

1. SAFETY

Za varno uporabo plovila s hibridnim pogonom mora uporabnik upoštevati navodila proizvajalca plovila in navodila *Hibridni pogon – Navodilo za uporabo*.

Ko plovilo ne pluje ali na njem ni nikogar ter med skladiščenjem ali v času prevoza plovila, mora biti stikalo *DIESEL / ELECTRIC HYBRID SWITCH* za izbiro med diesel in elektro pogonom vedno v *DIESEL* položaju. Stikalo *48V HYBRID DRIVE SWITCH* pa mora biti izklopljeno.

Upoštevajte vsa opozorila na nalepkah. Ne odstranjujte opozorilnih nalepk.



Med delovanjem se enota segreje in ostane vroča še nekaj časa. Uporabljajte zaščitno obleko, zaščitne rokavice in zaščitna očala, ko delate v bližini teh delov.

1.1 Warning

Elektronski krmilnik HCU nima zaščite proti zamenjavi polaritet pri priklopu krmilnika na baterijo. Napačna priključitev polaritet povzroči takojšnjo in trajno poškodbo elektronskega krmilnika HCU.

For the safe use of the hybrid drive boat, the user has to follow the instructions given by the boat manufacturer and instructions *Hybrid Drive – Owner's Manual*.

When the boat is not propelled or there is no person on board, on storage or transport of the boat the *DIESEL / ELECTRIC HYBRID SWITCH* must be always in *DIESEL* position and the *48V HYBRID DRIVE SWITCH* must be in OFF position.

Follow all labelled warnings. Do not remove the warning labels.



The unit is hot when running and for a time thereafter. Use protective clothing, protective gloves and protective eyeglasses when working around this components.

Hybrid control unit HCU is not protected against wrong polarity connection to the battery. Wrong polarity connection will immediately cause permanent damage to the HCU.

2. AUZ 4120 48V 5/7 kW HYBRID DRIVE OPERATION

2.1 Purpose and basic information

Hibridni pogon omogoča tiho plovbo z električnim motorjem pri nižjih hitrostih ter plovbo z dieselskim motorjem pri višjih hitrostih. Isti električni motor deluje tudi kot generator električne energije gnan z diesel motorjem.

Hybrid drive enables quiet navigation by electric motor at a lower speed and navigation by diesel engine at a higher speed. The same electric motor functions also as an electric energy generator powered by diesel engine.

Za zagon pogona plovila po vrsti vklopimo:

1. *12V ENGINE BATTERY SWITCH*,
2. *48V HYBRID DRIVE SWITCH*,
3. *48V HYBRID/HOUSE BATTERY SWITCH*.

To start the boat propulsion switch on in order:

1. *12V ENGINE BATTERY SWITCH*,
2. *48V HYBRID DRIVE SWITCH*,
3. *48V HYBRID/HOUSE BATTERY SWITCH*.

2.2 Diesel and E-motor mode selection of operation

Izbiro načina delovanja hibridnega sistema omogoča stikalo **DIESEL / ELECTRIC HYBRID SWITCH** na nadzorni plošči.

Za preklop iz enega načina delovanja v drugega potrebuje sistem približno 5 sekund.

Preklop je dovoljen samo ob ugasnjenem diesel motorju in mirujočem električnem motor – generatorju.

The mode of operation of the hybrid system is selected by the **DIESEL / ELECTRIC HYBRID SWITCH** positioned on dash board.

Switching between modes of operation requires about 5 seconds.

Switching between modes is allowed only when diesel engine is stopped and the electric motor – generator is stopped.

2.3 Instructions for a safe use of the hybrid drive

Pred vožnjo s plovilom mora uporabnik redno kontrolirati delovanje funkcij:

- Izbiro delovanja med dieselskim in električnim pogonom.
- Delovanje aktuatorja za vklop in izklop sklopke.
- Zagon diesel motorja in kontrolo mirnega teka.
- Delovanje v generatorskem režimu in polnjenje akumulatorjev.
- Vožnjo z dieselskim pogonom.
- Vožnjo z električnim pogonom.
- Delovanje ročke za nastavljanje vrtilne hitrosti dieselskega in električnega pogona.
- Delovanje DDI in ostalih kontrolnih instrumentov na plovilu.
- Delovanje hladilnega sistema za krmilnik in električni motor hibridnega pogona.

Uporabniku plovila priporočamo naslednje:

- Enakomerno in počasno dodajanje ter odzemanje plina.
- Izogibanje nemirnemu delovanju diesel motorja v prostem teku.
- V kolikor pride pri nekih vrtiljajih do povečanja vibracij pogonskega sistema ali celega plovila priporočamo izogibanje delovanju diesel motorja v tem področju.
- Stalen nadzor podatkov na kontrolnih instrumentih in druga opažanja o delovanju.

V primeru, da se pojavijo kakršnekoli nepravilnosti v delovanju hibridnega pogona je nujno takoj izklopiti hibridni pogon in stikalo **48V HYBRID DRIVE SWITCH** na palubi in se vrniti v najbližje пристanišče ali sidrišče s pogonom na diesel motor.

User has to regularly check the operation of functions before use of the boat:

- Selection of operation between the diesel and the electric drive.
- Actuator operation for clutch engagement and disengagement.
- Diesel engine start and smooth running control.
- Operation in the generator mode and battery charging.
- Driving with a diesel drive.
- Driving with an electric drive.
- 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.

We recommend the user of the boat to :

- Smoothly and slowly add and reduce power.
- Avoid unstable operation of the diesel engine with vibrations in the idle running.
- In case of increased vibrations of the drive system or of the entire boat avoid operation of the diesel engine in this specific speed range.
- Continuously monitor the data on the controlling instruments and observe behaviour of the system operation.

In case of any malfunction of the hybrid drive, you must immediately disengage the hybrid drive and switch off the **48V HYBRID DRIVE SWITCH** on the deck and return to the nearest port or mooring on diesel engine drive.

V vsakem primeru mora delovati električna črpalka, ki mora zagotoviti pretok hladilne vode.

Pred nadaljnjo uporabo plovila je potreben pregled sistema in plovila ter odprava napake.

In any case, the electric pump, which has to ensure the cooling water flow, must be in operation.

Before further use of the boat, it is necessary to check the system and the boat, and eliminate the fault.

2.4 Generator mode of operation

V generatorskem režimu delovanja elektronski krmilnik integriranega hibridnega pogona zagotavlja nadzorovano polnjenje pogonske baterije 48 V.

V primeru, ko je pogonska baterija močno izpraznjena lahko to pri polnjenju povzroči nemiren tek diesel motorja v prostem teku. To odpravimo z dvigom vrtljajev diesel motorja.

Med generatorskim delovanjem se ne sme izklopiti stikala **48V HYBRID DRIVE SWITCH**, ker to lahko povzroči trajno odpoved elektronskega krmilnika.

In the generator mode of operation, the electronic controller of the integrated hybrid drive enables a controlled charging of drive batteries 48 V.

In case of deep discharge of the propulsion battery the vibrations may occur on diesel engine in idle run. Increase of the diesel engine speed will suppress the vibrations.

When the hybrid drive operates in the generator mode it is not allowed to disconnect the **48V HYBRID DRIVE SWITCH**. In the extreme case this can cause a permanent failure of the electronic controller.

2.5 E-motor mode of operation

Želeno vrtilno hitrost E-motorja se nastavlja preko komandne ročke »plina« diesel motorja.

Med delovanjem E-motorja se pogonska baterija prazni in se zato niža napetost na njenih sponkah. Ko napetost pogonske baterije pade pod 44 V, se aktivira opozorilni signal iz polnilnega sistema Victron. Nadaljnje praznjenje baterije ni priporočljivo in je potreben prehod na diesel pogon in ponovno polnjenje baterije.

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

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 44 V warning signal comes from Victron charging system. From this point it is not recommended to continue discharging the battery and the system must be switched to diesel mode for recharging the battery..

2.6 Cooling system

Hladilni sistem uporablja zunanjo vodo za hlajenje električnega motor – generatorja in elektronskega krmilnika. Delovati mora v motorskem in generatorskem režimu delovanja hibridnega sistema.

Po vsakem daljšem mirovanju plovila je potrebno preveriti in zagotoviti pretočnost vode v hladilnem sistemu ter sistem po potrebi očistiti.

The cooling system uses external water for cooling the electric motor – generator and electronic controller. The cooling system has to operate in the motor and generator mode of the hybrid system.

After a longer pause, the cooling system should be checked and water flow in the cooling system should be normal. If necessary clean the cooling system.

Hibridni sistem ima temperaturno zaščito, ki se aktivira v slučaju pregretja in izklopi hibridni sistem. Hibridni pogon se mora ohladiti preden ga lahko ponovno uporabimo.

Preveriti je potrebno delovanje hladilnega sistema.

Diesel motor deluje neodvisno od vklopa temperaturne zaščite hibridnega pogona.

Hybrid system has a temperature protection which activates in case of exceeding maximal allowed temperatures and disengages the hybrid system. Hybrid system must cool down before it can be used again.

Check the cooling system.

Diesel engine operates independently of the hybrid system temperature protection activation.

2.7 Data Display Interface (DDI)

Podatkovni prikazovalnik DDI je namenjen prikazovanju podatkov za nadzor načina delovanja in izmerjenih vrednosti v hibridnem sistemu.

DDI prikazuje trenutni način delovanja sistema hibridnega pogona, baterijski tok, vrtilno hitrost in temperaturo električnega motorja, šifre napak in druge podatke uporabne za serviserje. .

Prikazani podatki so zgolj indikativni, z natančnostjo $\pm 5\%$.

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

DDI shows current working mode of the HCU, battery current, speed and temperature of electric motor, error codes and also some other data useful only for service personnel.

Presented data are only indicative, with a precision of $\pm 5\%$.



DDI - Data Display Interface device

3. COMPLETE OWNER'S MANUAL

Hibridni pogon – Navodilo za uporabo podajajo natančnejšo razlago za uporabo in servisiranje hibridnega pogona.

Hybrid Drive – Owner's Manual contains detailed description and detailed instructions for use and service of the hybrid drive.

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1. SAFETY

Za varno uporabo plovila s hibridnim pogonom mora uporabnik upoštevati navodila proizvajalca plovila in ta navodila za Hibridni pogon Greenline 33H – Navodila za uporabo.

Prosimo, najprej preberite navodila, ki so priložena hibridnemu pogonu tako, da boste spoznali vsa varnostna opozorila pred uporabo Hibridnega pogona.

Pred upravljanjem s hibridnim pogonom preberite ta priročnik, da vam bodo poznane vse lastnosti izdelka. Preberite tudi ločeni priročnik za diesel motor in ostale priročnike, ki so dodani plovilu.

Hibridni pogon se sme uporabljati samo za namen za katerega je bil izdelan.

Pomembno je, da se seznanimo z električno vezalno shemo plovila z vsemi originalno vgrajenimi aparati na krovu (priključek za polnjenje baterije iz stebrička na obali, solarni sistem, porabniki na krovu, potisni motorji na premcu, klimatske naprave, sidrni vitlel, ..)

Kasneje dodatno vgrajeni električni porabniki lahko vplivajo na pravilno delovanje hibridnega sistema ali drugih električnih komponent na plovilu.

Vsako nameravano spremembo v električni instalaciji na plovilu mora odobriti proizvajalec plovila in o tem obvestiti Iskro Avtoelektriko d.d. Spremembo sme opraviti samo za to usposobljena oseba.

For the safe use of the hybrid drive boat, the user has to follow the instructions given by the boat manufacturer and these instructions for the Hybrid Drive Greenline 33H – Owner's Manual.

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

Before operating the hybrid drive 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 should be used for the designated application only.

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 electrical components can have an impact on the correct function of the hybrid system 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 Iskra Avtoelektrika has to be informed about it. The change can be performed only by a professional person qualified to do so.

1.1 **WARNING: Danger of electrical shock**

Hibridni pogon uporabljamo v kombinaciji s trajnim virom energije (pogonska baterija), polnilcem iz stebrička na obali ter fotovoltaičnim sistemom. Tudi, ko je sistem izklopljen se na vhodnih in/ali izhodnih priključkih lahko pojavi visoka napetost. Vedno izklopite stikalo **48V HYBRID DRIVE SWITCH** preden opravite kakršenkoli vzdrževalni poseg na hibridnem pogonu tudi, ko hibridni pogon ni v uporabi.

Hibridni pogon ne vsebuje delov, ki bi jih uporabnik lahko sam servisiral. Ne odstranjujte zaščitnih pokrovov in ne vklaplajte hibridnega pogona, če zaščitni pokrovi niso pravilno nameščeni. Vsako vzdrževalno delo mora opraviti kvalificirana oseba.

Ne uporabljajte hibridnega pogona v okolju kjer lahko pride do eksplozije hlapov vnetljivih tekočin, plina in prahu.

Hibridni pogon je pripravljen za delovanje z originalno vgrajeno baterijo na plovilu. Pri zamenjavi baterije je potrebno uporabiti enak tip in velikost. Zamenjavo drugačne baterije in nastavitev hibridnega pogona lahko opravi samo pooblaščen servis za plovilo, ki mora obenem prilagoditi parametre polnjenja glede na nov tip in velikost pogonske baterije. Za več informacij glej poglavje : **Generator mode of operation**

Upoštevajte tudi navodila proizvajalca baterij in se prepričajte, da so baterije ustrezne za uporabo s tem izdelkom. V vsakem primeru je potrebno obvezno upoštevati varnostna navodila proizvajalca baterij.

