CANopen Protocol for Joysticks (J2.., J3.., J6..)

Preliminary User Manual

Index

1 Scope

This document represents the elobau CANopen definitions for joysticks.

2 Abbreviations and Terms

Abbreviation/ Term	Definition and Meaning
ADC	Analogue Digital Converter
COB	Communication object
COB-ID	COB identifier
EMCY	Emergency Message
LSS	Layer Setting Services and Protocol
LSS-PARA	Storable LSS Parameter
NA	Not available
NMT	Network Management
Node-ID	Node Identifier
PARA	Storable Parameter
PDO	Process Data Object
SDO	Service Data Object
TPDO	Transmit-PDO

Tab. 1: Abbreviations and terms

3 Plausibility Test

3.1 General

Signal 2 can have opposite or same direction of signal 1. There are two types of plausibility test:

- Plausibility Type 1:
  - Signal 2 has the same direction of signal 1.
  - Signal 1 - Signal 2 = 0mV +/- « Signal Plausibility Limit »
- Plausibility Type 2:
  - Signal (on Channel) 2 has the opposite direction of signal (on Channel) 1.
  - Signal 1 + Signal 2 = 5000mV +/- « Signal Plausibility Limit »

The Plausibility Type can be defined in the object dictionary (e.g. 0x2000.6 for X-axis).

The plausibility parameter “Signal Plausibility Limit” is defined in the object dictionary (e.g. 0x2000.7 for X-axis).

3.2 J2, J3, J6 specific

Due to hardware restrictions (non programmable Hall Sensor) it is only possible to have opposite (crossed) direction of signals for the X-/Y-axis.

4 CAN

4.1 Bus Off

If a bus off state occurred a counter will be incremented. After that the device tries to go on bus again. If bus off counter is greater than a given value the device stops communication, go off bus and doesn't try to send data again.

The number of bus off counts is changeable in the object 0x5001.

4.2 Zero Position after Power On or Bus Off

After power on or bus off, the axis signals must be in zero position, otherwise the zero position is sent permanently until this axis position reaches the zero position.

This function can be switched on/off by parameter in the object dictionary, e.g. 0x2000.4 for X- axis.

5 CANopen Features Summary

- Implemented CiA DS-301 Application Layer and Communication Profile V4.2.0 and CiA DSP-305 Layer Setting Services and Protocol V1.1.1
- Configurable Baud rate 50…1000Kbit/s (default 250Kbit/s) and Node-ID 1...127 (default 0x11 (17)) via LSS and SDO
- NMT Slave (Minimum Boot Up)
- Heartbeat Producer
- EMCY Producer
- SDO Server
- 1 Transmit PDO
- 1 Receive PDO
- PDO transmission types: Asynchronous event driven, cyclic (default 100ms)
- Analogue values scanning and coding cycle fixed to 5 ms
- Parameter configuration and LSS configuration can be saved in ROM memory due to hardware limitation only 25times!

6 Network Management (NMT)

The device supports CANopen network management functionality NMT Slave (Minimum Boot Up).

6.1 NMT Services

6.1.1 Start Remote Node

Through this service the NMT Master sets the state of the selected NMT Slaves to OPERATIONAL.

6.1.2 Stop Remote Node

Through this service the NMT Master sets the state of the selected NMT Slaves to STOPPED.

6.1.3 Enter Pre-Operational

Through this service the NMT Master sets the state of the selected NMT Slaves to PRE- OPERATIONAL.

6.1.4 Reset Node

This service causes a CANopen stack reset with parameter re-initialization.

6.1.5 Reset Communication

This service causes a CANopen stack reset.

7 Baud rate / Note-ID

Baud rate (object 0x5999.1) and Node-ID (object 0x5999.2) are configurable via Layer Setting Services and Protocol (LSS) and via SDO communication. To save all parameter including LSS parameters use object 0x5999.03 in a manner like by 0x1010.1.

Attention: Please use this service with care. Make sure before saving Baud rate or Node-ID, that only volitional parameters are changed. Changing these parameters can disturb the network. Use this service only if one device is connected to the network.

The default Baud rate is 250kbit/s and the default Node-ID 0x11 (17).

8 Parameter Setting

All object dictionary parameters (objects with marking PARA) are configurable via SDO communication.

To save all parameters (objects with marking PARA) except LSS parameters, write "save" (0x65766173) into the object 0x1010.1. Restart the joystick after saving procedure.

Attention: Please use this service with care. Make sure before saving parameters, that only volitional parameters are changed.

9 Restore Default Parameters (Factory Settings)

To restore all parameters to factory settings write "load" (0x64616F6C) into the object 0x1011.1. Restart the joystick after saving procedure

10 CAN Message Bit Order (CANopen Definition)

Byte	0	1	2	3
U16	Bit7 ... Bit0	Bit15 ... Bit8		
U32	Bit7 ... Bit0	Bit15 ... Bit8	Bit23 ... Bit16	Bit31 ... Bit24

Tab. 2: CAN message Bit order example

11 Heartbeat

The heartbeat mechanism for this device is established through cyclic transmission of the heartbeat message done by the heartbeat producer. One or more devices in the network are aware of this heartbeat message. If the heartbeat cycle fails from the heartbeat producer the local application on the heartbeat consumer will be informed about that event. The implementation of either guarding or heartbeat is mandatory.

The device shall support **Heartbeat Producer** functionality. The producer heartbeat time is defined in object 0x1017.

11.1 Heartbeat Message

COB-ID	Byte	0
0x700 + Node-ID	Content	NMT state

Tab. 3: Heartbeat message

12 Error Handling

12.1 Principle

Emergency messages (EMCY) shall be triggered by internal errors on device and they are assigned the highest possible priority to ensure that they get access to the bus without delay (**EMCY Producer**). By default, the EMCY shall contain the error code with pre-defined error numbers and additional information. Emergency messages (EMCY) are not sent in network management (NMT) state STOPPED.

12.2 Error Behavior (object 0x4000)

If a serious device failure is detected the object 0x4000 specifies, to which state the module shall be set:

0: pre-operational

1: no state change (default)*

2: stopped

* In this case, the corresponding error value will be sent:

Axes and Thumb Wheels: Object 0x200*.1D

Buttons: Object 0x210*.B

12.3 EMCY Message

The EMCY COB-ID is defined in object 0x1014. The EMCY message consists of 8 bytes. It contains an emergency error code, the contents of object 0x1001 and 5 byte of manufacturer specific error code. This device uses only the 1st byte as manufacturer specific error code.

