HPH Ltd.

Čáslavská 234
284 01 Kutná Hora
CZECH REPUBLIC
tel.: +420 327 512633
fax: +420 327 513441
info@hph.cz

TECHNICAL DESCRIPTION, OPERATING, MAINTENANCE AND REPAIR MANUAL SUPLEMENT FOR THE SAILPLANE

Glasflügel 304 eS

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TECHNICAL DESCRIPTION, OPERATING, MAINTENANCE AND REPAIR MANUAL SUPPLEMENT FOR THE SAILPLANE

Model: *Glasflügel 304 eS*
Serial No.:
Registration:

Document No.: 304eS/MMSupp

Date of Issue: 11/17

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0.2 Record of revisions

Any revision of this Manual must be recorded in the following table and in case of approved Sections endorsed by the responsible airworthiness authority.
The new or amended text in the revised page will be indicated by a black vertical line in the left hand margin, and the Revision No. and the date will be shown on the bottom left hand of the page.

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1. BASIC TECHNICAL DATA

1.1 Basic Technical data

Power-plant

Sailplane is equipped with a high-tech powerful FES front electric propulsion system developed for high performance sailplanes. Main parts of the FES system are:

- Brushless electric motor
- Controller for motor
- Foldable propeller
- Battery packs (FES-BP-14S) with internal BMS (Battery Management System)
- Charger (1200W or 600W)
- FCU (FES control unit) instrument
- LXUI box with Shunt (for current and voltage measurements)
- FCC box (FES connecting circuit)
- Power switch
- DC/DC converter (converts high voltage to 12V)

1.2 Technical Description

The ***GLASFLÜGEL 304 eS*** is single seat 18m flapped sailplane of 18m FAI class, constructed from fiber-reinforced plastics (FRP), featuring camber-changing flaps and a T-tail (with fixed horizontal stabilizer and elevator). The sailplane is equipped with FES (front electric propulsion system) which enables self-sustaining flight.

1.2.1 Fuselage

Front part of the fuselage is equipped with electric permanent magnet motor. The motor is directly connected with spinner and foldable propeller. The system enables restarting of the motor in flight and precise positioning of the spinner after motor turn off to achieve good aerodynamic qualities of the fuselage.

Motor controller and other electronic devices there are located in the central part of the fuselage in place of original baggage compartment.

Battery packs there are located aft the wing in battery compartment accessible through a covered opening in the upper side of the fuselage.

1.2.1.1 Battery compartment cover and venting valve

Battery compartment cover is equipped with venting valve. The valve consist of hole with diameter 40mm covered by special foil. The foil is hold in place by circular ring made of adhesive tape (inner diameter 30mm, outer diameter 50mm). **The valve must be attached only the way described above.** Other attachment options are prohibited.

1.2.2 Wing

Not affected.

1.2.3 Horizontal Tail Unit

Not affected.

1.2.4 Vertical Tail Unit

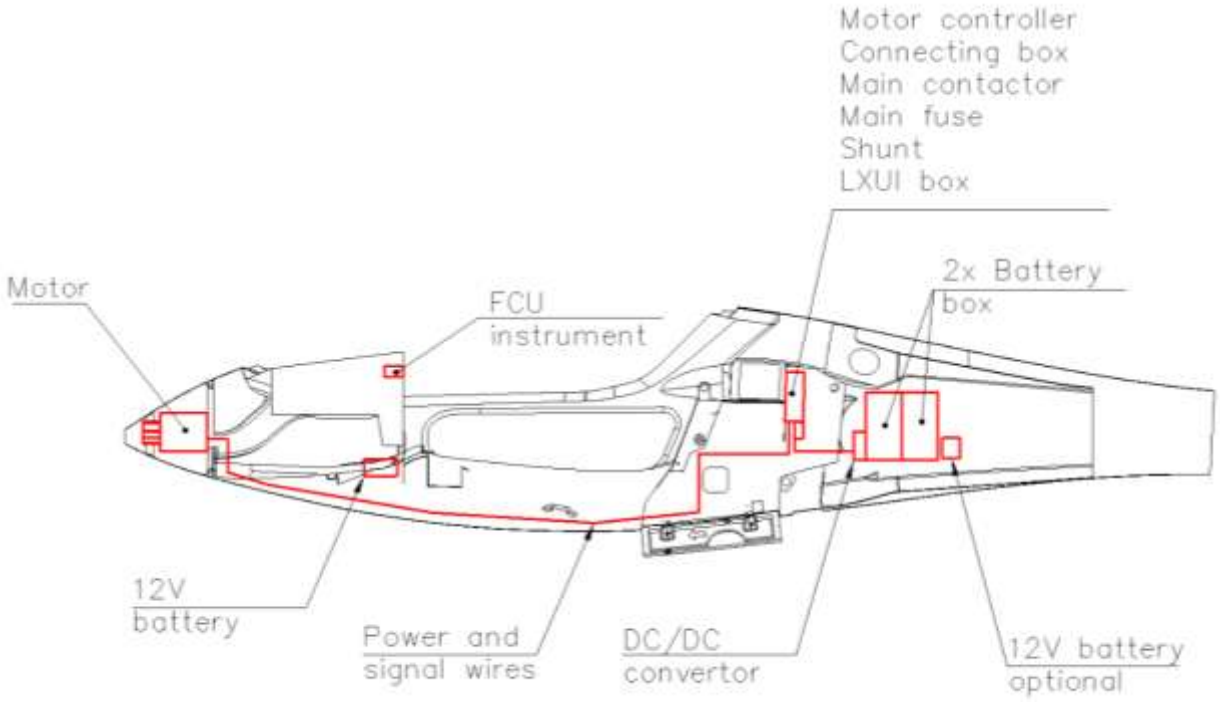
Not affected.

