CONTENTS

1. HYBRID SYSTEM DESCRIPTION

Each system includes the following elements:

- diesel engine
- e-motor/generator
- transmission gearbox
- electronic controller (HCU)
- electro-hydraulic actuator
- connection box with wiring
- Data Display Interface (DDI)
- propulsion battery
- cooling system

***There are single or twin hybrid system on different boat versions. In case of twin system, there are* starboard (*STBD*)-right and the port (*PORT*)-left hybrid drive system. *STBD* and *PORT* systems operate independently. The expression *hybrid drive system* designates both *STBD* and *PORT* hybrid drive system below.**

2. SAFETY

For the safe use of the hybrid drive system, the user has to follow the instructions given by the boat manufacturer and these instructions.

Please read the documentation supplied with the hybrid drive system first, so that you are familiar with the safety signs directions before using the hybrid drive system.

Before operating the hybrid drive system read this manual to understand the features of the unit. Also read the separate manuals for the diesel engine and other manuals that may have been included with **the boat.**

The hybrid drive system should be used only for the purpose which it was produced for.

It is important to be familiar with the electrical wiring diagram of the complete boat with all OEM on board electric components (shore chargers, solar systems, on board consumers, bow thrusters, air conditioning, anchor winch, ...).

Additionally installed electical components can have an impact on the correct function of the hybrid systems or other electrical components of onboard system.

Every planned change in the electrical installation on the boat has to be approved by the boat manufacturer and consulted with system components and installed in proper way. The change can be performed only by a professional person qualified to do so.

2.1 WARNING: Danger of electrical shock

The hybrid drive is used in combination with a permanent energy source (propulsion battery), shore charger and photovoltaic system. Even when the system is switched off, high voltage may

appear at the input and/or output terminals. Always turn-off power sources of all hybrid components before performing any maintenance, even when the hybrid drive is not in use.

The hybrid drive system contains on internal user-serviceable parts. Do not remove the protection covers and do not put the product into operation unless all protection covers are fitted correctly. All maintenance should be performed by qualified personnel.

Never use the hybrid drive system at sites where vapors of flammable liquids, gas and dust explosions could occur.

The hybrid drive system is ready for operation with a originally installed batteries to the boat. When replacing one or both batteries, the same type and size of both batteries are required.

Replacement of different battery and hybrid drive system settings can only be performed by an authorized boat service, which must also adjust charging parameters according to a new type and size of propulsion battery.

Refer also to the specifications provided by the manufacturer of the battery to ensure that the battery is suitable for use with this product. The battery manufacturer's safety instructions should always be observed.

When the boat is not propeled or there is no person on board the *DIESEL / ELECTRIC HYBRID SWITCH* must always be in *DIESEL* position.

2.2 Guidelines for safe operation

The service or repair work can be performed only by a professional person qualified to do so. Before any service work on hybrid drive system, all switches must be set to OFF.

Do not work on any components of the hybrid drive system when the system is running.

Do not remove any protective covers from the electric motors or connection boxes while diesel engine or electric motor is running.

When any cover is removed, only qualified maintenance personnel should operate on hybrid drive system maintenance or service.
Do not insert anything in the holes in the housing while the diesel engine or E-motor is running. Do not leave any foreign object in the cocoon housing of the diesel engine or E-motor.

The hybrid drive system contains hot coolant/cooling water under pressure. Inspect hoses and connections frequently for signs of leakage or damage.

2.3 Installation and maintenance

Ensure that the connection cables are provided with prescribed fuses and circuit breakers. Never replace a protective device by a component of a different type or value. Refer to the manual for the correct part.

Ensure that the hybrid drive system is used under the correct operating conditions. Never operate it in wet or dusty environment.

Ensure that there is always sufficient free space around the product, free airflow, functioning ventilation system and open ventilation holes. Ensure sufficient flow of coolant/cooling water, always when the hybrid drive system is operating in generator and E-motor mode.

Install the product in a heatproof environment. Ensure therefore that there are no chemicals, plastic parts, curtains or other textiles, etc. in the immediate vicinity of the equipment.

All connections and cables must be protected against the impact of the environment by a suitable protective shield. For protection against electric current strike, all connections have to be protected with protective covers.

The hybrid drive system's elements: *controller, electro-hydraulic actuator with a relay box for clutch control and connection box for HCU with CAN connector* must be installed in a protected compartment in a boat, where they cannot be exposed to water, heat, dust, and vibrations of the drive diesel engine or drive assembly. The E-motor must be protected against water and dust.

At diesel engine maintenance intervals or minimum at every 400hours of sum operation in diesel and electro mode it is recommended to check the E-motor part of hybrid drive system. If there is any unusual noise or vibration detected, it is necessary to take the detailed review of the E-motor. Also check the hydraulic oil level in hydraulic oil container and condition of hydraulic pipes and connections. Check the tightening of all electrical terminals and condition of all cables.

2.4 Transport, storage and disposal

On storage or transport of the boat, ensure that all hybrid drive components are disconnected.

