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1. SAFETY

Za varno uporabo plovila s hibridnim pogonom mora uporabnik upoštevati navodila proizvajalca plovila in ta navodila za Hybrid drive Greenline 33H – Users Manual and Troubleshooting.

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 dodane 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 baterij iz stebrička na obali, solarni sistem, porabniki na krovu, potisni motorji na premcu, klimatske naprave, siderna vitla, ..)

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 – Users Manual and Troubleshooting.

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 on board 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 (baterija) ter polnilcem baterij iz stebrička na obali ter fotovoltaičnim sistemom. Tudi, ko je sistem izklopljen se na vhodni in/ali izhodnih priključkih lahko pojavi nevarna visoka napetost. Vedno izklopite močnostno stikalo za baterijo 48V hibridnega pogona preden opravite kakršenkoli vzdrževalni poseg na hibridnem pogonu in tudi, ko hibridni pogon ni v uporabi.

V hibridnem pogonu ni 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 plina ali prahu.

Hybrid drive je pripravljen za delovanje z originalno vgrajeno baterijo na plovilu. Pri zamenjavi baterije je potrebno uporabiti enak tip in velikost baterije. Uporabo drugačne baterije in nastavitev hibridnega pogona lahko opravi samo pooblaščen servis za plovilo, ki mora obenem prilagoditi polnjenje glede na nov tip in velikost pogonskih akumulatorjev. 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 vozi ali na njem ni nikogar, mora biti stikalo za izbiro med diesel in elektro pogonom vedno v položaju diesel.

The Hybrid drive is used in combination with a permanent energy source (battery) and shore charger and photovoltaic system. Even if it is switched off, a dangerous electrical voltage can occur at the input and/or output terminals. Always switch the Battery power 48 V Hybrid drive switch to off before performing maintenance and when Hybrid drive is not in operation.

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 gas or dust explosions could occur.

Hybrid drive is ready for operation with a battery that is originally installed to the boat. When changing the battery it is necessary to use the same type and size of the battery. The use of a different battery and hybrid drive setting can only be performed by an authorized service for the boat, which has to adjust the charging with reference to the new type and size of drive batteries. For more information see chapter: **Generator (GEN) 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/electro switch must be always 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.

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 ali menjajte 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 deluje diesel motor ali elektro motor. Ne puščajte nobenih predmetov v zaščitnem ohišju diesel in elektro motorja.

Med delovanjem se enota segreje in ostane vroča še nekaj časa potem. 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 make sure that all switches are set to OFF position.

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 or replace 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.

Pred vklopom naprave preverite in zagotovite, da tip in napetost vgrajene baterije ustrežata 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, ko 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, DC/DC pretvornik, elektro-hidravlični aktuator s škatlo z relejem za krmiljenje aktuatorja in »Connection box for HCU with CAN connector« morajo biti vgrajeni na zaščiteno mesto 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.

Check before switching the device on whether the installed battery type and voltage conforms to the configuration settings of the hybrid drive installed on the boat.

Ensure that the equipment is used under the correct operating conditions. Never operate it in a 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 that there is always sufficient cooling water flow 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 have to 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 system's elements: controller, DC/DC converter, clutch actuator with a relay box for actuator control and connection box for HCU with CAN connector have to be built 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 pritvita priključnih kablov na vseh električnih sponkah hibridnega sistema in stanje kablov.

At maintenance intervals of diesel engine 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 baterije 48V hibridnega pogona izklopljeno.

On storage or transport of the boat, ensure that the battery 48 V *Hybrid drive* switches is disconnected.

Ne sprejemamo nobene odgovornosti za škodo med 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°C.

Store the product in a dry environment; the storage temperature should range from -20°C to 60°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 41XX 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:

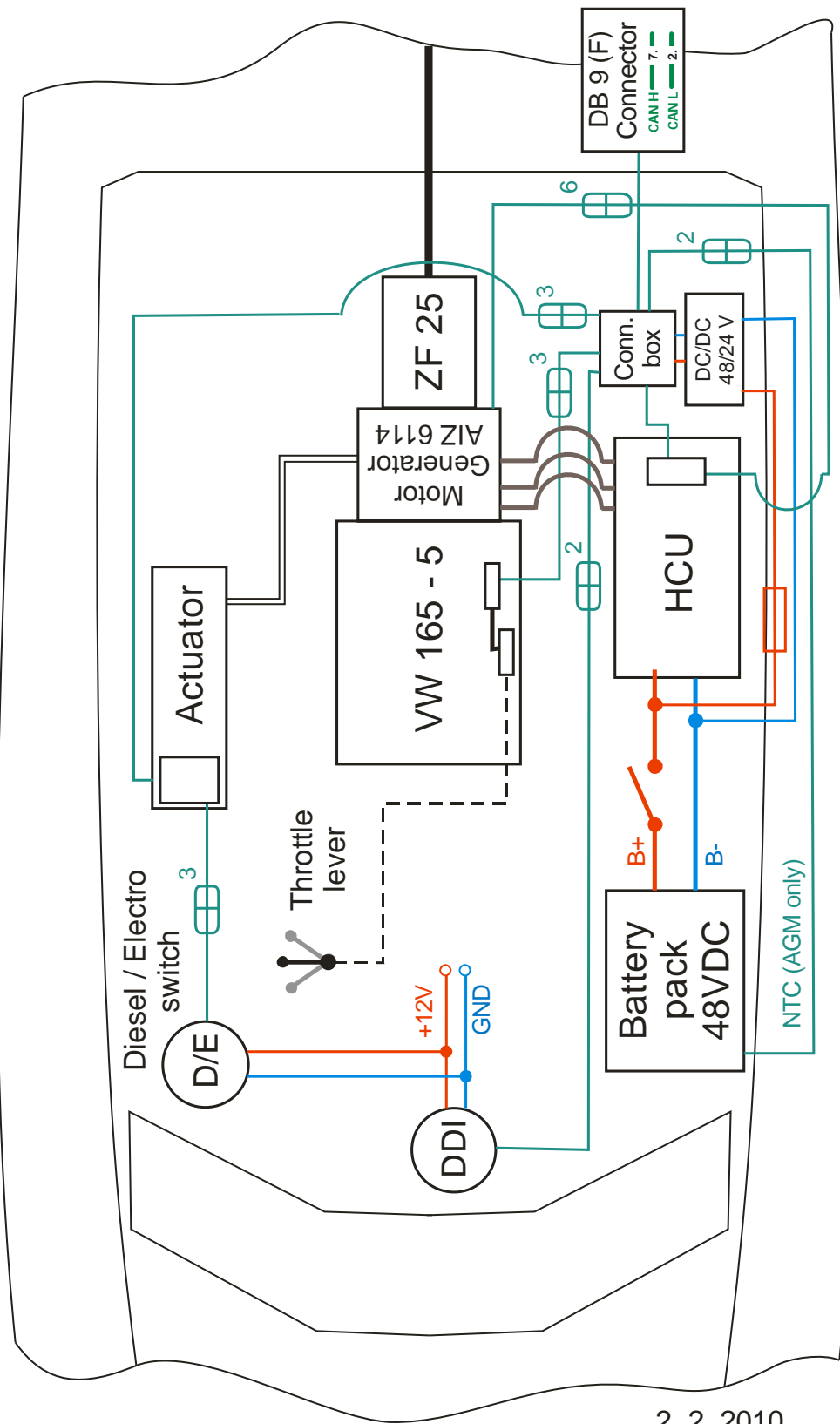
Hybrid drive AUZ 41XX 48V 5/7 kW	
Nominal voltage	48 V
Drive battery	48 V – 240Ah Li-Po*
Continuous power of the generator	up to 5 kW to 4000 rpm, limited with reference to the type and battery capacity
Electric drive	7 kW, max 20 minutes
Electric drive	5 kW, continuous
Electric drive duration	Dependent on the type and capacity of the battery and the running speed
Max revolutions E-mot/Gen	4000 rpm
Cooling water	<30°C, 4 litres/min for E-Mot/Gen and controller
Ambient temperature	- 10°C to 60°C
IP protection	IP 22
E-mot/Gen weight	~ 60 kg
Actuator weight	~ 6 kg
Controller weight	~ 27 kg
Boat	Seaway Greenline 33H

* Options are: 48 V 200 Ah AGM. To set the charging to 48 V 200Ah AGM, it is necessary to connect the terminal No. 14 (»Batt. Type Sel.«) in the connection box with the terminal No. 1 (supply voltage 24V).

