory cards or electronic devices out of the rotor's close-up range, because the strong magnetic field can cause a delete of data. Be also careful with medical devices (e.g. pacemakers) which might be sensitive to strong magnetic fields.*

The small gap between the stator and the magnets of the rotor function-bound has a thickness of only a few tenth millimeters. Here, the danger of foreign objects accumulating in this gap exists but can be heard by scratching-sounds. In this case spinner should be removed and the motor should be blown-out with compressed air. Do not at all simply keep on using the drive. Be especially aware of cuttings which can almost irremovably stick to the magnets. In this case, the only thing that helps is a disassembly of the drive by the manufacturer.

4.1.2 Propeller maintenance

Please refer to FES Propeller manual about.

4.1.3 Battery packs maintenance

Please refer to FES Battery pack manual.

4.1.4 FCU instrument maintenance

Please refer to FES FCU manual.

4.2 Normal procedures and inspections

4.2.1 Rigging and de-rigging of a FES equipped sailplane

It is valid the same as described in manual of pure sailplane.

Warning: *Make sure that connecting cable is not installed, between Battery packs (if they are fixed inside the fuselage) between rigging and de-rigging procedure.*

4.2.2 Daily inspection

Please keep in mind the importance of the inspection after rigging the glider. As a minimum check the following items:

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

If any problem is found it must be corrected before the flight.

4.2.3 Pre-flight inspection

Each day prior to the first take off it should be performed a pre-flight inspection.

- Check the sailplane itself as requested 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 battery compartment cover
3. Check that Power switch is OFF
4. Insert connecting cable between the battery packs
5. Seal battery compartment cover with glider tape
6. Seat into the glider, and close canopy
7. Check that no one is around propeller zone, in front of glider or in line of propeller
8. Switch on FCU
9. Switch on Power switch, and rotate gently a throttle knob clockwise
10. Wait about 8 second, for FCU to show all battery bottles
11. Start motor but use only low power to check proper operation

Caution*: In case that you would like to test system at maximum power, somebody needs to hold a fuselage tube down, and hold a glider.*

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

4.2.3 After flight inspection

Caution: *Always remove connecting cable between the packs after landing.*

(At older packs with external BMS: Always remove Power fuse after landing and put safety covers on free terminals.)

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

If motor was used during flight, take out both batteries and recharge them according detailed charging instructions in FES Battery pack manual.

4.2.4 Ground handling

On the ground propeller blades should be protected with a special blade protection covers, which prevents propeller blades from opening. Do not forget to remove propeller covers before flight!

Caution: *Make sure that propeller is in horizontal position when lifting rear part of fuselage to attach tail dolly.*

Warning: *Newer use a propeller or spinner for pushing, pulling or tail lifting!*

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

4.2.5 Tie down and ground-towing

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

Protect motor and battery compartment from water entering. Take Battery packs out of the glider and store them on dry place, and not on direct summer sunlight, in order to prevent to be overheated.

Towing on the ground should be always performed with Battery packs properly fixed, and propeller in horizontal position. It is recommended to use a tow gear equipment or at least a towing rope.

4.2.6 Storing and transportation

A sailplane with FES should be transported and stored in a high quality enclosed trailer constructed of metal or fiber glass reinforced plastics with a proper insulation, and ventilation characteristics.

- For **lighter fuselages** restriction of forward and jumping motions could be arranged with a nose cone support in shape of spinner with a big enough recess for propeller blades in horizontal position, covered with a soft thick material.

- For **heavier fuselages** is recomended that support which holds fuselage is aranged behind a spinner, otherwise loads on motor and propeller blades could be to high during transportation on bad roads.

It is recomended to use soft cotton canopy cover which goes also around spinner nose of sailplane, which than also prevent opening of propeller blades.

If canopy cover is not used, than supplied propeller blades covers, should be fitted to the blades, which would prevent opening of propeller blades during roll out of fuselage.

The fuselage should be supported in a fuselage dolly positioned just forward of the main landing wheel opening. Forward stop or a belt must be provided for the fuselage dolly in order to prevent slipping forward and leaving the fuselage with no support.

4.2.7 Cleaning and clean keeping

Avoid cleaning with water, around area of FES motor, and battery compartment. Spinner and propeller blades should be cleaned with a wet sponge or soft cotton towel. Tape adhesives are best removed using pure petroleum spirits or nitro thinner.

4.2.8 Inspection at the end of flight season

At the end of flying season or before expected long storage in a hangar or trailer, take out FES battery packs, and store them at dry place at room temperature. The best storage voltage is 3.7 V per cell (cca 52V per pack, or cca 104V on FCU total voltage measurement).