No liability can be accepted for damage in transit if the equipment is not transported in its original packaging or properly installed on the boat.
Store the product in a dry environment; the storage temperature should range from –20°C to +60°C.

For the disposal of parts of the hybrid drive system respect the environment and consider the recycling directives.

3. HYBRID DRIVE SYSTEM AUZ 48/60V 10/14 kW

3.1 Purpose and basic information

Hybrid drive system enables quiet navigation by E-motor at a lower speed and navigation by diesel engine at a higher speed. The same E-motor functions also as a electric energy generator during navigation on a diesel engine or when the boat is moored. For control, there is an electronic control unit, which charges the batteries in the generator mode or controls the E-motor for the boat drive in the E-motor mode.

A special control system gives the user a choice between the electric motor and diesel engine boat drive. Engagement or disengagement of the disc clutch between the diesel engine and the electric motor is carried out by the hydraulic actuator through the clutch master cylinder and the clutch slave cylinder.

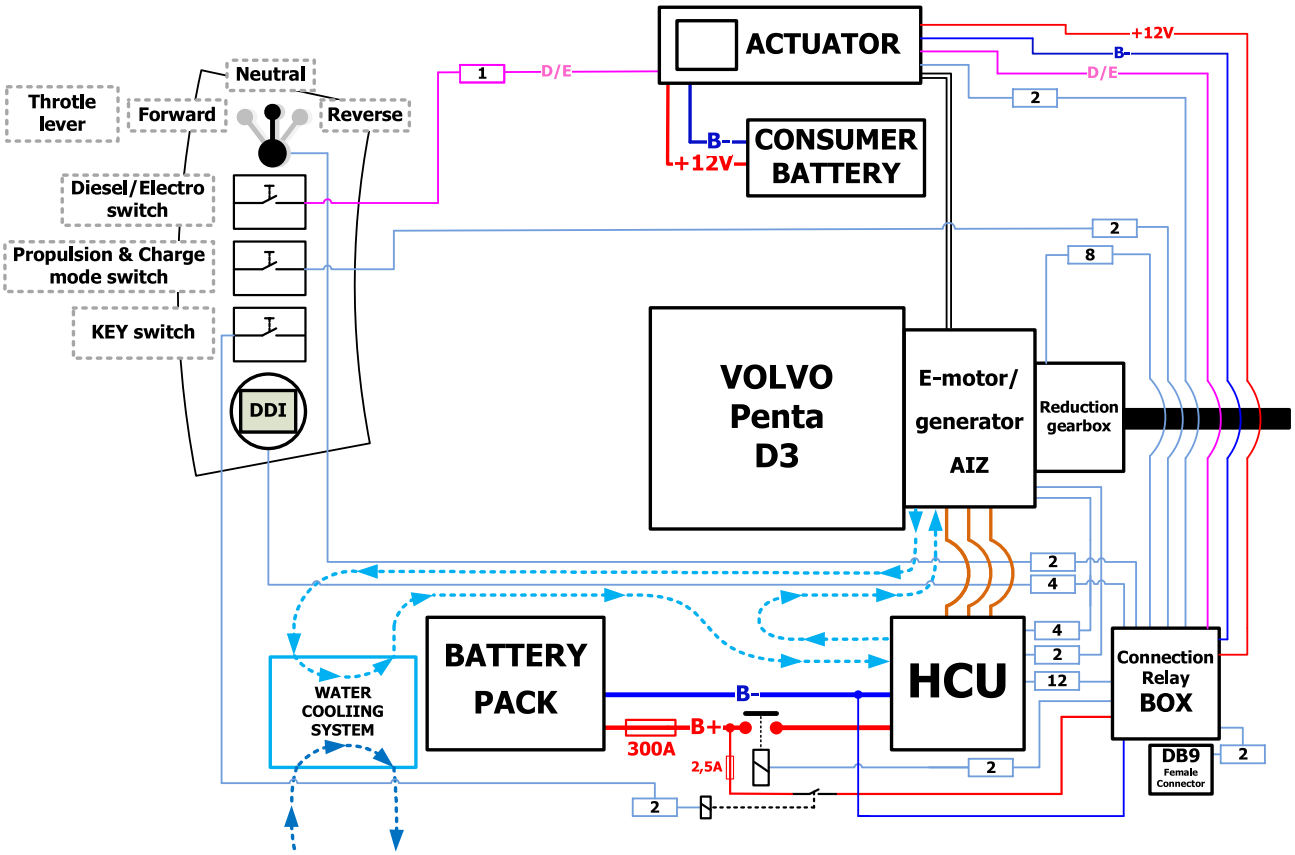

Figure 1: Example block diagram of the hybrid drive system; Block diagram of specific model of vessel vary from that according to boat design - for details consult boat builder

3.2 E-motor/Generator (AIZ)

The E-motor is a three-phase asynchronous induction motor with a squirrel-cage rotor. It is a brushless type motor as electrical power is transmitted from the stator to the rotor by induction.
Stator and rotor are placed to the supporting and at the same time protecting water-cooled cover which is installed between the diesel engine and drive reduction gearbox. Power transfer from the diesel engine to the E-motor/generator is performed by the disc clutch, which is managed by the electro-hydraulic actuator.
The E-motor is additionally equipped with an incremental encoder (speed sensor) and two integrated thermal sensors (one is redundant) on the stator winding.