2.2 *Description*

Električni motor – generator hibridnega pogona s suho lamelno sklopko je vgrajen med diesel motor in pogonski reduktor ZF 25. Elektronski krmilnik, elektro–hidravlični aktuator, električne in hidravlične povezave ter ostali sestavni deli hibridnega pogona so na plovilu razporejeni kot je prikazano na naslednji sliki: Blok diagram hibridnega sistema.

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



2. 2. 2010

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 6114 48 V 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.

The figure shows an integrated hybrid drive. Three-phase brushless motor – generator with permanent magnets AIZ 6114 48 V 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.

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.

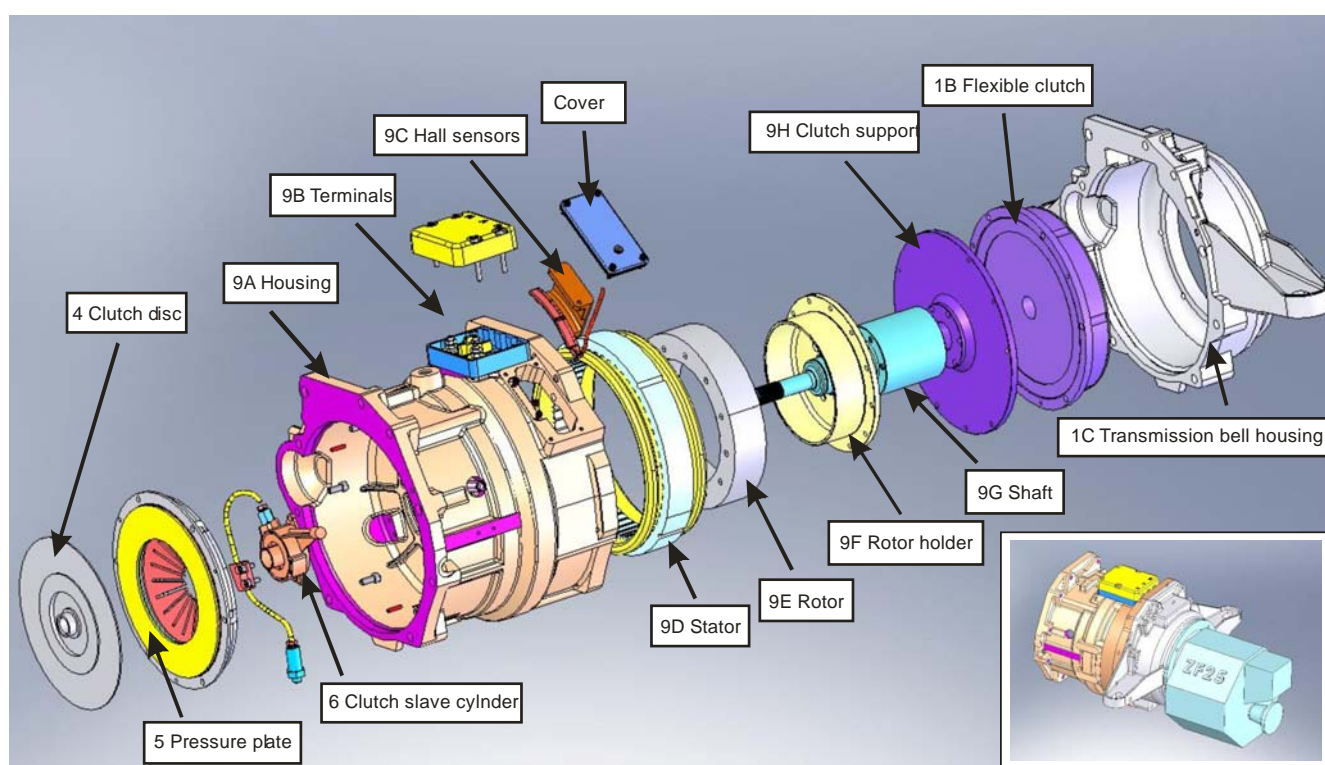
Electronic controller takes care of the proper operation of the hybrid system. The controller can charge batteries in the generator mode or control the electric motor to drive the boat in the motor mode. A special control system gives the user a choice between the electric motor and diesel engine boat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

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

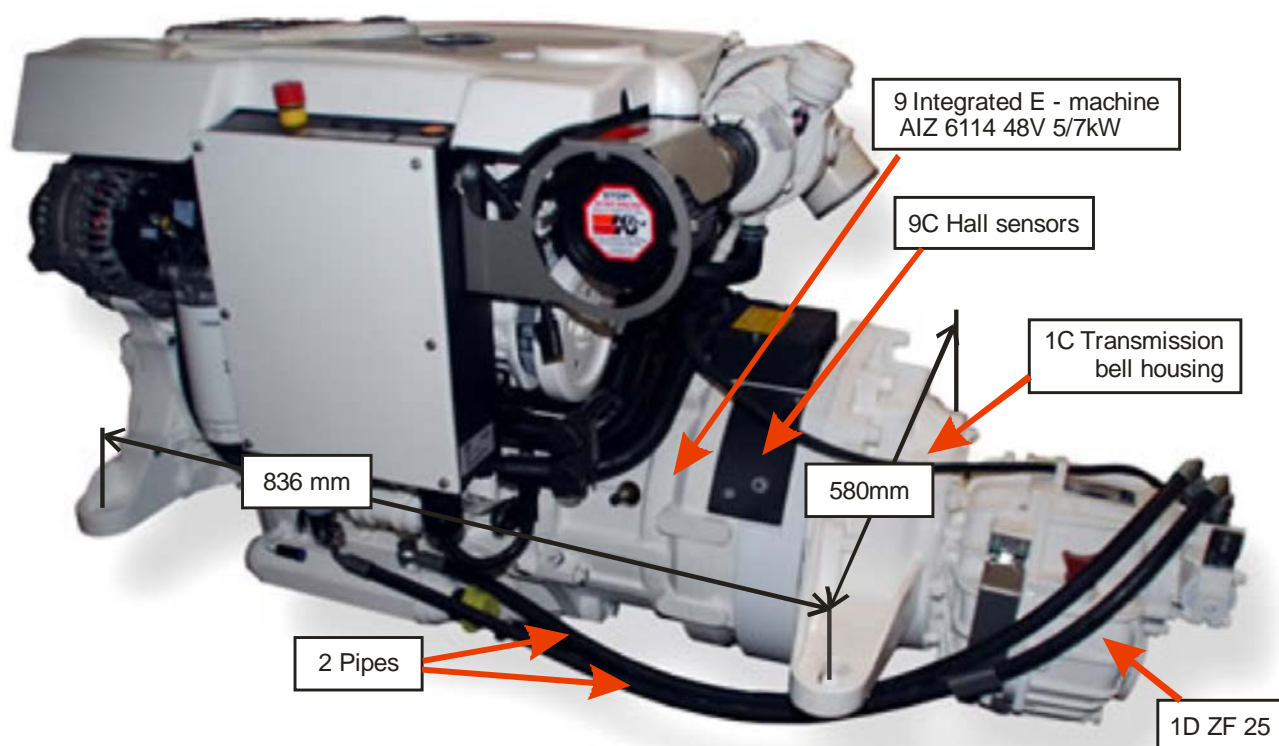
Data Display Interface (DDI) display is installed to the boat to show parameters and the operational mode of the hybrid system.