Ko plovilo ne pluje ali na njem ni nikogar, mora biti stikalo *DIESEL / ELECTRIC HYBRID SWITCH* za izbiro med diesel in elektro pogonom vedno v *DIESEL* položaju.

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 the **48V HYBRID DRIVE SWITCH** before performing any maintenance, even when the hybrid drive is not in use.

The hybrid drive contains no 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 at sites where vapors of flammable liquids, gas and dust explosions could occur.

Hybrid drive is ready for operation with a originally installed battery on the boat. When replacing the battery the same type and size is required. Replacement of different battery and other hybrid drive 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. For more information see chapter: **Generator mode of operation.**

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 propelled or there is no person on board the *DIESEL / ELECTRIC HYBRID SWITCH* must always be in *DIESEL* position.

1.2 Guidelines for safe operation

Servisni poseg na hibridnem pogonu sme opraviti samo za to usposobljena oseba. Pred vsakim posegom na elementih hibridnega pogona morajo biti vsa električna stikala v izklopljenem položaju (OFF).

Ne opravljajte nobenega posega na delih hibridnega pogona, ki so vgrajeni na diesel motor ali v njegovi bližini medtem, ko diesel motor deluje.

Ne odstranjujte zaščitnih pokrovov na električnem motorju ali priključnih omaricah medtem, ko diesel motor deluje.

Ko je kateri od zaščitnih pokrovov odstranjen, sme posege in servisiranje opraviti samo kvalificirana oseba za vzdrževanje hibridnega pogona.

Ne vtikajte nobenih predmetov v odprtine na ohišjih medtem, ko diesel ali elektro motor deluje. Ne puščajte nobenih predmetov v zaščitnem ohišju diesel in elektro motorja.

Med delovanjem se enota segreje in ostane vroča še nekaj časa po tem. Uporabljajte zaščitno obleko in zaščitne rokavice, ko delate v bližini teh delov.

Hibridni pogon vsebuje vročo hladilno vodo pod pritiskom. Redno pregledujte spoje in cevi in preverjajte, da tesnijo in ni puščanja hladilne vode.

1.3 Warning labels

Upoštevajte vsa opozorila na nalepkah. Ne odstranjujte opozorilnih nalepk.



The service or repair work can be performed only by a professional person qualified to do so.

Before any service work all switches must be set to OFF.

Do not work on any components of the hybrid drive located on or near the diesel engine when the engine is running.

Do not remove any protective cover from the electric motor 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 maintenance or service.

Do not insert anything in the holes in the housing while the diesel engine or electric motor is running. Do not leave any foreign object in the cocoon housing of the diesel engine or electric motor.

The unit is hot when running and for a time thereafter. Use protective clothing and gloves when working around hot components.

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

Observe all labelled warnings. Do not remove the warning labels



1.4 *Installation and maintenance*

Vsi povezovalni kabli morajo biti opremljeni s predpisanimi varovalkami in stikali za izklop. Nikoli ne zamenjate zaščitne naprave z drugo, ki ima drugačne tipske vrednosti. Upoštevajte navodila za izbiro ustreznih delov.

Tip in napetost vgrajene baterije mora ustrezati hibridnemu pogonu vgrajenemu na plovilu.

Zagotovite, da vsa oprema deluje v pravih delovnih pogojih. Ne vklaplajte in ne uporabljajte je v mokrem ali prašnem okolju.

Zagotovite, da je v vsakem primeru dovolj prostega prostora okoli izdelka, da bo zagotovljen prost pretok zraka in da so ventilacijske odprtine odprte. Zagotovite zadosten pretok hladilne vode, kadar hibridni pogon deluje v generatorskem in motornem načinu.

Izdelek mora biti montiran v prostor kjer je zaščiten pred vplivom povišane temperature. V neposredni bližini ne sme biti kemikalij, plastičnih delov, zaves ali drugih tekstilnih izdelkov itd.

Vsi priključki in vodniki morajo biti zaščiteni pred vplivi okolja z ustreznim zaščitnim ovojem. Za zaščito pred nevarnostjo udara električnega toka morajo biti vsi priključki zaščiteni z zaščitnimi pokrovi.

Elementi hibridnega sistema: krmilnik, elektro-hidravlični aktuator s škatlo z relejem za krmiljenje sklopke in povezovalna doza za HCU s CAN konektorjem morajo biti vgrajeni na zaščitenem mestu v plovilu, kjer ne smejo biti izpostavljeni vplivom vode, toplote, prahu in vibracij pogonskega diesel motorja ali pogonskega sklopa.

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.

Type and voltage of the installed battery have to conform to the hybrid drive installed on the boat.

Ensure that the equipment 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 for ventilation, and that ventilation openings are not blocked. Ensure sufficient flow of cooling water, always when the hybrid drive is operating in generator and propulsion 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 environmental influences by a suitable protective shield. For protection against electric current strike, all connections have to be protected with protective covers.

The hybrid 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.

Ob servisnih intervalih diesel motorja je potrebno kontrolirati motorni del hibridnega pogona. Pregledati je potrebno nivo olja v rezervoarju hidravličnega akuatorja in preveriti stanje hidravličnih cevi in priključkov. Poleg tega je potrebno preveriti trdnost pritvija priključnih kablov na vseh električnih sponkah hibridnega sistema in stanje kablov.

At diesel engine maintenance intervals it is recommended to check the electric motor part of hybrid drive. 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.

1.5 *Transport, storage and disposal*

Med skladiščenjem in v času prevoza plovila mora biti stikalo **48V HYBRID DRIVE SWITCH** izklopljeno.

On storage or transport of the boat, ensure that the **48V HYBRID DRIVE SWITCH** is disconnected.

Ne sprejemamo nobene odgovornosti za škodo med prevozom v kolikor prevoz opreme ni izveden v originalni embalaži ali oprema pravilno vgrajena na plovilo.

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.

Izdelek hranite v suhem prostoru s temperaturo med -20°C do $+60^{\circ}\text{C}$.

Store the product in a dry environment; the storage temperature should range from -20°C to $+60^{\circ}\text{C}$.

Upoštevajte navodila proizvajalca baterij glede transporta, skladiščenja, polnjenja, dopolnjevanja in odlaganja baterije po končani uporabi na plovilu.

Refer to the battery manufacturer's manual for information on transport, storage, charging, recharging and disposal of the battery.

Pri odlaganju delov hibridnega pogona varujte okolje in upoštevajte direktive za recikliranje.

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

2. *HYBRID DRIVE AUZ 4120 48V 5/7 kW*

2.1 *Purpose and basic information*

Hibridni pogon omogoča tiho plovbo z električnim motorjem z močjo do 7 kW pri nižjih hitrostih ter plovbo z dieselskim motorjem pri višjih hitrostih. Isti električni motor deluje tudi kot 5 kW generator električne energije med vožnjo z dieselskim motorjem ali med tem, ko je barka na privezu. Za upravljanje skrbi ustrezna elektronska krmilna enota, ki v generatorskem načinu polni baterije in v motorskem načinu krmili električni motor za pogon plovila.

Hybrid drive enables quiet navigation by electric motor with the power up to 7 kW at a lower speed and navigation by diesel engine at a higher speed. The same electric motor functions also as a 5 kW 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 electric motor for the boat drive in the motor mode.

Poseben upravljalni sistem omogoča izbiro med električnim ali motornim pogonom plovila. Izklop in vklop suhe lamelne sklopke med diesel motorjem in električnim motorjem opravlja elektro-hidravlični aktuator preko hidravlične batne črpalke in hidravličnega potisnega ležaja.

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.

Tehnični podatki hibridnega pogona:

Technical data of the hybrid drive:

Hybrid drive AUZ 4120 48V 5/7 kW	
Nominal voltage	48 V
Propulsion battery	48 V – 240Ah Li-Po
Continuous power of the generator	up to 5 kW, limited with reference to the diesel engine speed and drive battery SOC
Electric propulsion	7 kW, max 20 minutes
Electric propulsion	5 kW, continuous
Electric propulsion duration	Dependent on the type and capacity of the battery and the rotating speed
Max revolutions E-mot/Gen	4000 rpm
Cooling water	<30°C, 4 litres/min for E-Mot/Gen and HCU
Ambient temperature	-10°C to 40°C HCU / -10°C to 60°C E-mot/Gen
IP protection	IP 22
E-mot/Gen weight	~ 60 kg
Actuator weight	~ 6 kg
Controller weight	~ 27 kg
Boat	Seaway Greenline 33H

Table 1: Technical data of the hybrid drive

2.2 Description

Električni motor – generator hibridnega pogona s suho lamelno sklopko je vgrajen med diesel motor in pogonski reduktor ZF 25. Elektronski krmilnik (HCU), elektro-hidravlični aktuator, električne in hidravlične povezave ter ostali sestavni deli hibridnega pogona so na plovilu razporejeni kot je prikazano na sliki 1: Block diagram of the hybrid system.

Electric motor – generator hybrid drive with a disc clutch is installed between the diesel engine and drive reduction gear ZF 25. The electronic controller (HCU), clutch actuator, electric and hydraulic connections and other components of the hybrid drive are arranged on the boat as shown in the figure 1: Block diagram of the hybrid system.

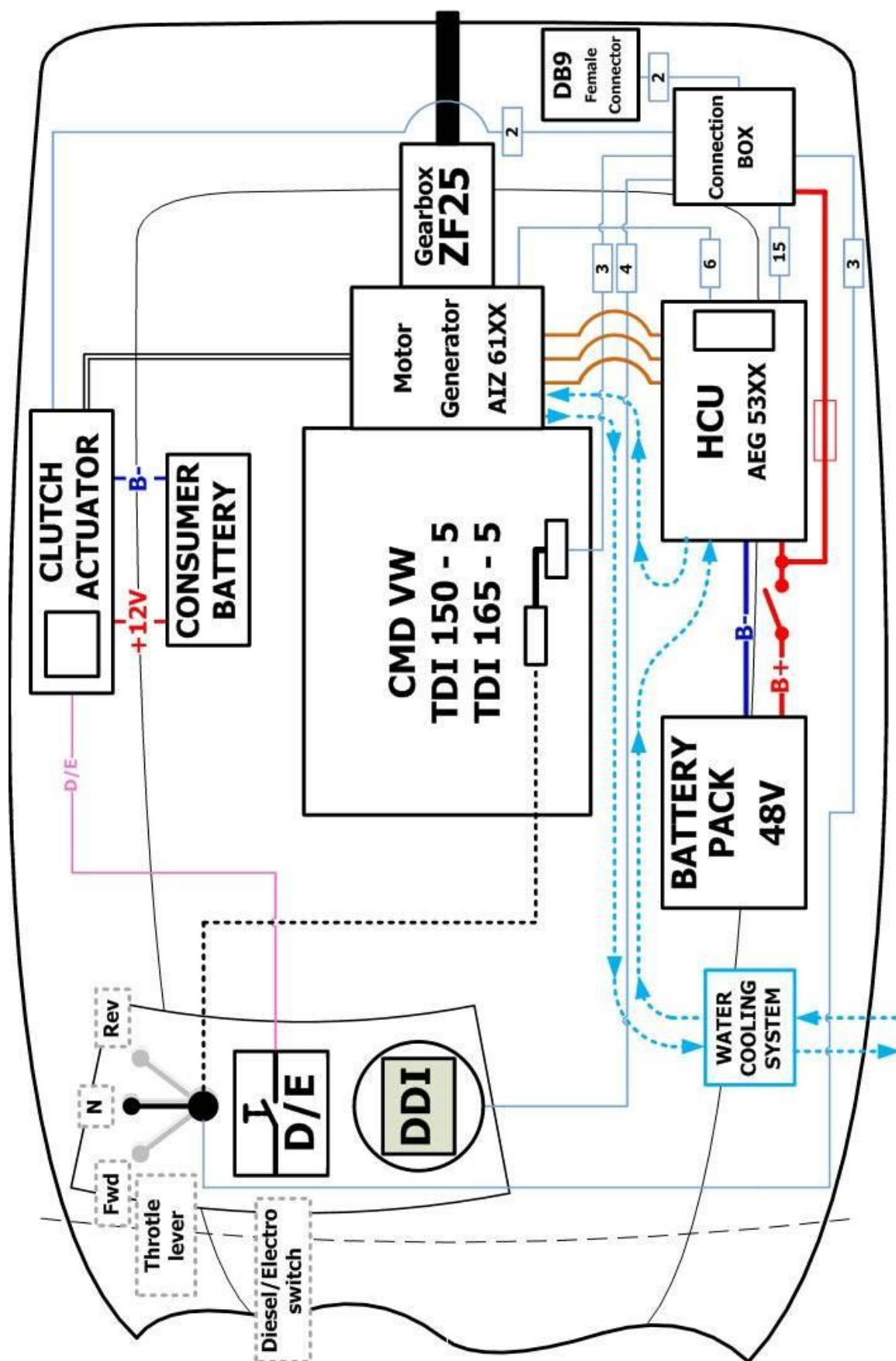


Figure 1: Block diagram of the hybrid system

Na risbi je prikazan integrirani hibridni pogon. V nosilnem in hkrati zaščitnem okrovu je nameščen 3 fazni brezkrtačni električni motor – generator s trajnimi magneti AIZ 61XX 48V 5/7 kW. Prenos moči iz diesel motorja na električni motor-generator opravlja suha lamelna sklopka, ki jo upravljamo z elektrohidravličnim aktuatorjem. Na drugi strani okrova je pritrjen pogonski reduktor ZF 25 s prestavo 1,969 z odgonom na propeler.