Motor maximal AC voltage	36 V_{RMS} (phase voltage)
Maximal power	14 kW
Maximum speed	1600 rpm
Maximum imposed speed	4000 rpm
Maximum torque	100 Nm
Operating ambient temperature	-15°C - 70°C
IP protection degree	IP55
Min. coolant flow	8 l/min at 30° C
Mass	120kg
Max allowed stator winding temperature	155°C
Motor temperature safety power reduction	115°C

Table 1: E-motor specifications

3.3 Hybrid Control Unit (HCU)

Hybrid (electronic) control unit AEK H60V 400A consists of power stage attached to the base plate, which also serves as a heat sink through which the coolant flows and logical part of the control unit with an appropriate software to ensure the efficient functioning of HCU.
HCU ensures the proper operation of the hybrid drive system. HCU can charge propulsion battery in generator mode or control the E-motor to navigate the boat in the E-motor mode. A special control system allows to choose between the E-motor mode and the diesel engine boat drive.

Operating voltage range	36 V < U_{DC} < 69 V
Maximum phase current	400 A
Operating ambient temperature	-15°C - 70°C
IP protection degree	IP65
Over-voltage protection	72 V
Under-voltage protection	32 V
Min. coolant flow	8 l/min at 30° C
Mass	3,15 kg
HCU temperature safety power reduction	85°C

Table 2: HCU specifications

POS	Part identifications	Part name
1a	Volvo Penta D3	Diesel engine
1b	Gear box	Gear box
2	11.221.016*	Electro Motor - Generator
3	11.258.476*	HCU – 48/60V 400Amp
4	16.913.168*	Clutch actuator
5	46.511.669*	Harness
6	11.255.110*	Indicator DDI AEB

* Letrika part numbers are informative only to define format; please consult with boat builder about.

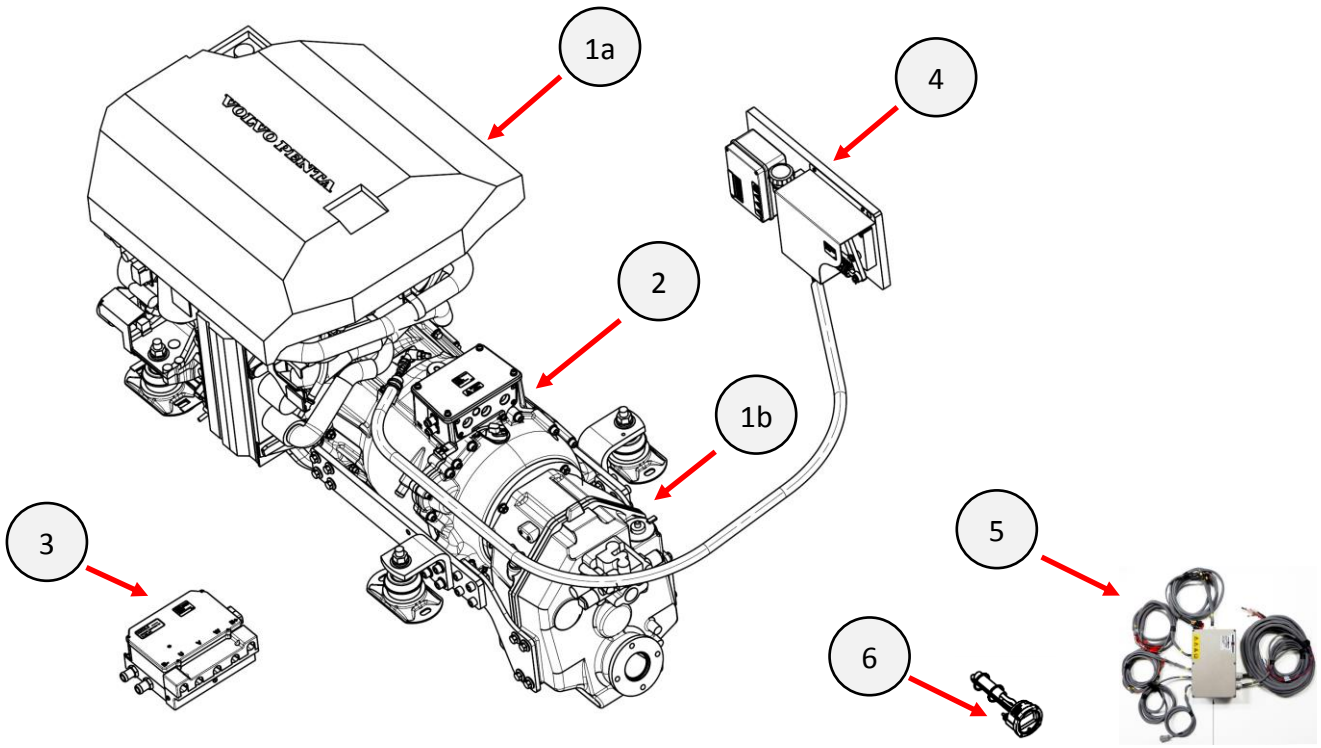

Table 3/Figure 2: The hybrid drive system's elements

4. DESIGNATIONS AND DATA

Letrika main hybrid drive system elements have the following designations:

- Trade mark and manufacturer's name.
- Type designation.
- Part number.
- Nominal voltage and nominal power.
- Designations of electric connections.
- Serial number with date/month of manufacture.