POS	Part number	Part name	PCS	Mass (kg)
1		Diesel engine VW TDI 165-5 or VW SDI 75-5	1	265,00
1A	VW: 074 105 266 M	Flywheel	1	
1B	VW: 065 311 592 ACAK	CENTA – flexible clutch P/N 26-60916-00	1	4,30
1C	VW: 065 923 924 C	Transmission bell housing for ZF25	1	7,06
1D	VW: 065 300 040 K	ZF25 -2.0 drive unit (1:1,97) P/N: 3315002013	1	24,00
2	VW: ?	300mm longer pipes from TDI 165-5 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	11.221.014	Integrated E - machine AIZ 6114 48V 5/7kW	1	57,30
9A	16.285.432	Housing with bearings	1	19,32
9B	16.420.666	Terminals	1	0,50
9C	16.912.178	Hall sensors set with cable	1	0,50
9D	16.350.589	Stator 48 V	1	7,66
9E	16.363.017	Rotor	1	8,00
9F	15.902.713	Rotor holder	1	4,42
9G	15.111.420	Rotor shaft	1	7,24
9H	15.902.851	Support for Centa flexible clutch	1	5,16

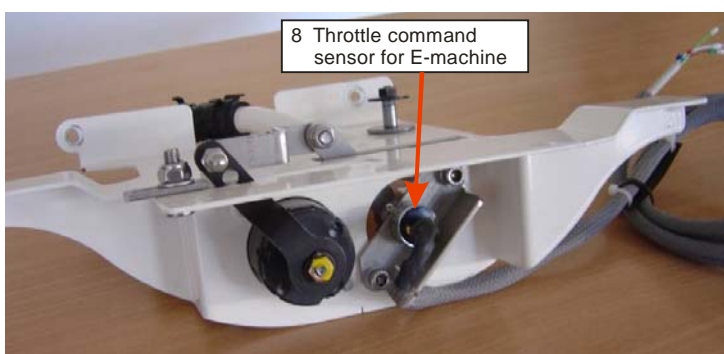
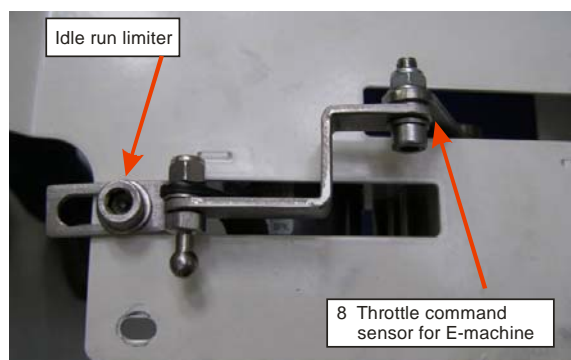
10	11.259.013	HCU – AEG 5302 48V 7/10kW 240 Ah Li-Po	1	26,10
11	16.912.110	Clutch actuator 12V (oil DOT4)	1	6,60
12	16.912.173	Cable for DC/DC 48V/24V		0,10
13	612.001.042	Power supply for HCU logic DC/DC 48V/24V 50W	1	0,70
14	11.255.098	Indicator DDI AEB 1126 - 24V	1	0,10
15	16.511.541	Cable for signal for DDI	1	0,50
16	16.511.540	Connection box for HCU with CAN connector	1	0,85
17	16.912.175	Temperature sensor NTK for AGM battery only	1	0,10
18	Boat instalation	Cables from AIZ to HCU (max 2,5m, min 50 mm ²)	1	
19	Boat instalation	Cables from HCU to Battery bank (max 3,5m, min 70 mm ²)	1	
20	Boat instalation	STECA Solarix 4401	1	
21	Boat instalation	Driving lever – throttle	1	
22	Boat instalation	Switch from Diesel to Electric	1	
23	Boat instalation	Water pump > 4 litres/minute for cooling of HCU and AIZ	1	
24	Boat instalation	Cooling water pipes	/	
25	Boat instalation	Inverter charger 48/3000/35	1	
26	Boat instalation	Battery monitoring	1	
27	Boat instalation	Battery bank 48 V – 240 Ah Li-Po	1	



Integrated hybrid drive



VW TDI 165-5 marine diesel engine with Integrated E - machine AIZ 6114 48V 5/7kW



Pos. 8: Throttle command sensor and idle run limiter



Pos. 9C: Hall sensor set with cable

POS. 10: Control unit - HCU



POS. 12: Cable for DC/DC 48V/24V



POS. 13: DC/DC 48V/24V 50W



POS. 14: DDI indicator



POS. 15: Cable for signal



POS. 16: Connection box for HCU



POS. 17: Temperature sensor NTK for AGM battery only

2.3 *Review of the size of currents, voltages and temperatures*

Generator cycle of operation	
Output adjustable voltage from the controller Li-Po / AGM	53,4 V \pm 0,2 V / 57,2 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 type and size of the drive battery
Max voltage on the stator terminals of the generator and the terminals of the controller	280 V between phases, 165 V phase
Max generator phase current	40 A
Max voltage in the controller	230 V _{DC}
E-motor (MOT) cycle of operation	
Max drive power	7 kW @ 1100 RPM, 20 min
Continuous drive power	5kW @ 1100 RPM
Min / Max operating voltage of drive battery	45 V / 56 V
Max current of drive battery	200 A
Max motor phase current	100 A short-time, 90 A continuous
Max voltage in the controller	100 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 (shown on DDI)

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

3. DESIGNATIONS AND DATA

Elektronska krmilna enota, električni stroj AIZ 4114, 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 4114, 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 ni zaščen proti napačni polariteti ob priklopu na akumulatorsko baterijo. Priključitev na napačno polariteto 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 Hybrid control unit.

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.

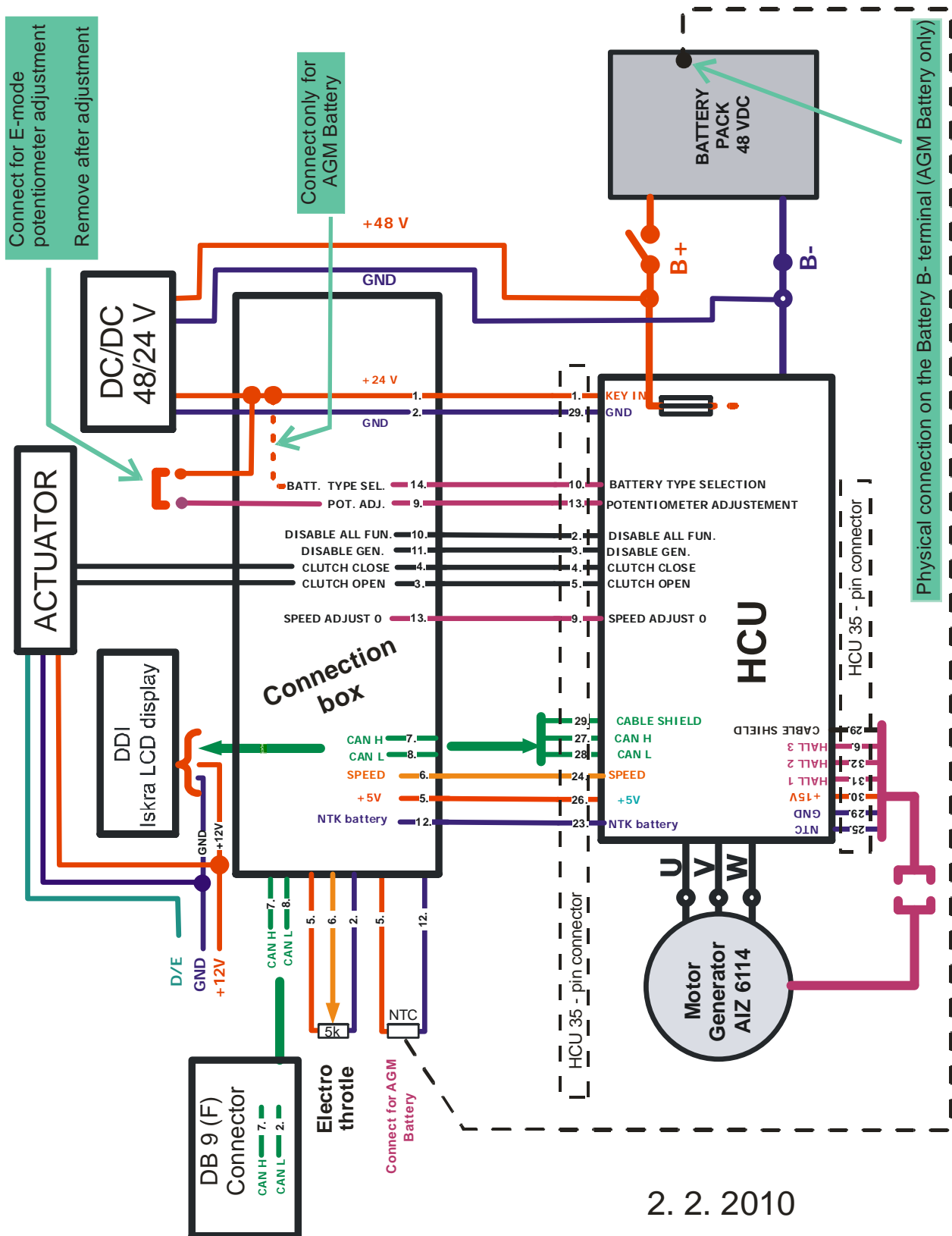
OPOZORILO 3: Pri odklapljanju hibridnega sistema najprej odklopimo vse B+ povezave in signalne vodnike. Šele nato lahko odklopimo B- pole hibridnega sistema in B- pole 12V in 48V baterij iz skupne mase.