Za pravilno delovanje hibridnega sistema skrbi elektronski krmilnik, ki lahko v generatorskem načinu polni baterije ali pa v motorskem režimu krmili električni motor za pogon plovila. Poseben upravljalni sistem omogoča izbiro med električnim ali motornim pogonom plovila.

The figure shows an integrated hybrid drive. Three-phase brushless motor – generator with permanent magnets AIZ 61XX 48V 5/7 kW is placed to the supporting and at the same time protecting cover. Power transfer from the diesel engine to the electric motor – generator is performed by the disc clutch, which is managed by the electric-hydraulic actuator. On the other side of the protecting cover a drive reduction gear ZF 25 is fixed with gear ratio 1: 1.969 with PTO for propeller.

Electronic controller takes care of the proper operation of the hybrid system. The controller can charge batteries in the generator mode or control the electric motor to drive the boat in the motor mode. A special control system gives the user a choice between the electric motor and diesel engine boat drive.

Za prikazovanje parametrov in režima delovanja hibridnega sistema je na plovilu vgrajen grafični prikazovalnik (DDI).

Data Display Interface (DDI) display is installed to the boat to show parameters and the operational mode of the hybrid system.

POS	Part number	Part name	PCS	Mass (kg)
1		Diesel engine: VW TDI 165-5 or VW TDI 150- 5 or VW SDI 75-5	1	265,00 265,00 233,00
1A	VW: 074 105 266 M	Flywheel	1	
1B	VW: 065 311 592 ACAK	CENTA – flexible clutch P/N 26-60916-00 for: VW TDI 165-5 and VW TDI 150-5	1	4,30
1B	VW: 065 311 592 CAK	CENTA – flexible clutch for VW SDI 75-5	1	4
1C	VW: 065 323 924 C	Transmission bell housing for ZF25	1	7,06
1D	VW: 065 300 040 K	ZF 25 -2.0 drive unit (1:1,97) P/N: 3315002013	1	24,00
2	VW: ?	300mm longer pipes from engine to ZF25 for cooling	2	
3	/	/	/	/
4	VW: 074 141 032 D	Clutch disc (fi 240)	1	1,18
5	VW: 074 141 025 M	Clutch pressure plate (fi 280)	1	5,02
6	VW: 02F 141 671 B	Clutch slave cylinder modified into 15.120.489	1	0,50
7	VW: 701 721 401 B	Clutch master cylinder for clutch actuator	1	0,36
8	16.912.102	Throttle command sensor for E-machine with cable	1	0,40
9	11.221.019	Integrated E - machine AIZ 6117 48V 5/7kW	1	57,50
9A	16.285.787 or 16.285.815	Housing	1	13,40
9B	16.420.666 and 16.421.670	Terminals	1+1	0,20
9C	16.912.178	Hall sensors set with cable	1	0,50
9D	16.350.589	Stator 48 V	1	7,66
9E	16.363.047	Rotor with holder	1	12,4
9G	15.111.552 and 5.902.984	Rotor shaft with hub	1+1	8,7
9H	15.902.982	Support for Centa flexible clutch	1	4,8

9J	400524500 and 400524501	Bearings	1+1	0,75
9K	16.285.785 and 15.902.981	Rear end bracket with spacer	1+1	7,0
10	11.259.014	HCU-AEG 5302 48V 7/10kW 240Ah Li-Po for : VW TDI 150-5 and VW TDI 165-5	1	26,10
10	/	HCU-AEG 53XX 48V 7/10kW 240Ah Li-Po for VW SDI 75-5	1	26,10
11	16.912.110	Clutch actuator 12V (oil DOT4)	1	6,60
12	16.912.650	Supply cable 48 V	1	0,05
14	11.255.101	Indicator DDI AEB 1129	1	0,10
15	16.511.612	Cable for signal for DDI	1	0,65
16	16.511.611	Connection box for HCU with CAN, potentiometer setting and hall connector	1	0,85
17	Boat instalation	Cables from AIZ to HCU (max 2,5m, min 50 mm ²)	1	
18	Boat instalation	Cables from HCU to Battery bank (max 3,5m, min 70 mm ²)	1	
19	Boat instalation	STECA Solarix 4401	1	
20	Boat instalation	Driving lever – throttle	1	
21	Boat instalation	Diesel-Electric hybrid switch	1	
22	Boat instalation	Water pump > 4 litres/minute for cooling of HCU and AIZ	1	
23	Boat instalation	Cooling water pipes	/	
24	Boat instalation	Inverter charger 48/3000/35	1	
25	Boat instalation	Battery monitoring	1	
26	Boat instalation	Battery bank 48 V – 240 Ah Li-Po	1	

Table 2: The hybrid system's elements

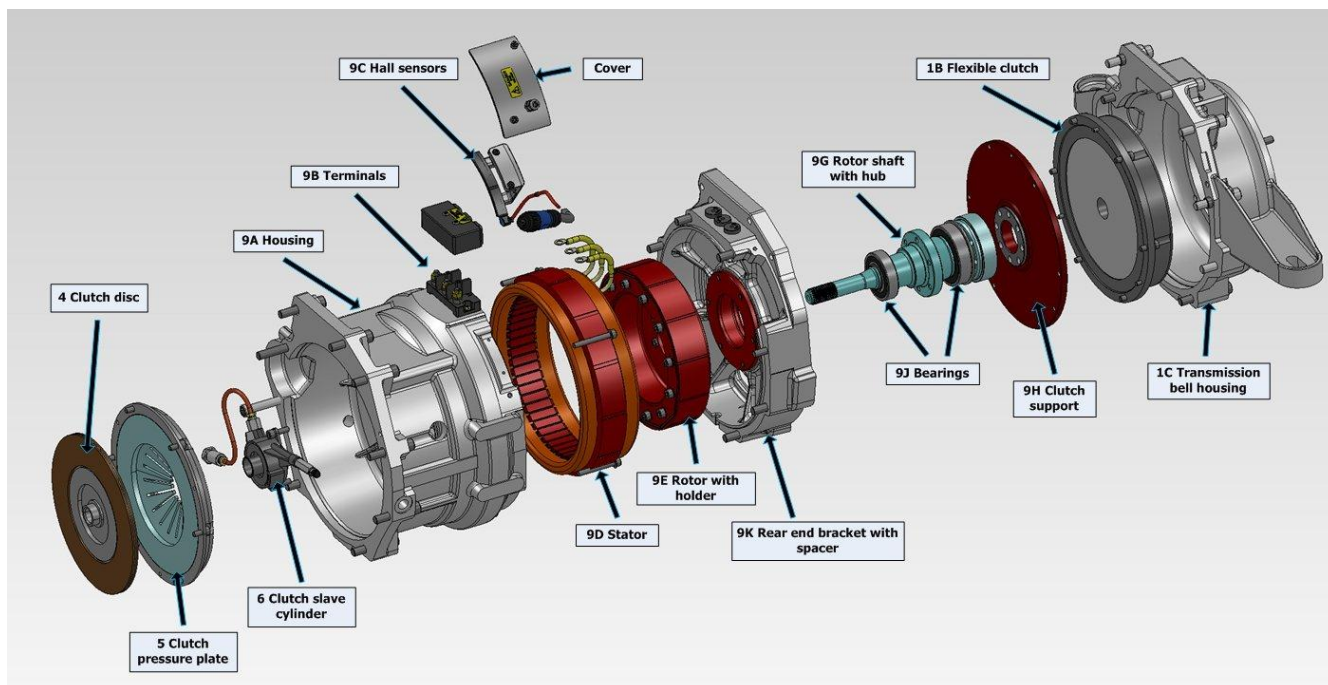


Figure 2: Integrated hybrid drive

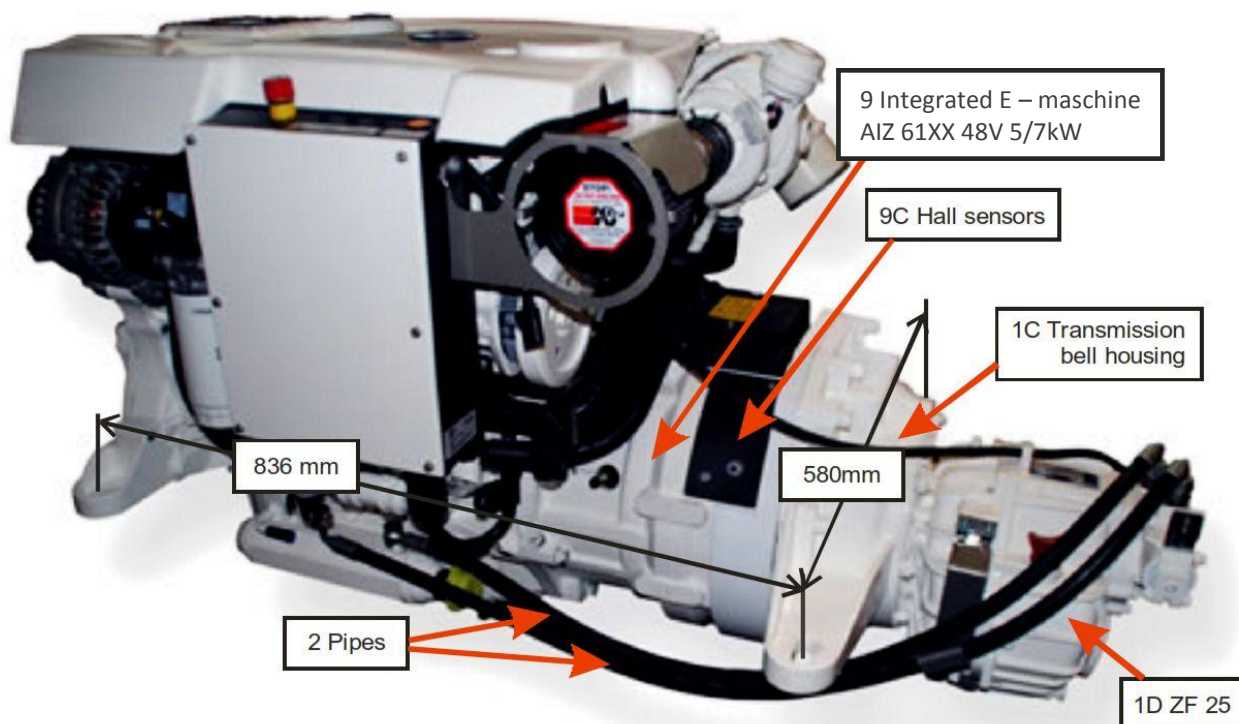


Figure 3: CMD-VW TDI 165-5 marine diesel engine with Integrated E-machine AIZ 61XX 48V 5/7kW

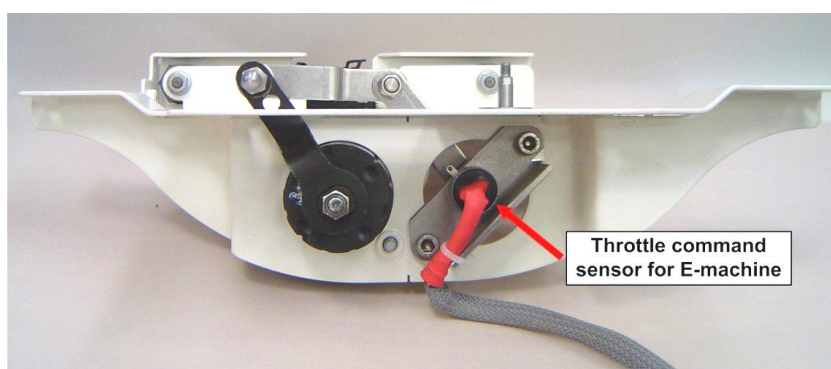
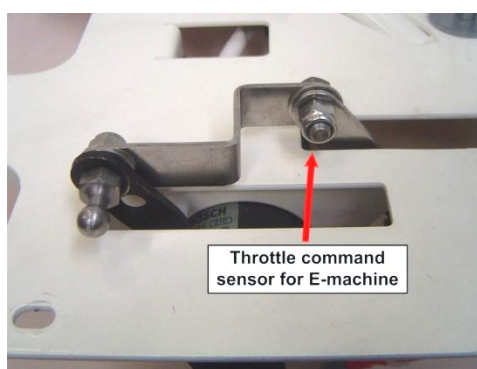


Figure 4 and Figure 5: Throttle command sensor (POS. 8)



Figure 6: Hall sensor set with cable (POS. 9C)



Figure 7: Hybrid control unit HCU (Electronic controller) (POS. 10)



Figure 8: DDI indicator (POS. 14)



Figure 9: Connection box for HCU (POS. 16)



Figure 10: Cable for signal for DDI (POS. 15)



Figure 11: Supply cable 48V (POS. 12)

2.3 Review of the size of currents, voltages and temperatures

Generator cycle of operation	
Output adjustable voltage from the controller Li-Po	53,4 V \pm 0,2 V
Continuous power and generator current	5,5 kW @ 100 A \pm 10 A @ \geq 2000 rpm
Max generator charging current	Limited with reference to the diesel engine speed and propulsion battery SOC.
Max voltage on the stator terminals of the generator and the terminals of the controller	280 V _{AC} between phases, 165 V _{AC} phase
Max generator phase current	45 A _{AC}
Max voltage in the controller	230 V _{DC}
Max controller consumption in stand by (48V HYBRID DRIVE SWITCH in ON position and diesel engine is stopped)	0,5 A @ 48 V
E-motor (MOT) cycle of operation	
Max propulsion power	7 kW @ 1100 RPM, 20 min
Continuous propulsion power	5kW @ 1100 RPM
Min / Max operating voltage of propulsion battery	45 V / 56 V
Max current of propulsion battery	200 A
Max motor phase current	100 A short-time, 90 A continuous
Max voltage in the controller	100 V
Max controller consumption in stand by (48V HYBRID DRIVE SWITCH in ON position and boat is not propelled)	0,5 A @ 48 V
Losses of E-motor / generator in idle running	
	200 W @ 800 RPM
	600 W @ 3000 RPM
	1000 W @ 4000 RPM
Temperature protection	
Max allowed temperature of the stator winding	155 °C
Max allowed rotor temperature	140 °C
Temperature of the motor safety disengagement	100 °C (shown on DDI)
Temperature of the controller safety disengagement	95 °C

Table 3: System currents, voltages and temperatures

2.4 Tightening torques for electric connections

Nut M8 Terminals U,V,W on E-motor / generator	10 +1 Nm max
Nut M8 Terminals U,V,W on HCU	10 +1 Nm max
Nut M8 Terminals B+ and B- on HCU	10 +1 Nm max

Table 4: Tightening torques for electric connections

3. DESIGNATIONS AND DATA

Elektronska krmilna enota, električni stroj AIZ 61XX, elektro–hidravlični aktuator in kabli imajo naslednje oznake:

- Zaščitni znak in ime proizvajalca.
- Tipsko oznako.
- Identifikacijsko številko (Part Number).
- Nazivno napetost in nazivno moč.
- Oznake električnih priključkov.
- Serijsko številko in lahko tudi datum proizvodnje.

