Instruction manual

L01-i levers

TH1016 rev. D

www.lilaas.no

Revision history

Rev.	Rev. date	Change no.	Comments	Author	Approved
D	11/04/16		Major rewrite	AK	EBH

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Disclaimer

As Lilaas is continuously improving this product, we retain the right to make changes to the product at any time which may not be reflected in this version of the manual. Please contact Lilaas if you require any further assistance.
Governing language: this document may be translated to another language. In the event of any conflict the English language version of the documentation will be the official version.

Trademarks and copyright

Warranty

Lilaas standard warranty terms apply unless otherwise agreed

Markings used in this document

A very important note. Must be read carefully and observed.

Scope

This manual is valid for the L01-i product family with firmware release 4.9.15 or later.

Definitions

long press a press on one of the pushbuttons which is released after at least 2 seconds

short press a press on one of the pushbuttons of maximum 1 second

in command a lever that is in command can be operated by the user and the set-points are made available via the CAN bus

master a CAN node that can send or requests data from slaves

slave a lever that is in slave mode listens to the signals on the *CAN* bus coming from the master, and follow this position

set-point the position the lever is in

Chapter 2: Operating instructions

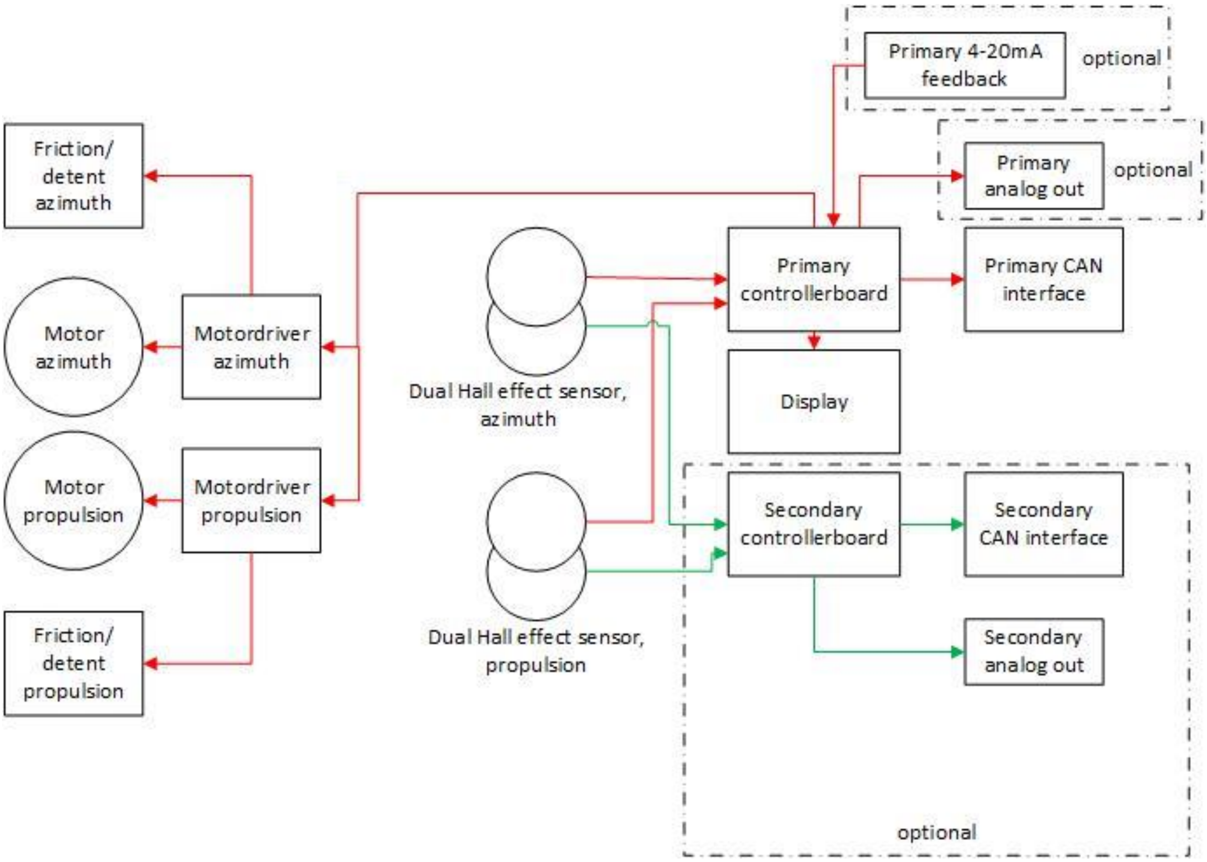

Figure 2.1: block diagram of L01 azimuth

2.1 Unit description

L01-i is a family of levers manufactured by Lilaas. Section 5.1 describes the basic models available. Figure 2.1 shows the key elements of an L01-i azimuth. Some important elements are:

- redundant sensors and redundant controllers allowing full redundancy on the sensor signal
- motors and friction controlled from the primary channel; friction can be adjusted by the user
- detents controlled by the controller board, allowing for up to 16 detent points, configurable at the factory

2.2 1 station setup

Figure 2.3 gives an example of a 1 lever system, with a secondary *CAN* bus for redundancy.

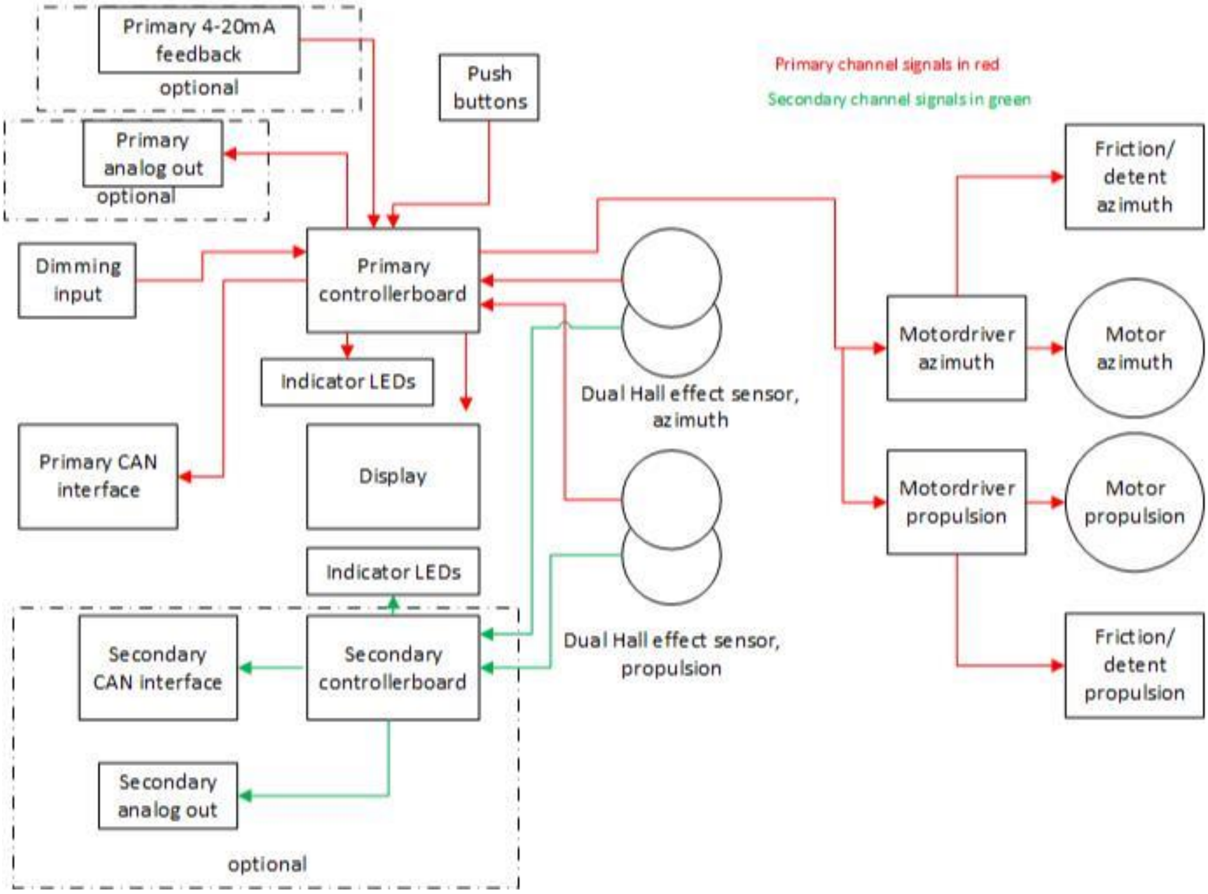

Figure 2.2: Alternative block diagram of L01 azimuth

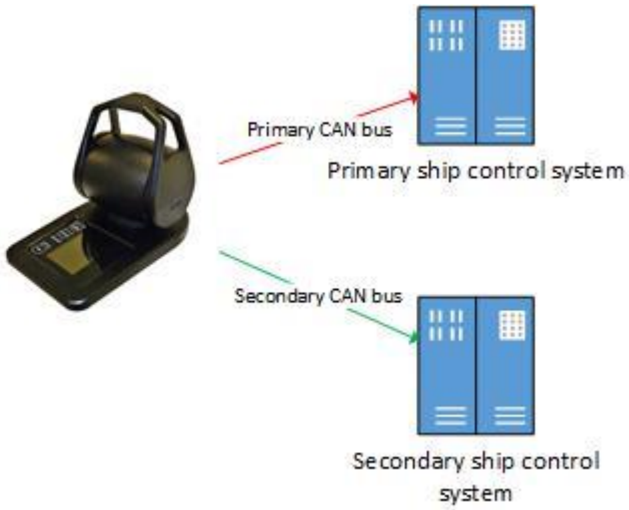

Figure 2.3: 1 lever

2.3 multiple connected stations setup

Figure 2.4 gives an example of a system with 3 consoles, with 1 lever in each console, and again a secondary *CAN* bus for redundancy. Figure 2.5 gives an example of a system where synchro-mode can be enabled. This system consists of 3 consoles, each containing 3 levers.