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



100120-table for connection.xls

Connection of cables in Connection box 16.511.540 for HCU

Cable	Designation on cable	No. of terminal in connecting box	Connection description
Power supply cable from DC/DC 48V/24V 50W	1	1	+24V from DC/DC converter
	2	2	GND from DC/DC converter
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 communication cable 16.541.541	7	7	CAN High
	8	8	CAN Low
	2	2	Shield GND

CONNECTION OF CABLES IN Clutch actuator 16.912.110

Cable	Designation on cable	No. of terminal in actuator relay box	Connection description
Power supply for actuator -boat installation cables	Boat installation cables	1	D/E Switch
		2	GND
		3	+12V

CONNECTION OF DC/DC 48V/24V POWER SUPPLY 612.001.042 FOR HCU

Cable	Designation on cable	Designation of terminal on HCU	Connection description	Designation of terminal on "Mascot" DC/DC 48/24V converter	Designation on cable
Power supply for DC/DC converter 48V/24V (Long cable)	B+	B+	+48V	in +	B+
	B-	B-	GND	in -	B-
Power supply for HCU 24V (Short cable)		No. of terminal in connecting box			
	1	1	+24V	out +	+
	2	2	GND	out -	-

CONNECTION OF CABLE 16.541.541 WITH DDI 11.255.098

4 pole connector connect on DDI
Power supply cable +12V, GND connect on power supply on boat dashboard

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 $< 30^{\circ}\text{C}$.

The cooling system uses external water for cooling of an 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 $< 30^{\circ}\text{C}$.

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

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

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

The cooling system operation is checked with a regular visual inspection of the cooling water flow.

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

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.

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.

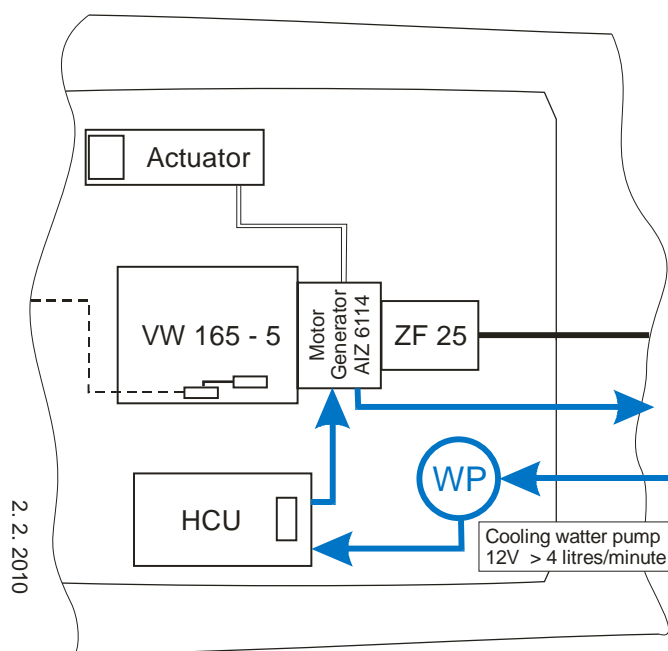
Preveriti je potrebno delovanje hladilnega sistema.

The temperature protection disengages the hybrid system in case if electric 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 motor deluje neodvisno od vklopa temperaturne zaščite hibridnega pogona.

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



Hybrid drive cooling system diagram

5.3 Diesel engine

Tech. specification	Unit	VW TDI 165–5 marine	VW SDI 75–5 marine
Motor	type	VW TDI 165–5	VW SDI 75–5
Cylinders	number	5	5
Volume	ccm	2461	2461
Power	kW	110 @ 4000 rpm	55 @ 3600 rpm
Idle speed	rpm	850	850
Torque	Nm	310 @ 2500 rpm	155 @ 2250 rpm
Mass	kg	265	233

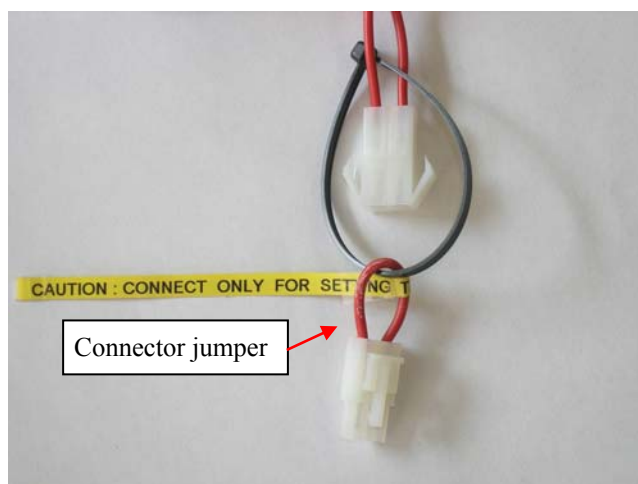
5.4 Setting the potentiometer for E-motor mode within the range of diesel motor throttle lever

1. Sikalo med 48V baterijo in krmilnikom HCU izklopimo
2. **Opozorilo:** Pogonski reduktor postavimo v nevtralni položaj
1. Main switch between 48 V battery and HCU unit must be set to **OFF**.
2. **Warning:** Set the transmission box to neutral.



Set the gear box to neutral

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

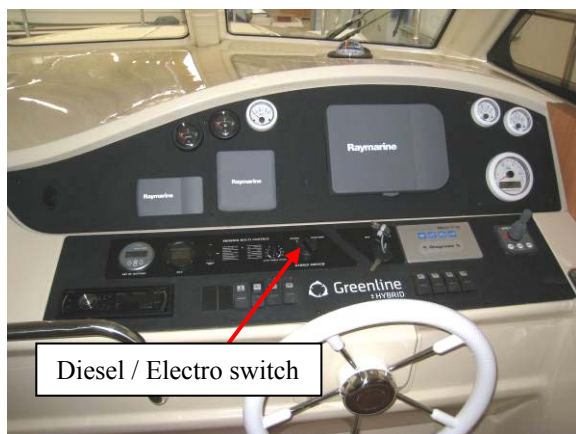


Cable and connector jumper

4. Stikalo za izbiro med Diesel/Elektro preklopimo na položaj *Diesel*
4. Set the **Diesel / Electro** switch to **Diesel** position.