1.2.5 Water ballast system

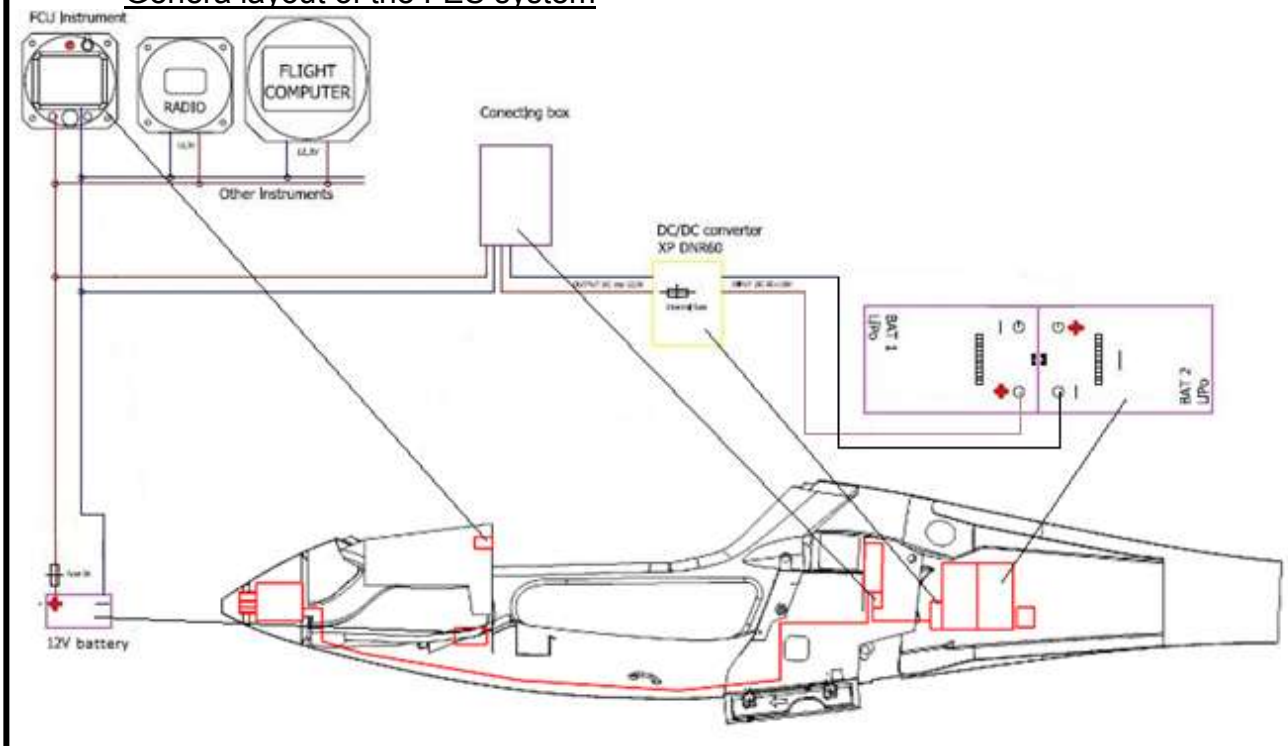
Not affected.

1.2.6 Power-plant

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.



Genera layout of the FES system



1.2.6.1 Electric motor

Motor construction is out-runner 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-HPH-M100) at 116V on motor controller and loaded with propeller (type FES-HPH-P1-102):

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-HPH-P1-102 propeller	4500 rpm
Battery current loaded (4500 rpm, 116V) with FES-HPH-P1-102	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.

1.2.6.2 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;
Propeller blade mass excluding attaching bolts:	approximately 245 g each blade;
Diameter of the propeller:	$d = 1000\ ^{+20}_{-0}$ 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 JAR 22 Subpart J. It is made of GFC and CFC from accurate metal moulds, 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.

1.2.6.3 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* analogue output for POWER (adjustable with rotary knob)
- 4* temperature (Controller/Motor/ 2* battery)
- Audio signal
- 1* analogue input for measuring current
- 1* analogue input for measuring 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 analogue input

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

More detailed description is provided at FES FCU instrument manual.

1.2.6.4 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.

"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-BP-14S GEN2
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 Battery pack GEN2 manual

Battery packs care

Charging:
Only approved charger can be used. For chargers description see **FES BATTERY PACK GEN2 manual.**

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

.