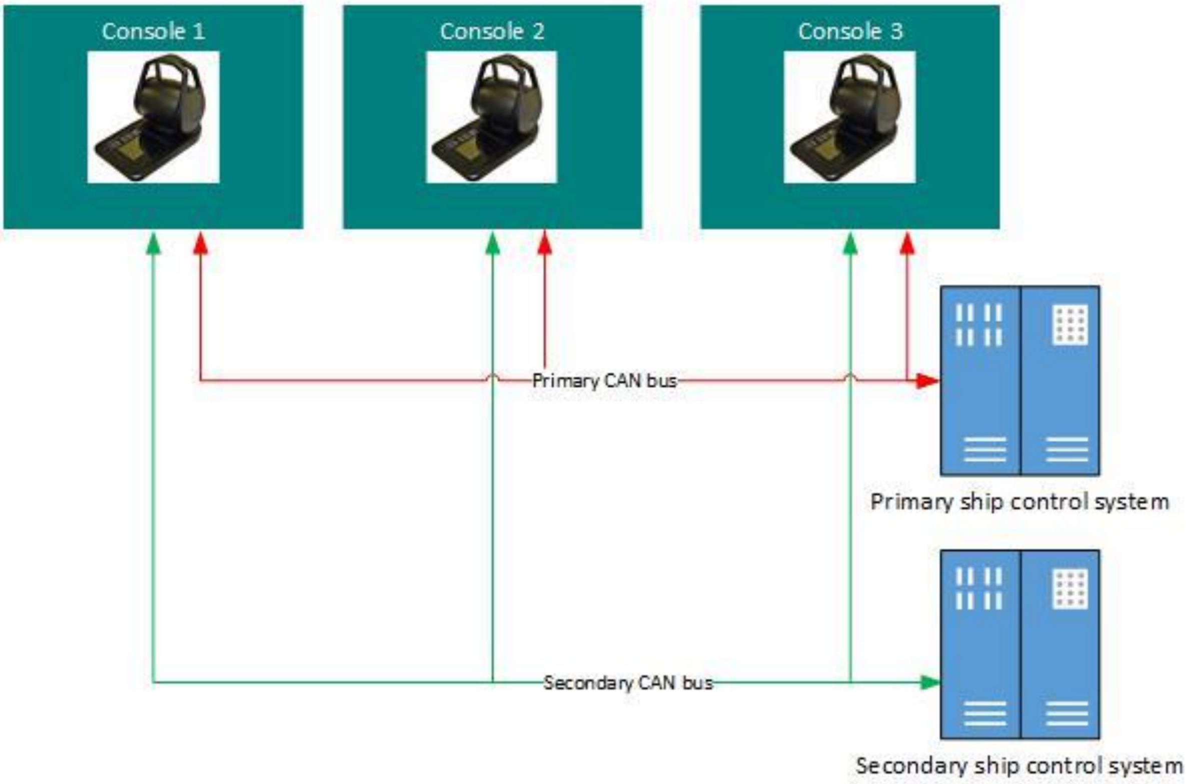

Figure 2.4: 3 consoles, 1 lever in each console

2.4 synchro mode

Figure 2.5 can be set up for synchro mode. In synchro mode 1 lever is in control of multiple engines. The other levers will follow the lever that is in control. As an example, it is possible to control 3 engines from lever 1 in console 1. In that case levers 2 and 3 in console 1 will follow lever 1, and all the levers in console 2 and 3 will also follow lever 1 in console 1. Entering synchro mode is described in section 2.6

2.5 Start-up

When power is applied to the lever these will go through a boot process. During the boot process a self-test is run. Any critical errors are shown in the display and the boot sequence is halted when a critical error occurs. To continue the boot sequence the menu touch button must be pressed.

⚠ **Normal operation can not be guaranteed if the boot sequence has been halted.**

If no errors were detected the start-up list will be visible for approximately 2 seconds, and then the Lilaas splash screen will show for circa 1 second. The start-up list display will also show the software revision number. The display will then change to the normal operation screen.

2.6 Normal operation

Depending on the lever model chosen the normal operation display will be as one of the pictures below. Note that there are 4 (or 8 on double thruster and double propulsion models) indicator *LED*s. The 4 *LED*s on the edge of the lever (i.e. the furthest left or right) are controlled by the secondary controller. The 4 *LED*s closest to the display are controlled by the primary controller.

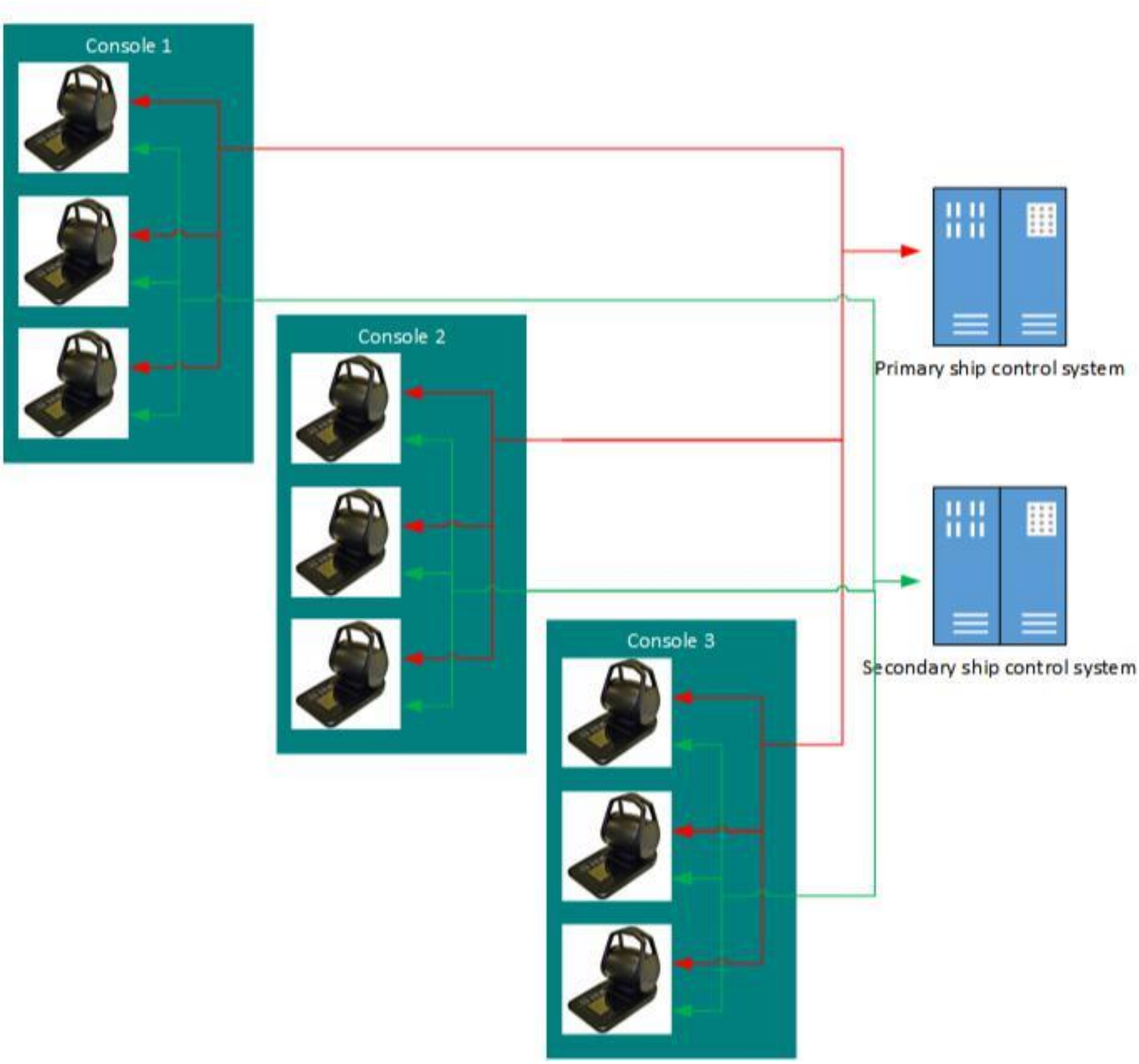

Figure 2.5: 3 consoles, 1 lever in each console

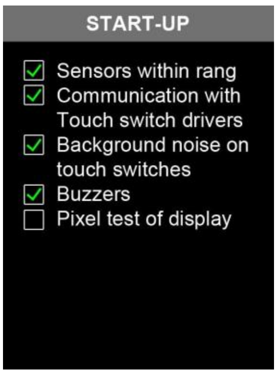

Figure 2.6: Self-test display during start-up

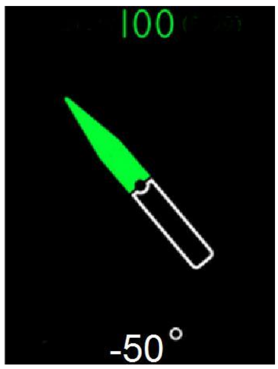

Figure 2.7: Normal operation screen for azimuth

Taking command

Before a lever can be used for controlling the engine it must be put in ’in-command’ mode. This is normally done by a pushbutton. When a lever is in command the in-command *LED* will be on.

⚠ **A lever can only take command when it is in the same position as the current in-command lever.**

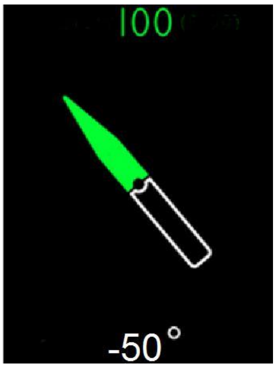

Figure 2.8: Azimuth

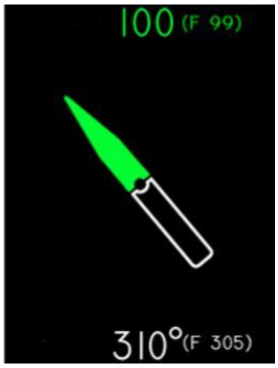

Figure 2.9: Azimuth

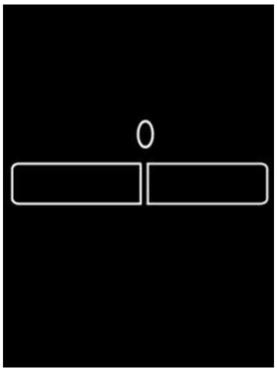

Figure 2.10: Single thruster without feedback

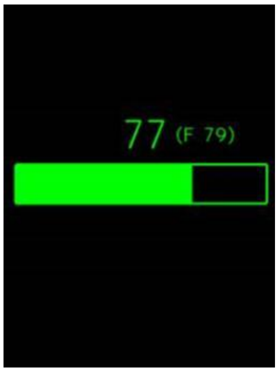

Figure 2.11: Single thruster with feedback

Entering synchro mode

Synchro mode is normally entered by pressing a push button. It is only possible to go into synchro mode on a lever that is already in 'in-command' mode. When a lever is in synchro mode the synchro *LED* will be on.

Redundancy

If ordered with the redundancy option the lever has 2 *CAN* interfaces, a primary and a secondary interface. The lever will have 2 redundant sensors During normal operation the primary *CAN* interface is used for communication between levers, and all functionality is as described. If however for some reason the primary channel fails the secondary channel will take over. In this case the motor(s) on the lever will no longer work any-more, as can be seen from figure 2.1. If the primary channel fails due to for example loss of power the detents are lost as well.

***LED*s**

The *LED*s have the following functionality:

- in command is lit when the lever is in command
- synchro is lit when the lever is in synchro mode
- in pos *rpm* is lit when a slave lever is in the same position as the in-command lever. It is off on the in-command lever or when the slave lever is not in position. On a system where no lever is in-command it is blinking
- in pos az is lit when a slave lever is in the same position as the in-command lever. It is off on the in-command lever or when the slave lever is not in position. On a system where no lever is in-command it is blinking

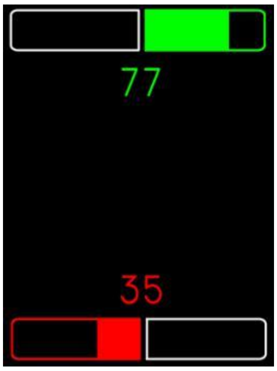

Figure 2.12: Double thruster without feedback

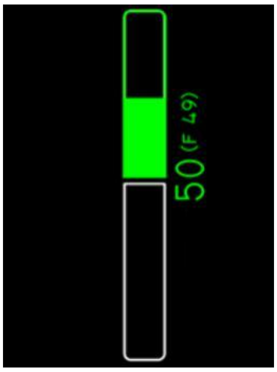

Figure 2.13: Single propulsion feedback

Figure 2.14: Display after long press on menu button

Figure 2.15: Configuration menu

2.7 Menu

The figure 2.15 shows the available configuration options as well as the software revision number. This menu is entered by a long press on the menu-button . With a short press on the menu-button the next menu item will be selected. A menu-point is entered by a long press on the menu-button. Leaving a menu-point is also accomplished by a long press on the menu-button.