5. Ročico za plin postavimo v nevtralno lego.

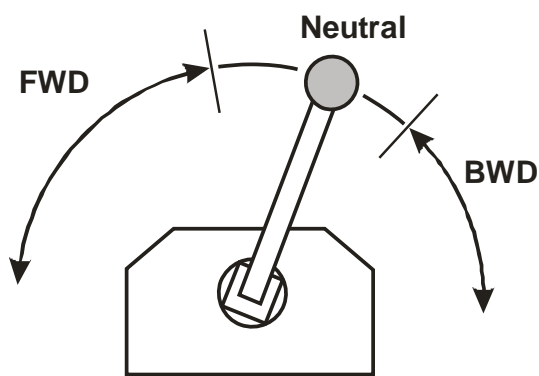
Ročica za plin ima položaje *Naprej* (FWD), *Nazaj* (BWD) in Nevtralno. Ročica za plin ima lahko različen kot pomika iz *Nevtralnega* v končni položaj *Naprej* oziroma končni položaj *Nazaj*.



Diesel / Electro Switch

5. Set the throttle lever to neutral.

Throttle lever has positions Forward (FWD), Backward (BWD) and Neutral. Throttle lever might have different angles at maximal shift from Neutral to maximal FWD and to maximal BWD position.



Throttle lever

6. Priključimo krmilnik HCU na 48V baterijo tako, da vklopimo glavno stikalo 48V baterije na ON.
7. V času 5 sekund premaknemo ročico za plin v končni položaj v tisti smeri kjer je kot hoda v skrajno lego manjši.
8. Odklopimo krmilnik HCU od baterije tako, da izklopimo glavno stikalo 48V baterije.
9. Odstranimo mostični konektor iz kabla.
10. Preizkusimo hitrost vrtenja električnega pogona pri obeh skrajnih legah ročice za plin. To naredimo v prostem teku elektro motorja. Postopek ponovimo v kolikor ni dosežena največja možna hitrost vrtenja.

6. Connect the HCU unit to 48 V battery by setting the main switch of 48 V battery to **ON**.
7. Then within 5 seconds put the throttle lever to its end position in the direction Forward or Backward where the angle from the neutral position is smaller.
8. Disconnect the HCU unit from 48 V battery by setting main switch of 48 V battery to **OFF**.
9. Remove the connector jumper from the cable.
10. Test the speed of rotation of electric motor in both end positions of throttle lever. The test is done in iddle run of electric motor. Repeat the procedure if maximal preset speed is not achieved.

5.5 Generator mode of operation

5.5.1 Settings for drive battery charging

V generatorskem režimu delovanja elektronski krmilnik integriranega hibridnega pogona zagotavlja nadzorovano polnjenje pogonskih akumulatorjev 48 V, ki je bazirano na merjenju napetosti in vrste akumulatorja ter temperature v primeru AGM akumulatorjev.

In the generator mode of operation, the electronic controller of the integrated hybrid drive enables a controlled charging of drive batteries 48 V, which is based on the voltage measurement, battery type, and temperature in the case of AGM batteries.

Predvidena sta dva tipa pogonskega akumulatorja: 48 V 200 Ah AGM in 48,1 V 240 Ah Li-Po KOKAM SLPB 160460330.

The two foreseen types of drive batteries are: 48 V 200 Ah AGM and 48,1 V 240 Ah Li-Po KOKAM SLPB 160460330.

Za nastavitev polnjenja na 48 V 200 Ah AGM je potrebno v dozi ob krmilniku sponko št. 14 („Batt. Type. Sel“) povezati na sponko št. 1 (napajalna napetost 24V). Za 48 V 400 Ah AGM je potrebna poleg tega še nova nastavitev parametrov v krmilniku.

To set the charging to 48 V 200Ah AGM, it is necessary to connect the terminal No. 14 (»Batt. Type Sel.«) in the connection box by the controller to the terminal No. 1. 1 (supply voltage 24V). In addition to this, new setting of parameters in the controller is required for 48 V 400 Ah AGM.

Za AGM tip akumulatorja priklopimo NTC senzor na negativni pol (B-) na enem od notranjih pogonskih akumulatorjev v paketu.

For the AGM battery type we connect the NTC sensor to the negative pole (B-) on one of the inside drive batteries in the pack.

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

Charging has to comply with the »Shore Charger« 35A and the solar power system of approximately 1kW (circa 20A) so that the selected type of the drive 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 pogonskega akumulatorja omejena tudi glede na trenutne vrtljaje diesel motorja.

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

Ko je pogonski akumulator delno napolnjen, lahko diesel motor zopet deluje v prostem teku.

Nastavitve polnjenja za posamezen tip in velikost pogonskega akumulatorja so podane v nadaljevanju.

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 drive battery is limited also with reference to the current revolutions of the diesel engine.

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

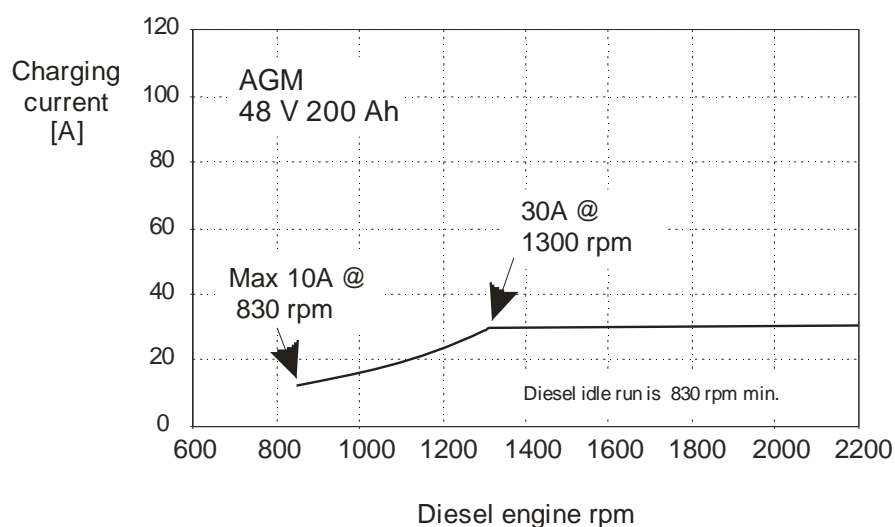
When the drive battery is partially charged, the diesel engine can operate in idle run.

The charging settings for an individual type and size of the drive battery are given below.

5.5.1.1 Settings for a 3-stage battery charging 48 V 200 Ah AGM

Za izbiro polnjenja pogonskega akumulatorja 48 V 200 Ah AGM je potrebno v »Connection box-u« izvesti povezavo kot je to označeno na vezalni shemi hibridnega pogona v točki 5.1 Diagram of hybrid drive installation on Greenline 33H

To select charging of the drive battery 48V 200Ah AGM, it is necessary to make a connection in the connection box as it is designated in the connection diagram of the hybrid drive in item 5.1 Diagram of hybrid drive installation on Greenline 33H



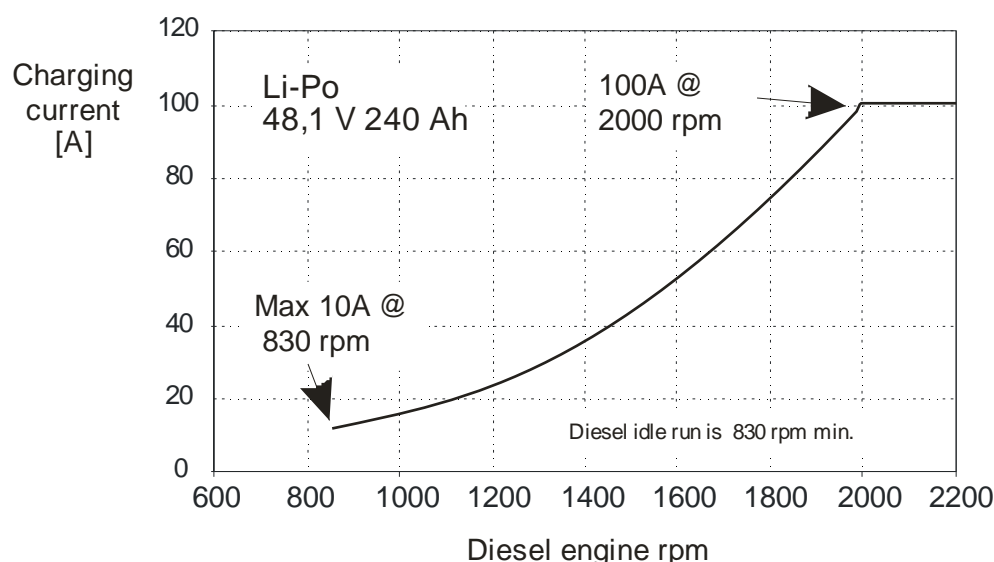
Level	U_{ch} [V]	I_{ch} [A]	Condition for switching / limitation	Shore Charger U_{ch} [V]	Solar system U_{ch} [V]
Bulk	$\leq 57,2$	30	$t_{bulk\ min} = 120s$ ($U_{ch} = 56,9$ V) $t_{bulk\ max} = 8h$ ($U_{ch} \geq 55,2$ V)	/	/
Absorption	56,9	≤ 30	$t_{abs} = 4 \times t_{bulk\ max}$ $t_{abs\ min} = 900\ s$, $t_{abs\ max} = 9999\ s$	57,6	57,6
Float	55,2	< 5	/	55,2	55,2