Electronic controller unit, electric machine AIZ 61XX, clutch actuator and cables 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 and sometimes also date of manufacture.

4. MATERIALS

Hibridni pogon je projektiran in izdelan iz gradiv skladno z direktivami za varovanje okolja.

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

5. HYBRID DRIVE OPERATION

OPOZORILO 1: Elektronski krmilnik HCU nima zaščite proti zamenjavi polaritet pri priklopu krmilnika na baterijo. Napačna priključitev polaritet povzroči takojšnjo in trajno poškodbo elektronskega krmilnika HCU.

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

OPOZORILO 2: Pri vgradnji hibridnega sistema moramo najprej priključiti in povezati vse povezave B– polov hibridnega sistema ter B- polov 12V in 48V baterij v skupno maso. Šele nato lahko priključimo vse ostale B+ povezave hibridnega sistema in signalne vodnike.

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

OPOZORILO 3: Pri odklapljanju hibridnega sistema najprej odklopimo vse B+ povezave in signalne vodnike. Šele nato lahko odklopimo B- pole hibridnega sistema in B- pole 12V in 48V baterij iz skupne mase.

WARNING 3: When disconnecting the hybrid drive first disconnect all B+ and signal connections. Disconnect all the B- terminals of hybrid drive and B- terminals of 12V and 48V battery from common ground after that.

Za zagon pogona plovila po vrsti vklopimo:

- 1. 12V ENGINE BATTERY SWITCH,**
- 2. 48V HYBRID DRIVE SWITCH,**
- 3. 48V HYBRID/HOUSE BATTERY SWITCH.**

Starting the boat propulsion switch on in order:

- 1. 12V ENGINE BATTERY SWITCH,**
- 2. 48V HYBRID DRIVE SWITCH,**
- 3. 48V HYBRID/HOUSE BATTERY SWITCH.**

5.1 Diagram of hybrid drive installation on Greenline 33H

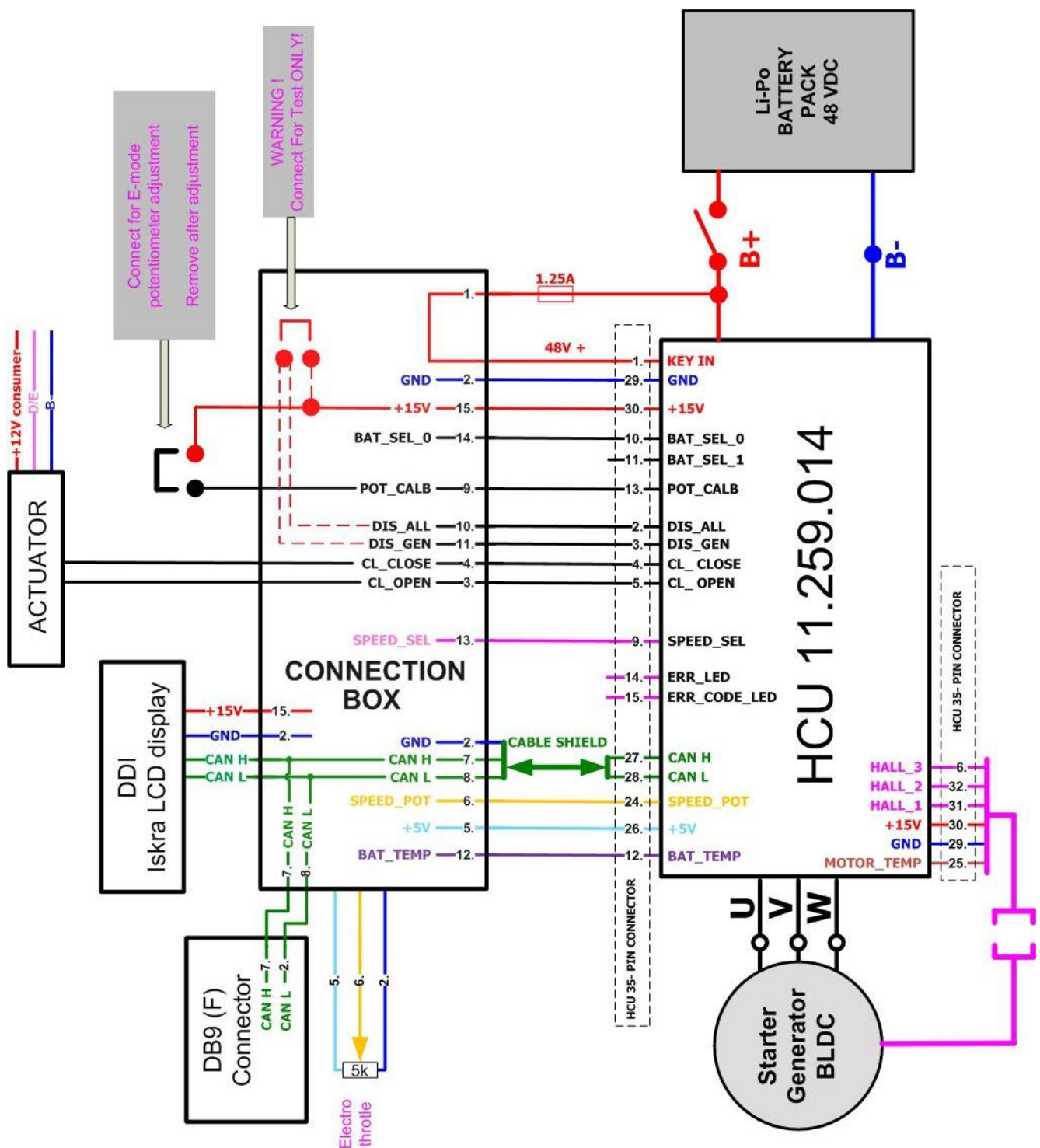


Figure 12: Hybrid system connection diagram

Connection of cables in Connection box 16.511.611 for HCU			
Cable	Designation on cable	No. of terminal in connecting box	Connection description
Supply cable 48V (with fuse)	1	1	48V from HCU
Cable from actuator	3	3	Actuator -Clutch open (C.O.)
	4	4	Actuator -Clutch close (C.C.)
Speed potentiometer 3 wire cable	2	2	Potentiometer GND
	5	5	Potentiometer +5V
	6	6	Potentiometer speed
DDI comunication cable 16.511.612	7	7	CAN High
	8	8	CAN Low
	15	15	+15V
	2	2	GND
Connection of cables in Clutch actuator 16.912.110 – Relay box 16.912.172			
Cable	Designation on cable	No. of terminal in actuator relay box	Connection description
Power supply for actuator - boat instalation cables	Boat instalation cables	1	D/E Switch
		2	GND
		3	+12V
Connection of supply cable 16.912.650 on HCU			
Cable	Designation on cable	Designation of terminal on HCU	Connection description
Supply cable 48V (with fuse)	B+	B+	48V
Connection of cable 16.511.612 with DDI 11.255.101			
4 pole connector connected to DDI			

Table 5: Cable connections

5.2 Cooling system

Hladilni sistem uporablja zunanjo vodo za hlajenje električnega motor – generatorja in elektronskega krmilnika. Na plovilu mora biti vgrajena primerna električna črpalka, ki mora zagotoviti pretok hladilne vode minimalno 4 litre / minuto in s temperaturo $< 30^{\circ}\text{C}$.

Hladilni sistem mora delovati v motorskem in generatorskem režimu delovanja hibridnega sistema.

Delovanje hladilnega sistema preverjamo z redno vizualno kontrolo pretoka hladilne vode.

Po vsakem daljšem mirovanju plovila je potrebno preveriti in zagotoviti pretočnost vode v hladilnem sistemu ter sistem po potrebi očistiti. Priporočeno sredstvo je *Volvo Penta QL-Neutra-Salt*.

Če temperatura električnega motor – generatorja ali elektronskega krmilnika iz kateregakoli vzroka preseže najvišje dovoljene temperature, se aktivira temperaturna zaščita ter se izklopi hibridni pogon. V tem primeru mora uporabnik počakati, da se hibridni pogon ohladi preden ga lahko ponovno uporabi.

Preveriti je potrebno delovanje hladilnega sistema.

Diesel motor deluje neodvisno od vklopa temperaturne zaščite hibridnega pogona.

The cooling system uses external water for cooling the electric motor – generator and electronic controller. The boat has to have installed an appropriate electric pump, which ensures flow of the cooling water minimum 4 litres / minute and with the temperature $< 30^{\circ}\text{C}$.

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 cooling water flow.

After a longer pause, it is needed to verify and ensure the water flow in the cooling system. If necessary clean the cooling system. Recommended agent is *Volvo Penta QL-Neutra-Salt*.

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 operates independently of the hybrid system temperature protection activation.

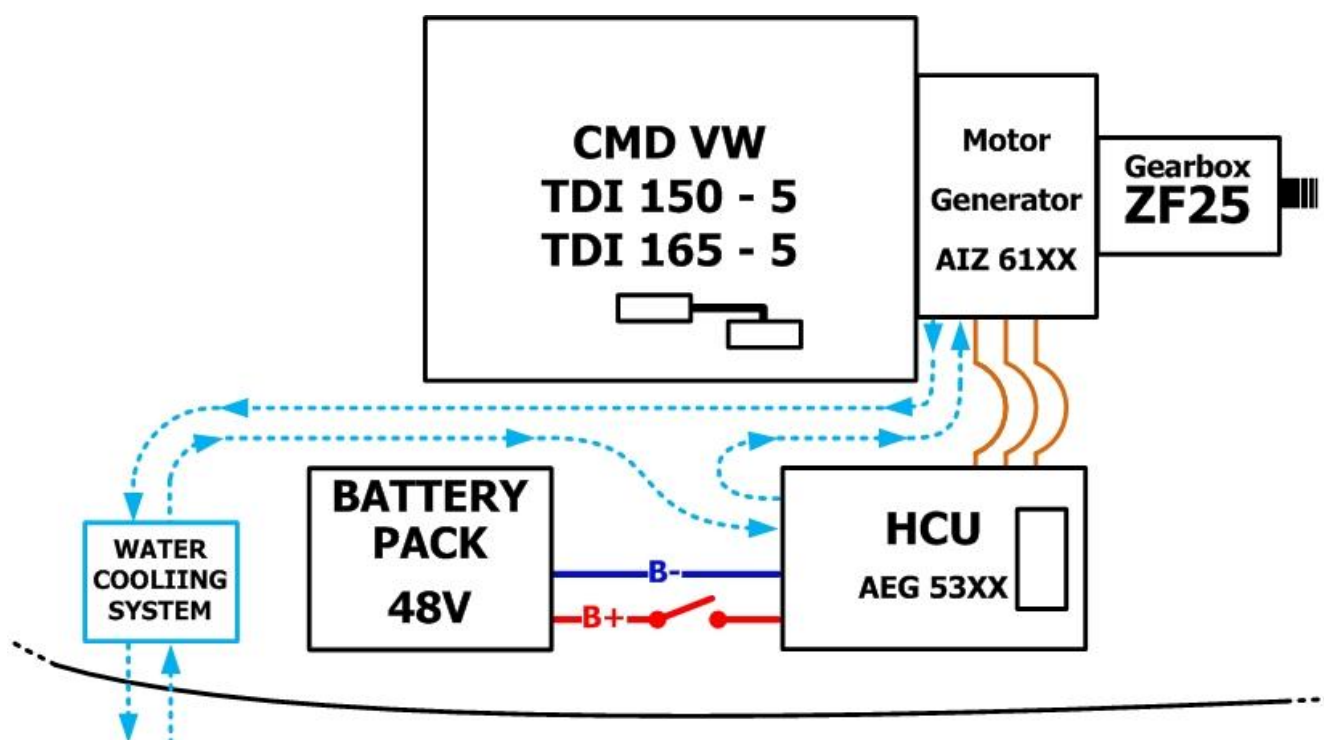


Figure 13: Hybrid drive cooling system diagram

5.3 Marine diesel engine

Tech. specification	Unit	CMD-VW SDI 75-5	CMD-VW TDI 150-5	CMD-VW TDI 165-5
Motor	type	VW SDI 75-5	VW TDI 150-5	VW TDI 165-5
Cylinders	number	5	5	5
Volume	ccm	2461	2461	2461
Power	kW	55 @ 3600 rpm	111 @ 4000 rpm	121 @ 4000 rpm
Idle speed	rpm	850	850	850
Torque	Nm	155 @ 2250 rpm	310 @ 2500 rpm	310 @ 2500 rpm
Mass	kg	233	265	265

Table 6: Marine diesel engines specifications

5.4 Setting the potentiometer for E-motor mode within the range of diesel motor throttle lever

1. Stikalo **48V HYBRID DRIVE SWITCH** izklopimo – **OFF**.
2. **Opozorilo:** Pogonski reduktor postavimo v nevtralni položaj.
1. Set the **48V HYBRID DRIVE SWITCH** to **OFF**.
2. **Warning:** Set the transmission box to neutral.

