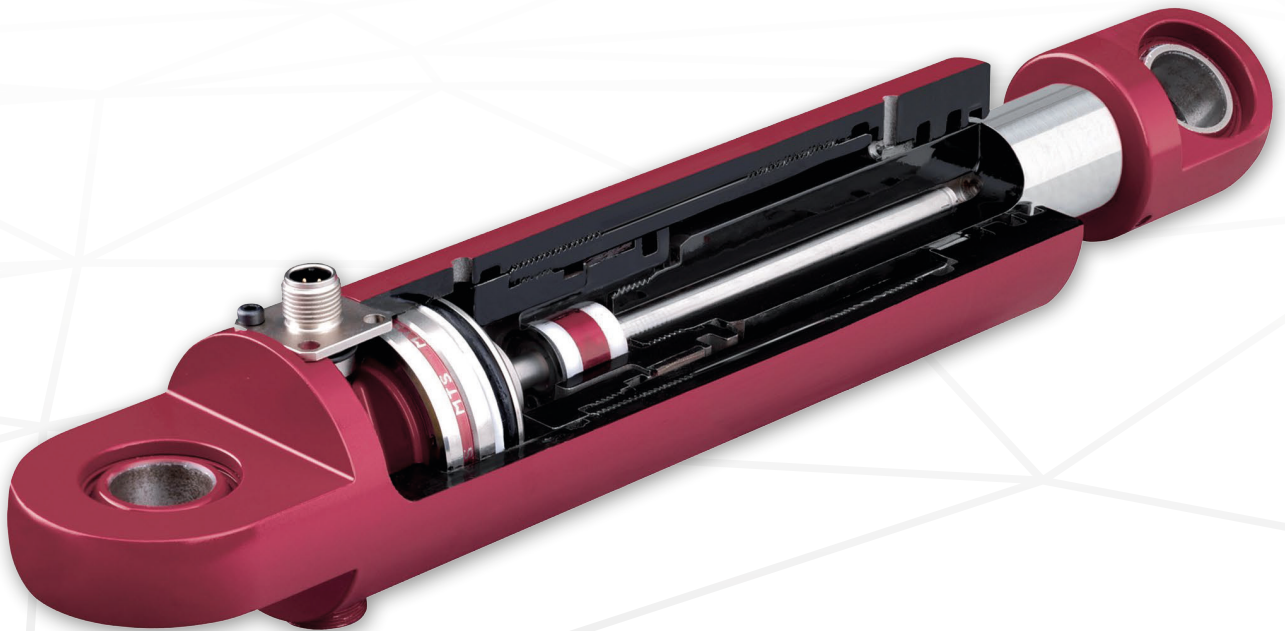


Protocol Manual

MH-Series CANopenSafety

Magnetostrictive Linear Position Sensors



1. History

Ver.	By	Date	Changes	Areas Affected	Comments
Revision A					
0.1	PL	20.07.10	First released		
0.2	PL	27.07.10	Document now only for CANopen Safety		
Revision B					
0.3	PL	11.02.11	Object dictionary changed	10.3	
0.4	PL	02.09.11	SRDO description Transmission type changed	10.3.2	
0.5	PL	10.11.11	Header changed		
Revision C					
1.0	PL	24.11.11	Changes for the working counter added. Manufacturer Area added. Revisions updated.	10.3 11.1.2	The layout of the SRDO message changed.
1.1	PL	21.03.13	Description for Safety configuration checksum changed.	10.3.2	
Revision D					
Rev D	PL	01.09.14	Product code and Revisions updated	10.1	
			Safety Configuration Checksum calculation updated	10.3	
			Literature changed	12	
Revision E					
Rev E	PL	30.10.2014	Add the Quick Start Guide as Chapter 7	all after 6	

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5. Abbreviations

Tx	-	MH CANopen sensor is the producer of the CAN data frame
Rx	-	MH CANopen sensor is the consumer of the CAN data frame
SDO	-	Service Data Object
PDO	-	Process Data Object
SRDO	-	Safety Relevant Data Object
CiA	-	CAN in Automation e.V.
ro	-	read only
rw	-	read/write
wo	-	write only

6. General Functionality

This document reflects the MTS Position Sensor protocol implementation of the standard CANopen Safety protocol. The Sensor supports the CANopen Communication profile DS301 V4.02, the Encoder profile DS406 V3.2, the LSS Service DS305 V2.1.1 and the DIN EN 50325-5 Industrial communications subsystem based on ISO 11898 (CAN).