1. Connect RED + and BLACK , cables from charger to first battery pack.
2. Connect charger and Battery pack with BMS, Charger signal cable.
3. Plug in Charger to (220V AC, 50,60hz only) outlet.
4. Turn on BMS switch on top of Battery pack cover
5. Immediately after BMS switching ON, the BMS starts test procedure. Red »Error LED« turns ON to signal the system's test procedure.
6. If the test procedure is OK then »Error LED« turns OFF and BMS starts working in normal mode. BMS sends signal to the CHARGER to start charging and »Orange LED« on CHARGER indicates the start of charging. It is also possible to hear the contactor "click" inside of the CHARGER. Charging current rises slowly to the final value of 18 A, and cooling fans in CHARGER start working.
7. In normal mode green »Power LED« of BMS is flashing. This means that the BMS is turned ON, but not necessary balancing. Normally balancing starts when one cell reaches pre, set value, usually 4,1V (could be changed by BMS Control Software). If any of 14 Green LED cell balancing indicators are ON, it means that those cells have slightly higher voltage compared to the lowest one. If there is more than 30mV (preset value) difference between highest and lowest cell than balancing start even before one cells reach 4,1V.

Possible scenarios:

- If one or more cells have higher voltage levels that the others, it will discharge them, the temperature rise of BMS will be minimum.
- If only one cell has lower voltage level than all the others, all higher cells need to be balanced. This leads to higher BMS temperature, even if voltage difference is only 0.010 V (10mV).

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

8. Red »Error LED« is ON only during the initial test procedure. After the test is completed it turns OFF. Some system errors are also indicated with red »Error LED« by the number of ON blinks, followed by a longer OFF state. Number of blinks identifies the error:

Number of ON blinks	Error
1	Single or multiple cell voltage is too high (4.2 V)*.
2	Single or multiple cell voltage is too low (3.24 V)*.
3	Cell voltages differs more than 20 mV (0.02 V).
4	Cells temperature is too high (>55 C)*.
5	BMS temperature is too high (>50°C)*.
6	Number of cells is not set properly.
7	Too low temperature for charging <-1°C.
8	BMS do not recognize temperature sensor.
9.	Communication error.
10	Measurement of cell below 0,1V or above 4,8V.
13	Wrong chemistry set by BMS control software.

*Initial settings may be changed with BMS Control Software.

9. When first cell reaches 4.160V, charging current is reduced. If there is a big difference between cells (more than 50mV) than it can take quite long until they all reach 4,16V, as charging current is only 1A.

10. When finally all cells reach 4.160V (+/, 2mV) then BMS send a signal to CHARGER to stop charging. Green “Power LED” stop flashing and is turned ON. When this happened charging and balancing is properly completed!

11. Switch OFF BMS on top of Battery pack. Unplug charger from outlet. Remove charging cables and signal cable from Battery pack.

12. Charge second Battery pack!

Both battery packs must have approximately the same cell voltage levels (close to 4.16 V per cell), before usage. Using two packs with too much difference in voltage levels is not allowed! Maximum 1V difference between total voltages of both pack is acceptable.
Higher difference is not acceptable!
For instance Pack 1: 58,24V (4.160 per cell), Pack 2: 57,82V (4,130V per cell), this is acceptable!

Storage:

When you will stop flying before the winter (or any other longer period of no flying) it is advisable to discharge Battery packs to middle voltage which is 3,7V per cell. (This is about 52V per pack, or 104V on FCU instrument). Store packs at room temperature of 20 degrees or lower. (At the basement where is usually colder), at normal humidity conditions.

Always try to avoid to have packs exposed to high temperature, and this is decreasing life of cells significantly.

Car transport:

When transporting your packs with your car, make sure that packs cannot move during car acceleration and braking. If surface in your car is very slippery than we advise you to use special transport box, which you can order as part of optional equipment. Its construction effectively prevent sliding and moving of packs in your car. Do not leave packs for longer time in hot car under sun.

1.3 Sailplane systems

1.3.1 Control systems in the fuselage

Not affected.

1.3.2 Control systems in the wing

Not affected.

1.3.3 Rudder control system

Not affected.

1.3.4 Main landing gear system

Not affected.

1.3.5 Control surface deflections and dimensions

Not affected.

1.3.6 Electric system

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 mm^2. 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.

1.3.6.1 Fire and smoke alarm

Fire and smoke alarm sensor JABLOTRON SD-283ST is installed in battery compartment. The alarm works only when the sensor is supplied by 12V. Therefore main switch must be switched on and at least 12V battery installed for proper function of the alarm. Fire and smoke alarm is based on smoke detection and detection of temperature (higher then 60°C). The sensor is connected with fire signalization on instrument panel (red LED and buzzer) according scheme in this manual section. Beeping sound of buzzer can be switched off using "FIRE ALARM" switch on instrument panel.

High amount of dust particles inside battery compartment may lead to incorrect sensor function. Therefore keep battery compartment clean.