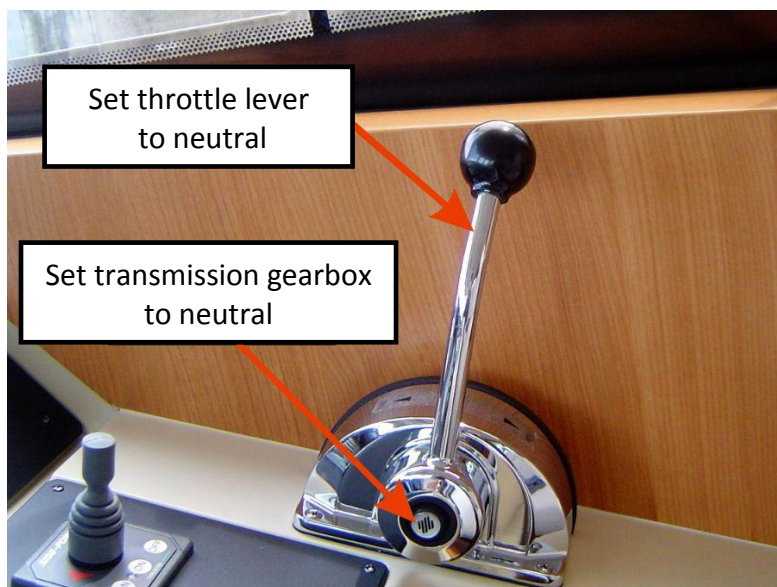


Figure 14: Set the gear box to neutral

3. Priključimo mostični konektor na kabel, ki je izpeljan iz povezovalne doze. Glej sliko 9.
3. Make a connection with the connector jumper on cable from connection box. See figure 9.

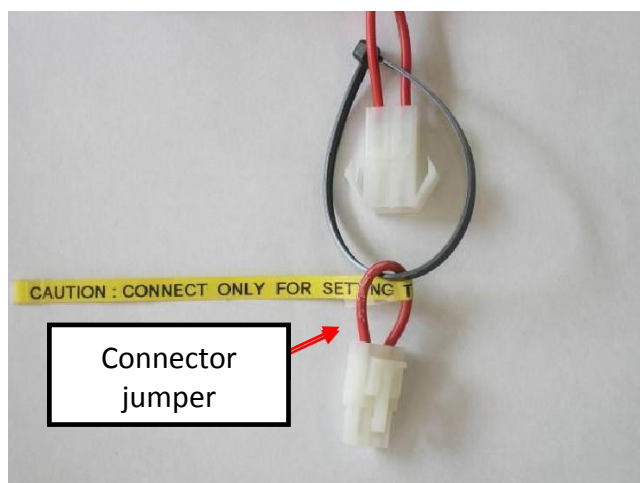


Figure 15: Cable and connector jumper

4. Stikalo **DIESEL / ELECTRIC HYBRID SWITCH** prekllopimo na položaj **DIESEL**.
4. Set the **DIESEL / ELECTRIC HYBRID SWITCH** to **DIESEL** position.

5. Ročico za plin postavimo v nevtralno lego.

Ročica za plin ima položaje: Naprej (FWD), Nazaj (REV) in Nevtralno. Ročica za plin ima lahko različen kot zasuka iz Nevtralnega v končni položaj Naprej oziroma končni položaj Nazaj.



Figure 16: *DIESEL / ELECTRIC HYBRID SWITCH*

6. Vključimo **48V HYBRID DRIVE SWITCH** stikalo – **ON**.
7. V času 5 sekund premaknemo ročico za plin v končni položaj v tisti smeri kjer je kot hoda v skrajno lego manjši. Počakamo še 5 sekund.
8. Stikalo **48V HYBRID DRIVE SWITCH** izklopimo – **OFF**.
9. Odstranimo mostični konektor iz kabla.
10. Preizkusimo hitrost vrtenja električnega pogona pri obeh skrajnih legah ročice za plin. To naredimo v prostem teku pogonskega reduktorja: Postopek ponovimo v kolikor ni dosežena največja možna hitrost vrtenja.

5. Set the throttle lever to neutral.

Throttle lever has positions: Forward (FWD), Reverse (REV) and Neutral (N). Throttle lever might have different angles at maximal shift from Neutral to maximal FWD and to maximal REV position.

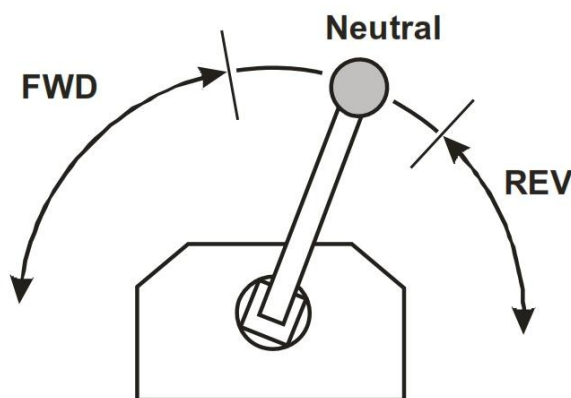


Figure 17: Throttle lever

6. Set the **48V HYBRID DRIVE SWITCH** to **ON**.
7. Then within 5 seconds put the throttle lever to its end position in the direction Forward or Reverse where the angle from the neutral position is smaller. After that wait another 5 seconds.
8. Set the **48V HYBRID DRIVE SWITCH** to **OFF**.
9. Remove the connector jumper from the cable.
10. Test the speed of electric motor rotation in both end positions of throttle lever. The test is done in neutral run of the gearbox. Repeat the procedure if maximal preset speed is not achieved.

5.5 Generator mode of operation

5.5.1 Settings for propulsion battery charging

V generatorskem režimu delovanja elektronski krmilnik integriranega hibridnega pogona zagotavlja nadzorovano polnjenje pogonske baterije 48 V, ki je bazirano na merjenju napetosti.

In the generator mode of operation, the electronic controller of the integrated hybrid drive enables a controlled charging of propulsion battery 48 V, which is based on the voltage measurement.

Predvidena je pogonska baterija 48,1 V 240 Ah Li-Po KOKAM SLPB 160460330.

The foreseen type of propulsion battery is 48.1 V 240 Ah Li-Po KOKAM SLPB 160460330.

Polnjenje mora biti usklajeno s »Shore Chargerjem« 35 A in solarnim sistemom moči približno 1kW (približno 20 A) tako, da ne pride do prenapolnjenja pogonske baterije.

Charging has to comply with the »Shore Charger« 35A and the solar power system of approximately 1kW (cca. 20A), so that the propulsion battery is not overcharged.

Diesel motor ima v prostem teku dovolj moči samo za lastno rabo in vzdrževanje mirnega teka. Hibridni pogon v generatorskem režimu črpa dodatno mehansko moč, ki je diesel motor v prostem teku ne more zagotavljati. Prosti tek diesel motorja mora biti programsko nastavljen na najmanj 830 rpm.

In idle running, the diesel engine has enough power only for its own use and maintenance of smooth running. The hybrid drive in the generator mode draws additional mechanical power, which the diesel engine in the idle running cannot provide. Idle running of the diesel engine must be programmed to 830 rpm minimum.

Zaradi uskladitve hibridnega sistema v režimu polnjenja z navorno karakteristiko diesel motorja je velikost maksimalnega polnilnega toka za posamezen tip pogonske baterije omejena tudi glede na trenutne vrtljaje diesel motorja.

Due to the harmonization of the hybrid 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.

V primeru, ko je pogonska baterija močno izpraznjena lahko to pri polnjenju povzroči nemiren tek diesel motorja v prostem teku. To odpravimo z dvigom vrtljajev diesel motorja.

In case of deep discharge of the 48V propulsion battery the vibrations may occur on diesel engine in idle run. Increase of the diesel engine speed will suppress the vibrations.

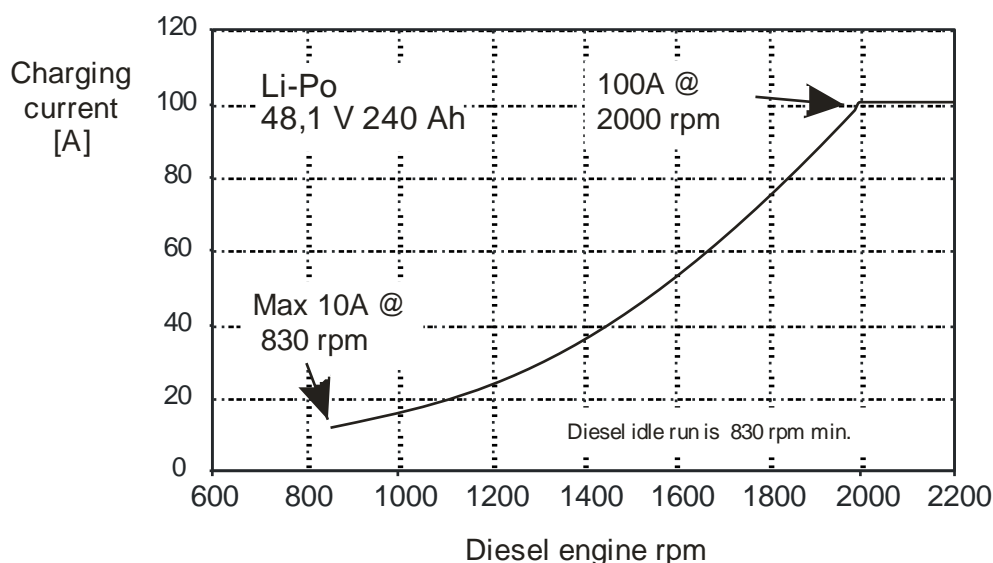
Ko je pogonska baterija delno napolnjena, lahko diesel motor zopet deluje v prostem teku.

When the propulsion battery is partially charged, the diesel engine can operate in idle run.

5.5.1.1 Settings for battery charging 48,1 V 240 Ah Li-Po KOKAM SLPB 160460330

Krmilnik je tovarniško nastavljen za polnjenje pogonske baterije 48,1 V 240 Ah Li-Po KOKAM SLPB 160460330.

The controller has been set in the factory for charging of the propulsion battery 48,1 V 240 Ah Li-Po KOKAM SLPB 160460330.



Level	U_{ch} [V]	I_{ch} [A]	Battery Temp. [°C]	Limitation	Shore Charger U_{ch} [V]	Solar system U_{ch} [V]
Chg	$\leq 53,6$	≤ 100	0 – 40	BMS system has to have: <ul style="list-style-type: none"> – temperature protection – protection against too high voltage 	54,2 V	53,6 V

Table 7: The indicated charging values

The charging voltage shall not exceed the allowed value. The indicated values are for $T = 25^{\circ}\text{C}$.

5.5.2 SOC (State Of Charge) of the propulsion battery

Kontrola SOC pogonske baterije je predvidena z Victron BMV 602. Za pravilno uporabo pogonske baterije je potrebno upoštevati navodila proizvajalca.

SOC of the propulsion battery is foreseen with the Victron BMV 602. For the proper use of the propulsion battery it is necessary to consider the instructions of the battery manufacturer.

5.5.3 Load dump WARNING

Med generatorskim delovanjem se ne sme odklopiti pogonske baterije.

Zato odsvetujemo izklapljanje stikala *48V HYBRID DRIVE SWITCH*, ko hibridni pogon deluje v generatorskem režimu. V skrajnem primeru lahko odklop bremena povzroči trajno odpoved elektronskega krmilnika.

Load dump is the situation that will occur in the generator operation at disconnection of the propulsion battery.

Therefore we advise not to disconnect the *48V HYBRID DRIVE SWITCH*, when the hybrid drive operates in the generator mode. In the extreme case the load dump can cause a permanent failure of the electronic controller.

5.6 *E-motor mode of operation*

Glede na moč pogonskega diesel motorja je izbrana tudi moč električnega pogona, ki je namenjena predvsem za plovbo pri nizki hitrosti do 5 knots in do 1300 vrtljajev.

Želeno vrtilno hitrost E-motorja se nastavlja preko komandne ročke »plina« dieselnega motorja. Na dieselskem motorju je za to vzporedno prigraden potenciometer, ki krmilniku posreduje signal za želeno vrtilno hitrost E-motorja.