All 3 voltages are adjusted to the battery temperature 48 V 200 Ah AGM. The indicated values are for $T = 25^{\circ}C$. The temperature compensation is $93.3\ mV/^{\circ}C$.

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

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

The controller has been set in the factory for charging of the drive 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

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 drive battery

Kontrola SOC pogonskega akumulatorja je predvidena z Victron BMV 602. Za pravilno uporabo pogonskega akumulatorja je potrebno upoštevati navodila proizvajalca akumulatorjev.

SOC of the drive battery is foreseen with the Victron BMV 602. For the proper use of the drive 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 pogonskega akumulatorja.

Zato odsvetujemo izklapljanje ločilke 48 V Hybrid drive, ko hibridni pogon deluje v generatorskem režimu. V skrajnem primeru lahko odklop bremena povzroči trajno odpoved elektronskega krmilnika.

Load dump is the situations that can occur in the generator operation at disengagement of the drive battery.

Therefore we advise not to disconnect the circuit breaker 48 V Hybrid drive, 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, a parallelly embedded 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 pogonski akumulator prazni in se zato niža napetost na njegovih sponkah. Ko napetost pogonskega akumulatorja pade na 44 V, se aktivira opozorilni signal iz polnilnega sistema Victron. Nadaljne praznjenje akumulatorja ni priporočljivo in je potreben prehod na diesel pogon in ponovno polnjenje akumulatorja.

During E-motor mode of operation the electric energy from drive battery is used and voltage on battery terminals is getting lower. At the voltage of 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 ob pomiku komandne ročke »plina« v nevtralni legi ne vrti. Ob pomiku ročke iz nevtralne lege se 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 "zero" position. It engages when the lever is moved from "zero" 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 fully open controller, »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					

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

Vrednosti so izmerjene s 5-listnim propelerjem 17" x 14,5". Z izbiro drugačnega propelerja, spremembo mase plovila ter velikost valov in jakost 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 ZF25 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 has to be installed to the protected and dry place in a boat and cannot 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 omogoča prikazovanje podatkov za nadzor načina delovanja in izmerjene vrednosti v elektronskem krmilniku HCU.

Data Display Interface (shortly DDI) displays the information for monitoring the functions and measured values in the HCU (Iskra hybrid 48 V controller).

DDI prikazuje trenutni način delovanja sistema in HCU, napetost na bateriji, temperaturo in tok, stanje napolnjenosti baterije, vrtilno hitrost in temperaturo električnega motorja, šifre napak in druge podatke uporabne za serviserje.

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

DDI preklaplja med dvema ali tremi različnimi ekrani glede na trenutni način delovanja. Vsak ekran je prikazan 20 sekund. Vsak preklop ekran ima še dodatno utripajočo led diodo, ki označuje spremembo.

DDI switches between 2 or 3 different screens depending on the current working mode. Each screen is shown for 20 seconds. The screen switching is additionally perceivable by toggling of LED light mounted on DDI cover.

Vsi prikazani podatki so indikativni z natančnostjo $\pm 5\%$.

All data have to be considered as indicative only, precision is $\pm 5\%$.



DDI - Data Display Interface device

5.8.2 Hardware installation

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

Pogled oznečevanja pinov je iz zadnje strani

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

VCC mora biti priključen na +12 V glavnega tokokroga na čolnu.

GND mora biti priključen na maso glavnega tokokroga na čolnu.

CAN_HI mora biti priključen na pin številka 27 na HCU glavnem konektorju.

CAN_LO mora biti priključen na pin številka 28 na HCU glavnem konektorju.

Za zagotovitev zanesljivega delovanja sistema priporočamo uporabo kablov z oklopom za povezavo CAN_HI in CAN_LO. Oklop mora biti povezan na pin št. 29 na glavnem konektroju na HCU

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

Connector pin number listing (rear view):

- 1 – CAN_LO (CAN low line)
- 2 – CAN_HI (CAN high line)
- 3 – GND (negative power supply)
- 4 – VCC (positive power supply)

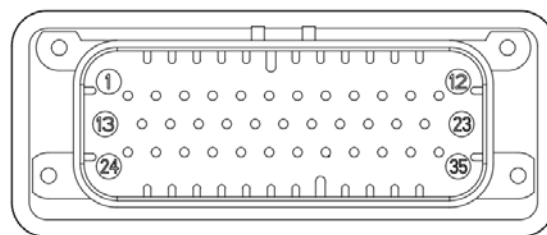
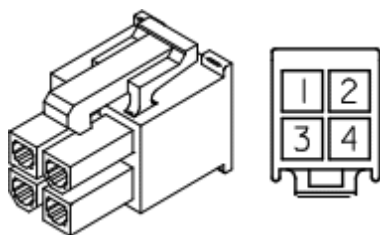
VCC must be connected to +12 V voltage (boat main electric network)

GND must be connected to ground (boat main electric network)

CAN_HI must be connected to pin number 27 (HCU main connector)

CAN_LO must be connected to pin number 28 (HCU main connector)

For device reliable working the usage of shielded cable for wires CAN_HI and CAN_LO is highly recommended. Shielding must be connected to pin number 29 of HCU main connector.



A cross-view of 4-pin connector (on DDI device) and 35-pin connector (on HCU controller)

5.8.3 DDI screen's description

Na vsakem ekranu so štiri vrstice. Zadnja je skupna in je namenjena prikazu možnih napak v delovanju HCU.

All screens have four lines. A common fourth line is reserved for showing eventual errors, which can occur on HCU.

5.8.3.1 DDI Quick screen listing

	Data 1	Data 2
SCREEN 1		
Line 1	Mode	Motor temp.
Line 2	IG module temperature	AC module temperature
Line 3	Speed (RPM)	Battery temperature
Line 4	IG Errors	AC Errors
SCREEN 2		
Line 1	IG DC-link voltage	AC DC-link voltage
Line 2	Battery current	Motor current
Line 3	Battery voltage	Remaining Battery cap.
Line 4	IG Errors	AC Errors
SCREEN 3		
Line 1	Charging phase	Battery temperature
Line 2	Charging level	Final chg. level / absorption time
Line 3	Charging phase duration	Total charging duration
Line 4	IG Errors	AC Errors
SCREEN: Connection lost		
!!! HCU LOST !!		

The values shown in DDI are merely indicative.