5. MATERIALS

Hybrid drive system is designed and made of materials compliant with the environmental directives.

6. HYBRID DRIVE SYSTEM OPERATION

WARNING 1: Hybrid control unit HCU is not protected against wrong polarity connection to the propulsion battery. Wrong polarity connection could immediately cause permanent damage to the HCU.

WARNING 2: When installing the hybrid drive system first connect all the B- terminals of hybrid drive system and B- terminals of 12V and 48V battery to common ground. Connect all the other B+ and signal connections after that.

WARNING 3: When disconnecting the hybrid drive system first disconnect all B+ and signal connections. Disconnect all the B- terminals of hybrid drive and B- terminals of 12V and propulsion battery from common ground after that.

6.1 Cooling system

The cooling system uses external water with heat exchanger for cooling the E-motor / generator and HCU. Each hybrid drive system on the boat must have installed an appropriate electric pump, which ensures flow of the cooling water through the system, minimum 8 litres / minute and with the temperature max. 35ºC.
Proper sequence of installation: From heat exchanger output to HCU, and from HCU to E-motor.

The cooling system has to operate in the motor and generator mode of the hybrid system.

The cooling system operation is checked with a regular visual inspection of the coolant flow.
After a longer pause, it is needed to verify and ensure the coolant flow in the cooling system.

The temperature protection disengages the hybrid system in case if E-motor / generator or electronic controller exceeds maximal allowed temperature. In this case the user must wait for hybrid system to cool down before the hybrid system can be used again.

Check the cooling system.

Diesel engine could be used regardless of hybrid system temperature protection activation.

6.2 Generator mode of operation

6.2.1 Settings for propulsion battery charging

In the generator mode of operation, the electronic controllers of the hybrid drive system ensure a controlled charging of propulsion battery, which is based on the voltage measurement.

In idle running, the diesel engines have enough power only for its own use and maintenance of smooth running. The hybrid drives in the generator mode draws additional mechanical power, which the diesel engines in the idle running cannot provide. In idle mode battery charging is disabled. Generator mode begin charging when speed on diesel engine is higher than 900 rpm end interrupt when speed drops below 850 rpm.

Due to the harmonization of the hybrid drive system in the charging mode with the torque characteristics of the diesel engine, the size of the maximum charging current for an individual type of the propulsion battery is limited also with reference to the current revolutions of the diesel engine.

6.3 E-motors mode of operation

With reference to the power of the drive diesel engine, the power of the electric drive is selected and is used mostly for navigation at low speed.

The desired rotational E-motor speed is set through the throttle control lever of the diesel engine.

During E-motor mode of operation the electric energy from propulsion battery is used and voltage on battery terminals is getting lower. When the voltage drops below defined limit the system must be switched to diesel mode for recharging the battery.

Similar to the diesel engine, E-motor has to operate compliant with the combination of the prescribed reduction gearbox.

The system operates so that the E-motor does not rotate when the throttle control lever is in neutral position. It engages when the lever is moved from neutral position. Then the E-motor rotates with 400 revolutions and the clutch in the reduction gearbox is activated. A short time-lag occurs between the shift of the throttle lever and the reaction of the E-motor. At the moment of clutch engagement in the reduction gearbox, a small thrust can be felt.

6.4 Data Display Interface (DDI)

6.4.1 Introduction

DDI is intended to display data of the operation mode and the measured values of the hybrid drive system.

DDI shows the current working mode of the hybrid drive system, battery current, speed and temperature of electric motor, error codes and also some other data useful for service personnel. Presented data are only indicative, with a tolerance of ±5%.

6.4.2 DDI screen's description

Screen consists of two lines. When error is occurred in hybrid system the third line is displayed (Table 4).
Below the display is LED and when the hybrid system works properly, the LED is green. If malfunction occur somewhere in the hybrid system, the LED turns red.

The mode of operation of the hybrid drive system in the boat has to be adjusted so that all values shown in the DDI are within the limits of the frame value at the normal use.

6.4.2.1 NORMAL MODE

	Data 1	Description	Data 1 normal range	Data 2	Description	Data 2 normal range
SCREEN						
Line 1	***Mode***	Operation mode	Idle, Motor, Generator	***Ib***	Battery current	from -150 to 310 A
Line 2	***MotT***	Motor temperature	from -10°C to 100°C	***RPM***	Speed (RPM)	0 to 1600(Electric) 0 to 4500 (Generator)

Table 4: The values shown on DDI

Figure 3: Electric mode (picture is symbolic)

Line 1, Data 1: *Mode: x*
Mode: x shows the current operation i.e. working mode of HCU unit.