Pomik komandne ročke »plina« za električni pogon ustreza pomiku komandne ročke za diesel motor.

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 up to 5 knots and up to 1300 rpm.

The desired rotational speed of the E-motor can be set through the control lever of the diesel engine »gas«. On the diesel engine is, for this reason, embedded a parallel potentiometer, which forwards signals to the controller for the desired rotational speed of the E-motor.

Shift of the control lever of the electric drive »gas« corresponds with the shift of the control lever for a diesel engine.

Med delovanjem E-motorja se pogonska baterija prazni in se zato niža napetost na njegovih sponkah. Ko napetost pogonske baterije pade pod 44 V, se aktivira opozorilni signal iz polnilnega sistema Victron. Nadaljnje praznjenje baterije ni priporočljivo in je potreben prehod na diesel pogon in ponovno polnjenje baterije.

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 44 V warning signal comes from Victron charging system. From this point it is not recommended to continue discharging the battery and the system must be switched to diesel mode for recharging the battery.

E-motor mora podobno kot diesel motor usklajeno delovati v kombinaciji z reduktorjem ZF 25.

Za vklop sklopke v reduktoru ZF 25 je potrebno 400 vrtljajev na vstopni gredi.

Similar to the diesel engine, E-motor has to operate compliant with the combination of the reduction gear ZF 25.

To engage the clutch in the reduction gear ZF 25, 400 revolutions are required on the inlet shaft.

Sistem deluje tako, da se E-motor, ko je ročica »plina« v nevtralni legi ne vrti. Ob pomiku ročke iz nevtralne lege se E-motor zavrti s 400 vrtljaji ter se aktivira sklopka v reduktorju ZF 25. Pri tem nastane krajši časovni zamik med pomikom ročke »plina« in odzivom E-motorja. V trenutku aktiviranja sklopke v reduktorju ZF 25 se lahko začuti manjši sunek.

The system operates so that the E-motor does not rotate when the "gas" 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 gear ZF 25 is activated. A short time-lag occurs between the shift of the »gas« lever and the reaction of the E-motor. At the moment of clutch engagement in the reduction gear ZF 25, a small thrust can be felt.

5.6.1 Output characteristics in the E-motor mode of operation

V tabeli so prikazane srednje vrednosti vrtljajev, izhodne moči in porabe toka v odvisnosti od izhodnega momenta E-motorja pri polno odprtem krmilniku, »100% gas«.

The table shows the middle values of revolutions, output power and consumption of power depending on the output moment of the E-motor at the controller fully opened, »100% gas«.

Power (kW)	1			2			3			4			5			6			7		
	M	I bat	n	M	I bat	n	M	I bat	n	M	I bat	n	M	I bat	n	M	I bat	n	M	I bat	n
	Nm	A	rpm	Nm	A	rpm	Nm	A	rpm	Nm	A	rpm	Nm	A	rpm	Nm	A	rpm	Nm	A	rpm
Greenline 33H	7	30	1415	14	55	1390	21	75	1390	30	105	1300	38	130	1260	47	155	1220	57	185	1175
	Continuous															Limited to 20 min max					

Table 8

5.6.2 The expected boat speed in the E-motor mode of operation

Motor revolutions (RPM)	I battery (A)	Boat speed (knots)
600	30	3,0
800	55	4,0
1100	110	5,0
1250	135	5,9

Table 9

Vrednosti so izmerjene s 5-listnim propelerjem 17" x 14,5". Z izbiro drugačnega propelerja, spremembo mase plovila ter v odvisnosti od velikosti valov in jakosti vetra bodo vrednosti drugačne.

The values were taken on a 5-blade propeller 17" x 14,5". By selecting a different propeller, changing the weight of the boat, depending on the size of the waves, and wind force, the values will differ.

5.6.3 Drive reduction gear ZF 25

Izbrani pogonski reduktor ZF 25 ima prestavo 1,969.

The selected drive reduction gear ZF 25 has a transmission ratio 1.969.

5.7 *Electronic control unit 48 V - controller*

Krmilnik mora biti vgrajen na zaščiteno in suho mesto v plovilu ter ne sme biti izpostavljen vibracijam pogonskega diesel motorja ali pogonskega sklopa.

Vgrajena programska oprema krmilnika (software) zagotavlja delovanje funkcij hibridnega pogona.

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

Installed controller software ensures operation of all hybrid drive functions.

5.8 *Data Display Interface (DDI)*

5.8.1 Introduction

Podatkovni prikazovalnik DDI je namenjen prikazovanju podatkov za nadzor načina delovanja in izmerjene vrednosti v hibridnem sistemu.

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

DDI prikazuje trenutni način delovanja sistema hibridnega pogona, baterijski tok, vrtilno hitrost in temperaturo električnega motorja, šifre napak in druge podatke uporabne za serviserje.

DDI shows the current working mode of the HCU, battery current, speed and temperature of electric motor, error codes and also some other data useful only for service personnel.

Prikazani podatki so zgolj indikativni, z natančnostjo $\pm 5\%$.

Presented data are only indicative, with a precision of $\pm 5\%$.



Figure 18: DDI - Data Display Interface device

5.8.2 Hardware installation

DDI je priključen na hibridni pogon s 4-pinskim ženskim Molex konektorjem (slika 19)

Pogled označevanja pinov je iz zadnje strani

- 1) CAN_LO (CAN low line)
- 2) CAN_HI (CAN high line)
- 3) GND (- napajanje)
- 4) +15 V(+ napajanje)

+15 V mora biti priključen na vrstno sponko številka 15 v povezovalni dozi.

GND mora biti priključen na vrstno sponko številka 2 v povezovalni dozi.

CAN_HI mora biti priključen na vrstno sponko številka 7 v povezovalni dozi.

CAN_LO mora biti priključen na vrstno sponko številka 8 v povezovalni dozi.

Za zagotovitev zanesljivega delovanja sistema priporočamo uporabo kablov z oklopom za povezavo CAN_HI in CAN_LO. Oklop mora biti povezan na vrstno sponko številka 2 (GND) v povezovalni dozi.

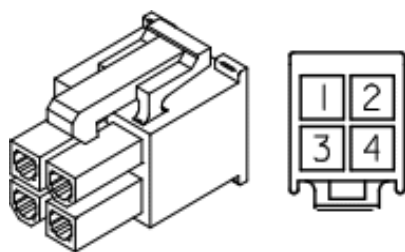


Figure 19: 4-pin connector
(on DDI device)

DDI is connected to the hybrid system by 4-pin female Molex connector (figure 19).

Connector pin number listing (rear view):

- 1) CAN_LO (CAN low line)
- 2) CAN_HI (CAN high line)
- 3) GND (negative power supply)
- 4) +15 V (positive power supply)

+15 V must be connected to terminal block number 15 in connectin box.

GND must be connected to terminal block number 2 in connectin box.

CAN_HI must be connected to terminal block number 7 in connectin box.

CAN_LO must be connected to terminal block number 8 in connectin box.

For device reliable working the usage of shielded cable for wires CAN_HI and CAN_LO is highly recommended. Shielding must be connected to terminal block number 2 (GND) in connection box.

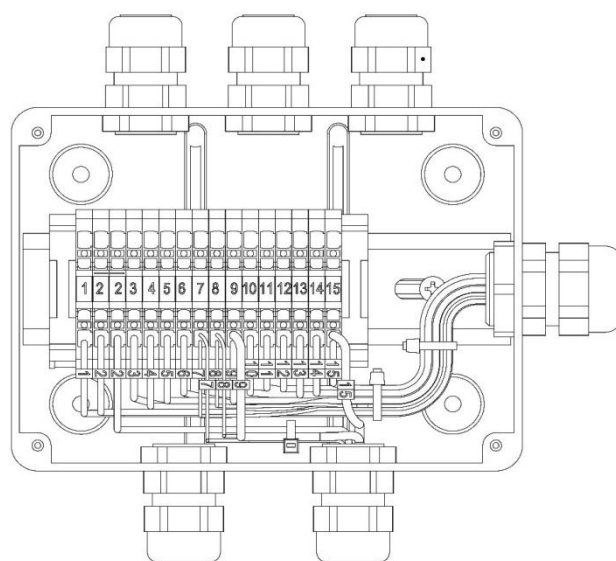


Figure 20: Connection box

5.8.3 DDI screen's description

Zaslon je sestavljen iz dveh vrstic. Ob zaznavi napake v delovanju hibridnega sistema se izpiše še tretja vrstica.

Pod zaslonom se nahaja LED dioda, ki ob normalnem delovanju sveti zeleno. Če se na hibridnem sistemu pojavi napaka pa LED dioda sveti rdeče.

Screen consists of two lines. When error occurs in hybrid system the third line is displayed.

Below the display there is a LED and when the hybrid system works properly, the LED is green. If malfunction occurs somewhere in the hybrid system, the LED turns red.

5.8.3.1 DDI Quick screen listing

Režim uporabe hibridnega sistema na plovilu moramo prilagoditi tako, da so prikazane vrednosti na DDI v mejah podanih okvirnih vrednosti pri normalni uporabi, ki so podane v naslednji tabeli.

The mode of operation of the hybrid 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, given in the next table.

	Data 1	Description	Data 1 normal range	Data 2	Description	Data 2 normal range
SCREEN						
Line 1	<i>Mode</i>	Operation mode	Neutral, Error, Electric, Generator	<i>Ib</i>	Battery current	from -180 to 110 A
Line 2	<i>MotT</i>	Motor temperature	from -10°C to 100°C	<i>RPM</i>	Speed (RPM)	0 to 4500
ERROR LINE						
Line 3	<i>IG Errors</i>			<i>AC Errors</i>		
SCREEN: Connection lost						
Line 1	<i>!! HCU LOST !!</i>					
Line 3	AC software version			DDI software version		
Line 4	IG software version			HCU serial number		

Table 10: The values shown on DDI

5.8.3.2 SCREEN



Figure 21: Electric mode



Figure 22: Generator mode

Line 1, Data 1: *Mode: x*

Mode: x shows the current operation i.e. working mode of HCU unit.

'x' can be:

- **Neutral** – neutral mode (only logic part of HCU is active)
- **Error** – error mode i.e. failure mode, which can become active in case of a malfunction, bad system connection, overloading, overheating, etc...
- **Electric** – 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.

5.8.3.3 ERROR LINE

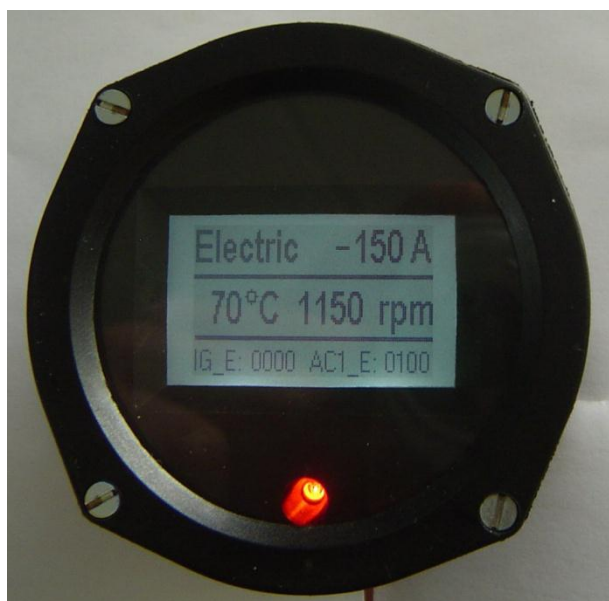


Figure 23: Error screen with red LED

When 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 errors occur at the same time. Single bit (error flag) has default value '0', and changes to '1', if a corresponding error occurs. The errors are shown until the cause of the failure persists, and then are automatically cleared.

Line 3, data 1: *IG_E:x*

IG_E:x indicates the errors which occurred in "IG" controller part.

Line 3, data 2: *AC1_E:x / AC2_E:x*

The *AC errors* group consists of 2 distinctive sub-groups (*AC errors 1* and *AC errors 2*) each containing 16 independent failure types.

x indicates the errors which occurred in the "AC" controller part.



Figure 24: Error screen with green LED

The error with the decimal code number 26 (AC2_E:0200) shall not be regarded as an error, because this is usual hybrid system behavior when battery is overcharged. In this situation the LED keeps green.