4.3 Adjustments

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

1. Gap between spinner and fuselage, should be around 0,5-1,0 mm. You can adjust the gap with tightening or un-tightening of 4 nuts on back side of mounting wall (valid only for LAK types)
2. Closing and opening of ventilation. With ventilation knob, fully rearward, ventilation should be fully closed. If not adjust it with two M3 bolts which hold wire inside of instrument panel.

4.4 De-rigging and rigging of sailplane FES parts

4.4.1.1 Taking Battery packs out of sailplane:

1. Check that Power switch (or Key switch at Silent) is OFF
2. Check that FCU instrument and all other instruments (Flight computer, Flarm, Radio, Transponder, PDA...) are switched OFF
3. Open cover
4. Take out connecting cable between the packs
5. Take out RED + and BLACK - power connectors
6. Fix supply cables to the side of battery compartment box
7. Remove both temperature sensor connectors (DATA), from each battery pack
8. Fix temperature sensor cable to the side of battery compartment box
9. Un-tighten battery pack fixation knobs
10. Take the fixation plate out
11. Firmly grip the front battery by a carrier strap
12. Lift it out of the fuselage and put it on safe place
13. Firmly 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 put it on safe place
15. Close cover

Caution: *Make sure you put battery packs on a dry, and safe place. Read FES Battery pack manual.*

4.4.1.2 Installation of Battery packs into sailplane:

Warning: *Make sure that both battery packs are fully charged before installation into sailplane. Both battery packs **must have** approximately the same voltage level of each cell (close to 4.16 V per cell). There should be less than 0,4V difference, between total voltage level of each battery pack!*

1. Open cover
2. Check that Power switch (Key) is OFF
3. Check that FCU instrument and all other instruments (Flight computer, Flarm, Radio, Transponder, PDA...) are switched OFF
4. Put one pack into the fuselage so that contacts are facing forward
5. Slide it back to rear position
6. Put another pack into the fuselage so that contacts are facing rearward

7. Place fixation plates
8. Tighten battery pack fixation knobs
9. Insert and secure temperature sensor (DATA) connectors, to each battery pack
10. Insert RED (+ contact) pin on cable to front pack, and BLACK (– contact) pin on cable to rear pack power connectors
11. Close cover

4.4.2 Removing and installing the motor

Note: *Removal of motor from sailplane is only allowed in case of* ***written permission*** *from manufacturer otherwise warranty is not valid any more!*

Warning: *It is not allowed to fly with removed motor from the sailplane, as C.G. position change significantly!*

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

1. Open ventilation (fully forward position)
2. Remove round laminated cover from center of front motor mounting rib (from cockpit side)
3. Unlock springs which hold DB15 cable connector and than carefully unplug connector from motor rear wall.
4. Unscrew 3 self-locking nuts from rear motor wall and disconnect 3 power cables. Before disconnection is recommended to mark them as A, B, C, and draw their position against each other on list of paper.
5. Un-secure six M8 bolts and unscrew them out. One of M8 bolts which is below powers wires have lower head. Hold motor assembly, and carefully take it out of fuselage.

To install motor back to the glider, follow the reverse order.

Take care about additional steps:

1. Open ventilation fully-lever pushed forward.
2. It is recommended to use new bolt securing plates to secure M8 motor fixation bolts.
3. Make sure that power cables are connected in the same order A, B, C like before and use only new M6 self-locking nuts. Make sure that there is no contact between cable shoes aluminum mounting wall or M8 fixing bolts. Below cables must be M8 bolt with shorter head.
4. Carefully plug in signal wires connector into motor rear wall connector. Lock springs which hold connector in place.

After motor is reinstalled, check the following:

- Spinner is in the center of fuselage.
- Gap between spinner and fuselage is 0,5-1mm
- All bolted connections assembled correctly and secured properly
- Start the motor on a ground and run it for a few seconds to check:
- Motor rotating direction, smooth run of motor

- Braking of propeller works OK
- FCU instrument is functioning properly;

4.4.3 Mounting and removal of the propeller

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

4.5 Lubrication instructions

There are only 3 parts in FES system which requires lubricating:

- two propeller pins which hold propeller blades should be very slightly lubricated
- ventilation valve pin which goes trough the shaft of motor should be very slightly lubricated, so that travels forward and backward easily under spring pressure.

Avoid of too much lubricant, as centrifugal force will anyway quickly spill it out, resulting in dirty spinner from inside, and dirty lower surface of propeller blades, which might initially looks like a crack, but is only excessive lubricant.

5. Periodical inspections

5.1 Introduction

In this section there is defined a list of inspections to ensure safe operation of FES during its lifetime.

The periodical inspections shall be performed by qualified staff authorized to perform the work at the time of sailplane inspections.