Byte	0	1	2	3	4
Content	Emergency Error Code		Error Register (object 0x1001*)	Manufacturer specific error code (object 0x4001)	

Byte	5	6	7
	Manufacturer specific error code - Not used (default value 0xFF)!	Manufacturer specific error code - Not used (default value 0xFF)!	Manufacturer specific error code - Not used (default value 0xFF)!

Tab. 4: EMCY message

* Always 0

12.4 Emergency Error Code

0x0000: Error Reset or No Error

0x1000: Generic Error = Manufacturer Specific Error
0x81xx: Communication

0x8120: CAN in Error Passive Mode

0x8140: Recovered from Bus Off (in this case the Manufacturer Specific Error Code contains the amount of Bus Offs)

12.5 Supported Manufacturer Specific Error Codes (object 0x4001)

Manufacturer specific error code	Error name	Description
0x0000	No Manufacturer Specific Error Code	
0x0002	Parameter Checksum Error	CRC32 Joystick remains in NMT state Preoperational This error is also set until first parameter saving process.
0x0003	Not used.	
0x0004	Not used.	
0x0005	RAM Test Error	Not supported.
0x0010	X Axis, Signal 1, Out Of Range	
0x0011	X Axis, Signal 2, Out Of Range	
0x0012	X Axis, Signal Plausibility Error	Error if Signal Plausibility Limit is out of Range. Refer to object 0x2000.7.
0x0020	Y Axis, Signal 1, Out Of Range	
0x0021	Y Axis, Signal 2, Out Of Range	
0x0022	Y Axis, Signal Plausibility Error	Error if Signal Plausibility Limit is out of Range. Refer to object 0x2001.7.
0x0030	Thumb Wheel A, Signal 1, Out Of Range	
0x0031	Thumb Wheel A, Signal 2, Out Of Range	
0x0032	Thumb Wheel A, Signal Plausibility Error	Error if Signal Plausibility Limit is out of Range. Refer to object 0x2002.7.
0x0040	Thumb Wheel B, Signal 1, Out Of Range	
0x0041	Thumb Wheel B, Signal 2, Out Of Range	
0x0042	Thumb Wheel B, Signal Plausibility Error	Error if Signal Plausibility Limit is out of Range. Refer to object 0x2003.7.
0x0050	Thumb Wheel C, Signal 1, Out Of Range	
0x0051	Thumb Wheel C, Signal 2, Out Of Range	
0x0052	Thumb Wheel C, Signal Plausibility Error	Error if Signal Plausibility Limit is out of Range. Refer to object 0x2004.7.
0x0060	Button 1 Stuck at Start up	Refer to object 0x2100.3
0x0061	Button 1 Out of Range	
0x0062	Button 2 Stuck at Start up	Refer to object 0x2101.3

Manufacturer specific error code	Error name	Description
0x0063	Button 2 Out of Range	
0x0064	Button 3 Stuck at Start up	Refer to object 0x2102.3
0x0065	Button 3 Out of Range	
0x0066	Button 4 Stuck at Start up	Refer to object 0x2103.3
0x0067	Button 4 Out of Range	
0x0068	Button 5 Stuck at Start up	Refer to object 0x2104.3
0x0069	Button 5 Out of Range	
0x006A	Button 6 Stuck at Start up	Refer to object 0x2105.3
0x006B	Button 6 Out of Range	
0x006C	Button 7 Stuck at Start up	Refer to object 0x2106.3
0x006D	Button 7 Out of Range	
0x006E	Button 8 Stuck at Start up	Refer to object 0x2107.3
0x006F	Button 8 Out of Range	
0x0070	Button 9 Stuck at Start up	Refer to object 0x2108.3
0x0071	Button 9 Out of Range	
0x0072	Button 10 Stuck at Start up	Refer to object 0x2109.3
0x0073	Button 10 Out of Range	
0x0074	Button 11 Stuck at Start up	Refer to object 0x210A.3
0x0075	Button 11 Out of Range	
0x0076	Button 12 Stuck at Start up	Refer to object 0x210B.3
0x0077	Button 12 Out of Range	

Tab. 5: Supported Manufacturer Specific Error Codes

If there is an Application Program Checksum Error the Application. it will not send anything. Therefore there will be no Error Code. But the Application is also CRC32 tested.

13 SDO Communication

The device fulfils the **SDO Server** functionality.

14 PDO Communication

14.1 Transmit PDO #0

This PDO transmits asynchronously the axis and thumb wheel values (channel 1) and the buttons status. The Tx PDO #0 is transmitted cyclic, when the cyclic timer (object 0x1800.5) is programmed > 0. Values between 1ms and 65535ms are selectable by parameter settings. The Tx PDO #0 is transmitted after entering the "Operational" state.

Byte	0	1	2	3
Content	X Axis Signal 1 (object 2000.20)	Y Axis Signal 1 (object 2001.20)	Thumb Wheel A Signal 1 (object 2002.20)	Thumb Wheel B Signal 1 (object 2003.20)

Byte	4	5	6	7
Content	Thumb Wheel C Signal 1 (object 2004.20)	Buttons 1…4 (object 2110.1)	Buttons 5…8 (object 2110.2)	Buttons 9…12 (object 2110.3)

Tab. 6: TPDO #0 with the default mapping

NOTICE! It is suggested that Transmit PDOs cycle rate should not be less than 5 ms as the ADC scanning and coding time is fixed to 5 ms. Sending Transmit PDOs faster than 5 ms will only repeat last sent message until the end of the next coding cycle

14.2 Receive PDO #0

Receive PDO, described in the following table, receives LED commands. LED commands are described in chapter 15.3 LED Commands.

NOTICE! While Receive PDO has priority over Transmit PDOs and because of a maximum time of 50ms for LED refresh reaction, the Receive PDO transmit rate should not be less than 50ms. When cyclic transmit is necessary a cycle rate of 200ms is suggested. Sending RxPDO faster than 50ms makes only higher busload and has no additional affect on LED functionality. Please notice that LEDs are always triggered with last received LED command. Therefore cyclic update is not necessary.