5.8.3.4 AC1 Error listing (HEX code):

Error Name	HEX Code	DEC Code	HCU response	Reason	Remedy	Note
No error	0x0000	0	/	/	/	
IG part lost	0x0001	01	Permanent error mode	CAN communication with IG part interrupted	Check / replace HCU	1
Actuator fail	0x0002	02	Permanent error mode	Clutch signals have the same logic state for more than 6 s	Check clutch signals	
Cont. high ph. current	0x0004	03	Permanent power reduction	Phase current is continuously above max level	Stop / Check load	3
Cont. high bat. current	0x0008	04	Permanent power reduction	Calculated battery current is continuously above max level	Stop / Check load	3
Hall failure	0x0010	05	Error mode	Hall sensor malfunction	Check / replace hall sensors assembly	
Motor temp. max	0x0020	06	Error mode	Measured motor temperature is above 120°C	Stop, electric motor cooling required	
HCU temp. max	0x0040	07	Error mode	HCU temperature is above 95°C	Stop, HCU cooling required	
Battery voltage max	0x0080	08	Error mode	Battery voltage is above 58 V	Check battery	
DC-link overvoltage	0x0100	09	Error mode	DC-link voltage is above 270 V	Wait for DC-link voltage drop	4
Invalid HCU command	0x0200	10	Error mode	Wrong state of HCU command inputs	Check HCU inputs wiring	
Battery temp. max	0x0400	11	Error mode	Battery temperature is above 55°C	Check battery and temp. sensor	5
Motor temp. min	0x0800	12	Error mode	Measured motor temperature is below -20°C	Check / replace hall sensors assembly	
Battery temp. min	0x1000	13	Error mode	Battery temperature is below -20°C	Check battery and temp. sensor	5
Short-circuit in Gen. mode	0x2000	14	Error mode	Potential short-circuit detected during generator mode	Check HCU power terminals	
ECU part lost	0x4000	15	Permanent error mode	CAN communication with ECU part interrupted	Check ECU	1,2
/	0x8000	16	/	/	/	

Table 11: AC1 errors listing

Note 1: The errors with the decimal code numbers 1 and 2 can occur due to:

- AC part HW or SW failure,
- IG part HW or SW failure,
- bad CAN BUS wiring of both controllers inside HCU,
- electromagnetic noise inside HCU.

Note 2: The error with the decimal code number 2 can occur due to:

- ECU stops to send PGN0 message
- bad CAN BUS wiring of external devices (PC, DDI, etc.),
- external electromagnetic noise.

Note 3: Exact limit value depends on current HCU operating mode.

Note 4: The error with the decimal code number 09 shall not be apprehend as an error, if the battery voltage is between 53,4 V and 54 V when the HCU operates in generator mode (this is usual HCU behavior when battery is overcharged).

Note 5: The errors with the decimal code number 11 and 13 cannot occur when the HCU is set up for the Li-Po battery pack due to the absence of the battery temperature measurement. The battery temperature is fixed to 20°C for the Li-Po battery pack.

5.8.3.5 AC2 Error listing (HEX code):

Error Name	HEX Code	DEC Code	HCU response	Reason	Remedy	Note
No error	0x0000	/	/	/	/	
Overcurrent	0x0001	17	Power reduction	Phase current is above 200A rms in electric propulsion mode	Check load	1
Motor overheat	0x0002	18	Power reduction	Measured motor temperature is above 115°C	Reduce load, el. motor cooling required	
HCU overheat	0x0004	19	Power reduction	HCU temperature is above 85°C	Reduce load, HCU cooling required	
High battery current	0x0008	20	Power reduction	Calculated battery current is above max level	Reduce load	2
High phase current	0x0010	21	Power reduction	Phase current is above max level	Reduce load	2
High electric power	0x0020	22	Power reduction	Calculated electrical power is above max level	Reduce load	2
High mechanical power	0x0040	23	Power reduction	Calculated mechanical power is above max level	Reduce load	2
/	0x0080	24				
Charging level invalid	0x0100	25	Error mode / Charging interrupted	Battery voltage does not follow expected level at charging	Wait for battery voltage drop	
Charging voltage high	0x0200	26	Charging interrupted	Battery voltage in generator mode is above 53,4 V	Wait for battery voltage drop	
Bat. volt. prop. min	0x0400	27	Error mode / El. prop. interrupted	Battery voltage in electric propulsion mode is below 43 V	Recharge battery	
DC-link volt. prop. min	0x0800	28	Error mode / El. prop. interrupted	DC-link voltage in electric propulsion mode is below min level	Recharge battery / Reduce load	3
DC-link volt. prop. max	0x1000	29	Error mode / El. prop. interrupted	DC-link voltage in electric propulsion mode is above max level	Wait for DC-link voltage-drop	3
Overspeed el. prop. mode	0x2000	30	Error mode / El. prop. interrupted	Rotational speed in electric propulsion is above max level	Wait for electric motor speed-drop	3
/	0x4000	31				
Bad temp. sensors	0x8000	32	Warning	After power-up detected HCU, motor or battery temperature is out of normal limits	Check temperature sensors	

Table 12: AC2 errors listing

Note 1: The error with the decimal code number 17 can occur if the boat's propeller is blocked.

Note 2: Exact limit value depends on the current HCU operating mode.

Note 3: Exact limit value depends on chosen speed setting of the electric propulsion mode.

5.8.3.6 IG Error listing (HEX code):

Error Name	HEX Code	DEC Code	IG response	Reason	Remedy	Note
No error	0x0000	0	/	/	/	
DC-link overvoltage	0x0001	01	Error mode	DC-link voltage is above 270 V	Wait for DC-link voltage drop	1
Power module warm	0x0002	02	Power reduction	IG IGBT module temperature is above 85°C	Reduce load / Check HCU cooling	
Power module hot	0x0004	03	Increased power reduction	IG IGBT module temperature is above 90°C	Reduce load / HCU cooling required	
Power module excessive hot	0x0008	04	Error mode	IG IGBT module temperature is above 95°C	Stop / HCU cooling required	
Step up under-voltage	0x0010	05	Electric propulsion interrupted	Battery voltage dropped below 42 V	Recharge battery	
Bad power module	0x0020	06	Only error flag signalization	IG IGBT module temp. sensor failed	Check / replace IGBT	
CAN lost	0x0040	07	Permanent error mode	CAN Communication with AC part interrupted	Check / replace HCU	2
Battery overvoltage	0x0080	08	Error mode	Battery voltage is above 61 V	Check battery	

Table 13: IG errors listing

Note 1: The error with the decimal code number 01 shall not be apprehend as an error, if the battery voltage is between 53,4 V and 54 V when the HCU operates in generator mode (this is usual HCU behaviour when battery is overcharged).

Note 2: The error with the decimal code number 07 can occur due to several reasons:

- AC part HW or SW failure,
- IG part HW or SW failure,
- bad CAN BUS wiring of both controllers inside HCU,
- bad CAN BUS wiring of external devices (PC, DDI, etc.),
- electromagnetic noise,
- etc.

Note 3: Permanent error mode means HCU main operation modes are permanently disabled. In such case, the user shall first try to re-start the hybrid system, thus disconnect the HCU from the battery and then re-connect both parts together after at least 10 seconds. If the problem still persists, it is necessary to check and eventually repair the hybrid system.

5.8.3.7 SCREEN: *Connection lost*



Figure 25: “!! HCU LOST !!” screen

If CAN communication between HCU and DDI is interrupted then the following message appears:

“!! HCU LOST !!”.

This screen displays the software version of AC controller, IG controller, DDI and also HCU’s serial number. The software versions are displayed in HEX format, while the HCU serial number is displayed in decimal format.

5.9 Clutch actuator

Elektro–hidravlični aktuator opravlja izklop in vklop suhe lamemlne sklopke med diesel motorjem in elektičnim motorjem preko hidravlične batne črpalke in hidravličnega potisnega ležaja. Za preklop iz enega položaja v drugega potrebuje elektro–hidravlični aktuator približno 5 sekund.

Clutch actuator engages and disengages the clutch disc between the diesel engine and the electric 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.

Glavni sestavni deli elektro–hidravličnega aktuatorja so prikazani na sliki 26.

The main components of the clutch actuator are shown in the figure 26.

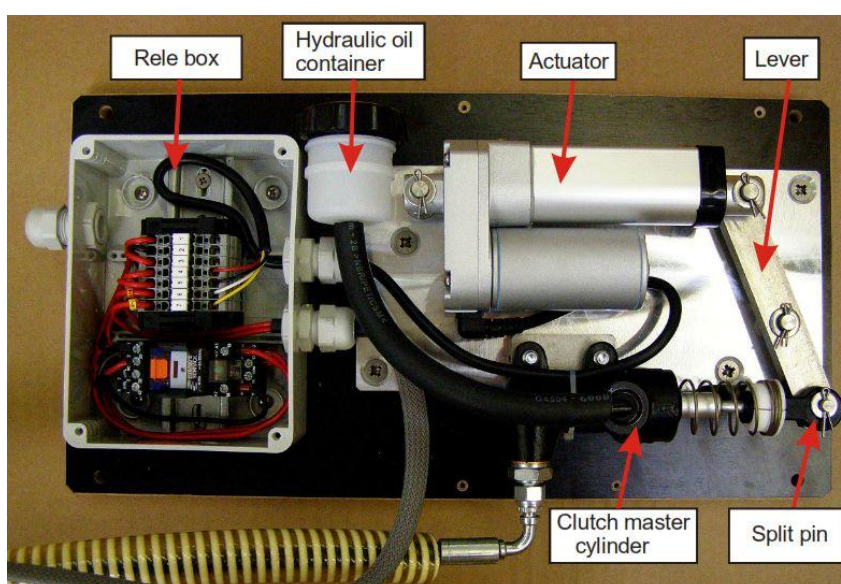


Figure 26: Electro-hydraulic clutch actuator

Elektro–hidravlični aktuator mora biti vgrajen na zaščiteno in suho mesto v plovilu ter ne sme biti izpostavljen vibracijam pogonskega diesel motorja ali pogonskega sklopa.

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.

V hidravličnem sistemu je zavorna tekočina DOT 4.

Hydraulic system is filled with brake fluid DOT 4.

Nivo zavorne tekočine v hidravličnem sistemu je potrebno kontrolirati 1 krat na mesec.

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

5.9.1 Manual engagement of the disc clutch

V primeru odpovedi aktuatorja in ko ostane suha lamelna sklopka v odprti poziciji ter zato diesel motor ni povezan z reduktorjem ZF 25, je potrebno za prehod na diesel pogon vklopiti suho lamelno sklopko. To storimo tako, da:

- Izklopimo stikalo *48V HYBRID DRIVE SWITCH* med pogonskim akumulatorjem in krmilnikom.
- Razstavimo mehansko zvezo med vzvodom električnega aktuatorja in tlačnim cilindrom. Izvlečemo razcepko in sornik, ki povezuje vzvod in batnico hidravličnega cilindra. S tem sprostimo bat in posledično pade tlak v hidravličnem cilindru in potisnem ležaju, kar omogoči povratek lamelne sklopke v delovni položaj.
- Poženemo diesel motor.

OPOMBA:

Do odprave napake uporaba elektro pogona ni več možna.

In the case of actuator failure and when the clutch stays in the open position and therefore the diesel engine is not connected with the reduction gear ZF 25, it is necessary to engage the clutch to make a transition to the diesel drive. This can be done so that we:

- Disengage the *48V HYBRID DRIVE SWITCH* between the drive battery and the controller.
- Disassemble the mechanical connection between the electric actuator lever and the pressure cylinder. Draw out the »split pin« and the split pin, which connects the lever and the clutch master cylinder piston rod. 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 electric propulsion is possible after the service repair.

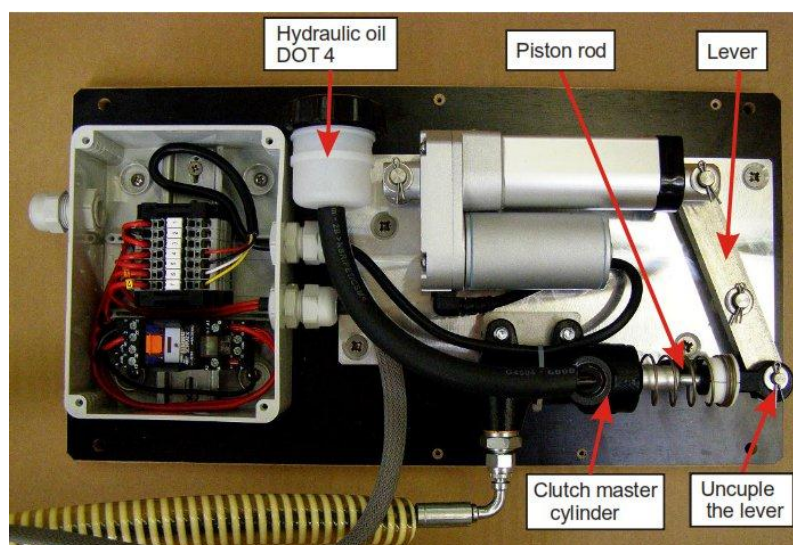


Figure 27: Electro-hydraulic clutch actuator

5.10 *Disc clutch*

Suha lamelna VW avtomobilska sklopka je vgrajena na dvomasni vztrajnik na diesel motorju.

Ko je sklopka vklopljena, se preko nje prenaša mehanska moč iz diesel motorja naprej preko električnega motor – generatorja na pogonski reduktor ZF 25. Obenem električni motor – generator proizvaja električno energijo za polnjenje pogonskega akumulatorja in napajanje porabnikov.

Ko je sklopka izklopljena, električni motor – generator lahko deluje v motorskem režimu za pogon plovila.

Izklop in vklop suhe lamelne sklopke med diesel motorjem in električnim motorjem opravlja hidravlični potisni ležaj preko elektrohidravličnega aktuatorja. Izklop in vklop suhe lamelne sklopke je dovoljen samo ob ugasnjenem diesel motorju in mirujočem električnem motor – generatorju.

VW automotive disc clutch is installed to the dual-mass flywheel in a diesel engine.

When the clutch is engaged, the mechanical power is transmitted through it from the diesel engine over the electric motor – generator to the drive reduction gear ZF 25 generator. At the same time, the electric motor – generator produces electric energy to charge propulsion battery and consumers.

When the clutch is disengaged, the electric motor – generator can operate in the motor mode to drive a boat.

Engagement and disengagement of the clutch disc between the diesel engine and the electric 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 electric motor – generator is still.