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 1						
Line 1	Mode	Current working mode	N, FWD, G, GS, ERR	MotT	Motor temp.	From -10°C to 100°C
Line 2	IG T	IG module temperature	From -10°C to 90°C	AC T	AC module temperature	From -10°C to 90°C
Line 3	RPM	Speed (RPM)	0 to 1550	Bat_T	AGM battery temperature	From -10°C to 50°C
Line 4	IG Errors			AC Errors		
SCREEN 2						
Line 1	IG	IG DC-link voltage	From 0 to 200V	AC	AC DC-link voltage	From 0 to 200V
Line 2	Ib	Battery current	From -100 to 140 A	Imot	Motor current	From -50 to 110 A
Line 3	Vb	Battery voltage	From 45 to 58V	C	Remaining Battery cap.	Only for lead-acid batteries
Line 4	IG Errors			AC Errors		
SCREEN 3						
Line 1	x	Charging phase	Lead-acid batteries: BULK, ABSRPT FLOAT, Li-PO batteries: ABSRPT	Bat_T	Battery temperature	From -10°C to 50°C
Line 2	chL	Charging level	from 0 to 255b		Final chg. level / absorption time	from 0 to 255b or from 0 to 9999 s
Line 3	tPH	Charging phase duration	from 0 to 9999s	tTOT	Total charging duration	from 0 to 9999 s
Line 4	IG Errors			AC Errors		
SCREEN: Connection lost						
!!! HCU LOST !!						

5.8.3.2 SCREEN 1

Line 1, data 1: *Mode: x*

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

‘*x*’ can be:

- **N** – neutral mode (only logic part of HCU is active)
- **FWD** – electric motor mode i.e. electric propulsion
- **G** – generator mode i.e. diesel engine active, HCU charges batteries
- **GS** – gear shifting mode i.e. a special mode active only during between changing of generator and electric mode
- **ERR** – error mode i.e. failure mode, which can become active in case of a malfunction, bad system connection, overloading, overheating, etc...

Line 1, data 2: *MotT: xC*

MotT: xC indicates electric motor temperature in Celsius degree.

Line 2, data 1: *IG_T: xC*

IG_T: xC indicates temperature of IG power module inside HCU unit.

Line 2, data 2: *AC_T: xC*

AC_T: xC indicates temperature of AC power module inside HCU unit.

Line 3, data 1: *RPM: x*

RPM: x indicates the speed of electric engine in ratio-per-minute (RPM) unit.

Line 3, data 2: *Bat_T: xC*

Bat_T: xC indicates temperature of GEL or AGM batteries, if Li-PO batteries are used, then the value is forced to show always 25°C.

5.8.3.3 SCREEN 2

Line 1, data 1: *IG: xV*

IG: xV indicates HCU internal voltage on DC-link of IG part in 0.05V resolution.

Line 1, data 2: *AC: xV*

AC: xV indicates HCU internal voltage on DC-link of AC part in 0.05V resolution.

Line 2, data 1: *Ib: xA*

Ib: xA indicates current flowing into / out of HCU battery terminals in 0.05A resolution. Sign ‘–’ appears before the value when HCU charges batteries, i.e. during generator mode.

Line 2, data 2: *Imot: xA*

Imot: xA indicates motor phase current of electric engine in 0.05A resolution.

Line 3, data 1: *Vb: xV*

Vb: xV indicates battery voltage measured at HCU battery terminals in 0.05V resolution.

Line 3, data 2: *C: xAh*

C: xAh indicates the remaining battery capacity in 0.05Ah resolution. This data is available only for lead–acid battery type. The shown value strongly depends on the battery type and is not accurate, due to the absence of battery current measurement. This value is inaccurate if HCU parameters are not properly chosen.

5.8.3.4 SCREEN 3

The contents of the third screen strongly depends on the battery type used. AGM type batteries are charged with three-step charging method. Li-PO batteries are charged with a current limit - constant voltage method.

Line 1, data 1: *x*

x indicates the current state (phase) of the three-step charging method.

For lead-acid batteries '*x*' could be:

- **BULK** – bulk phase
- **ABSRPT** – absorption phase
- **FLOAT** – float phase

For Li-PO batteries '*x*' is forced to show ABSRPT.

Line 1, data 2: *Bat_T: xC*

Bat_T: xC indicates temperature of GEL or AGM batteries, if Li-PO batteries are used, then the value is forced to always show 25°C.

Line 2, data 1: *chL: xb*

chL: xb indicates current charging voltage level in 1b (bit) resolution. If AGM batteries are used (and current phase is BULK), then this value gradually approaches to the final value (shown in line 2, data 2). Variation speed of this value depends on the battery state-of-charge and on charging current amplitude. If Li-PO battery is used, then the value depends on the desired (constant) charging voltage.

The range of shown data goes from 0 to 255b.

Line 2, data 2

The meaning of this data depends on the current state of the three-step charging method.

If the current charging state is BULK (only for AGM batteries), then this data shows *chLD: xb*, which means the final (desired) charge level. The value '*x*', in 1b (bit) resolution, is calculated considering battery temperature.

The range of shown data goes from 0 to 255b.

If the current charging state is ABSRPT or FLOAT, then this data shows *tABS: xs*, which means the expected duration of the absorption phase in 1s (second) resolution. The value 'x' is calculated considering the duration of the BULK phase.

The range of the shown data goes from 0 to 9999s.

Line 3, data 1: *tPH:xs*

tPH:xs indicates the current charging phase progress (i.e. how long HCU works in the current phase), in seconds.

The range of the shown data goes from 0 to 9999s. The actual value (in BULK or FLOAT phase) can exceed the maximum value. In this case, the displayed value is not correct anymore.

Line 3, data 2: *tTOT:xs*

tTOT:xs indicates the duration of the total charging progress (i.e. how long HCU operates in the charging mode), in seconds.

The range of the shown data goes from 0 to 9999s. The actual value can exceed the maximum value. In this case, the displayed value is not correct anymore.

5.8.3.5 ERROR LINE

The fourth line is reserved for showing potential errors of both controllers inside HCU. More than 1 error can occur at the same time; consequently the values are displayed as 2 HEX bytes to simplify error recognition. 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 4, data 1: *IG_E:x*

IG_E:x indicates the errors which occurred in "IG" controller part. Only low byte is used, the high byte is unused and left for future error listing expansion.

Line 4, data 2: *AC_E:x*

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

5.8.3.6 AC Error listing (HEX code):

Error Code	Error Name	Consequence	Reason	Action	Note
0x0000	No error	/	/	/	
0x0001	DC_link over voltage	ERROR mode	DC_link voltage exceeded 270 V	Wait for DC_link voltage drop	1
0x0002	<i>Not significant</i>	/	/	/	
0x0004	Generator over voltage	Charging interrupted	Battery voltage exceeded 53,6 V	Wait for battery voltage drop	2
0x0008	<i>Not significant</i>	/	/	/	
0x0010	Propulsion under voltage	El. propulsion interrupted	Battery discharged	Recharge battery	
0x0020	Power module warm	Power reduction	Power module temperature above 85°C	Reduce speed Check water cooling	
0x0040	Power module excessive hot	ERROR mode	Power module temperature above 95°C	Stop Check water coolingx	
0x0080	Over current HW	Power reduction	Phase current exceeded maximum limit	Reduce speed	
0x0100	Battery hot	ERROR mode	Battery temperature exceeded maximum limit	Stop Battery must cool	3
0x0200	Hall sensor	Permanent ERROR mode	Damaged hall sensors	Service needed	
0x0400	CAN lost	Permanent ERROR mode	CAN Communication with IG part interrupted	Service needed	4
0x0800	<i>Not significant</i>	/	/	/	
0x1000	Actuator fail	Permanent ERROR mode	Actuator failed to switch position within 6 s	Check actuator / Service needed	
0x2000	Over speed	El. propulsion interrupted	Rotational speed in electric propulsion exceeded maximum limit	Wait for motor speed stabilisation	
0x4000	Motor over heat	Warning	Motor temperature above 112°C	Reduce speed	
		Power reduction	Motor temperature above 115°C	Check water cooling	
		ERROR mode	Motor temperature above 120°C	Stop Check water cooling	
0x8000	High battery current	Possible overload	Battery current exceeded maximum limit	Reduce speed	

ERROR mode means Electric propulsion and Generator mode (HCU charging) are disabled.