Byte	0	1	2
Content	LED 1 to 4 Command Bit 0,1: LED 1 Bit 2,3: LED 2 Bit 4,5: LED 3 Bit 6,7: LED 4 (object 2200.21)	LED 5 to 8 Command Bit 0,1: LED 5 Bit 2,3: LED 6 Bit 4,5: LED 7 Bit 6,7: LED 8 (object 2200.22)	LED 9 to 10 Command Bit 0,1: LED 9 Bit 2,3: LED 10 Bit 4-7: not used (object 2200.23)

Tab. 7: RPDO #0

15 Function Description

15.1 Axes and Thumb Wheels

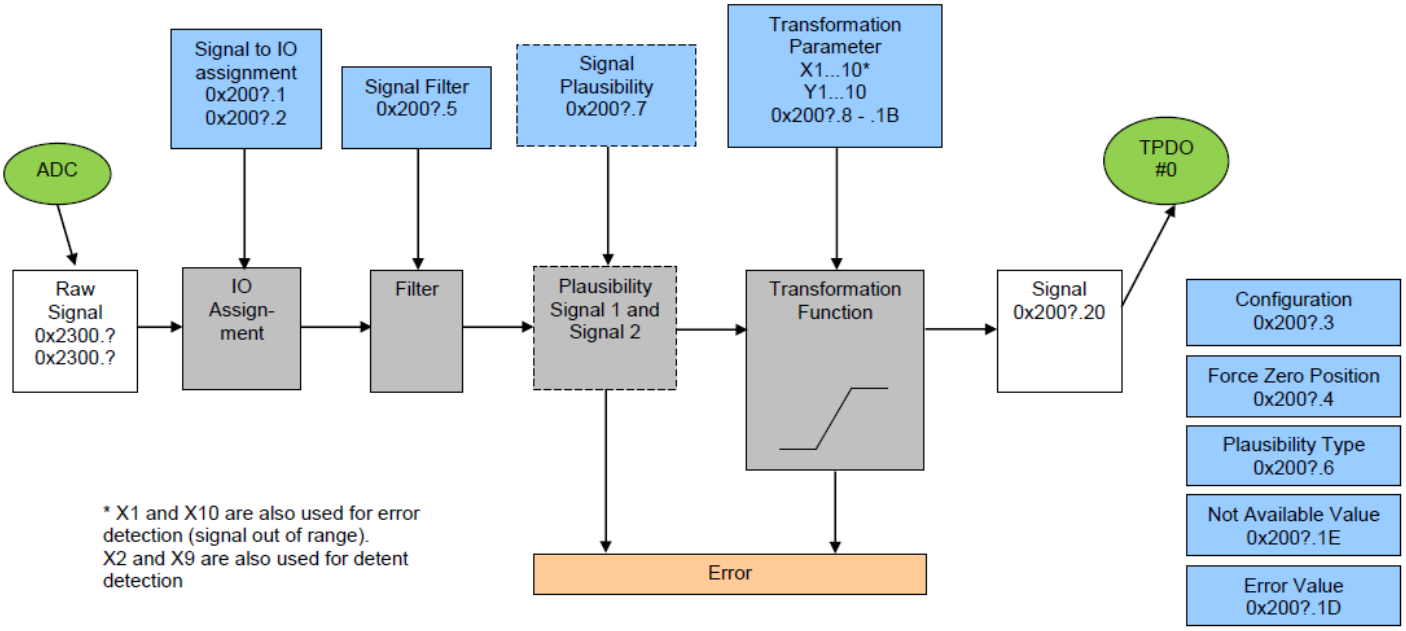

Fig. 1: Axes and Thumb Wheels Overview

This function reads the analogue input value; transforms it according to transformation function and transmits this value cyclic via CAN bus. Error detection and filter functions are also included.

Input value range (X): 0...5V

Transformed signal maximal possible range (Y): -128 ... 127%

15.1.1 Teach parameters

The Joystick axes are designed with non programmable Hall IC's. Therefore it is necessary to teach the analog values to the microcontroller. This is done by the Eol-Tester by deflecting the shaft and readout of the analog values. Afterwards the analog values are written to the corresponding object code ⇒ teach parameters.

Signal 1 is used for teaching.

The deflection angles have to be determined according to the sliding gate.

Thumb Wheels normally use programmable Hall-IC's and become programmed in the production process. In this case a teaching is not necessary.

An example for the teach parameters is shown in the following chapters 15.1.2 and 15.1.3.

15.1.2 Axis without detent

The following table shows a typical transformation function from -100% to 100%:

X1*	X2	X3	X4	X5	X6	X7	X8	X9	X10*
0,2V	0,2	0,6	0,6	2,3	2,7	4,4	4,4	4,8	4,8
Y1	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**
-100%	-100%	-100%	-100%	0%	0%	100%	100%	100%	100%

Tab. 8: Transformation function example without detent

* X1 and X10 are also used for error detection (signal out of range).

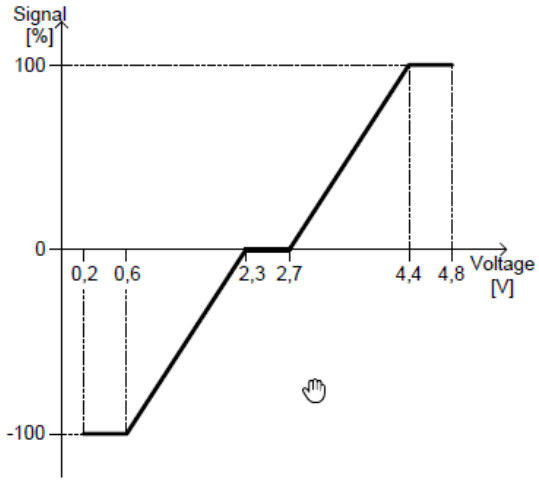

Fig. 2: Example for Axis without detent

In this example the teach parameters are:

X3, X4, X5, X6, X7 and X8

15.1.3 Axis with detent

The following table shows a typical transformation function with detent on both sides. A detent is indicated with a selectable value (Default: 110% and -110%). The detent function is a jump from 100% to the defined value, see following example.

X1*	X2**	X3	X4	X5	X6	X7	X8	X9**	X10*
0,2V	1,0	1,001	1,3	2,3	2,7	3,7	3,999	4,0	4,8
Y1	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**
-110%	-110%	-100%	-100%	0%	0%	100%	100%	110%	110%

Tab. 9: Transformation function example with detent

* X1 and X10 are also used for error detection (signal out of range).