'*x*' can be:

- **Idle** - neutral mode (only logic part of HCU is active)
- **Motor** - electric motor mode i.e. electric propulsion
- **Generator** - generator mode i.e. diesel engine active, HCU charges batteries

Line 1, Data 2: *Ib: xA*
Ib: xA indicates current flowing into / out of HCU battery terminals in 1A resolution.
Sign '–' appears before the value when the battery is discharging, i.e. during electric mode.

Line 2, Data 1: *MotT: xC*
MotT: xC indicates electric motor temperature in Celsius degree.

Line 2, Data 2: *RPM: x*
RPM: x indicates the speed of E-motor / generator in revolutions-per-minute (RPM) unit.

6.4.2.2 WARNING/ERROR MODE

When warning//errors are detected, the LED changes from green to red and the third line shows up. The values are displayed in HEX format to simplify error recognition when more warnings/errors ocurr at the same time. Single bit (warning/error flag) has default value ‘0’, and changes to ‘1’, if a corresponding warning/error occurs. The warnings/errors are shown until the cause of the failure persists, and then are automatically cleared.

Figure 4: Warning/Error screen with red LED

	Data 1	Description	Data 1 normal range	Data 2	Description	Data 2 normal range
SCREEN						
Line 1	***E:***	Warning/Error mode	Warning/Error number	***Ib***	Battery current	from -150 to 310 A
Line 2	***MotT***	Motor temperature	from -10°C to 150°C	***RPM***	Speed (RPM)	0 to 1600(Electric) 0 to 4500 (Generator)
ERROR LINE						
Line 3	***Warning/Error in binary format*** (0000 0000 0000 0000)					

Line 1, data 1: *E:000xx*
E:x indicates the warning/error which occurred on hybrid drive system.

Line 3:
Shows warning/error in hex format e.g. 0002 0000 0000 0000.

6.4.2.3 SCREEN: Connection lost

SCREEN: Connection lost	
Line 1	***!! HCU LOST !!***

Figure 5: "!! HCU LOST !!" screen

If CAN communication between HCU and DDI is interrupted then the following message appears: **"!! HCU LOST !!"**.

6.4.2.4 Warning/Error list

Warning/Error	DDI display	Code	Description	Controller action	Possible cause
High DC link voltage	E:0013	13	Voltage on DC link capacitors increased over 72 V.	Power stage off, then if capacitors' voltage drops below 70 V power stage again on.	Generating too high charge current when battery fully charged. Contactor opened during Generator mode (charging). Bad contact on battery power cables, connections or contactor contacts when charging.
Low DC link voltage	E:0014	14	Voltage on DC link capacitors dropped below 32 V.	Power stage off, if capacitors' voltage increases over 38 V power stage again on.	Empty or bad battery. Contactor opened during Motor mode. Bad contact on battery power cables, connections or contactor contacts when accelerating.
5 V supply	E:0015	15	5 V supply line failed.	Power stage off, main contactor open	5 V voltage supply (pin 10) shorted to ground (pin 8 or B-).
12 V supply	E:0016	16	12 V supply line failed.	Power stage off, main contactor open	12 V voltage supply (pin 9) shorted to ground (pin 8 or B-). Encoder fault.
Current and voltage sensors calibration	E:0017	17	Wrong parameters for current and voltage sensor calibration in FRAM memory.	Power stage off, main contactor open.	Bad FRAM memory reading. Controller fault.
Current sensors offset	E:0018	18	Current sensors failed.	Power stage off, main contactor open.	Controller fault.
Motor phase shorted	E:0021	21	U, V or W shorted to B+ or B- or a short between two motor phases.	Power stage off, main contactor open	Bad connection of controller power cables. Motor failure. Controller power stage failure. Can be triggered by short circuit on 12 V line (pin 9). (1)
Contactor coil over-current	E:0023	23	Excessively high current flowing through contactor coil.	Power stage off, main contactor open	Contactor coil failed or controller pin 2 (DIGOUT1) directly connected to B+.
Contactor bridge	E:0024	24	Contactor did not close. Contactor bridge opened during drive.	Power stage off, main contactor open	Contactor fault. Bad contactor power studs connection.