6. BLEEDING THE CLUTCH HYDRAULIC SYSTEM

OPOZORILO: Opisani postopek lahko izvaja samo usposobljeno osebje.!

Ta postopek zahteva dve osebi.

Seznam opreme in materialov, potrebnih za izvedbo postopka odzračevanja:

- zavorna tekočina DOT4,
- prozorno plastično cev (notranji premer 4mm),
- posoda (prozorna plastenka) za zbiranje odvečnega olja pri odzračevanju,
- viličasti ključ 11mm, viličasti ključ 13mm,
- moment ključ 2 ÷ 20 Nm, visok natični ključ 11mm in nizek natični ključ 13mm,
- dvoje kombiniranih klešč (ene naj bodo koničaste kombinirane klešče),
- kos suhe čiste krpe.

WARNING: Only qualified personnel should perform this operation!

This task requires two persons.

List of accessories and material needed to complain the task:

- brake fluid DOT4,
- transparent plastic hose (inner diameter 4mm),
- container (transparent plastic bottle) for excessive oil collection during bleeding process,
- fork wrench 11mm, fork wrench 13mm,
- torque wrench 2÷20 Nm; deep socket 11mm and normal socket 13mm,
- two pairs of pliers (one pair preferably needle pliers),
- a piece of clean dry cloth.

6.1 Bleeding the clutch hydraulic system procedure

Stikalo **48V HYBRID DRIVE SWITCH** mora biti **izklopljeno**.

Stikalo **DIESEL / ELECTRIC HYBRID SWITCH** preklapimo v **DIESEL** (Slika 28). S tem zagotovimo, da je hidravlični sistem odprt in v sistemu ni pritiska.

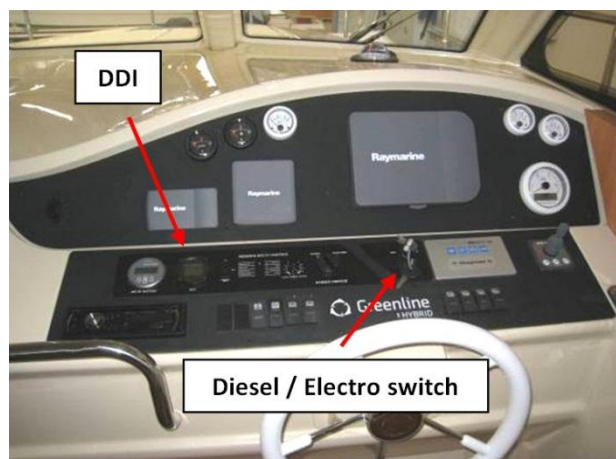


Figure 28

Preverite nivo zavorne tekočine v posodi – nivo tekočine mora biti med **min** in **max** indikatorjem na posodi (Slika 30). Na aktuatorju odstranite sornik, ki povezuje ročico z batnico hidravličnega cilindra (Slika 30). Potegnite batnico ven (Slika 32). Nataknite prozorno cev na ventil za odzračevanje (Slika 29) in vstavite drugi konec cevi v prazno posodo za zbiranje odvečnega olja. S krpo zaščitite ohišje (Slika 31). Dopolnite ali napolnite posodo z zavorno tekočino.

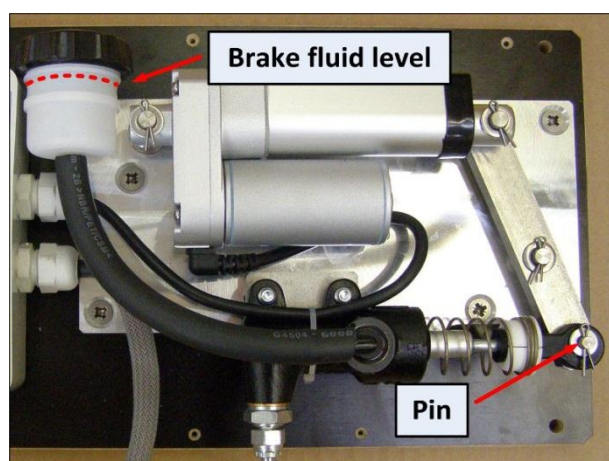


Figure 30

The **48V HYBRID DRIVE SWITCH** must be set to **OFF**.

Set the **DIESEL / ELECTRIC HYBRID SWITCH** to **DIESEL** (Figure 28). This assures that there is no pressure in the clutch hydraulic actuating system and the system is opened.

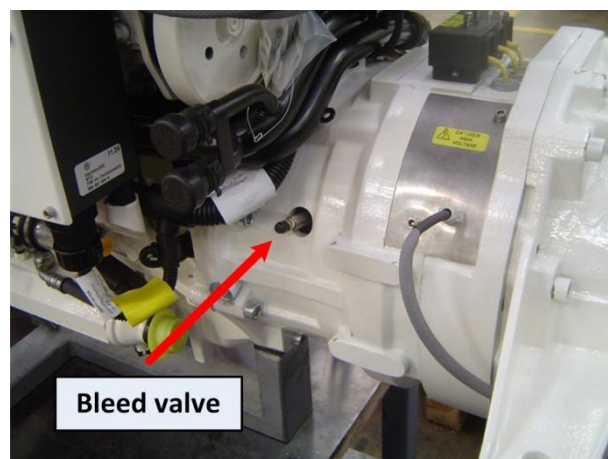


Figure 29

Check brake fluid level in the container – must be between **min** and **max** indicator (Figure 30). On the actuator remove the pin connecting lever and the master cylinder piston rod (Figure 30). Pull the piston rod OUT (Figure 32). Put transparent hose on bleed valve (see location on Figure 29) and insert the other end of the hose in an empty bottle. Protect housing with a piece of cloth (Figure 31). Add or fill the brake fluid.

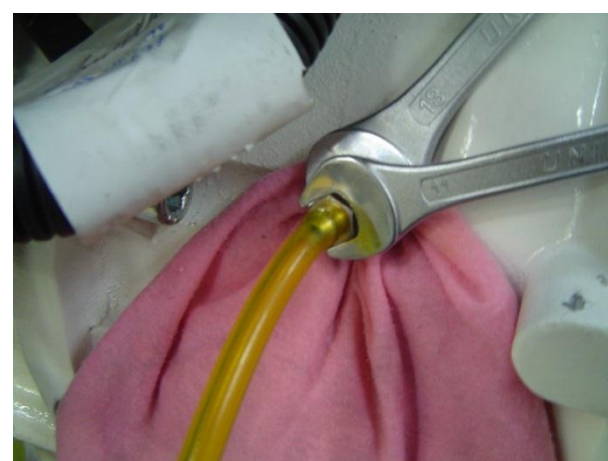


Figure 31

Nato naredite naslednje:

- **Odvijte** odzračevalni ventil na hidravličnem priključku z viličastim ključem 11mm (Slika 31) in **potisnite** batnico noter (Slika 32).
- **Privijte** odzračevalni ventil in **potegnite** batnico ven (Slika 32).

Ta postopek ponavljajte toliko časa dokler se zračni mehurčki pojavljajo v prozorni cevi. Pri izvajanju postopka je potrebno hidravlični priključek zavarovati, z viličastim ključem 13mm, pred odvitjem in pred prekomernim privitjem. Potrebno je stalno preverjati raven zavorne tekočine, ki ne sme biti nikoli nižja od 1/3 višine posode.

Ko je sistem odzračen, nudi batnica cilindra močan odpor, pri potisku z roko navznoter. Privijte odzračevalni ventil z navorom 13^{+2} Nm, pri tem pa, z viličastim ključem 13mm, zavarujte hidravlični priključek pred prekomernim privitjem (Slika 31).

Odstranite cev in vstavite sornik, podložko in razcepko na svoje mesto. Po potrebi dodajte zavorno tekočino v posodo.

Then do the following:

- **Loosen** the bleed valve on the hydraulic connector with fork wrench 11mm (Figure 31) and **push** the piston rod **IN** (Figure 32).
- **Tighten** the bleed valve and **pull** the piston rod **OUT** (Figure 32).

Repeat this procedure as long as air bubbles appear in the transparent hose. While performing this operation connector must be secured with wrench 13mm against unscrewing and over tightening. Also constantly check brake fluid level which should never fall below 1/3 of the container.

When the system is bled, master cylinder piston rod becomes very stiff to push **IN** by hand. Tighten the bleed valve with torque 13^{+2} Nm while securing the connector with wrench 13mm against over tightening (Figure 31).

Remove the hose and put the pin, washer and split pin back to their place. If necessary, add brake fluid in the container.

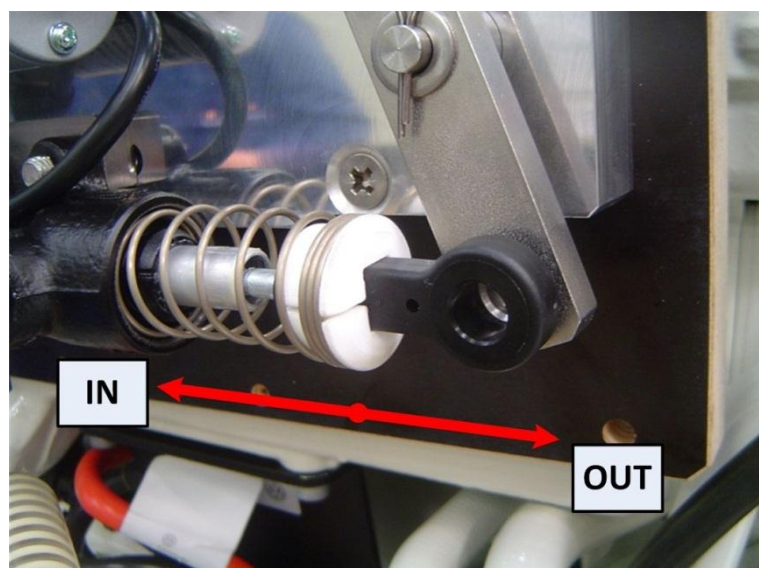


Figure 32

6.2 Clutch function test

Kako preveriti, če je sklopka deaktivirana:

- stikalo **DIESEL / ELECTRIC HYBRID SWITCH** preklapimo v **ELECTRIC**,
- E-motor mora delovati z menjalnikom v nevtralnem položaju pri maksimalnih vrtljajih.
- DDI mora pri tem delovanju prikazovati naslednje vrednosti:
 - **minimalno 1400 rpm**
 - **maksimalni baterijski tok 40A**

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 min. 1400 rpm**
 - **battery current draw max. 40A**

7. FUNCTIONAL OPERATION CONTROL

Za varno uporabo celega plovila s hibridnim pogonom mora uporabnik redno kontrolirati delovanje vseh funkcij. Pri tem ne sme priti do nepredvidenih pojavov ali celo odpovedi.

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

Uporabnik mora kontrolirati funkcije:

Izbiri delovanja med dieselskim in električnim pogonom.

- Delovanje aktuatorja za vklop in izklop sklopke.
- Zagon diesel motorja in kontrolo mirnega teka.
- Delovanje v generatorskem režimu in polnjenje akumulatorjev.
- Vožnjo z dieselskim pogonom.
- Vožnjo z električnim pogonom.
- Delovanje ročke za nastavljanje vrtilne hitrosti dieselskega in električnega pogona.
- Delovanje DDI in ostalih kontrolnih instrumentov na plovilu.
- Delovanje hladilnega sistema za krmilnik in električni motor hibridnega pogona.

The user has to 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.
- Operation in the generator mode and battery charging.
- Driving with a diesel drive.
- Driving with an electric drive.
- 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.

8. INSTRUCTIONS FOR A SAFE USE OF THE HYBRID DRIVE

Proizvajalec plovila izdelava navodila za varno uporabo celega plovila s hibridnim pogonom.

Uporabniku plovila priporočamo, da za uporabo hibridnega pogona upošteva naslednje:

- Enakomerno in počasno dodajanje ter odvzemanje plina v dieselskem režimu delovanja.
- Izogibanje nemirnemu delovanju diesel motorja v prostem teku.
- Izogibanje delovanju diesel motorja v področju vrtljajev, kjer lahko pride do povečanja vibracij pogonskega sistema ali celega plovila. Ob morebitni zamenjavi pogonskega sistema plovila, njegovega dela ali propelerja, se razmere za delovanje lahko spremenijo.
- Stalen nadzor podatkov na kontrolnih instrumentih in druga opažanja o delovanju.

V primeru, da se pojavijo kakršnekoli nepravilnosti v delovanju hibridnega pogona je nujno takoj izklopiti hibridni pogon z izklopom stikala *48V HYBRID DRIVE SWITCH* na palubi in se vrniti v najbližje пристanišče ali sidrišče s pogonom na diesel motor.

V vsakem primeru mora delovati električna črpalka, ki mora zagotoviti pretok hladilne vode.

Pred nadaljnjo uporabo plovila je potreben pregled sistema in plovila ter odprava napake.

Uporabnik plovila mora poskrbeti za upoštevanje vseh navodil za varnost pri uporabi hibridnega pogona in plovila.

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

We recommend to the user of the boat, when using the hybrid drive, to:

- Equally and slowly add and reduce gas in the diesel mode of operation.
- Avoid unstable operation of the diesel engine with vibrations in the idle running.
- Avoid operation of the diesel engine 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 of the hybrid drive, you must immediately disengage the hybrid drive by turn off the *48V HYBRID DRIVE SWITCH* on the deck and return to the nearest port or mooring on diesel engine drive.

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 and boat.