** X2 and X9 are used for detent detection

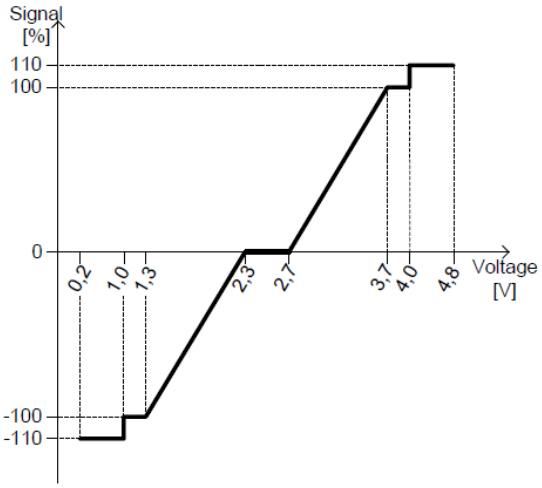

Fig. 3: Example for Axis with detent

In this example the teach parameters are:

X2, X3, X4, X5, X6, X7, X8 and X9

15.2 Buttons

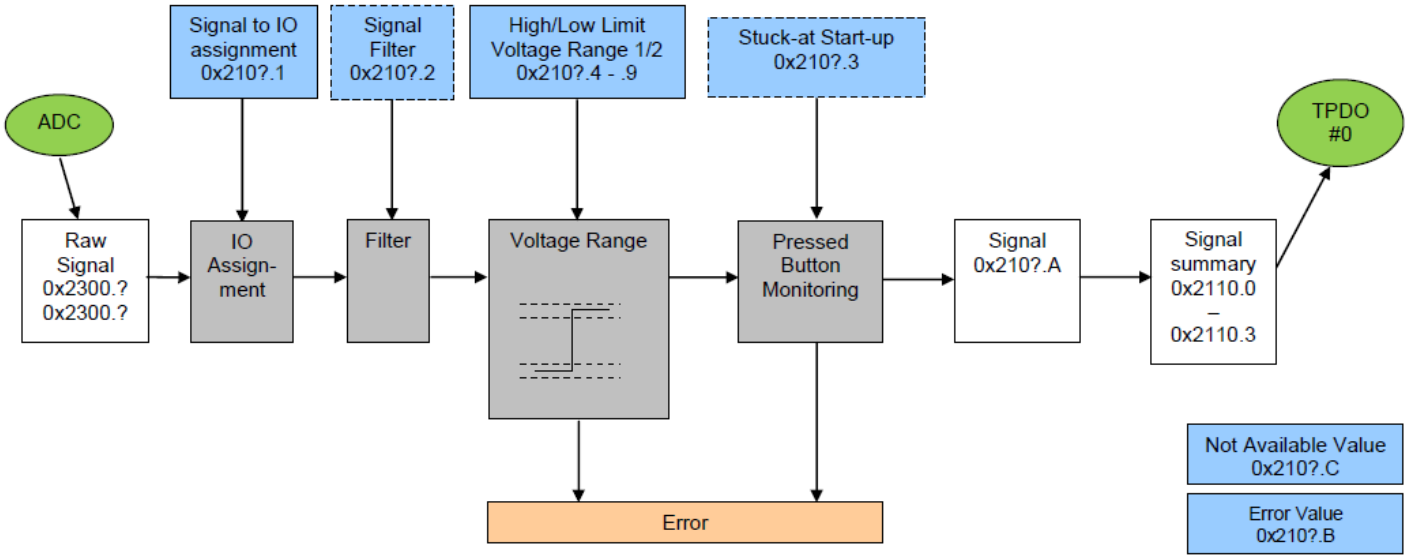

Fig. 4: Buttons Overview

This function reads the button status and transmits it cyclic via CAN Bus. Each Button has two bits for representation:

Button coding	00	01	10	11
Function	Button not pressed	Button pressed	Error Indicator	Not available (NA)

Tab. 10: Button coding

15.3 LED Commands

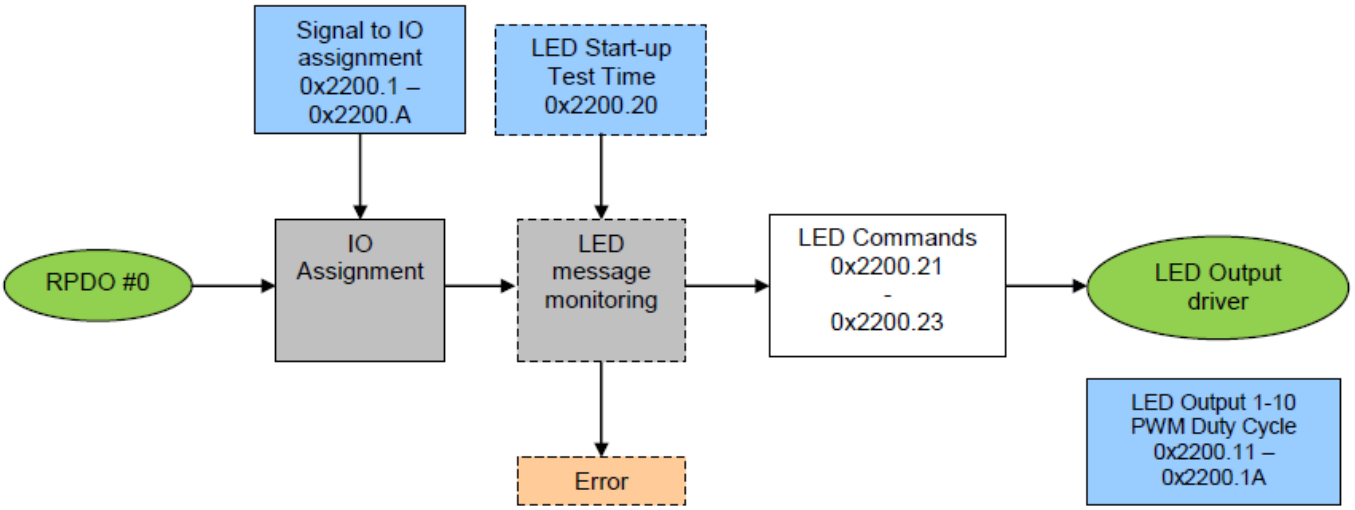

Fig. 5: LED Commands Overview

The LEDs are controlled with CAN command. It is possible to command up to 10 LEDs. The LED coding follows this rule:

LED coding	00	01	10	11
Function	LED off	LED on	LED bink (periodically on/off) – blinking frequency is set to 1Hz	Not available (NA) or not installed or no change in previously LED funtion