Test procedure - during preflight inspection

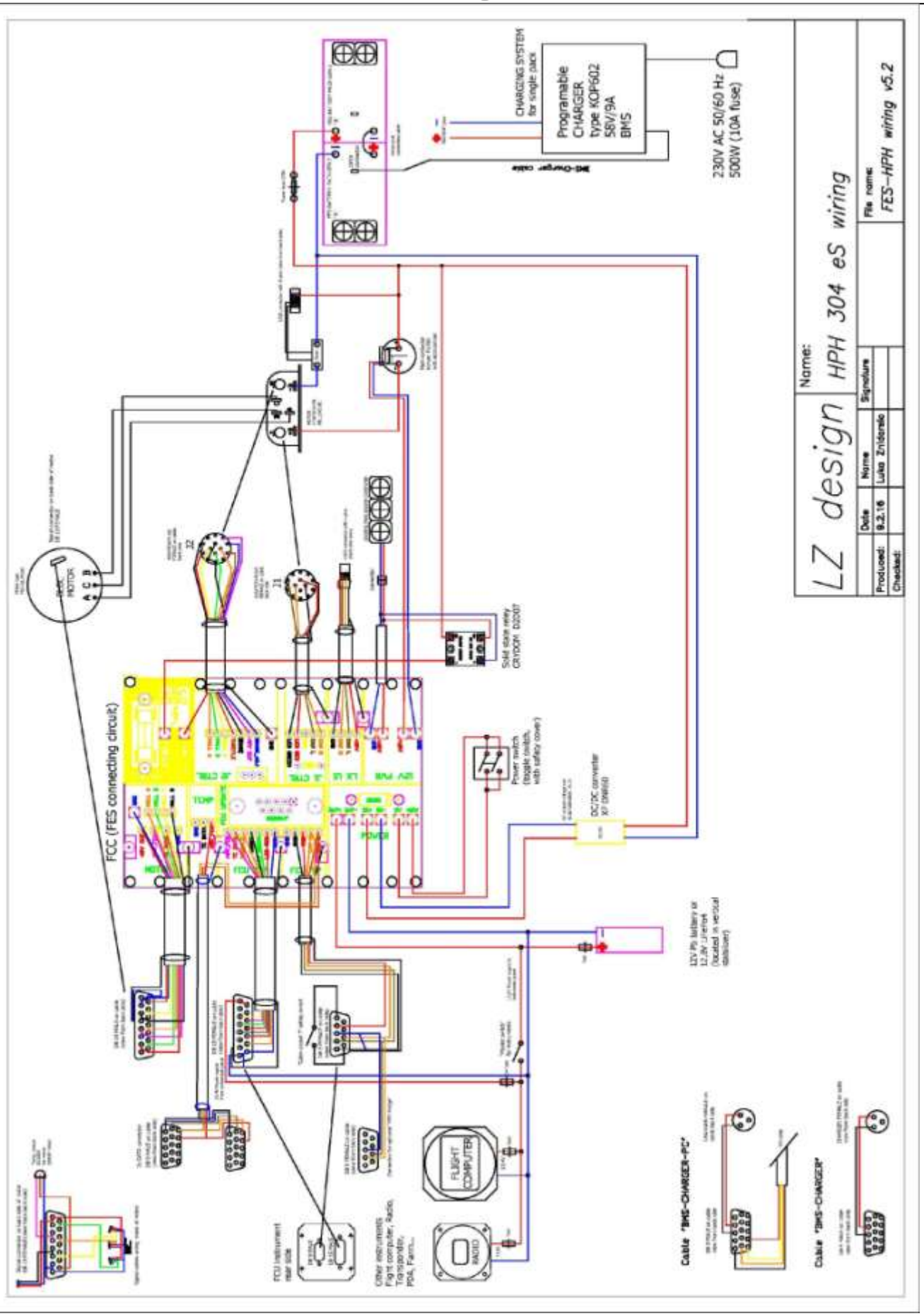
The test must be provided with 12V battery installed and Main electric switch turned on.

To test the detector press the detector against the base and wait until a LED indicator switches on. The LED flashing signals switchover to the testing mode. The LED is flashes for the whole duration of the test. When the test is complete, the LED switches off. The detector then signals the result. If the detector beeps once, the test has been done successfully. If a failure is discovered, the LED flashes and beeps three times. If the battery is low, there is no acoustic signalling but just one flash when the test is completed. When the testing is completed the ALARM terminal is activated for a short time. Than red LED warning and buzzer on instrument panel is engaged. Once the alarm terminal in not activated the red LED warning and buzzer on instrument panel is deactivated.