Dimming adjustment

Dimming can be adjusted on a scale of 1-10. A short press on the menu-button increases the intensity by 1 step. The intensity of the display and LEDs can also be adjusted by using the dimming input signal, described in section 5.6.6

Lamp test

Lamp test is not really a configuration option, but it allows verification that the lamps are working correctly. A short press on the menu-button starts the lamp test, which consists of flashing the *LED*s 4 times.

Feedback settings

The feedback settings menu is not available to all users, depending on the options selected when ordering the lever, see also section 5.7. When available it has 4 options:

- set-point displays the actual set-point of the lever
- feedback displays the feedback signal (provided via the 4-20*mA* interface)

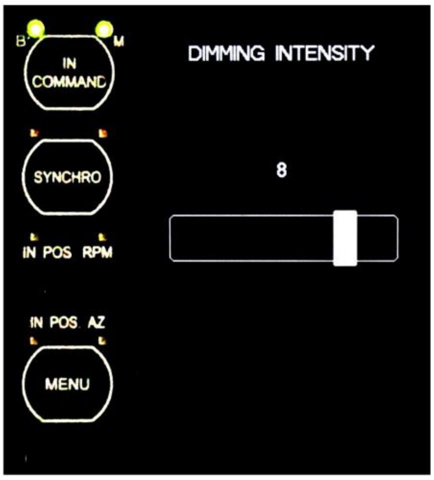

Figure 2.16: Adjustment of dimming

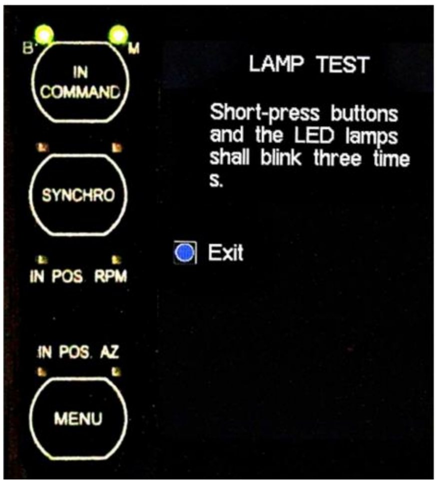

Figure 2.17: Lamp test

- set-point and feedback displays both set-point and feedback signal, with the set-point signal begin displayed dominantly, as shown in figure 2.9
- feedback and set-point displays both feedback and set-point, with the feedback signal being displayed dominantly

Friction

The menu item 'Friction' allows setting the friction, depending on the lever model this allows setting of friction for one of thruster, thruster port, thruster starboard, propulsion, propulsion port, propulsion starboard or azimuth. The friction ranges from 0-10, and is increased by a short press on the menu button. It wraps around from 10 to 0. See also figures 2.18 and 2.19

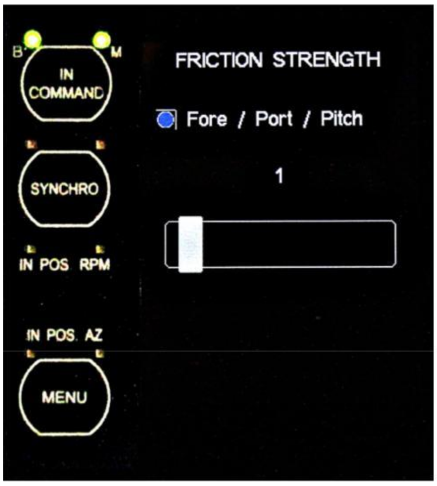

Figure 2.18: Friction 1

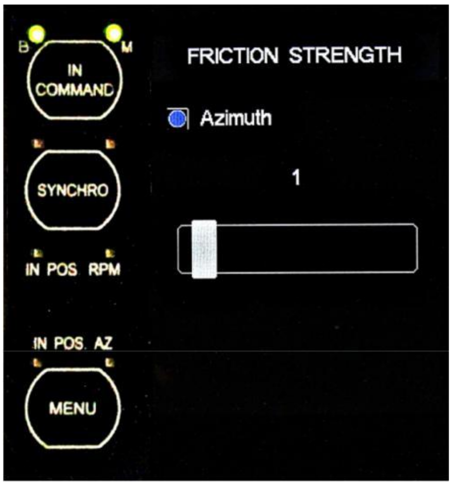

Figure 2.19: Friction 2

Detents

The menu item 'Detent' allows setting the detent strength, depending on the lever model this allows setting of detent strength for one of thruster, thruster port, thruster starboard, propulsion, propulsion port, propulsion starboard or azimuth. The detent strength ranges from 0-10, and is increased by a short press on the menu button. It wraps around from 10 to 0. See also figures 2.20 and 2.21

Figure 2.20: Detent 1

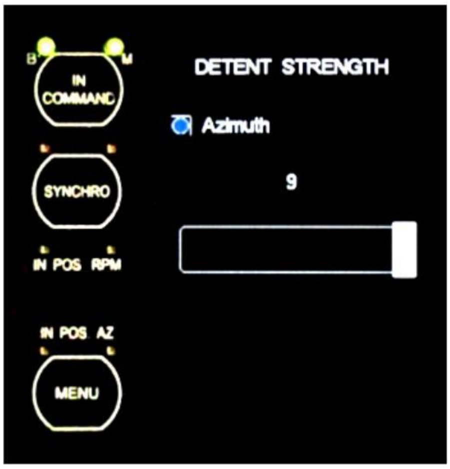

Figure 2.21: Detent 2

CAN **open ID**

This is not really a configuration setting, but displays the *CAN* open ID for the lever. Normally all *CAN* nodes in a lever have the same node-id, but they can be configured with different node id's at the factory.

Chapter 3: Maintenance

3.1 Normal maintenance

No special maintenance from the end-user is required. It is recommended, but not required, to send the levers to the manufacturer for service every 5 years (or 7.5 years for ships that operate with an extended dry-dock interval)

3.2 Calibration

The levers are calibrated at the factory. The end-user can recalibrate the levers using the procedure described here, for example in the unlikely event one of the error messages in chapter 6 occurs.

⚠ **For succesful calibration the below steps need to be followed exactly. An improper calibrated lever can result in unreliable operation**

- With no power applied set the calibration switch on all microcontroller cards in calibration mode (to-wards the display), see figure 3.1; The switch is located next to the USB connector.
- Position the lever in the neutral position[1]:
  - for azimuth: position at 0 degrees
  - for thrusters/propulsion: position at 0%. The lever is in 0% position when the notch on the handle is aligned with the black dot on the barrel, as in figure 3.2 [2]
- Turn on power to **all** controller boards in the lever. The lever will boot in calibration mode; the screen will remain blank.
- Move the levers to the endpoints, starting with thruster/propulsion, and then azimuth
  - move forward until the end-stop is reached (i.e. to the 100% position), and then backwards until the other end-stop is reached (i.e. to -100% or 0% depending on configuration chosen)
  - rotate the azimuth twice, at a speed of approximately 50 seconds per rotation
- set the calibration switch back to normal operation mode (towards the connectors). The lever will reboot

[1] Note that there are no detents when the power is turned off because the detents are electrical

[2] On some models the notch is coloured red, as in the figure. The default is for the notch to be black

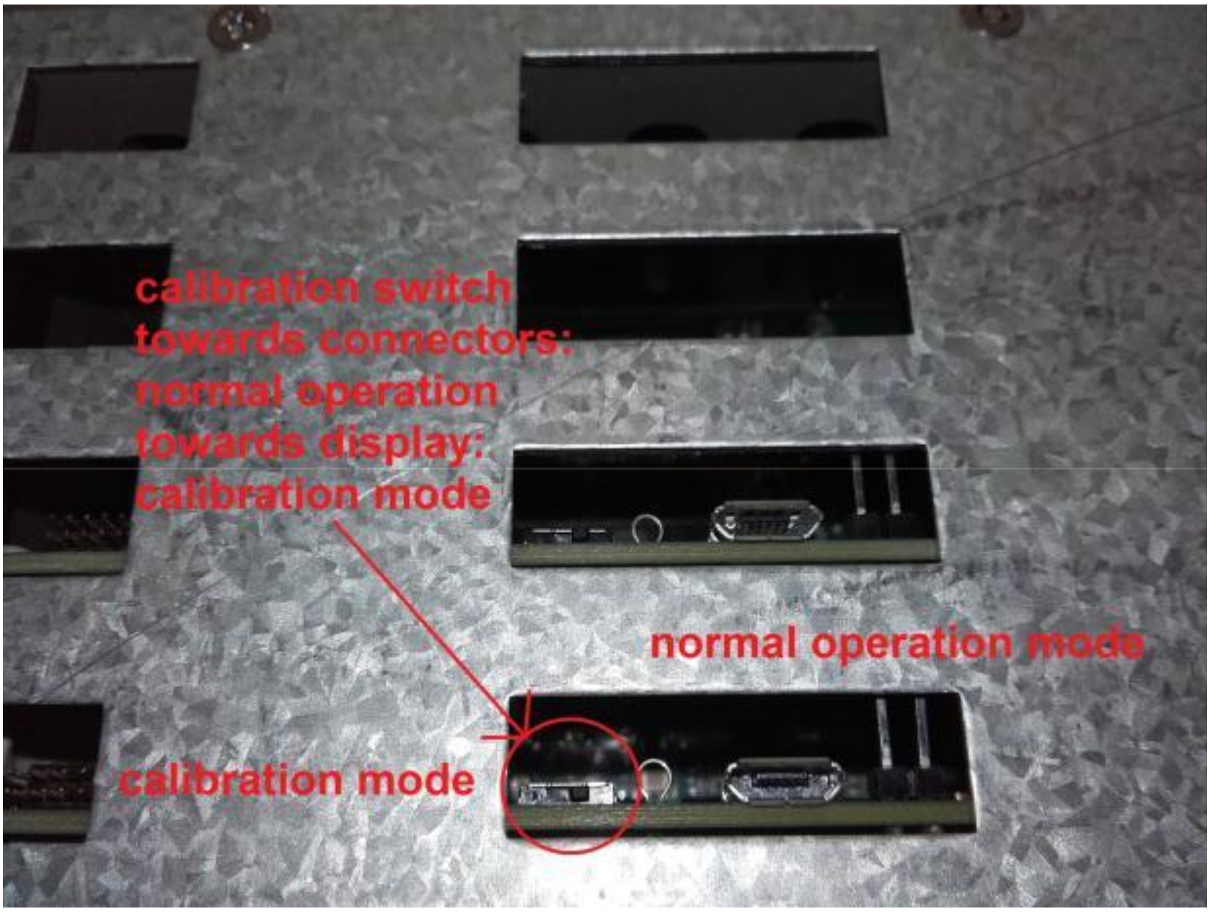

Figure 3.1: calibration switch set to normal operation mode

Figure 3.2: positioning the lever in the 0% position

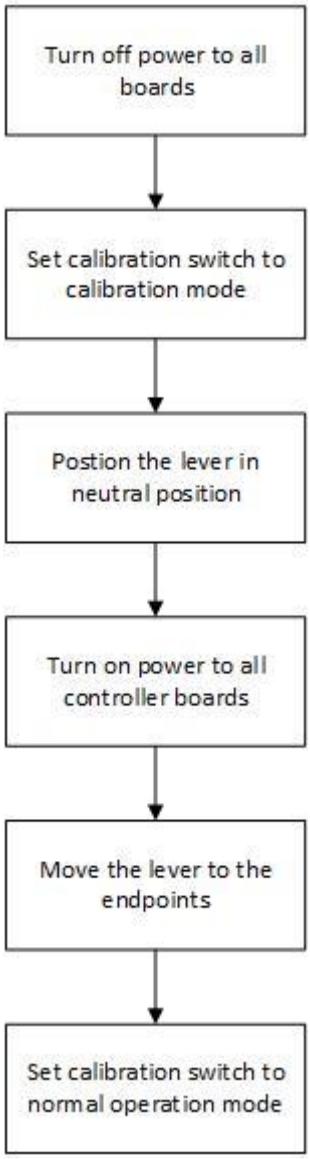

Figure 3.3: Flowchart for calibration

Chapter 4: Installation

4.1 Mechanical dimensions

Table 4.1 show the basic mechanical dimensions. Figure 4.1 shows more details, including the required cut-out.