Tab. 11: LED coding

16 Annex A: Object Dictionary

* = will take effect after parameter stored and device reset

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
		Communication Profile Area (0x1000...0x1FFF)							
0x1000		Device Type	U32	ro			0x00000000		No standardized device profile used.
0x1001		Error Register	U8	ro			0x00		Always 0.
0x1008		Manufacturer Device Name	String	const			"JST"		"JST": Joystick
0x1009		Manufacturer Hardware Version	String	const			"x.xx"		"Maj.MinMin" Read in via analogue input. Range from 1.00 to B.00.
0x100A		Manufacturer Software Version	String	const			"x.xx"		"Maj.MinMin"
0x1010		Store Parameters							**Attention: Please use this service with care. Make sure before saving parameters, that only volitional parameters are changed.**
	0x0	Number of Entries	U8	const			1		
	0x1	Save all Parameters	U32	rw					"save" (0x65766173) to save all parameters (objects with marking PARA except LSS parameter).
0x1011		Restore Default Parameters							
	0x0	Number of Entries	U8	const			1		
	0x1	Restore all Default Parameters	U32	rw					"load" (0x64616F6C) to restore all parameters (objects with marking PARA) to factory settings.

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
0x1014		COB-ID EMCY	U32	const			0x80 + Node-ID		
0x1017		Producer Heartbeat Time - PARA	U16	rw			0	1ms	0: not used
0x1018		Identity Object							
	0x0	Number of Entries	U8	const	4	4	4		
	0x1	Vendor ID	U32	ro			0x000000B4		elobau Vendor ID: 0x000000B4
	0x2	Product Code	U32	ro			0x00000106		
	0x3	Revision Number	U32	ro			0x00000000		Major Revision Number: Bit16...31 Minor Revision Number: Bit0...15
	0x4	Serial Number	U32	ro					
0x1200		SDO #0 Server Parameter							
	0x0	Number of Entries	U8	const	2	2	2		
	0x1	COB-ID Client->Server (Rx)	U32	const			0x600 + Node-ID		
	0x2	COB-ID Server->Client (Tx)	U32	ro			0x580 + Node-ID		
0x1400		Rx PDO #0 Communication Parameter							
	0x0	Number of Entries	U8	const	2	2	2		
	0x1	COB-ID	U32	const			0x200 + Node-ID		
	0x2	Transmission Type	U8	const			254		Asynchronous transmission, transmission event is manufacturer specific, i.e. event timer
0x1600		Rx PDO #0 Mapping Parameter							
	0x0	Number of Entries	U8	const		64	3		

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
	0x1	Mapping Parameter 1	U32	const			0x22002108		object 0x2200.21
	0x2	Mapping Parameter 2	U32	const			0x22002208		object 0x2200.22
	0x3	Mapping Parameter 3	U32	const			0x22002308		object 0x2200.23
0x1800		Tx PDO #0 Communication Parameter							
	0x0	Number of Entries	U8	const	2	5	5		
	0x1	COB-ID	U32	const			0x180 + Node-ID		
	0x2	Transmission Type	U8	const			254		Asynchronous transmission, transmission event is manufacturer specific, i.e. event timer.
	0x3	Inhibit Time	U16	rw			0	100us	Not supported.
	0x4	Reserved	U8	rw			0		Not supported.
	0x5	Event Timer - PARA	U16	rw			100	1ms	
0x1A00		Tx PDO #0 Mapping Parameter							
	0x0	Number of Entries	U8	const		64	8		
	0x1	Mapping Parameter 1	U32	const			0x20002008		object 0x2000.20 (X-Axis)
	0x2	Mapping Parameter 2	U32	const			0x20012008		object 0x2001.20 (Y-Axis)
	0x3	Mapping Parameter 3	U32	const			0x20022008		object 0x2002.20 (TWA)
	0x4	Mapping Parameter 4	U32	const			0x20032008		object 0x2003.20 (TWB)
	0x5	Mapping Parameter 5	U32	const			0x20042008		object 0x2004.20 (TWC)
	0x6	Mapping Parameter 6	U32	const			0x21100108		object 0x2110.01 (Button 1-4)
	0x7	Mapping Parameter 7	U32	const			0x21100208		object 0x2110.02 (Button 5-8)
	0x8	Mapping Parameter 8	U32	const			0x21100308		object 0x2110.03 (Button 9-12)

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
		Manufacturer Specific Profile Area (0x2000...0x5FFF)							
0x2000		X Axis							
	0x0	Number of Entries	U8	ro			32		
	0x1	X Axis Signal 1 to IO assignment	U8	ro	0	255	0		0= not used, 1=IO1, …, 8=IO8
	0x2	X Axis Signal 2 to IO assignment	U8	ro	0	255	0		0= not used, 1=IO1, …, 8=IO8
	0x3	Configuration - PARA	U8	rw	0	1	0		0: X-axis signal normal, 1: X-axis signal inverted
	0x4	Force Zero Position after Power On or Bus Off - PARA	U8	rw	0	1	1		0: Off, 1: On
	0x5*	Analogue Signal Filter - PARA	U8	rw	0	12	8		0: disabled, 1-12: amount of filter values (moving average filter)
	0x6	Plausibility Type – PARA	U8	rw	0	2	0		0: not used 1: channels are even 2: channels are crossed
	0x7	Signal Plausibility Limit - PARA	U16	rw	0	5000	300	1mV	0: no monitoring activated Defines the signal plausibility limit
	0x8	Transformation Function X1 - PARA	U16	rw	0	5000	200	1mV	This parameter is used for error detection (signal out of range).
	0x9	Transformation Function Y1 - PARA	S16	rw	-128	127	-100	%	
	0xA	Transformation Function X2 - PARA	U16	rw	0	5000	200	1mV	Teach parameter – used for detent detection
	0xB	Transformation Function Y2 - PARA	S16	rw	-128	127	-100	%	
	0xC	Transformation Function X3 - PARA	U16	rw	0	5000	600	1mV	Teach parameter