Contactor welded	E:0025	25	Whole battery voltage is present on capacitors before contactor is closed.	Error signalization.	Contactor fault. Contactor power studs are shorted together.
Parameters error	E:0026	26	The controller parameters stored in FRAM memory are bad.	Power stage off, main contactor open.	Wrong procedure when changing the controller parameters through CAN j1939 or console.
Encoder fault	E:0032	32	Encoder error.	Power stage off, main contactor open.	Bad encoder connection or encoder failed. It can be triggered by strong (mechanical) braking with very low motor load.
Charging capacitors failed	E:0036	36	Capacitors did not charge in time.	Power stage off, main contactor open.	Bad system harness, controller fault.
Controller over-temperature	E:0041	41	Controller temperature above 95 °C.	Power stage off, main contactor open, vehicle coasts. (3)	Continuously high motor load.
Motor over-temperature	E:0042	42	Motor temperature above 150 °C.	Power stage off, main contactor open, vehicle coasts. (4)	Continuously high motor load.
Controller temperature sensor	E:0043	43	Bad controller temperature sensor reading.	Performance reduced as if controller temperature was 90 °C.	Controller temperature sensor fault.
Motor temperature sensor	E:0044	44	Bad motor temperature sensor reading.	Performance reduced as if controller temperature was 140 °C.	Motor temperature sensor fault or bad sensor connection.
High controller temperature	E:0051	51	Controller temperature above 85 °C.	Reduced performance (motor current, speed and acceleration limited). (3)	Continuously high motor load.
High motor temperature	E:0052	52	Motor temperature above 140 °C.	Reduced performance (motor current, speed and acceleration are limited). (4)	Continuously high motor load.

Digital output 3 over-current	E:0072	72	Excessively high current flowing through relay coil.	Digital output 3 (controller pin 4) is switched off. (2)	Controller pin 4 (DIGOUT3) is shorted to B+. Relay failed. Bad relay wiring. Wrong relay type.
Digital output 4 over-current	E:0073	73	Excessively high current flowing through digital output.	Digital output 4 (controller pin 5) is switched off. (2)	Controller pin 5 (DIGOUT4) is shorted to B+. Bad relay wiring. Wrong relay type.
Motor stalled	E:0083	83	Motor blocked.	Power stage off.	The motor could not rotate. Rotor blocked. Clutch error.
Clutch error	E:0091	91	Signals on digital inputs CL_OPEN, CL_CLOSE are equal (0 or 1) for more than 8 seconds	Power stage off, main contactor open.	Clutch damage, error on wiring.
CAN communication Throttle Lever	E:0093	93	No CAN messages from throttle for more than 300 milliseconds	Motor speed decrease to 0rpm.	Wiring error, throttle/controller/DDI error
CAN communication Volvo Penta controller	E:0094	94	No CAN messages from Volvo controller for more than 300 milliseconds	Motor speed decrease to 0rpm.	Wiring error, throttle/controller/DDI error
WARNINGS: Report, that some failure present, but mainly little or nothing affect normal controller operation.					
Main contactor welded	E:0025	25	Voltage on DC link capacitors present at key ON.		Bad contactor contacts, failure on contactor.
Controler temperature sensor	E:0043	43	Measured controller temperature is lower than -70 °C or higher than 250 °C	Reduced performance	Bat controller PTC sensor, failure on PTC
Motor temperature sensor	E:0044	44	Measured controller temperature is lower than -70 °C or higher than 300 °C	Reduced performance	Bat motor PTC sensor, failure on PTC

Controller high temperature	E:0051	51	Controller temperature between 85 °C and 85 °C	Reduced performance	No proper cooling, failure on PTC
Motor high temperature	E:0052	52	Motor temperature between 150 °C and 160 °C	Reduced performance	No proper cooling, failure on PTC
Dig.OUT 2 (pin3) open load	E:0061	61	Open load of digital output 2 (if DOUT2 is used in application)		Wiring broken, not connected
Dig.OUT 3 (pin4) open load	E:0062	62	Open load of digital output 3 (if DOUT3 is used in application)		Wiring broken, not connected
Dig.OUT 4 (pin5) open load	E:0063	63	Open load of digital output 4 (if DOUT4 is used in application)		Wiring broken, not connected
Dig.OUT 5 (pin6) open load	E:0064	64	Open load of digital output 5 (if DOUT5 is used in application)		Wiring broken, not connected
Dig.OUT 6 (pin7) open load	E:0065	65	Open load of digital output 6 (if DOUT6 is used in application)		Wiring broken, not connected
Digital output 2 over-current	E:0071	71	Excessively high current flowing throughdigital output.(if used in application)	Digital output 2 (controller pin 3) is switched off. (2-see above)	Controller pin 3 (DIGOUT2) is shorted to B+. Bad relay wiring. Wrong relay type.
Digital output 5 over-current	E:0074	74	Excessively high current flowing throughdigital output.(if used in application)	Digital output 5 (controller pin 6) is switched off. (2-see above)	Controller pin 6 (DIGOUT5) is shorted to B+. Bad relay wiring. Wrong relay type.
Digital output 6 over-current	E:0075	75	Excessively high current flowing throughdigital output.(if used in application)	Digital output 6 (controller pin 7) is switched off. (2-see above)	Controller pin 7 (DIGOUT6) is shorted to B+. Bad relay wiring. Wrong relay type.

(1) The error can also be triggered due to encoder failure at high motor speeds.
2) If one of the controller's digital outputs is shorted to B+, all digital outputs are switched off. Manual checking of the contactor, relay, must be performed. Warning light signaling will not work, so the error log must be checked.
(3) When the controller cools down to 82 °C the power stage and contactor are switched on and controller function is allowed.