Table 4.1: basic mechanical dimensions

Dimension	Size [mm]
Baseplate width	105
Baseplate length	168
Lever height	125
Lever depth	152
Display diagonal	61 (2.4inch)

4.2 connectors

The following connectors are delivered with the lever:

- B2L 3.50/16/180F, manufacturer Weidmüller part number 1748060000
- B2L 3.50/20/180F, manufacturer Weidmüller part number 1748080000

Detailed specifications can be found at the manufacturer site (http:\\catalog.weidmueller.com). Table 4.2 shows the required dimensions for the different connections.
Figure 4.2 shows how the switch for the in-command signal (and optionally the synchro signal) must be wired. It is important that the in-command input and the synchro input are not left open (floating). Tables 4.3, 4.5 and 4.4 give the pinout of the available connectors. Connectors X31, X41, X32 and X42 are not used on an azimuth, single thruster and single propulsion lever. Connectors X21, X31, X22 and X32 are not used if the lever is ordered without the redundancy option.

4.3 *CAN* termination

In order for the *CAN* bus to work properly the end-nodes in a *CAN* network must be terminated. If an L01 lever is an end-node it must be terminated by using the dip-switches shown in figure 4.4.

Table 4.2: Cable specification

Cable	Min. diameter AWG (mm^2 in brackets)	Max. diameter AWG (mm^2 in brackets)	Max. length (m)	Cable type
CAN	24 (0.2)	18 (0.82)	50	Shielded twisted pair
In-command	24 (0.2)	18 (0.82)	10	Shielded twisted pair
Synchro	24 (0.2)	18 (0.82)	10	Shielded twisted pair
Supply	18 (0.82)	18 (0.82)	10	
All others	28 (0.08)	18 (0.82)	10	

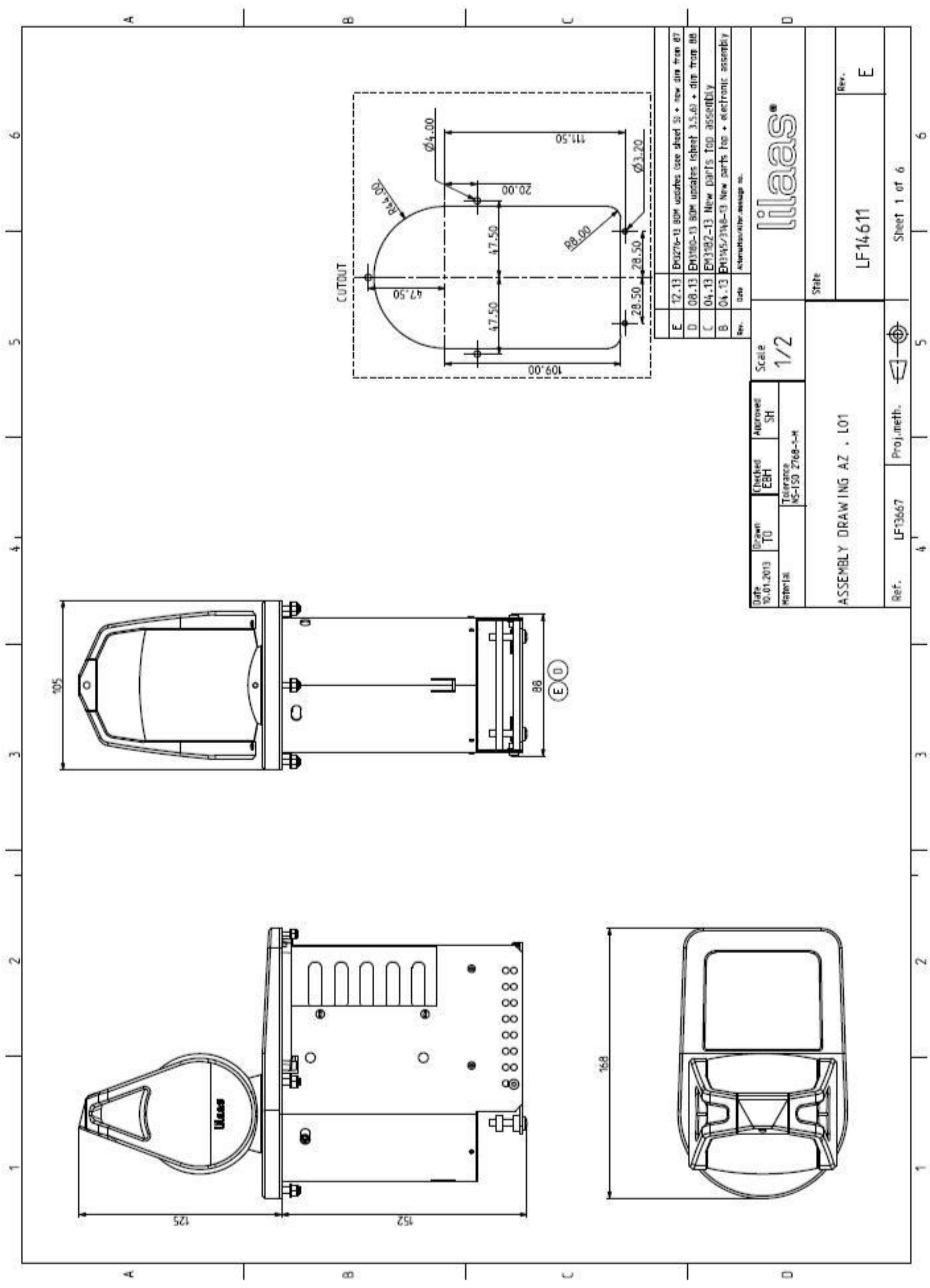

Figure 4.1: Mechanical dimensions of L01

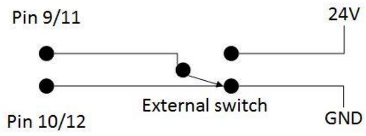

Figure 4.2: In command and synchro connection

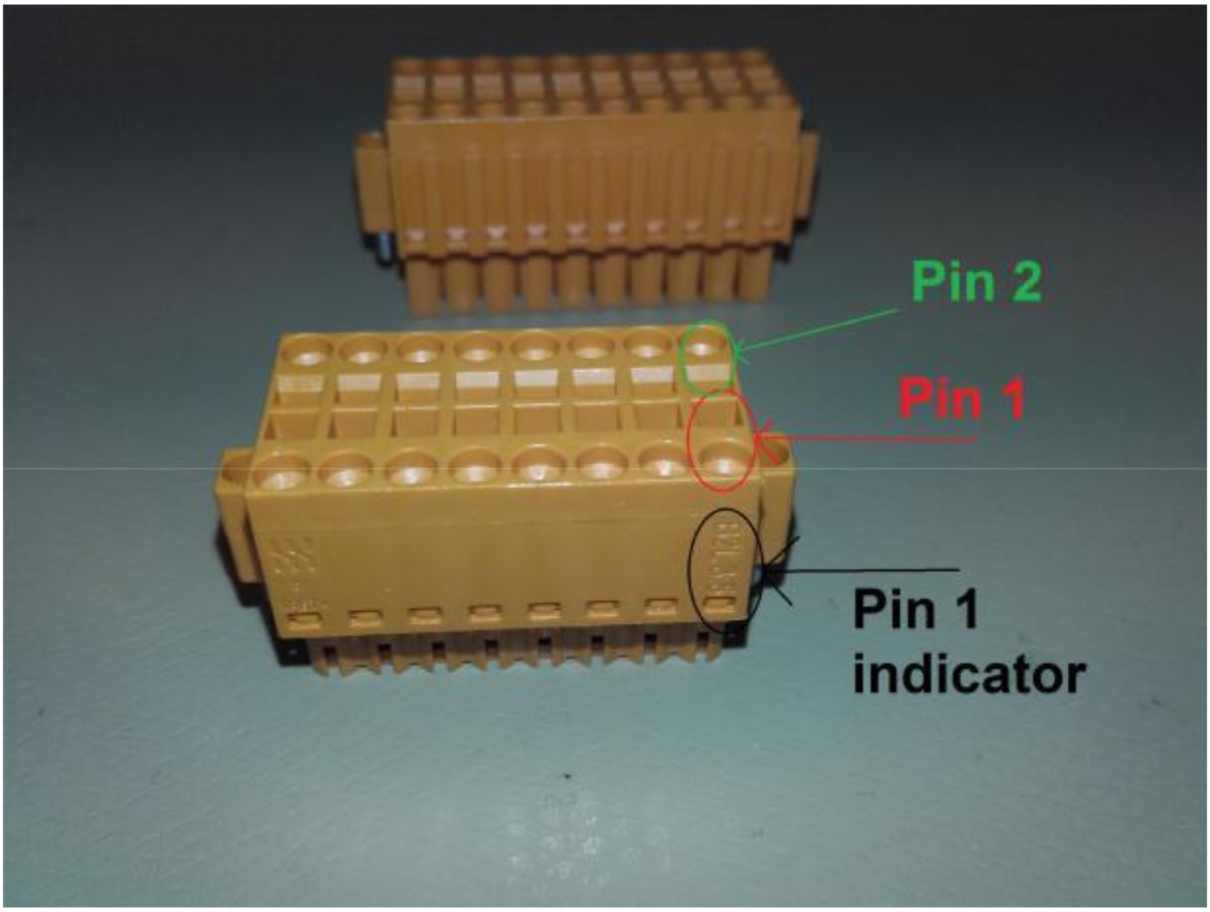

Figure 4.3: Location of pin 1

Table 4.3: Pinout X11 and X41

description	pinnumber	pinnumber	description
digital output 1 (low side)	2	1	digital output 1 (high side)
digital output 2 (low side)	4	3	digital output 2 (high side)
digital output 3 (low side)	6	5	digital output 3 (high side)
4-20 *mA* current loop (low side)	8	7	4-20*mA* current loop (high side)
In-command input (low side)	10	9	In-command input (high side)
Synchro input (low side)	12	11	Synchro input (high side)
Dimming input (low side)	14	13	Dimming input (high side)
4-20*mA* current loop (low side)	16	15	4-20*mA* current loop (high side)
RS232 RX	18	17	RS232 TX
n.c.	20	19	RS232 GND