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
	0xD	Transformation Function Y3 - PARA	S16	rw	-128	127	-100	%	
	0xE	Transformation Function X4 - PARA	U16	rw	0	5000	600	1mV	Teach parameter
	0xF	Transformation Function Y4 - PARA	S16	rw	-128	127	-100	%	
	0x10	Transformation Function X5 - PARA	U16	rw	0	5000	2300	1mV	Teach parameter
	0x11	Transformation Function Y5 - PARA	S16	rw	-128	127	0	%	
	0x12	Transformation Function X6 - PARA	U16	rw	0	5000	2700	1mV	Teach parameter
	0x13	Transformation Function Y6 - PARA	S16	rw	-128	127	0	%	
	0x14	Transformation Function X7 - PARA	U16	rw	0	5000	4400	1mV	Teach parameter
	0x15	Transformation Function Y7 - PARA	S16	rw	-128	127	100	%	
	0x16	Transformation Function X8 - PARA	U16	rw	0	5000	4400	1mV	Teach parameter
	0x17	Transformation Function Y8 - PARA	S16	rw	-128	127	100	%	
	0x18	Transformation Function X9 - PARA	U16	rw	0	5000	4800	1mV	Teach parameter – used for detent detection
	0x19	Transformation Function Y9 - PARA	S16	rw	-128	127	100	%	
	0x1A	Transformation Function X10 - PARA	U16	rw	0	5000	4800	1mV	This parameter is used for error detection (signal out of range).
	0x1B	Transformation Function Y10 - PARA	S16	rw	-128	127	100	%	
	0x1C	Spare	U8	ro					
	0x1D	Error Value - PARA	S8	rw	-128	127	126	%	This value is sent via CAN bus in case of an error.
	0x1E	Not Available Value - PARA	S8	rw	-128	127	127	%	This value is sent via CAN bus in case of not available.
	0x1F	Spare	U8	ro					
	0x20	Transformed Signal	S8	ro	-128	127	0	%	
0x2001		Y Axis							

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
	0x0	Number of Entries	U8	ro			32		
	0x1	Y Axis Signal 1 to IO assignment	U8	ro	0	255	0		0= not used, 1=IO1, …, 8=IO8
	0x2	Y Axis Signal 2 to IO assignment	U8	ro	0	255	0		0= not used, 1=IO1, …, 8=IO8
	0x3	Configuration - PARA	U8	rw	0	1	0		0: Y-axis signal normal, 1: Y-axis signal inverted
	0x4	Force Zero Position after Power On or Bus Off - PARA	U8	rw	0	1	1		0: Off, 1: On
	0x5*	Analogue Signal Filter - PARA	U8	rw	0	12	8		0: disabled, 1-12: amount of filter values (moving average filter)
	0x6	Plausibility Type – PARA	U8	rw	0	2	0		0: not used 1: channels are even 2: channels are crossed
	0x7	Signal Plausibility Limit - PARA	U16	rw	0	5000	300	1mV	0: no monitoring activated Defines the signal plausibility limit
	0x8	Transformation Function X1 - PARA	U16	rw	0	5000	200	1mV	This parameter is used for error detection (signal out of range).
	0x9	Transformation Function Y1 - PARA	S16	rw	-128	127	-100	%	
	0xA	Transformation Function X2 - PARA	U16	rw	0	5000	200	1mV	Teach parameter – used for detent detection
	0xB	Transformation Function Y2 - PARA	S16	rw	-128	127	-100	%	
	0xC	Transformation Function X3 - PARA	U16	rw	0	5000	600	1mV	Teach parameter
	0xD	Transformation Function Y3 - PARA	S16	rw	-128	127	-100	%	
	0xE	Transformation Function X4 - PARA	U16	rw	0	5000	600	1mV	Teach parameter
	0xF	Transformation Function Y4 - PARA	S16	rw	-128	127	-100	%	

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
	0x10	Transformation Function X5 - PARA	U16	rw	0	5000	2300	1mV	Teach parameter
	0x11	Transformation Function Y5 - PARA	S16	rw	-128	127	0	%	
	0x12	Transformation Function X6 - PARA	U16	rw	0	5000	2700	1mV	Teach parameter
	0x13	Transformation Function Y6 - PARA	S16	rw	-128	127	0	%	
	0x14	Transformation Function X7 - PARA	U16	rw	0	5000	4400	1mV	Teach parameter
	0x15	Transformation Function Y7 - PARA	S16	rw	-128	127	100	%	
	0x16	Transformation Function X8 - PARA	U16	rw	0	5000	4400	1mV	Teach parameter
	0x17	Transformation Function Y8 - PARA	S16	rw	-128	127	100	%	
	0x18	Transformation Function X9 - PARA	U16	rw	0	5000	4800	1mV	Teach parameter – used for detent detection
	0x19	Transformation Function Y9 - PARA	S16	rw	-128	127	100	%	
	0x1A	Transformation Function X10 - PARA	U16	rw	0	5000	4800	1mV	This parameter is used for error detection (signal out of range).
	0x1B	Transformation Function Y10 - PARA	S16	rw	-128	127	100	%	
	0x1C	Spare	U8	ro					
	0x1D	Error Value - PARA	S8	rw	-128	127	126	%	This value is sent via CAN bus in case of an error.
	0x1E	Not Available Value - PARA	S8	rw	-128	127	127	%	This value is sent via CAN bus in case of not available.
	0x1F	Spare	U8	ro					
	0x20	Transformed Signal	S8	ro	-128	127	0	%	
0x2002		Thumb Wheel A							
	0x0	Number of Entries	U8	ro			32		
	0x1	TWA Signal 1 to IO assignment	U8	ro	0	255	0		0= not used, 1=IO1, …, 8=IO8
	0x2	TWA Signal 2 to IO assignment	U8	ro	0	255	0		0= not used, 1=IO1, …, 8=IO8

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
	0x3	Configuration - PARA	U8	rw	0	1	0		0: Signal normal, 1: Signal inverted
	0x4	Force Zero Position after Power On or Bus Off - PARA	U8	rw	0	1	1		0: Off, 1: On
	0x5*	Analogue Signal Filter - PARA	U8	rw	0	12	8		0: disabled, 1-12: amount of filter values (moving average filter)
	0x6	Plausibility Type – PARA	U8	rw	0	2	0		0: not used 1: channels are even 2: channels are crossed
	0x7	Signal Plausibility Limit - PARA	U16	rw	0	5000	300	1mV	0: no monitoring activated Defines the signal plausibility limit
	0x8	Transformation Function X1 - PARA	U16	rw	0	5000	200	1mV	This parameter is used for error detection (signal out of range).
	0x9	Transformation Function Y1 - PARA	S16	rw	-128	127	-100	%	
	0xA	Transformation Function X2 - PARA	U16	rw	0	5000	200	1mV	Teach parameter – used for detent detection
	0xB	Transformation Function Y2 - PARA	S16	rw	-128	127	-100	%	
	0xC	Transformation Function X3 - PARA	U16	rw	0	5000	600	1mV	Teach parameter
	0xD	Transformation Function Y3 - PARA	S16	rw	-128	127	-100	%	
	0xE	Transformation Function X4 - PARA	U16	rw	0	5000	600	1mV	Teach parameter
	0xF	Transformation Function Y4 - PARA	S16	rw	-128	127	-100	%	
	0x10	Transformation Function X5 - PARA	U16	rw	0	5000	2300	1mV	Teach parameter
	0x11	Transformation Function Y5 - PARA	S16	rw	-128	127	0	%	
	0x12	Transformation Function X6 - PARA	U16	rw	0	5000	2700	1mV	Teach parameter
	0x13	Transformation Function Y6 - PARA	S16	rw	-128	127	0	%	