Permanent ERROR mode means Electric propulsion and Generator mode (HCU charging) are permanently disabled. The customer shall first try to **re-start the hybrid system**. Switch off circuit breaker *48 V Hybrid drive*. Wait 10sec and then switch on circuit breaker *48 V Hybrid drive*. If the problem persists, hybrid system service is required.

More than 1 error can sometimes occur at the same time. Therefore HEX arithmetic shall be used to decode error types in such cases. For example error number 0x0291 means that errors 0x0200, 0x0080, 0x0010 and 0x0001 occurred.

Note 1:

DC_link over voltage error shall not be understood as an error when battery voltage is between 53,6 V and 54 V and HCU operates in Generator mode.

Note 2:

Generator over voltage error shall not be understood as an error. It is a signalization that battery reached the maximum voltage 53,6 V and therefore HCU stopped charging.

Note 3:

Battery hot error is valid only for system with AGM batteries.

Note 4:

CAN lost error: In such case, the customer shall first try to re-start the hybrid system. If the problem persists, hybrid system service is required.

5.8.3.7 IG Error listing (HEX code):

Error Code	Error Name	Consequence	Reason	Action	Note
0x0000	No error	/	/	/	
0x0001	DC_link over voltage	ERROR mode	DC_link voltage exceeded 270 V	Wait for DC_link voltage drop	1
0x0002	Power module warm	Power reduction	Power module temperature above 85°C	Reduce speed Check water cooling	
0x0004	Power module hot	Increased power reduction	Power module temperature above 90°C	Reduce speed Check water cooling	
0x0008	Power module excessive hot	ERROR mode	Power module temperature above 95°C	Stop Check water cooling	
0x0010	Step up under voltage	El. propulsion intermittent / stopped	Battery voltage below 42 V	Recharge battery	
0x0020	Bad power module	Possible malfunction or failure	Damaged power module	Service needed	
0x0040	CAN lost	Permanent ERROR mode	CAN Communication with AC part interrupted	Service needed	4
0x0080	Battery over voltage	ERROR mode	Battery voltage exceeded 61 V	Check battery and all charging systems	

ERROR mode means Electric propulsion and Generator mode (HCU charging) are disabled.

Permanent ERROR mode means Electric propulsion and Generator mode (HCU charging) are permanently disabled. The customer shall first try to **re-start the hybrid system**. Switch off circuit breaker *48 V Hybrid drive*. Wait 10sec and then switch on circuit breaker *48 V Hybrid drive*. If the problem persists, hybrid system service is required.

More than 1 error can sometimes occur at the same time. Therefore HEX arithmetic shall be used to decode error types in such cases. For example error number 0x0291 means that errors 0x0200, 0x0080, 0x0010 and 0x0001 occurred.

Note 1:

DC_link over voltage error shall not be understood as an error when battery voltage is between 53,6 V and 54 V and HCU operates in Generator mode.

Note 4:

CAN lost error: In such case, the customer shall first try to re-start the hybrid system. If the problem persists, hybrid system service is required.

5.8.3.8 SCREEN: Connection lost

If AC controller part inside HCU loses communication with IG part for more than 3 s, then the following message appears: **“!!! HCU LOST !!!”**. The user must try to re-establish normal HCU operation with power reset. This is done by switching off the diesel engine and setting the main switch of 48 V battery to **OFF**. After that, the user should restart the hybrid system. If the problem persists or arises very frequently, there is a high possibility that hardware inside HCU is damaged or wiring has become loosened.

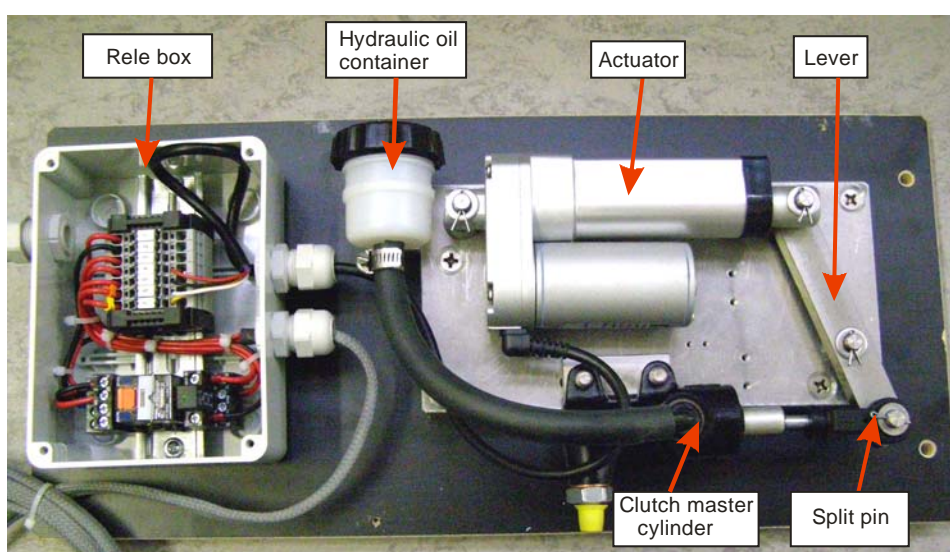
5.9 Clutch actuator

Elektro–hidravlični aktuator je opravlja izklop in vklop suhe lamemlne sklopke med diesel motorjem in elektičnim motorjem preko hidravlične batne črpalke in hidravličnega potisnega ležaja. Za prekllop 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 5 seconds to switch from one position to another.

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

The main components of the clutch actuator are shown in the photo.



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

The clutch actuator has to 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.

5.9.1 Manual engagement of the disc clutch

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

- Izklopimo ločilko 48 V Hybrid drive med pogonskim akumulatorjem in krmilnikom.
- Razstavimo mehansko zvezo med vzvodom električnega akuatorja in tlačnim cilindrom. Izvlečemo »split pin« in čep, ki povezuje vzvod in ročico »clutch master cylinder«. S tem sprostimo bat in posledično pade tlak v »clutch master cylinder« in »clutch slave cylinder«, kar omogoči povratek lamelne sklopke v delovni položaj.
- Poženemo diesel motor.

OPOMBA:

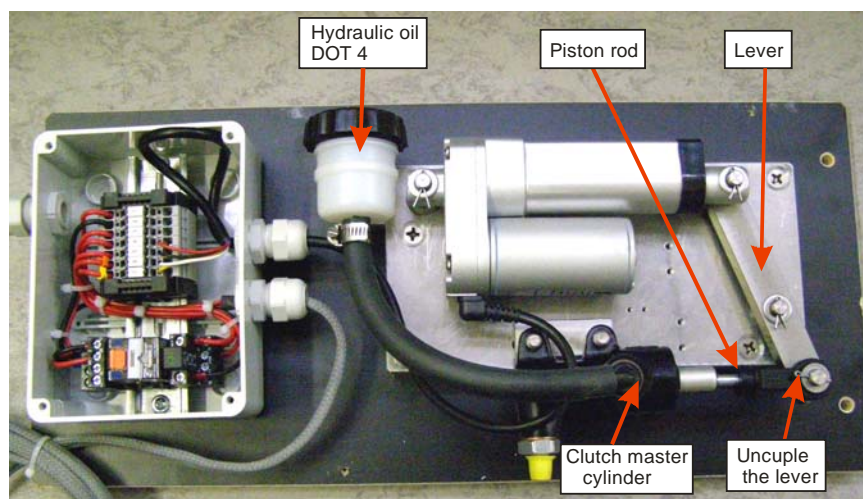
Do odprave napake uporaba elektro pogona ni več možna.

In the case of actuator failure and when the clutch disc 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 disc to make a transition to the diesel drive. This can be done so that we:

- Disengage the circuit breaker 48 V Hybrid Drive 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«. 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.



5.10 Disc clutch

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

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

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 pogonskih akumulatorjev 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 elektro–hidravličnega aktuatorja. Izklop in vklop suhe lamelne sklopke je dovoljen samo ob ugasnjenem diesel motorju in mirujočem električnem motor – generatorju.

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 drive batteries 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. 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:

- 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 v 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.

7. 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 propelerje, 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 pristanišče 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.