Table 4.4: Pinout X21 and X31

description	pinnumber	pinnumber	description
digital output 1 (low side)	2	1	digital output 1 (high side)
digital output 2 (low side)	4	3	digital output 2 (high side)
digital output 3 (low side)	6	5	digital output 3 (high side)
n.c.	8	7	n.c.
In-command input (low side)	10	9	In-command input (high side)
Synchro input (low side)	12	11	Synchro input (high side)
RS232 RX	14	13	RS232 TX
n.c.	16	15	RS232 GND

Table 4.5: Pinout X12, X22, X32, X42

description	pinnumber	pinnumber	description
Vref RPM	2	1	*CAN* High
Vout RPM	4	3	*CAN* Low
Vgnd RPM	6	5	*CAN* gnd
Vref Azimuth	8	7	n.c.
Vout Azimuth	10	9	n.c.
Vgnd Azimuth	12	11	n.c.
n.c.	14	13	n.c.
Supply GND	16	15	Supply 24V

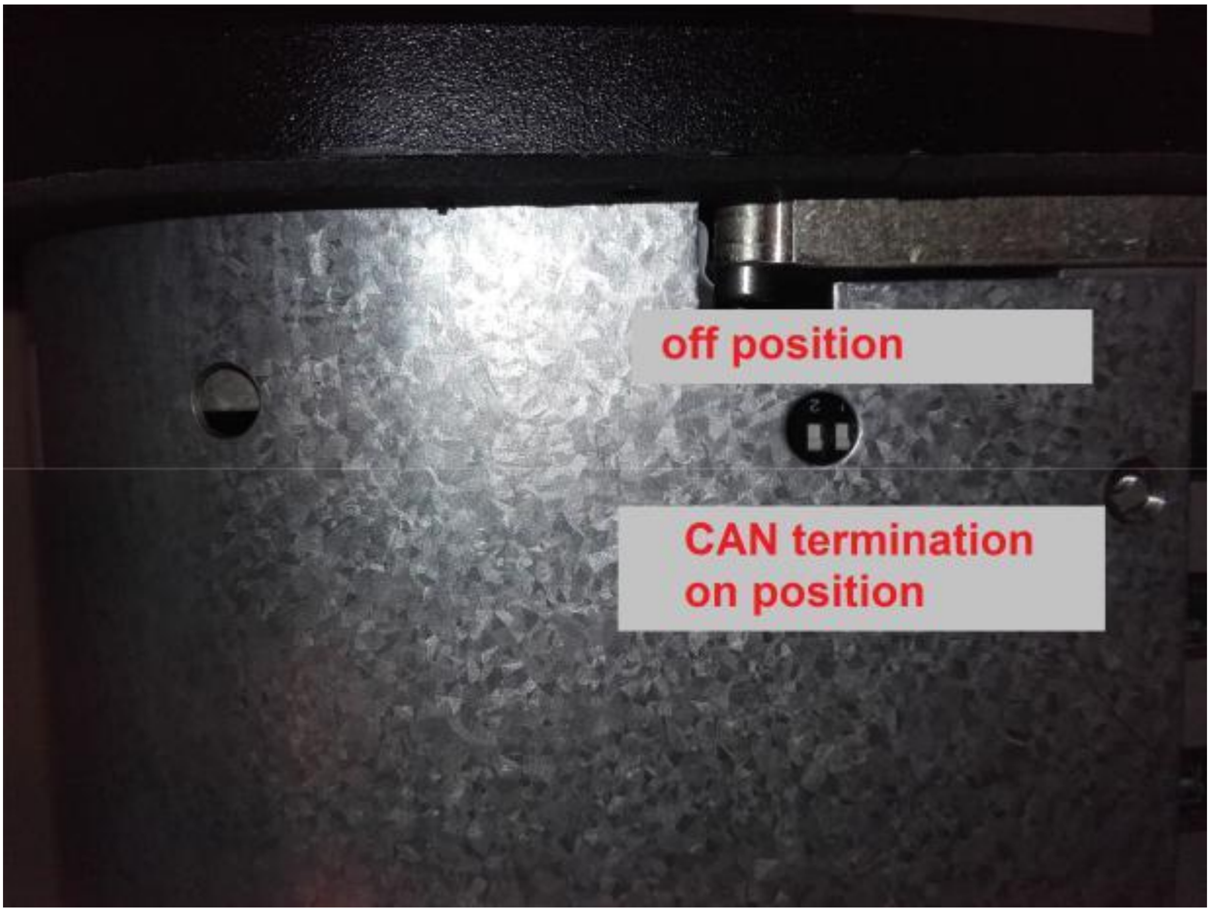

Figure 4.4: *CAN* termination switch, termination on

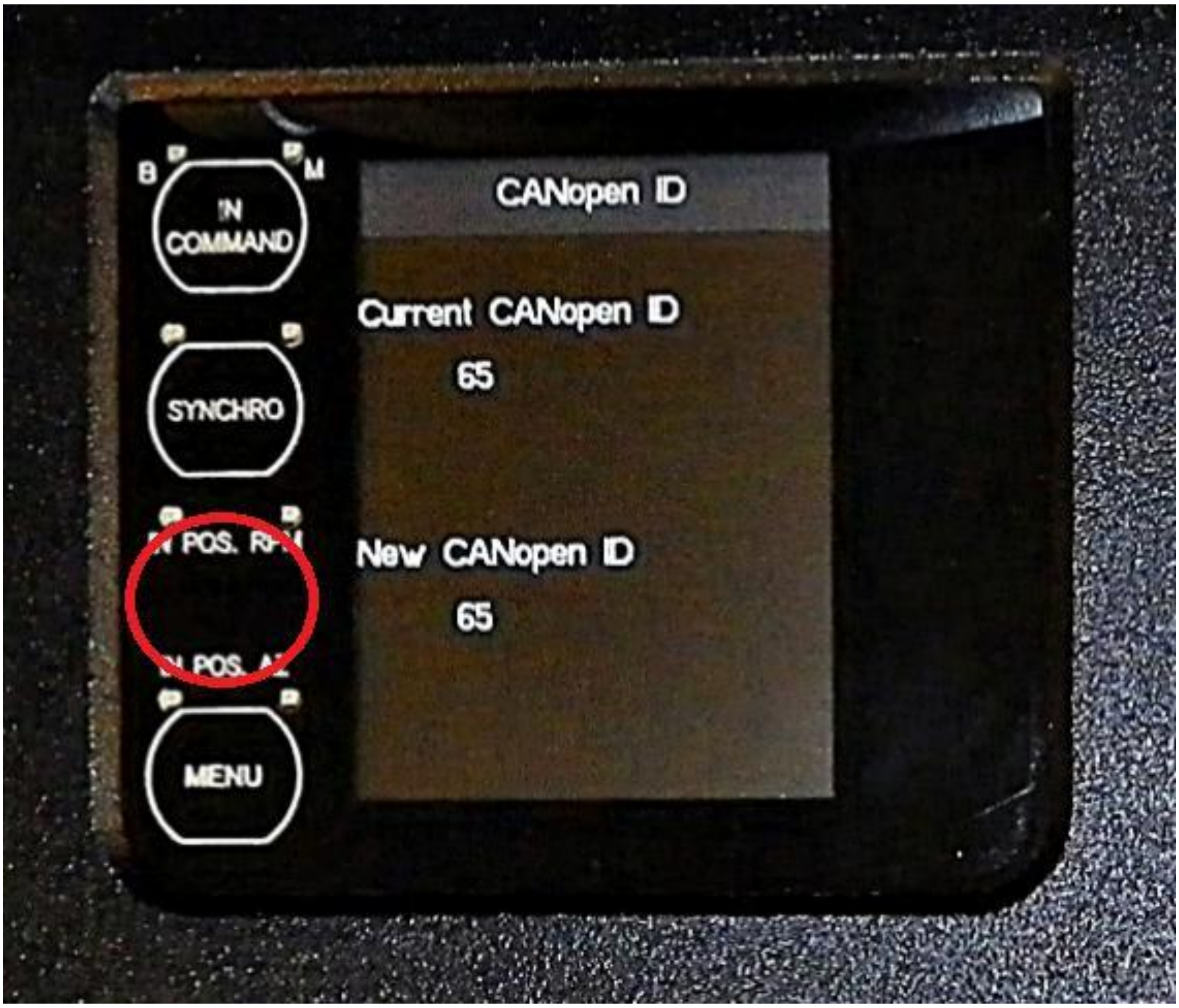

Figure 4.5: Button to press for entering the node ID configuration screen

4.4 Setting the *CAN* node ID

The L01 lever supports configuring the node ID to use on the *CAN* open network. This can be done with the following procedure:

- Power cycle the L01 lever, this must be done for all the controller boards in the lever
- The indicator *LED*s will blink once during start-up. *After the LEDs have blinked once, but* before the buzzer has sounded 3 times, hold down the area above the menu button, indicated by the red circle in figure 4.5
- When the setup screen is displayed, release the button
- Use the linear axes to setup the *CAN* open node ID to the desirable value. On a thruster double or propulsion double 2 node IDs need to be set.
- Confirm the selection with a long press on the menu button and boot the lever normally

Chapter 5: Product Specification

5.1 Product variants

The L01-i lever is available in several basic types.

5.1.1 Lever types

At the moment the following 5 lever types are available

- Azimuth: the handle can rotate 360° around its axis and can move between aft and forward from maximum -60° to +60°
- Propulsion single: the handle can not rotate, but can move between aft and forward, from maximum -60° to +60°
- Propulsion double: there are 2 handles, starboard and port, these move individually between aft and forward, from maximum -60° to +60°
- Thruster single: similar to a propulsion single, but now the handle moves between starboard and port
- Thruster double: similar to a propulsion double, but now the 2 handles move between starboard and port

5.1.2 Orientation

Depending on user requirements the levers can be configured in one of four positions.

5.1.3 Mechanical limited

Normally the azimuth range is 0° to 360°. It is possible to limit this range mechanically at the factory. This must be specified when ordering the lever. Similarly the normal range for the propulsion or thruster movement is -60° to +60°. Also this range can be limited to for example a ’blocked aft’ version where the range is from 0° to +60°. This also needs to be specified when ordering the lever.

5.1.4 Motorised versus Mechanical detents

L01-i can be ordered with either motorised detents or mechanical detents. When ordered with mechanical detents L01-i can not be motorised.

5.2 Mechanical

The mechanical dimensions are specified in table 4.1 and figure 4.1

5.3 Redundancy

Figure 5.4 (identical to 2.1) shows how redundancy is implemented in L01-i. There is a dual hall-effect sensor for each channel. The output of one deck of this sensor goes to the primary controllerboard, the other out-put goes to the secondary controllerboard. From each controllerboard there is a separate *CAN* channel for interfacing with the ship control system. The figure shows that L01-i has redundancy in the sensor, the con-trollerboard and the signal-output. There is no redundancy in the display, motor-control and detent-settings. The primary and secondary channel are completely separate from one another, and do not share a power supply. Where redundancy is not required it is possible to run the system without the secondary channel.