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
	0x14	Transformation Function X7 - PARA	U16	rw	0	5000	4400	1mV	Teach parameter
	0x15	Transformation Function Y7 - PARA	S16	rw	-128	127	100	%	
	0x16	Transformation Function X8 - PARA	U16	rw	0	5000	4400	1mV	Teach parameter
	0x17	Transformation Function Y8 - PARA	S16	rw	-128	127	100	%	
	0x18	Transformation Function X9 - PARA	U16	rw	0	5000	4800	1mV	Teach parameter – used for detent detection
	0x19	Transformation Function Y9 - PARA	S16	rw	-128	127	100	%	
	0x1A	Transformation Function X10 - PARA	U16	rw	0	5000	4800	1mV	This parameter is used for error detection (signal out of range).
	0x1B	Transformation Function Y10 - PARA	S16	rw	-128	127	100	%	
	0x1C	Spare	U8	ro					
	0x1D	Error Value - PARA	S8	rw	-128	127	126	%	This value is sent via CAN bus in case of an error.
	0x1E	Not Available Value - PARA	S8	rw	-128	127	127	%	This value is sent via CAN bus in case of not available.
	0x1F	Spare	U8	ro					
	0x20	Transformed Signal	S8	ro	-128	127	0	%	
0x2003		Thumb Wheel B							
		dto.							
0x2004		Thumb Wheel C							
		dto							
0x2100		Button 1							
	0x0	Number of Entries	U8	ro			12		
	0x1	Button 1 Signal to IO Assignment	U8	ro	0	255	0		0= not used, 1=IO1, …, 8=IO8

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
	0x2*	Signal Filter (Analogue or Debounce Value) - PARA	U8	rw	0	12	8		0: disabled, 1-12: amount of filter values (moving average filter)
	0x3	Stuck-at Start-up Test – PARA	U8	rw	0	1	1		0: disabled, 1: enabled
	0x4	Error Detection Low - PARA	U16	rw	0	5000	0	1mV	This parameter is used for error detection (signal out of range).
	0x5	Low Limit Voltage Range 1 - PARA	U16	rw	0	5000	2500	1mV	Voltage Range 1. Has to be adjusted according to Configuration (1 Button or 2 Buttons, Position of 2nd Button)
	0x6	High Limit Voltage Range 1 - PARA	U16	rw	0	5000	5000	1mV	
	0x7	Low Limit Voltage Range 2 - PARA	U16	rw	0	5000	2500	1mV	Voltage Range 2. Has to be adjusted according to Configuration (1 Button or 2 Buttons, Position of 2nd Button)
	0x8	High Limit Voltage Range 2 - PARA	U16	rw	0	5000	5000	1mV	
	0x9	Error Detection High - PARA	U16	rw	0	5000	5000	1mV	This parameter is used for error detection (signal out of range).
	0xA	Transformed Signal Button 1	U8	ro	0	3	0		
	0xB	Error Value – PARA	U8	ro	0	3	2		This value is sent via CAN bus in case of an error.
	0xC	Not Available Value – PARA	U8	ro	0	3	3		This value is sent via CAN bus in case of not available.
0x2101		Button 2							
		dto.							
0x2102		Button 3							
		dto.							
0x2103		Button 4							
		dto.							
0x2104		Button 5							

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
		dto.							
0x2105		Button 6							
		dto.							
0x2106		Button 7							
		dto.							
0x2107		Button 8							
		dto.							
0x2108		Button 9							
		dto.							
0x2109		Button 10							
		dto.							
0x210A		Button 11							
		dto.							
0x210B		Button 12							
		dto.							
0x2110		Button 1 to 12							
	0x0	Number of Entries	U8	ro			3		
	0x1	Button 1 – 4: Bit 0,1: Transf. Signal Button 1 (0x2100.0A) Bit 2,3: Transf. Signal Button 2 (0x2101.0A) Bit 4,5: Transf. Signal Button 3 (0x2102.0A) Bit 6,7: Transf. Signal Button 4 (0x2103.0A)	U8	ro	0	255			

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
	0x2	Button 5 – 8: Bit 0,1: Transf. Signal Button 5 (0x2104.0A) Bit 2,3: Transf. Signal Button 6 (0x2105.0A) Bit 4,5: Transf. Signal Button 7 (0x2106.0A) Bit 6,7: Transf. Signal Button 8 (0x2107.0A)	U8	ro	0	255			
	0x3	Button 9 – 12: Bit 0,1: Transf. Signal Button 9 (0x2108.0A) Bit 2,3: Transf. Signal Button 10 (0x2109.0A) Bit 4,5: Transf. Signal Button 11 (0x210A.0A) Bit 6,7: Transf. Signal Button 12 (0x210B.0A)	U8	ro	0	255			
0x2200		LED Commands							
	0x0	Number of Entries	U8	ro			35		
	0x1	LED Output 1 Signal to IO Assignment	U8	ro	0	255	0		0= disabled, 1=IO1, …, 8=IO8
	0x2	LED Output 2 Signal to IO Assignment	U8	ro	0	255	0		0= disabled, 1=IO1, …, 8=IO8
	0x3	LED Output 3 Signal to IO Assignment	U8	ro	0	255	0		0= disabled, 1=IO1, …, 8=IO8
	0x4	LED Output 4 Signal to IO Assignment	U8	ro	0	255	0		0= disabled, 1=IO1, …, 8=IO8