Table 4: Error list

6.5 Clutch actuator

Clutch actuator engages and disengages the clutch disc between the diesel engine and the E-motor through the clutch master cylinder and the clutch slave cylinder. The clutch actuator requires approximately 5 seconds to switch from one position to another.

The main components of the clutch actuator are shown in the Figure 6.

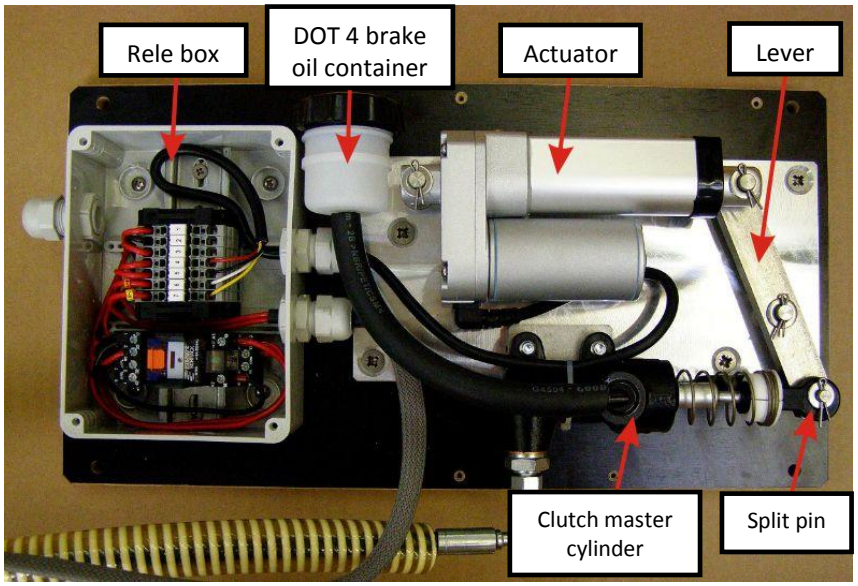

Figure 6: Electro-hydraulic clutch actuator

The clutch actuator must be installed to a protected and dry place in the boat and should not be exposed to vibrations of the diesel engine or drive assembly.

Hydraulic system is filled with brake fluid DOT 4.

The brake fluid level in the hydraulic oil container must be checked every month.

6.5.1 Manual engagement of the disc clutch

In case of actuator failure and when the clutch stays in the open position and therefore the diesel engine is not connected with the reduction gearbox, it is necessary to engage the clutch to make a transition to the diesel drive. This can be done so that we:

- Disengage the hybrid system power sources.

- Disassemble the mechanical connection between the electric actuator lever and the pressure cylinder. Draw out the »split pin« and the pin, which connects the lever and the »clutch master cylinder«. In this way we release the piston rod and as a consequence, the pressure in the clutch master cylinder and the clutch slave cylinder falls, what enables the return of the disc clutch to the working position.
- Start the diesel engine.

NOTE:
The use of E-motor mode is possible after the service repair.

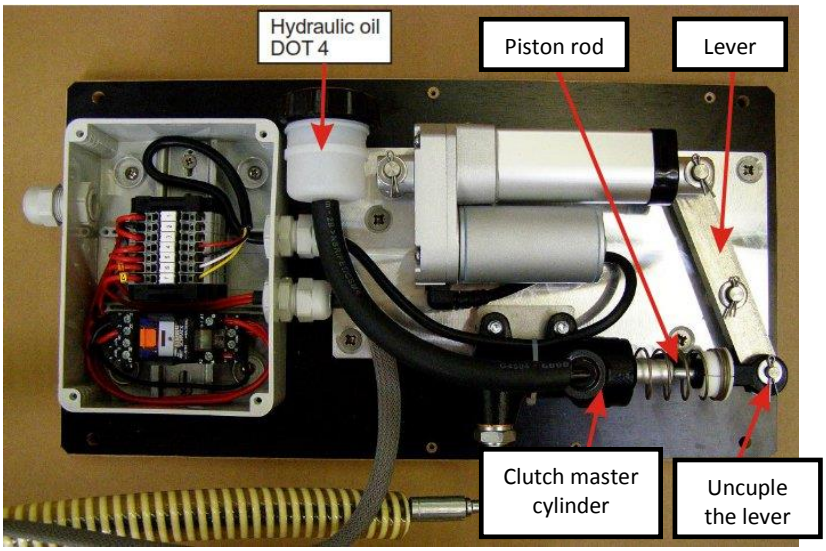

Figure 7: Electro-hydraulic clutch actuator

6.6 Disc clutch

Automotive disc clutch is installed to the flywheel in a diesel engine.

When the clutch is engaged, the mechanical power is transmitted through it from the diesel engine over the E-motor / generator to the drive reduction gearbox. At the same time, the E-motor / generator produces electric energy to charge propulsion battery and consumers.

When the clutch is disengaged, the E-motor / generator can operate in the E-motor mode to drive a boat.

Engagement and disengagement of the clutch disc between the diesel engine and the E-motor is performed by the clutch slave cylinder through the clutch actuator. Engagement and disengagement of the clutch disc is allowed only when a diesel engine is stopped and the E-motor / generator is still.