Figure 5.1: Azimuth

Figure 5.2: Thruster single

Figure 5.3: Thruster double

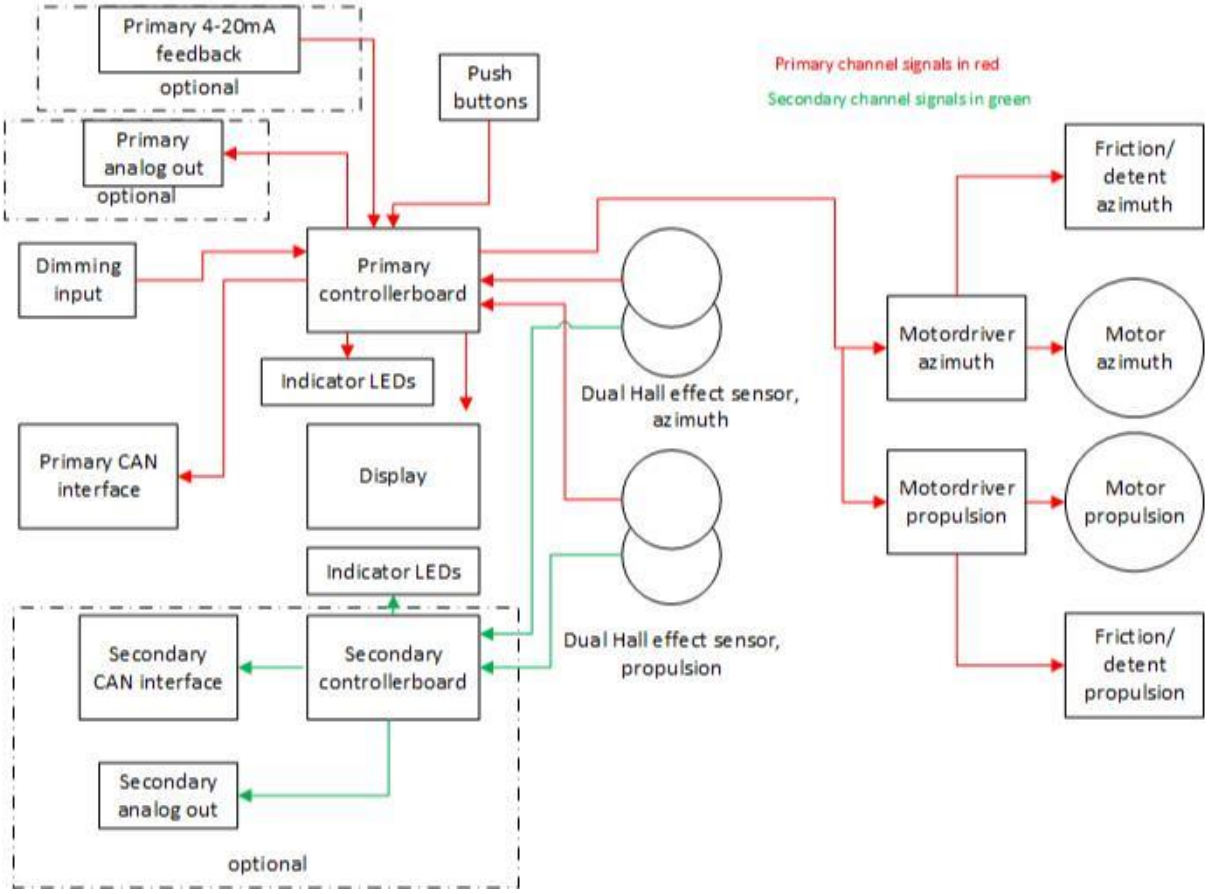

Figure 5.4: block diagram of L01 azimuth

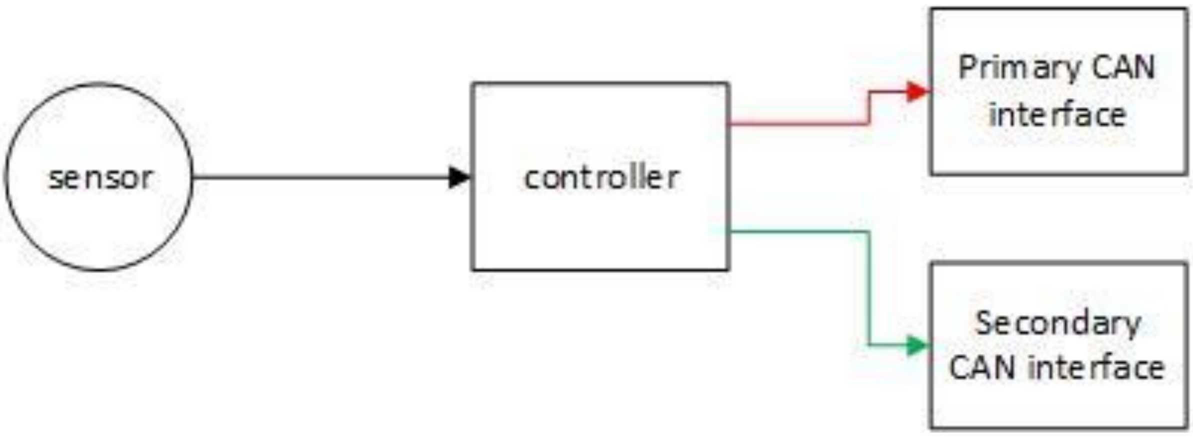

Figure 5.5: block diagram of a cable redundant system

board redundancy versus cable redundancy

Chapter 6 of *CiA*307, [1], describes 'cable redundancy'. A diagram of such a system is shown in figure 5.5. Figure 5.4 shows a card redundant system. In the card redundant system (as implemented on L01) there is redundancy through the complete electronics path, starting at the sensor, all the way through to the output signal(s) available. In the cable redundant system there is only redundancy at the communication level.

5.4 Lever operation

Figure 5.6 shows the different states the lever can be in.

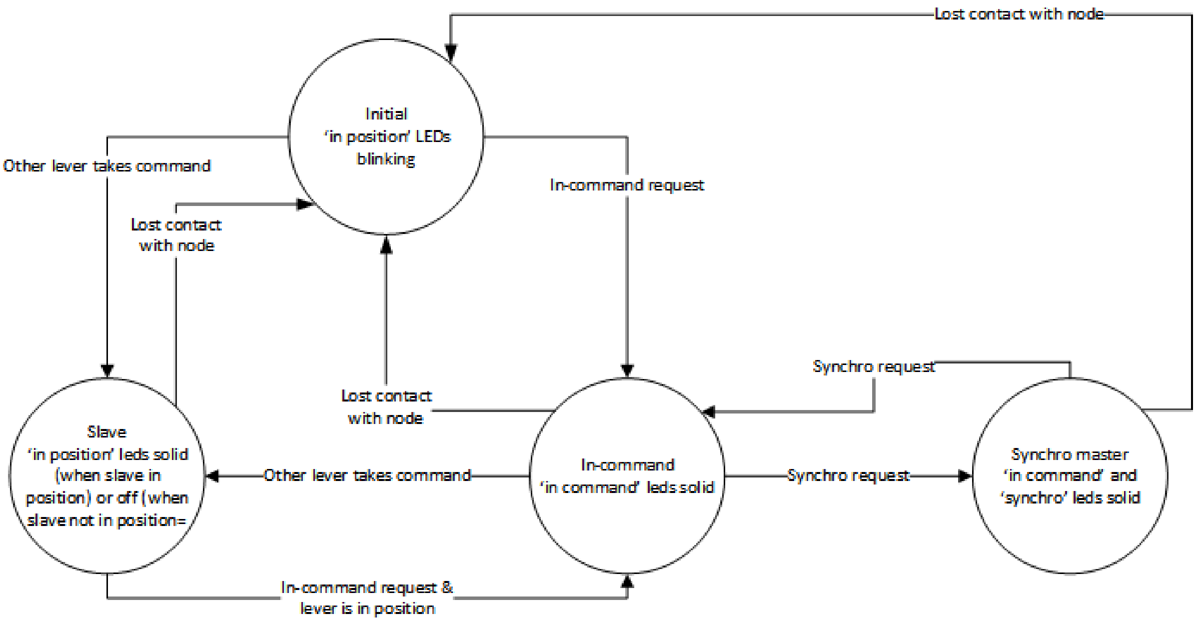

Figure 5.6: Lever state diagram

5.4.1 initial mode

After boot the lever is in initial mode[1]. In this mode no position information is available on the *CAN* bus. A lever must be put in 'in-command' mode before position information is available.

5.4.2 in-command mode

Only 1 lever in a system can be in command at a time. The lever that is in command will send out position information once per second. Any other levers in the system will follow this position, and the ship control system can read this position information for further processing.

5.4.3 slave mode

In a system where 1 lever is in command the other levers go into slave mode. A lever in slave mode will receive position information, and follow this position.

5.4.4 synchro mode

A lever that is in command can go into synchro mode. Synchro mode is described in section 5.6.4

5.4.5 motorisation

The L01-i lever is motorised. A slave lever will receive position information from a master (or in-command) lever, and the motor(s) will put the slave lever in this position

5.4.6 detents

The L01-i lever has by default electrical detents, generated by an electrical brake. The same brake is used for generating friction, and as a result it is important that the friction strength is less than the detent strength.

[1] In CAN terminology this is called the preoperational state

5.4.7 soft endpoints

It is possible to configure (at the factory) the L01-i lever with 'soft endpoints'. With soft endpoints the motor is used to limit the usable range of the lever: whenever the lever is moved outside of the allowed range the motor will move the lever back.
If for example soft endpoints are specified to be at -90 °and +90 °then it is still possible to move the lever to for example 100 °, but the azimuth motor will turn the lever back to its +90 °limit.

5.5 *CAN* open

5.5.1 *SDO*

A complete overview of available objects is given in appendix C, but table 5.1 shows the most important objects available. A '.eds' file can be supplied upon request.

Table 5.1: basic objects available in *CAN* open

Object	Subindex	Data type	Content	Minimum	Maximum
0x7130	0x01	Unsigned16	Position of the linear axis in promille	-1000	1000
0x7130	0x02	Unsigned 16	Position of the azimuth axis in 0.1 degrees	0	3599

5.5.2 *PDO*

The lever that is in-command transmits a *PDO* once per second, with the format shown in table 5.2. Linear axis position is in 1/thousands, while azimuth position is in $1/10^{th}$ of a °. The actual settings of the lever can be found from word 2 and 3 with the following formula:

$$Set\text{-}point_{linearaxis} = 10 * (256 * Byte_{MSB} + Byte_{LSB})[\%] \quad (5.1)$$

$$Set\text{-}point_{azimuth} = 10 * (256 * Byte_{MSB} + Byte_{LSB})[°] \quad (5.2)$$

The **net number** tells what net the lever belongs to, its functionality is explained in section 5.5.5 and 5.5.5.

Table 5.2: Format of information being transmitted over *CAN* bus from in-command lever

Word nr.	Content	(*SDO*) Object nr.	Object index
1	controller nr	0x2001	0x00
2	linear axis position, 2 bytes, LSB first	0x7130	0x01
3	azimuth position, 2 bytes, LSB first	7130	0x02
4	net number, 2 bytes	0x2002	0x00
5	lever mode	0x2000	0x00

Table 5.3: Definition of controller number in transmit *PDO*

controller number	meaning
1	primary channel azimuth, port or aft
2	secondary channel azimuth, port or aft
3	secondary channel starboard or forward
4	primary channel starboard or forward

Table 5.4: Definition of lever mode in transmit *PDO*

lever mode	meaning
0	leaving synchro mode
1	in synchro mode
2	in command mode

5.5.3 Heartbeat

The L01-i levers send a heartbeat once per second. This is used so that the levers can detect when connection with a node is lost, in which case an alarm will go off, and the levers will go back to initial state. An external master (if configured as such) should also send a heartbeat once per second.