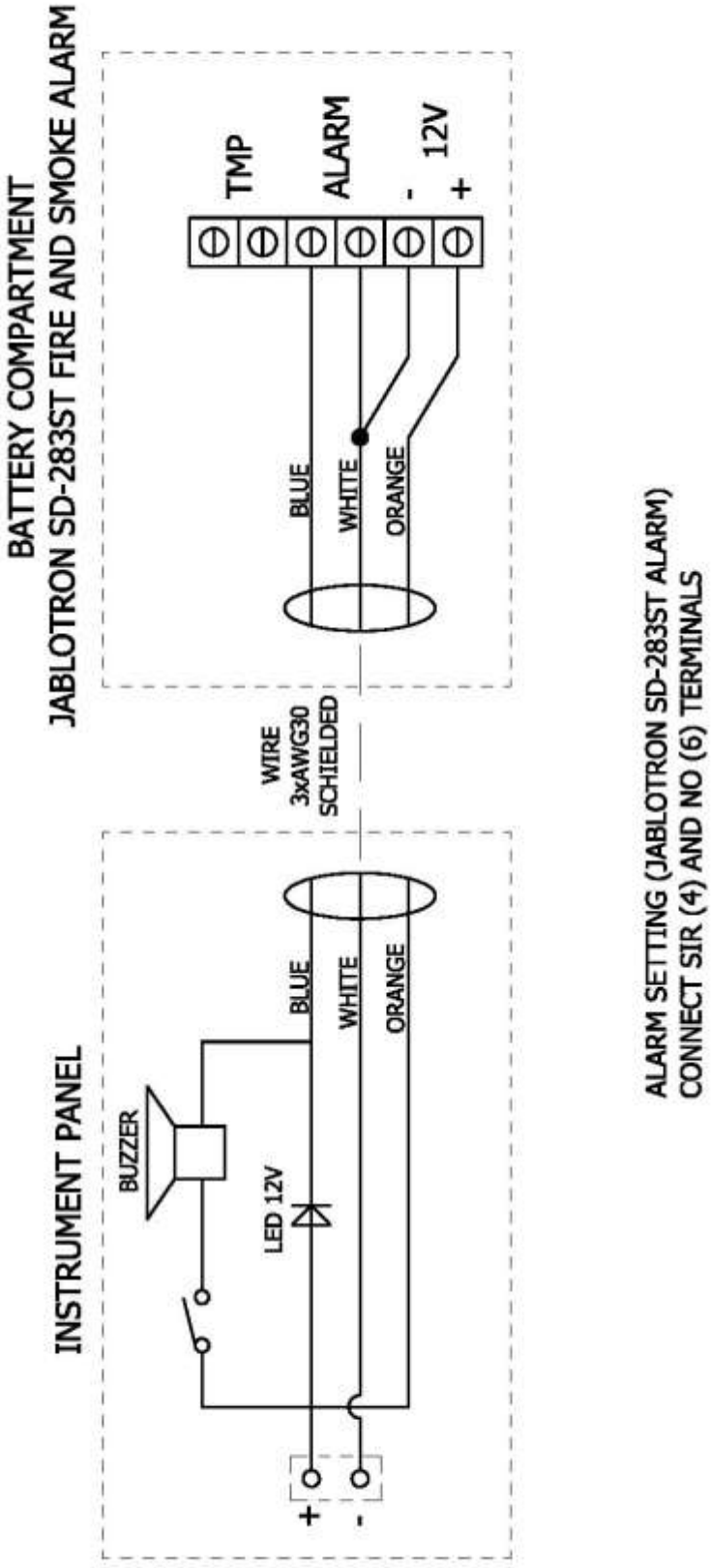
Annual check

During annual check the above test must be performed. The complete functioning of the detector can be tested with a testing spray (e.g. SD-TESTER). The heat sensor can be tested with heated air (e.g. with a hair dryer). **Warning:** never test the detector with fire.

If the fault is recognized the alarm must be repaired by manufacturer or replaced with a new one.


CHARGING SYSTEM for single pack
Programable CHARGER type KOP602 58V/9A BMS
230V AC 50/60 Hz 500W (10A fuse)
LZ design
Name: HPH 304 eS wiring
File name: FES-HPH wiring v5.2
Date
Name
Signature
Produced: 9.2.16 Lukas Zridarelo
Checked:
FCC (FES connecting circuit)
Power switch (toggle switch, with safety cover)
DC/DC converter
FLIGHT COMPUTER
RADIO
Cable "BMS-CHARGER-PC"
Cable "BMS-CHARGER"

Fire and smoke alarm wiring scheme



2. HANGARING, TRANSPORT, RIGGING

2.1.1 Hangaring, Parking, and Ground Handling

2.1.1.1 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.

2.1.1.2 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.

It is recommended to use support which holds fuselage behind a spinner, otherwise loads on motor and propeller blades could be too high during transportation on bad roads.

It is recommended 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.

2.2 Rigging

Not affected.

2.2.1.1 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!*

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

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

2.3 De-rigging

Not affected.

2.3.1.1 Taking Battery packs out of sailplane:

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

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

3. MAINTENANCE

3.1 Mandatory Maintenance

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.

3.1.1 Inspections periods

- After every 100 flight hours (sailplane);
- 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;

3.1.2 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 (sailplane)	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		

3.1.3 Propeller

At the 25 propeller hours inspection (periodically to be done up to the annual inspection):

- clean the propeller with any car wash solution or equivalent.
- make the normal preflight inspection, but especially pay attention to the center part of the propeller, leading and trailing edges of the blades for cracks and de-laminations and the lacquer surface for condition.
- inspect blades for stone damages, and mark them.

3.1.4 Motor – Propeller

After propeller change (each 200 motor hours)

Motor – propeller assembly must be balanced to the vibration value lower than 0,1 IPS.

3.2 Regular Maintenance

3.2.1 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!

3.2.2 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).

3.2.3 Adjustments

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

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

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.

3.2.4 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 cannot 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 millimetres. 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.

For detail description refer **FES HPH M100 MOTOR manual.**

3.2.5 Propeller maintenance

Every time you go to fly, thoroughly perform preflight inspection:

- Take a look at the entire propeller inspecting for damages, leading and trailing edges for possible splitting or de-lamination.
- Composite propeller blades are always as good as they look. If the total blade surface show no cracks, no reconditioning or overhaul will be necessary. Pay special attention to the root part of the blade, leading and trailing edges.
- Inspect central part of the propeller for possible cracks or deformations. No cracks or deformations are allowed. If such are found, contact the manufacturer.