7. BLEEDING THE CLUTCH HYDRAULIC SYSTEM

Bleeding of clutch actuator is required in case of drop of pressure in hydraulic actuator system unable proper clutch disc engagement / disengagement due to leakage of fluid or maintenance work.

WARNING: Only qualified personnel should perform this operation!

7.1 Bleeding the clutch hydraulic system procedure

Letrika is using special equipment for oil pumping that we recommend to use or we suggest to consult boat builder for alternative procedure.

When the system is bled, master cylinder piston rod becomes very stiff to push **IN** by hand.
If necessary, add brake fluid in the container.

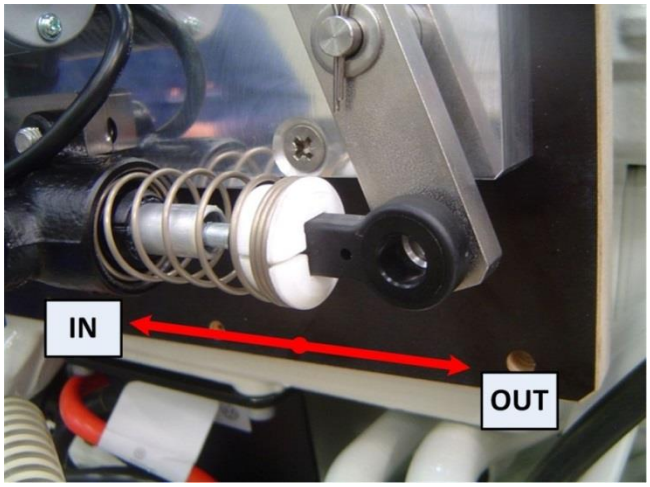

Figure 20

7.2 Clutch function test

How to check if the clutch is disengaged:

- Set the ***DIESEL / ELECTRIC HYBRID SWITCH*** to ***ELECTRIC***,
- E-motor should be run at gearbox neutral position and full throttle – max. revolutions.
- Data display interface (DDI) must display:
  - **E-motor speed min. 1000 rpm.**
  - **Max. battery current – according to system specification.**

8. FUNCTIONAL OPERATION CONTROL

For a safe use of the entire boat with a hybrid drive system, the user has to regularly check the operation of all functions. In so doing, no unexpected events or failures should occur.

The user must regularly check the following functions:

- **Selection of operation between the diesel and the electric drive.**
- **Actuator operation for clutch engagement and disengagement.**
- **Diesel engine start and smooth running control.**
- **Diesel drive operation (without unusual noise and vibration).**
- **Electric drive operation (without unusual noise and vibration).**
- **Operation in the generator mode and battery charging.**
- **Operation of the lever for the rotational speed setting in the diesel and electric drive.**
- **Operation of DDI and other controlling instruments in the boat.**
- **Operation of the cooling system for a controller and an electric motor of the hybrid drive.**

9. INSTRUCTIONS FOR A SAFE USE OF THE TWIN HYBRID DRIVE SYSTEM

The manufacturer of the boat prepares instructions for a safe use of the entire boat with the twin hybrid drive system.

The boat user must, for using the hybrid drive system, consider the following:

- **Equally and slowly add and reduce gas in the diesel and E-motor mode of operation.**
- **At various boat manoeuvres in the electric mode of operation, such as:**
  - **turning the boat around (in case of twin hybrid system - one throttle lever in Forward, the other in Reverse),**
  - **jerky start (throttle lever fully open in Forward or Reverse),**
  - **fast change of propulsion direction (throttle levers from Forward to Reverse or vice versa),**
  - **propulsion with berthed or anchored vessel,**

  can cause a major controller and E-motor overload, therefore it is recommended not to use full power of the drive. At the boat navigation and manoeuvring is necessary to control values on DDI, for each hybrid drive system. In the case of exceeded maximum values, errors can occur in the hybrid drive system (short-term or permanent power reduction, other errors.

Avoid unstable operation of the diesel engine with vibrations in the idle running.

- **Avoid operation of the hybrid drive system in the range of revolutions, where vibrations of the drive system or the entire boat can be increased. In case of potential replacement of the boat's drive system, its part or propeller, the working conditions can change.**
- **Continued surveillance of data in the controlling instruments and other observations about operation.**

In case of any malfunction in the operation of each hybrid drive system (e.g. irreparable error on the controller, vibration or unusual noise from the mechanical drive system, ...) it is necessary to immediately disengage the defective system by turning off hybrid system power sources. It is necessary to return to the nearest port or mooring with a functioning hybrid drive system.

In the case of cancellation or malfunction in the operation of both electrical drives, it is necessary to immediately disengage both systems by turning off the hybrid system power sources and return to the nearest port or mooring on diesel engine drive, with reduced power.

In any case, the electric pump, which has to ensure the cooling water flow, must be in operation.
Before the further use of the boat, it is necessary to check the system and the boat, and eliminate the fault.

The boat user has to follow the instructions for safety when using the hybrid drive system and boat.