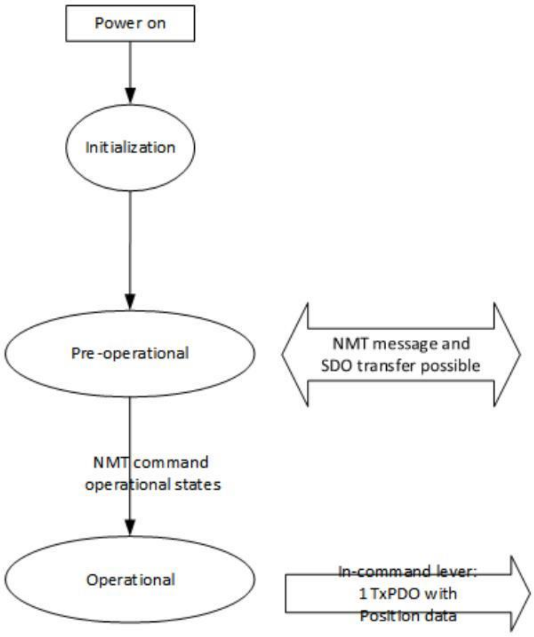

Figure 5.7: *CAN* state flow

5.5.4 *CAN* open states

On an L01-i system that is configured to run without external master the levers will automatically go from the pre-operational state to the operational state. If L01-i is configured for operation with external master the master will have to tell the lever to go from pre-operational state into operational state. More details can be found in [2]

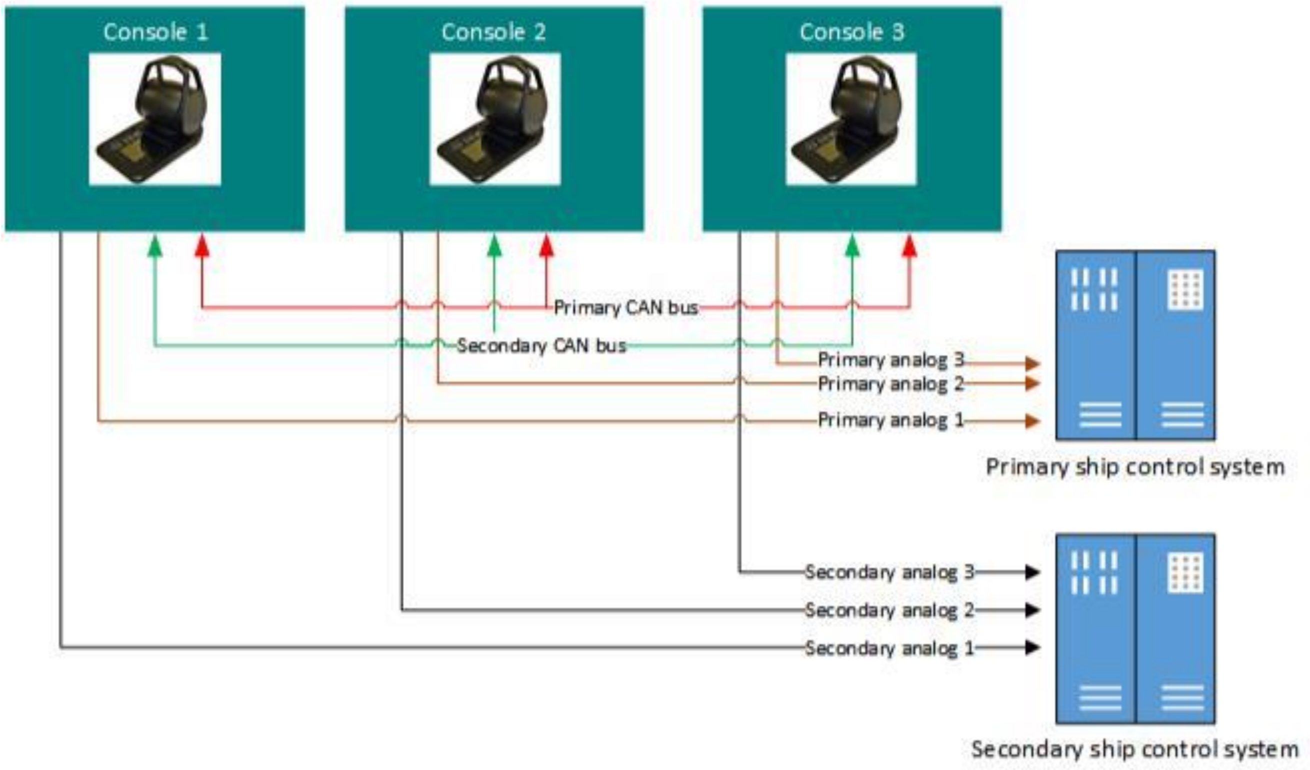

Figure 5.8: L01 only network

5.5.5 Network topology

Many different network topologies are possible with L01. This section lists some basic configurations.

L01 only network

Although not recommended it is possible to have a network with only L01 levers, using the analog output for ship control. This configuration is shown in figure 5.8

L01 with *CAN* sniffer

It is possible to connect to the L01 *CAN* bus and only read the position information. This is the configuration drawn in figure 2.4. In this case the ship control systems *CAN* interface only listens on the *CAN* bus, and reads the position information from the lever that is in command.

Alternatively the ship control system can explicitly read object 0x7130 from the lever that is in command. Table 5.1 describes the format of this object.

L01 with external master

L01 can also be configured to operate with an external master. The configuration of figure 2.4 can be used here as well. This configuration allows the ship control system to control the position of the levers, as described in section 5.5.6. The *CAN* master will have to set the levers from pre-operation into operational state, see also figure 5.7 After the levers are set in operational mode the master will also have to configure them by writing to the receive-*PDO* corresponding to the node-ID's off all connected devices:

$$RxPDO_{towriteto} = 0x1400 + nodeID_{device} - 1 \quad (5.3)$$

The following data must be written:

- index 0x01: 0x0180 + node-ID of the device
- index 0x02: 0xFE

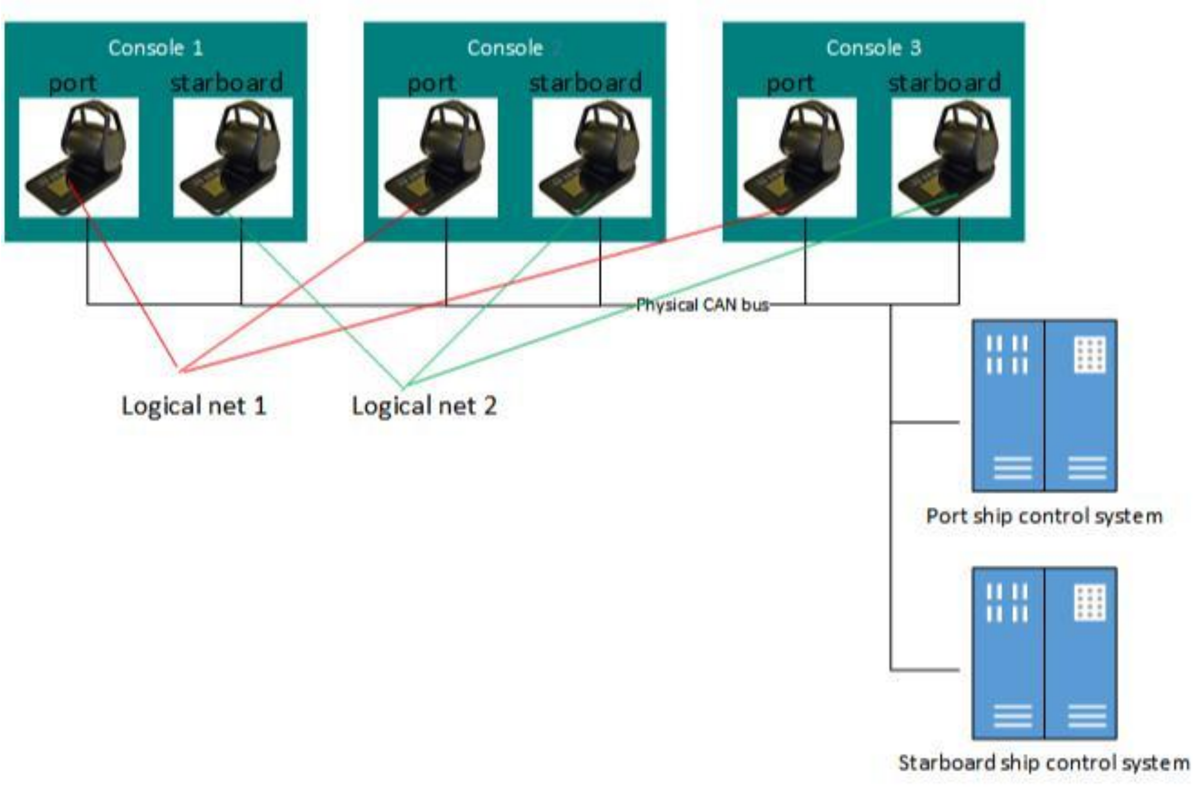

Figure 5.9: combining ship control systems, only primary channel shown

Mixing different types of levers on one *CAN* bus

Different types of levers can share the same physical *CAN* bus. It is not possible to control one lever type from another even if they share the same physical bus. This means for example that a single propulsion lever can not control the propulsion part of an azimuth or a double propulsion lever.

Combining ship control systems on one *CAN* bus: command net option

Figure 5.9 shows a possible configuration where one physical bus is used to connect several ship control systems. The figure also shows the logical connections. The net number parameter in the *PDO* is used to differentiate between the logical nets. The ship control systems can use this parameter to determine if a *PDO* contains data for them or not. The net number parameter must be configured at the factory.

Controlling multiple ship control systems from one lever: synchro topology

Normally a lever can not control the position of levers in another logical sub-net. However the levers can be configured at the factory with synchro-mode enabled. In this mode the net number is replaced with a synchro-net number, and the appropriate levers will follow the controlling lever. All levers must be of the same type, i.e. a thruster lever can not control a propulsion lever. To ensure proper configuration of the levers the exact configuration must be specified when ordering the levers.

5.5.6 controlling L01 motors from external master

The master can control the position of the connected levers by transmitting a *PDO* with the contents described in section 5.5.2. This *PDO* must be transmitted every second, even if the contents does not change.

5.6 Connections

There are several connections available on L01-i.

5.6.1 Supply voltage

The supply voltage is nominally 24V. L01-i has been designed to work with a supply voltage in the range 18-32V. Each channel has its own supply connections, allowing for the use of independent power supplies for the primary and secondary interfaces.

5.6.2 *CAN*

The *CAN* interface is used for connecting the levers in a system together, as well as send position data to the ship control system. See section 5.5 for a detailed description of the *CAN* implementation. The *CAN* interface is opto-isolated from the system.

5.6.3 Analog out

The lever has one analog output for each axis. These analog outputs are opto-isolated signals. They require an external power supply. The maximum load on the analog output is 100K. With a lower load resistance the linearity can not be guaranteed. Independent linearity is better than 1%. The primary and secondary channel each have their independent analog output signal.

The analog output will vary from lever to lever, when using analog output a calibration at system level is required.

5.6.4 Digital inputs

There are 2 digital inputs available on each channel. The digital inputs are opto-isolated from the system. 3 configuration options are available:

- ignore the digital input
- default behaviour is that digital input 1 is used for setting the lever in in-command mode and digital input2 is used for setting the lever in synchro mode
- the 3*r d* option is that the digital input controls the *LED*

Take command

Digital input 1 can be used for setting the lever in in-command mode by applying a 24V pulse of at least 500 milliseconds.