Annual inspection or inspection after up to 15 % over-speed of the rated maximum rotational speed RPM:

The inspection does not differ from 25h inspection, refer to the point 3.1.3. At more than 15 % over-speed the propeller should be sent to the factory for inspection.

Possible damages and allowables

No structural cracks or de-laminations of composite structure are allowed for the propeller.

- Small cracks up to 10 mm of length in a lacquer are allowed. Make sure cracks are in a lacquer layer only and not going into the composite structure. Fine cracks in the lacquer surface across the blade axis are indications of bending vibrations. Such cracks mostly occur in the outer part of the blade. No sudden blade failure can occur due to these cracks. If such cracks do occur, the factory should be consulted regarding airworthiness, if possible together with a photo and information about operating time.
- The erosion occurs due to the peripheral speed of the blade and is normal. However, always take care that the erosion never becomes so deep that FRP-coat is damaged and there is a possibility that moisture may enter into the blade body. In this case the blade must be repaired/overhauled immediately.
- Stone damages. If stone damages are visible, mark them and check them periodically. Maximum size of stone damages permitted for operation is 2x4 mm large and 0,7 mm deep. Maximum number of damages allowed is one damage per 4 cm^2. If bigger or more damages exist on a blade, send propeller to manufacture for inspection and overhaul.
- Cracks or deformations in a center part of the propeller are not allowed. If such occurs, send propeller back to manufacture for the overhaul.

For more detail refer **FES HPH P1 102PROPELLER manual.**

3.2.6 Battery packs maintenance

With proper and careful use of FES battery packs, there is practically no maintenance required. FES battery packs are built from the most suitable cells available, so that they are able to provide high power and good endurance and will serve you for many years and charging cycles.

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 this deterioration include:

- During powered flight, use low power settings as much as possible and practical.
- Do not discharge cells below 3,4V (total voltage at 95V), if is not really necessary.
- Store battery packs at suitable temperatures when they are not in use (review next chapter 3.2.6.1)
- Store battery packs at suitable charge levels (around 50% SOC, see next chapter 3.2.6.1).

Good indication of the battery packs 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. With poor treatment of the battery packs, their cells internal resistance will be rising faster, and so calculated SOH % level will become lower. When it will be as low as 50%, it would be time to think about replacement of the battery packs (at least the cells, BMS electronic could be reused).

Poor condition of the cells can be recognizable also during powered flight:

- much deeper voltage drops at max power settings
- much reduced maximum achievable power (with fully charged packs)
- much reduced usable capacity – altitude gain and range of level flight
- temperature rise gradient of the battery pack will become much faster

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

3.2.6.1 Battery packs storage

When you stop flying for longer time, for instance during winter time, it is mandatory to discharge FES battery packs to 50% of charge. This is to middle voltage, 3,7V per cell (this is about 52V per pack, or 104V indicated on FCU instrument, when motor is stopped).

- you can discharge them during last flight at the end of season, or
- you can use FES discharging assistant device (more info about this optional equipment you can find on our FES website)

The most important environmental factor for slowing aging is the temperature at which battery packs are stored. Store battery packs between 10°C to 20°C, at normal humidity conditions. Do not store batteries at high temperatures or below freezing temperatures or in very humid environment (like in poor all metal glider trailer).

3.3 Special Inspection Procedure

3.3.1 After hard landing, ground loops and battery pack impact

In case of battery pack impact (for instance fall to the ground during manipulation or hard barking during car transport) provide battery pack test according procedure in chapter 3.3.1.1.

- check Battery packs according procedure in chapter 3.3.1.1
- 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

3.3.1.1 Battery pack inspection

Required tools and equipment for inspection:

- Digital electronic multi-meter for voltage measurement

Note: It has been found that some higher quality multi-meters (e.g. Fluke) are not suitable for this measurement. It would appear that these quality meters have a different internal resistance and do not show a reading, even when the range is set manually. The difference is apparent when one shows 45V and the other 0V.

1. Visual inspection of the housing
   Carefully inspect the housing of each battery pack for any mechanical damages such as that shown below. Mark the damaged area with the serial number of the pack and the date. Take a clear photo of the damaged area and the label and send it to Manufacturer for further evaluation. In the case of significant damage, the battery pack must be sent to Manufacturer, for further inspection. In most cases replacement of the housing will be required. In the event that individual cells are damaged the damaged cell will also need to be replaced.

2. Measuring of potential difference.
   Battery pack must be checked for voltage on the housing. For this step, an inexpensive digital multi-meter is required. The multi-meter must be set to measure DC voltage, starting with a higher range (Volts) changing to a lower range (Milli-volt) as required.

a) Measure voltage between the negative terminal and the housing. Check in multiple places on the housing (i.e. bolts on the housing, bolts on fans, etc.).
b) Measure voltage between the positive terminal and the housing. Check in multiple places on the housing (i.e. bolts on the housing, bolts on fans, etc.).

The measurement should be close to 0,0V on all possible places between the negative terminal and the housing and between the positive terminal and the housing. In most cases a very low value will be measured, for example 0,052V or 0,066. This is just a small residual static charge and is of no significance.
However, if the measured voltage between the negative terminal and the case or between the positive terminal and the case is higher than 1,0V continuously and it shows the same level with more measurements, then the battery pack must inspected by Manufacturer.
Ideally this measurement should be done when battery pack is fully charged.
On completion, the battery pack should be discharged to 50% capacity using the FES discharging assistant and a suitable load.
Any anomalies found regarding any aspect of the above should be reported to Manufacturer.