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
	0x5	LED Output 5 Signal to IO Assignment	U8	ro	0	255	0		0= disabled, 1=IO1, …, 8=IO8
	0x6	LED Output 6 Signal to IO Assignment	U8	ro	0	255	0		0= disabled, 1=IO1, …, 8=IO8
	0x7	LED Output 7 Signal to IO Assignment	U8	ro	0	255	0		0= disabled, 1=IO1, …, 8=IO8
	0x8	LED Output 8 Signal to IO Assignment	U8	ro	0	255	0		0= disabled, 1=IO1, …, 8=IO8
	0x9	LED Output 9 Signal to IO Assignment	U8	ro	0	255	0		0= disabled, 1=IO1, …, 8=IO8
	0xA	LED Output 10 Signal to IO Assignment	U8	ro	0	255	0		0= disabled, 1=IO1, …, 8=IO8
	0xB – 0x10	Spare	U8	ro					
	0x11*	LED Output 1 PWM Duty Cycle - PARA	U8	rw	0	100	100	%	Duty Cycle. Used for LED balancing
	0x12*	LED Output 2 PWM Duty Cycle - PARA	U8	rw	0	100	100	%	Duty Cycle. Used for LED balancing
	0x13*	LED Output 3 PWM Duty Cycle - PARA	U8	rw	0	100	100	%	Duty Cycle. Used for LED balancing
	0x14*	LED Output 4 PWM Duty Cycle - PARA	U8	rw	0	100	100	%	Duty Cycle. Used for LED balancing
	0x15*	LED Output 5 PWM Duty Cycle - PARA	U8	rw	0	100	100	%	Duty Cycle. Used for LED balancing
	0x16*	LED Output 6 PWM Duty Cycle - PARA	U8	rw	0	100	100	%	Duty Cycle. Used for LED balancing
	0x17*	LED Output 7 PWM Duty Cycle - PARA	U8	rw	0	100	100	%	Duty Cycle. Used for LED balancing

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
	0x18*	LED Output 8 PWM Duty Cycle - PARA	U8	rw	0	100	100	%	Duty Cycle. Used for LED balancing
	0x19*	LED Output 9 PWM Duty Cycle - PARA	U8	rw	0	100	100	%	Duty Cycle. Used for LED balancing
	0x1A*	LED Output 10 PWM Duty Cycle - PARA	U8	rw	0	100	100	%	Duty Cycle. Used for LED balancing
	0x1B – 0x1F	Spare	U8	ro					
	0x20*	LED Start-up Test Time - PARA	U8	rw	0	3	1	1s	0: Test not active
	0x21	LED 1 to 4 Command: Bit 0,1: LED 1 Bit 2,3: LED 2 Bit 4,5: LED 3 Bit 6,7: LED 4	U8	wo	0	255	0		
	0x22	LED 5 to 8 Command: Bit 0,1: LED 5 Bit 2,3: LED 6 Bit 4,5: LED 7 Bit 6,7: LED 8	U8	wo	0	255	0		
	0x23	LED 9 to 10 Command: Bit 0,1: LED 9 Bit 2,3: LED 10 Bit 4-7: 1111 (not used)	U8	wo	0	255	0		

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
0x2300		IO Raw Values							
	0x0	Number of Entries	U8	ro			8		
	0x1	Raw Value IO1	U16	ro	0	1023	0		Used for internal diagnostics
	0x2	Raw Value IO2	U16	ro	0	1023	0		Used for internal diagnostics
	0x3	Raw Value IO3	U16	ro	0	1023	0		Used for internal diagnostics
	0x4	Raw Value IO4	U16	ro	0	1023	0		Used for internal diagnostics
	0x5	Raw Value IO5	U16	ro	0	1023	0		Used for internal diagnostics
	0x6	Raw Value IO6	U16	ro	0	1023	0		Used for internal diagnostics
	0x7	Raw Value IO7 / HW-Version Input	U16	ro	0	1023	0		Used for internal diagnostics
	0x8	Raw Value IO8 / Ubat Monitor Input	U16	ro	0	1023	0		Used for internal diagnostics
0x2400		Ubat and HW-Version IO Assignment							
	0x0	Number of Entries	U8	ro			2		
	0x1	HW-Version Input	U8	ro	0	8	7		0= not used, 1=IO1, …, 8=IO8
	0x2	Ubat Monitor Input	U8	ro	0	8	8		0= not used, 1=IO1, …, 8=IO8
0x4000		Error Behavior - PARA	U8	rw	0	2	1		0: pre-operational 1: no state change 2: stopped
0x4001		Error Code	U16	ro			0		0: no error
0x5000	*	Auto NMT Start - PARA	U8	rw	0	1	0		0: not activated 1: activated (starts the PDO transmission automatically after power on – no CANopen standard)

Index	Subindex	Name	Type	Access	Min	Max	Default	Unit	Comment
0x5001		Bus-Off Counter Limit - PARA	U16	rw	0	10000	20		0: no limit >0: if Bus-Off counter exceeds this limit, the device will be set in off-line mode (no broadcast/no receive)
0x5999		LSS							Attention: Changing this parameter can disturb the network! Use this service only if one device is connected to the network!
	0x0	Number of Entries	U8	ro			3		
	0x1*	Baudrate - PARA	U16	rw	20	1000	250	Kbit/s	Possible values: 20, 50, 125, 250, 500, 800, 1000kbit/s.
	0x2*	Node-ID - PARA	U8	rw	1	127	0x11 (17)		
	0x3	Save all Parameters (incl. LSS)	U32	rw					"save" (0x65766173) to save all parameters (objects with marking PARA including LSS parameters).
0x599A		SNaFS - INTERNAL							For internal use only. Refer to additional documentation.
		Standardized Device Profile Area (0x6000...0x9FFF)							

Tab. 12: Object dictionary

17 Annex B: Joystick Axis Definition

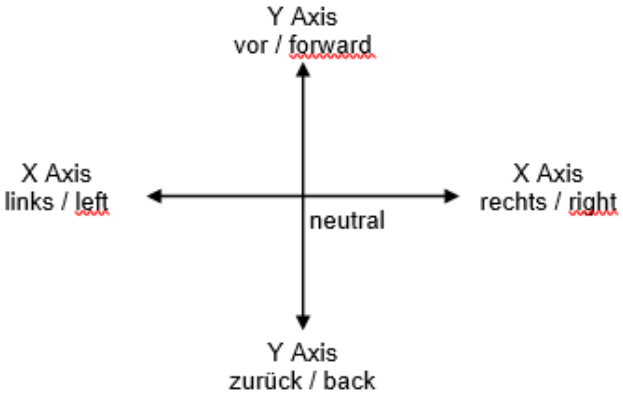

Fig. 6: Joystick Axis Definition