Synchro

A lever that is in-command mode, and that is configured appropriately, can be put in synchro mode by apply-ing a 24V of at least 500 milliseconds to digital input 2.

5.6.5 Digital outputs

There are 3 digital outputs available on each channel. These outputs are opto-isolated from the system. 3 configuration options are available for these outputs:

- always stable inactive
- default behaviour is showing the lever status: digital output 1 is active when the lever is in in-command mode. Digital output 2 is active when the lever is in synchro mode.
- optionally the digital outputs follow the state of the associated push button: digital output 1 follows the in-command button, digital output 2 follows the synchro button, digital output 3 follows the unlabelled button

5.6.6 Dimming

The dimming input is not opto-isolated from the system. The expected signal level is a *DC* signal in the range 3-24V, with 3V resulting in the lowest dimming level, while at 24V the maximum intensity of the display is achieved. A *PW M* signal can not be used.

5.6.7 RS232

The RS232 connection is available for levers that have the option for customer configuration. In that case a special configuration program is supplied by Lilaas.

5.6.8 4-20*mA* feedback

A 4-20*mA* feedback input is available on the primary channel(s)[2]. This feedback signal can be shown in the display (configurable at factory and optionally also by the end-user).A current below 3.5*mA* or above 21.5*mA* will result in an error-message on the display.

⚠ **For SW revision 4.9.16 and earlier the lever expects a valid feedback signal immediately at power-up. If no signal is available at start-up an alarm will be raised**

⚠ **For SW revision 4.9.17 and higher the lever starts monitoring the feedback signal 10 seconds after start-up**

5.7 Configuration options

Several configuration options are available. These options are set at the factory, and must be specified when ordering the lever.

5.7.1 redundancy

L01-i is available with redundancy, as described in section 5.3. Default configuration is with redundancy

5.7.2 buzzer

Default configuration is with buzzer enabled. It is possible to turn off the buzzer. Note that errors will still be displayed in the screen.

5.7.3 mechanical detents

Default is no mechanical detents. It is possible to configure L01-i with mechanical detents. In that case motorising is not possible, and a slave lever will not follow the position of the in-command lever.

5.7.4 analog output

Default is analog output enabled. It is possible to disable the analog output if it is not required.

5.7.5 propulsion/thruster output range

The default setting for range is -100% to +100%. It is possible to limit this range to 0% to +100%. This affects both the display and the *CAN* output.

5.7.6 orientation

The default orientation setting is ’forward’, but L01-i can be configured as ’aft’ or as rotated 90 degrees. See sections 5.1

5.7.7 4-20*mA* feedback

Default configuration is for no feedback signal, and that the user can change this setting. At factory one of the configurations described in section 2.7 can be set. It is also possible to disable the functionality that the user can change this setting.

5.7.8 *CAN* configuration

Several *CAN* parameters can be configured at factory.

[2] The 4-20*mA* feedback is a configuration option

L01 only vs. external master

Default configuration is for an L01 only network. L01 can be configured to operate in a network with an external master, see also section 5.5

CAN **node id**

L01-i will be configured with a default node id, depending on the number of levers ordered. If a specific range of node-ids is required this needs to be specified.

baudrate

The default baudrate of the *CAN* network is 125kbaud. Optionally the baudrate can be set to 250, 500 or 1000kbaud. Note that higher baudrates limit the maximum cablelength.

command net

Default value for command net is 0. See section 5.5.5 for details on this parameter.

synchro net

The default value for synchro net is 0. See section 5.5.5 for details on this parameter.

5.7.9 force feedback

Force feedback (sometimes referred to as haptic) [3] can be disabled. In that case there is very little friction, and the slave levers will not follow the position of the in-command lever.

5.7.10 friction

Friction is configured to a reasonable strength at factory. Note that the user can adjust this setting via the menu.

5.7.11 detent strength

Detent strength is configured to a reasonable strength at factory. Note that the user can adjust this setting via the menu.

5.7.12 motor strength

Motor strength is configured to a reasonable strength at factory. Normally this should not be changed, but a different strength setting can be specified when ordering the lever.

5.7.13 Detent location

The default is for electrical detents, in which case up to 16 detent locations can be specified.

5.7.14 Soft endpoints

The operating range of the lever can be limited mechanically, but also electrically. See section 5.4.7 for more details. When ordering the lever the range can be specified.

[3] Haptic refers to the branch of engineering dealing with tactile human-machine interfaces.

Force feedback is a term that originates from control theory where force is used as input for the control system, rather than for instance position.

Haptic interfaces are often suitable for force feedback based control systems (because of compliance), which is why many haptic devices are controlled using force feedback. However, force feedback could also be applied in other fields, such as robotics.

If you want to refer to the control system behind the haptic interface specifically, then use force feedback. If you want to point out the fact that it is a haptic interface (i.e. tactile human-machine interaction), then use haptic feedback.

5.8 Error handling by lever

The lever will detect several error conditions. In case of an error-condition an error message will be displayed, and the buzzer will sound (if enabled).

5.8.1 Supply voltage out of range

The lever is very tolerant for supply voltage variations. If the voltage drops significantly below the minimum specified the lever will turn off. The lever has protection for over-voltage.

5.8.2 Broken *CAN* cable

In case the *CAN* cable breaks an error message will be displayed on all levers. In addition all levers will go back to initial mode, as shown in figure 5.6

5.9 Compliance

5.9.1 RoHS and Reach

L01-i is compliant with the EU RoHS and Reach directives

5.9.2 IP grade

L01-i has IP grade IP66

5.9.3 certification

L01-i has the following type approvals:

- DNV Rules for Classification of Ships, High Speed & Light Craft and DNV Offshore Standards
- EN60945
- IACS E10

5.10 Parameters

Table 5.5: Environment

	Name	Min.	Typ.	Max.	Unit
A1	$T_{operating}$	-25	25	70	°C
A2	$T_{storage}$	-25	25	70	°C
A3	Vibration			TBD	g
A4	Weight		TBD		kg

Table 5.6: Supply

	Name	Min.	Typ.	Max.	Unit
B1	Vsupply	18	24	32	V
B2	I_{supply}		800		*mA*

Table 5.7: *CAN* bus

	Name	Min.	Typ.	Max.	Unit
C1	Busspeed	125	125	1000	KBps
C2	Time between transmission of position information		1		seconds
C3	Time between heartbeats		1		seconds
C4	Number of nodes in network	2		99	

Table 5.8: RS232 bus

	Name	Min.	Typ.	Max.	Unit
D1	Busspeed		38400		Bps

Table 5.9: Analog out

	Name	Min.	Typ.	Max.	Unit
E1	V_{ref}	3	5		V
E2	R_{load}	1			M-
E3	Linearity			1	%
E4	V_{out} in 0-position	49		51	% of Vref
E5	V_{out} at maximum	89		90	% of Vref
E6	V_{out} at minimum	10		11	% of Vref

Table 5.10: Dimming signal in

	Name	Min.	Typ.	Max.	Unit
F1	V_{dim}	3.0		24.0	V
F2	I_{dim}			3	*mA*

Table 5.11: Currentloop in

	Name	Min.	Typ.	Max.	Unit
G1	I_{signal}	3.8		20.5	*mA*
G2	$I_{error,high}$	21	23		*mA*
G3	$I_{error,low}$		3.5	3.6	*mA*

Table 5.12: Digital out

	Name	Min.	Typ.	Max.	Unit
H1	V_{ref}			32	V
H2	I_{out}			120	*mA*
H3	$V_{out,low}$	0		1	V
H4	$V_{out,high}$	V_{ref} - 1.0		V_{ref}	V

Table 5.13: Digital in

	Name	Min.	Typ.	Max.	Unit
I1	$V_{in,high}$	18	24	32	V
I2	$V_{in,low}$	0		1.0	V
I3	I_{in}	5		10	*mA*

Chapter 6: Error messages

This chapter lists the possible error messages from L01-i. The chapter is divided in two sections: errors that can be fixed by the user and errors that require repair at the factory.

6.1 User fixable errors

6.1.1 Linear lever sensor not within acceptable bounds.

The linear sensor gives out-of-range values. Normally a re-calibration of the lever fixes this problem.

6.1.2 Azimuth lever sensor not within acceptable bounds.

The azimuth sensor gives out-of-range values. Normally a re-calibration of the lever fixes this problem.

6.1.3 Linear sensor outside calibration.

The propulsion or thruster sensor gives out-of-range values. Normally a re-calibration of the lever fixes this problem.

6.1.4 Azimuth sensor outside calibration.

The azimuth sensor gives out-of-range values. Normally a re-calibration of the lever fixes this problem.

6.1.5 Backup and main linear sensor readings deviation.

The position reading of the propulsion or thruster sensors are different between primary and secondary channel. Normally a re-calibration of the lever fixes this problem.

6.1.6 Backup and main azimuth sensor readings deviation.

The position reading of the azimuth sensors are different between primary and secondary channel. Normally a re-calibration of the lever fixes this problem.

6.1.7 *CAN* open stack error.

This error comes when there are problems with communication over the *CAN* line. Typically this is caused by a broken cable or another lever being turned off. If the cable is broken this needs to be repaired. If another lever was turned off no further action is required to fix this error since L01 does not depend on a particular network configuration.

6.1.8 *CAN* open lost contact with node.

This error comes when a node (lever) disappears from the *CAN* network. Typically this is caused by a broken cable or another lever being turned off. If the cable is broken this needs to be repaired. If another lever was turned off no further action is required to fix this error since L01 does not depend on a particular network configuration.

6.1.9 Feedback value out of range.

The signal on the 4-20*mA* feedback input is outside of the range 4 - 20 *mA*. This is typically generated by the ship control system to indicate that there is an error. The manual from the ship control system should explain how to proceed. Alternatively the cable is broken, in which case the cable must be repaired.

6.2 Repair required at factory

6.2.1 Lost contact with backup board.

Communication with the secondary board was lost. Repair of the lever is required.

6.2.2 Lost contact with other main board.

Communication with the secondary board was lost. Repair of the lever is required.

6.2.3 Lost contact with touch button controller.

Communication between the primary board and the touch button controller is lost. Repair of the lever is required

6.2.4 Touch controller background noise too high.

This error indicates a failure with the touch button controller. Repair of the lever is required

6.2.5 No contact with the display or wrong setting on the display.

Communication with the display driver was lost. Repair of the lever is required.

6.2.6 Lost contact with feedback motor.

Communication with the motor controller was lost. Repair of the lever is required.

6.2.7 Checksum failed for config value. Loaded default.

Configuration information in the lever is not valid anymore. Repair of the lever is required.

Appendix A: Abbreviations

CAN	Controller Area Network	1–7, 10, 12, 17, 20, 22, 23, 26–30, 32–34, 36, 40
CiA	CAN in Automation	25
DC	Direct Current	31
LED	Light Emiting Diode	8–11, 22, 31
mA	milli-ampere	2, 12, 19, 31, 32, 34, 35, 37
PDO	Process Data Object	1–3, 27, 29, 30, 40
PW M	Pulse Width Modulation	31
rpm	Revolutions Per Minute	10
SDO	Service Data Object	1, 2, 27, 40

Appendix B: References

[1] *CiA 307 Framework for maritime electronics*, 2004.

[2] *CiA 301 CANopen application layer and communication profile*, 2011.

Appendix C: *CAN SDO* and *PDO* definition

The SDO and PDO definition can be taken from the .eds file, available upon request.

Appendix D: FAQ: frequently asked questions

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