3.4 Free Play in the Control Circuits

Not affected.

3.5 Free Play in Wing and Tail plane Attachments

Not affected.

3.6 Primary and secondary structures

Not affected.

3.7 Damage

Not affected.

3.8 Repairs

Not affected.

3.9 Removal and Re-Installation of Releases

CG release:

Procedure of removal and reinstallation of CG release is not affected.

Front release:

For removing or reinstallation of front release follow next steps:

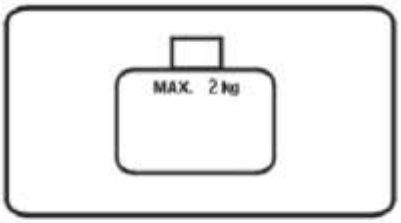
- remove front 12V battery cover
- unscrew bolts holding front 12V battery compartment bottom
- remove 12V battery compartment bottom
- Disconnect actuating cable from release
- using spanners size 10 unscrew three self-locking nuts holding the release
- remove M6 bolts holding the release
- now release can be removed and replaced

For installing new release use previous list in reversed order.

3.10 Control Surface Moments

Not affected

3.11 Placards and markings in the Cockpit



MAX. LUGGAGE COMPARTEMENT

AIRSPEED LIMITATION IAS					
V_{PO} Powrplant max. oper. speed	160	km/h	86	KIAS100	mph
V_{POmax} Max. speed to start motor	160	km/h	86	KIAS100	mph
V_{POmim} Min. speed to start motor	80	km/h	43	KIAS50	mph

FCU UNIT must be turned ON
during the flight

3.12 Cleaning and care

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.

3.13 Lubrication scheme

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 through 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.

3.14 Tightening Torque Moments Table

Nuts holding power cables with FES M100 motor should be tightened with torque moment of **7Nm !**

Higher torque moment may cause damage of the screws. When lower torque moment is applied insufficient contact between cable lug and motor connector may occur.

3.15 Safety Harness

Not affected

3.16 Pitot and Static Lines and Instrument Connections

Opposed G 304S/MS sailplanes G 304eS is equipped with only one Pitot tube located on the top of the fin. Other parts of the pitot-static system are not affected.

3.17 List of instruments

3.17.1 Airspeed Indicators

Not affected.

3.17.2 Altimeters

Not affected.

3.17.3 Variometers

Not affected.

3.17.4 Magnetic Compasses

Not affected.

3.17.5 Turn and Bank Indicators

Not affected.

3.17.6 **COMM**

Not affected.

3.17.7 **Transponders**

Not affected.

3.17.8 **FCU Instrument**

Only original FCU instrument with updated software can be used for power-plant control. See FES FCU INSTRUMENT manual for detail description.

3.18 Oxygen system

Not affected.

3.19 Service instructions

Other service instructions related to the FES power-plant can be found in following manuals:

- G 304eS/AFMSupp
- FES HPH M100 MOTOR manual
- FES HPH P1 102 PROPELLER manual
- FES BATETRY PACK GEN2 manual
- FES BMS CONTROL manual
- FES BMS LCD Display manual
- FES FCU INSTRUMENT manual

3.20 List of special tools

Not affected.

3.21 Motor removing and installation

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

1. Open ventilation (fully forward position)
2. Remove round laminated cover from centre of front motor mounting rib (from cockpit side)
3. Unlock springs which hold DB15 cable connector and then 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 aluminium mounting wall or M8 fixing bolts. Below cables must be M8 bolt with shorter head. Use torque moment of 7Nm to tightening of the nuts.
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;

3.22 Installation of propeller

- Check propeller type and condition. Clean propeller and let it dry.
- Oil on any of the surfaces must be avoided. Check bolts for cracks, thread and corrosion. Replace if needed (important that the bolts would be of the same length, so as not to damage the motor bearings).
- Assemble propeller blades with the propeller holder. Make sure that blade marked with a small dot is inserted into propeller holder side which is also marked with small dot.
- Insert special blade holding bolts, from back side of propeller. This means that head of the bolt must be on trailing edge side of propeller. One of the bolts is marked on the head with a small dot. Be sure to install it into marked side of the holder. Before inserting bolts, grease them just slightly on the stable. Too much grease will be removed by centrifugal force, so use really a minimum amount of grease.
- On the threaded side of a bolt put M8 Inox washer, and thread in crown nut M8. Tighten the crown nut with 13 key so that there is some tension in holder forks, so that bolt cannot rotate. However blades must still be able to open and close freely. Then insert into a bolt hole and trough crown nut a safety pin (with 1,4 mm diameter), cut it to proper length and bend it around crown nut.
- Tighten the spinner p.4 with special M4 Inox bolts p.3.
- Removal - use previous list in reverse order. In any case, if hard tools are used, the propeller will be damaged.

3.23 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 0,06 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!

3.24 Controller alarm codes

This chapter contain list of controller alarm codes and required maintenance actions. These alarm codes are displayed by red blinking of right bottom FCU diode.