5.2 Sailplane inspection periods

The FES inspections shall be performed together and at the same time as it is requested for specific type of sailplane. For most of sailplanes types this is usually:

- After every 100 flight hours;
- At annual inspection;
- After rough landings, after ground loops;
- At the end of flight season or before long storing in a hangar or in a trailer;

5.3 Inspection after every 100 flight hours

Apart of required check list for the glider after every 100 flight hours, it is necessary to check also thoroughly the FES system according next check list:

	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 motor manual		
5	Check mounting of the motor on a motor frame		
6	Check gap between spinner and fuselage		
7	Check all bolted connections		
8	Check power cables for any damage		
9	Check battery packs		
10	Check 12V battery condition - if installed		
11	Inspect controller and main contactor		
12	Perform ground test run of the motor		
13	Check functioning of the propeller brake		
14	Check functioning of the propeller positioning		

5.4 Annual inspection

It is necessary to check the sailplane every 12 months in accordance with the 100 flight hours inspection. Additionally check if there was any update of FES manuals on FES website under download section!

5.5 Inspection after rough landing, or after ground loop

- check Battery packs if there is any visible damage
- check the FCU instrument for proper operation
- check if there is any damage on the propeller blades in case they touched the ground
- Check motor attachment and spinner

5.6 Inspection at the end of flight season

Remove FES battery packs from the glider, and store them at dry place at room temperature. The most suitable is to storage them at middle voltage which is about 3.7V per cell (cca 52V per pack, or cca 104V on FCU total voltage measurement).

6. Parts with limited service life

The following FES system parts have limited service life:

-12V Pb battery should be replaced every 5 years (if is installed in a glider)

Other components of FES system are necessary to replace according their condition.

7. Placards

When sailplane is equipped with FES there should be next additional placards in the cockpit:

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

8. Balancing of rotating parts

In order to have a smooth run of FES, complete assembly of motor, spinner, and propeller blades are balanced (to vibration level of less than 0,1 IPS) with special equipment before installation to the glider.
At that time all components are marked with small marking dots, and assembled so that all this little dots are all located on the same side. These marks must be taken into account when assembling spinner or propeller blades, so that they are assembled in proper orientation as before. If these marks are not taken into account, excessive vibrations could occur during motor run!

9. Repair

9.1 List of potential problems

Charger do not start charging	Check if power cord is plugged into wall outlet
Charger do not start charging	Check if connecting cable is connected between Battery pack (DATA) and charger
Charger do not start charging	Check grid fuse
Capacity bottles on FCU do not fill up after installation of fully charged batteries.	You must wait about 8 second after power switch is turned ON. Additionally total Voltage level of packs must be above 114V.
Remaining time is not showing on FCU	Enter code 00040 and than 00030
Voltage and Current measurement is not available	Check connectors on LXUI box
Motor is not starting, or it starts just a little and then stops	Check power switch, flip it OFF an ON a few times

When you are reporting a problem, please describe the problem and its behavior as much as possible accurately.
It might be helpful for you and also for us if you fill up next table:

FCU serial number	
Software version of FCU	
When power switch is OFF *	
Are Battery pack temperatures available?	
Is motor temperature available?	
When power switch is ON, motor stopped *	
Is lower left Green LED burning?	
Is »CONTROLER READY« message visible?	
Is lower right Red LED burning or blinking?	
Is controller temperature available?	
Voltage measurement data available?	
Voltage level?	
Any message appears, and which one?	
Power switch is ON, motor starting and running *	
Is lower left Green LED burning	
Is »CONTROLER READY« message visible?	
Is lower right Red LED blinking?	
Current measurement data available?	
Power calculation data available?	
RPM data available?	
Any message appears, and which one?	

*If possible make 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
-composite covers
-FCU instrument
-FCC (FES electronic circuit plate)
-main contactor
-power switch (or key switch)
-motor controller
-motor
-2A fuse inside of FCC box
-325A power fuse
-Battery packs (GEN1 or GEN2)
-internal BMS electronic circuit
-external BMS box

9.3 Soldering

In case that any soldering of wires is required, use only suitable equipment for the job. There is plenty info available on the web, about proper soldering techiques, here are just basic tips:

-use quality soldering iron, or soldering station
(http://en.wikipedia.org/wiki/Soldering_iron)

-keep the iron tip clean. A clean iron tip means better heat conduction and a better joint
-use a wet sponge to clean the iron tip between soldering of joints.
-keep the iron tip well tinned.
-make sure there will be 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 repair of small damages on the propeller blades
-sand away excessive filler with fine sanding paper (initially granulation 360, later 600 and 800, and finally 1000)

10. Revision history

October 2013	Initial release of Maintenance manual v1.0
November 2013	Minor updates v1.1
June 2015	Minor updates v1.11
September 2016	Minor updates v1.12