Diode code	Description	Maintenance action
* **	Over voltage error	• Battery voltage is higher than max. Operating voltage of controller. Check the battery voltage and configuration • Over voltage at regeneration. Controller will cut back or stop regeneration.
* ***	Low voltage error	• The controller will attempt to clear the fault code automatically after 5 second if battery voltage returns to normal. • Check the battery voltage • Charge battery if necessary
* ****	Over temperature warning	• The controller temperature is over 90°C. The controller will cut back current in that case. Stop or reduce output to ensure temperature fall. • Check controller compartment and venting holes and cooling fan function
** *	Motor fails to start	• Motor has not reached 25 electrical RPM after 2 seconds from starting. Most likely the hall or phase wiring problem
** **	Internal voltage fault	• Check if B+ and PWR voltage are correct; refer to B- or RTN. Could be power voltage low. • Check load on 5V supply. Could be high load on 5V. Incorrect pot wiring can load it heavily. • The controller is damaged. Contact manufacturer.
** ***	Over temperature	• The controller temperature is over 100°C. Controller stops driving in the case. • Stop driving and wait for temperature fall. The controller will restart if temperature drops below 80°C.
** ****	Throttle error at power up	• The throttle signal is higher than configured dead zone at power on. • The fault will disappear if restart or release throttle.

*** *	Frequent reset	• The controller will stop driving after detect too many resets • Mostly because of B- or return wiring. Check return wires. • Could be over current protection. • Restart will clean the error • Contact manufacturer if happens repeatedly.
*** **	Internal reset	• Reset caused by over current, high battery voltage or low supply voltage. It can occur occasionally.
*** ****	Throttle is not zero when try to change direction	• The controller won't change drive direction if throttle is not zero. Also it won't change direction at high speed. The controller will wait throttle ad speed close to zero before change direction.
**** *	Over voltage at start-up or regeneration	• The controller won't drive motor if detect overvoltage at power up. It will cut back regen. Current or stop regen. at overvoltage.
**** **	Hall sensor signal error	• Most likely caused by incorrect hall wiring, to wrong pin or lose wire. • Intermitted or damaged hall sensor • Double check hall angle setting
**** ***	Motor over temperature	• The motor temperature higher than configured max temperature. Controller will shut down and wait for motor temperature drops.

4. AIRWORTHINESS LIMITATIONS

4.1 General

Not affected.

4.2 Service Time

Only time limited parts of FES assembly are:

Propeller:

Time between inspections	25h of motor run time
Time between overhauls	50h of motor run time
Total service life	200h of motor run time

12V Battery:

Should be replace after 5 years of service.

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

4.3 Inspection

Not affected.

4.4 Check out program

Not affected.

4.5 Inspection results

Not affected.

4.6 Obligatory inspections

Not affected.

4.7 Life Limited Component Section

Approved life limited components installed in the glider should be operated according to instructions of the corresponding manufacturer (see 3.19). Instructions are delivered with each new glider or component.
If the component is installed in another aircraft or if it is installed from another aircraft, then the number of takeoffs and the months of operating life already expired must be recorded by a qualified inspector in the log of the aircraft which is the object of installation.

Life limited parts - Glasflügel 304 eS				
Manufacturer	Address	Product	Type	TBO
LZ design d.o.o.	Brod 3D, 1370 Logatec, Slovenia	FES HPH P1 102 Propeller	HPH P1 102	50 hours of motor run time

5. CENTER OF GRAVITY

5.1 Center of Gravity position

CG position must be established in sailplane configuration intended for flight. CG position must lay within the limits specified in G 304S/FM chapter 2.5. Following configurations are allowed:

- Motor and Battery packs installed - standard configuration
- Motor and propeller installed, Battery packs removed - always check CG position by weighting
- Motor installed, Battery packs and propeller blades removed - always check CG position by weighting
- Motor and Battery packs installed, Propeller blades removed.

5.2 Payload Range

Not affected.

6. INSTRUCTIONS FOR REPAIRS

6.1 CHECKLIST

6.1.1 General

Not affected

6.1.2 Wing

Not affected.

6.1.3 Fuselage

Not affected.

6.1.4 Propeller

Check for crack especially in root section. Additionally check for scratches and nicks.

Serious cracks which originate from the inside of the blade, are extending through the lacquer and so are visible from outside. These cracks are radial cracks or tangential cracks. Fine cracks in the lacquer as described above, are considered of serious character, although they usually start at first in the lacquer and not in the composite structure.

Normal small stone nicks are unimportant as long as there is not obvious structural damage. Scratches and nicks should be filled and protected during routine maintenance with a coating of water resistant lacquer. Description of allowed damage is listed in chapter 3.2.5.

Broken tips and damaged blades are not reparable and have to be replaced. Small damages on the trailing edge can be repaired by manufacture.

6.1.5 Motor

Warning: *Do not open or disassemble the motor! It could be very dangerous, due to very strong magnets on rotor! See* ***HPH-M100-Motor Manual.***

6.1.6 Batteries

No maintenance action is required to Battery packs. See **FES Battery pack GEN2 manual.**

6.1.7 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 then 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.

6.2 Structure of Components

Not affected

6.3 Materials

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)

6.3.1 List of FES 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 GEN2)
-internal BMS electronic circuit
-external BMS box

6.4 Type of waves

Not affected.

6.5 Basic Techniques and Tools

6.5.1 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!