7. Quick Start Guide

The following flowchart shows the standard start up sequence of a MH CANopen Safety Sensor

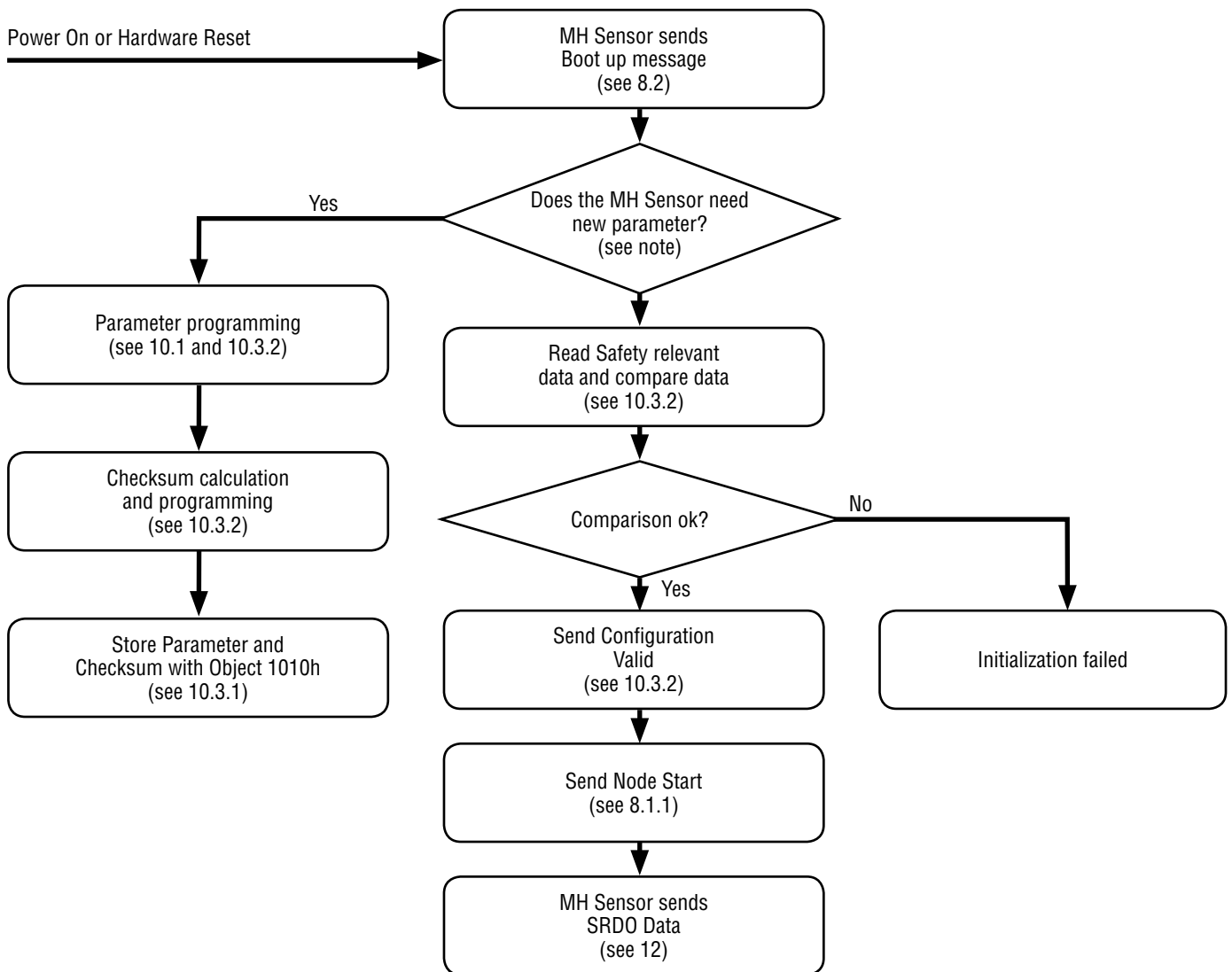


Figure 1 Flowchart of the standard start up sequence

Note:

The factory default value of the Safety configuration checksum, Object 13FFh is 0. This means the checksum has to be calculated and programmed at least one time even if the factory safety parameters did not change.

Example:

The example below shows the start-up sequence of a MH CANopen Safety Sensor without additional parameter and checksum programming.

The safety relevant mapping parameters (Object 1381) and the Transmission type should not be read and compared by the user because these parameters are fixed.

For the Safety relevant checksum these parameters are still needed.

Node ID of the example sensor is 0x40 and the Refresh time is 25 ms.

COB-ID	Rx/Tx	DLC	Data								Comment
			D0	D1	D2	D3	D4	D5	D6	D7	
0x740	Tx	1	0	-	-	-	-	-	-	-	Boot up message
Read Safety relevant parameter incl. Checksum											
0x640	Rx	8	0x40	0x01	0x13	0x01	0x00	0x00	0x00	0x00	Read information direction
0x5C0	Tx	8	0x42	0x01	0x13	0x01	0x01	0x00	0x00	0x00	Response to Information direction
0x640	Rx	8	0x40	0x01	0x13	0x02	0x00	0x00	0x00	0x00	Read Refresh Time
0x5C0	Tx	8	0x42	0x01	0x13	0x02	0x19	0x00	0x00	0x00	Response to Refresh Time
0x640	Rx	8	0x40	0x01	0x13	0x05	0x00	0x00	0x00	0x00	Read SRDO COB-ID1
0x5C0	Tx	8	0x42	0x01	0x13	0x05	0x7F	0x01	0x00	0x00	Response SRDO COB-ID1
0x640	Rx	8	0x40	0x01	0x13	0x06	0x00	0x00	0x00	0x00	Read SRDO COB-ID2
0x5C0	Tx	8	0x42	0x01	0x13	0x06	0x80	0x01	0x00	0x00	Response SRDO COB-ID 2
0x640	Rx	8	0x40	0xFF	0x13	0x01	0x00	0x00	0x00	0x00	Read Safety config. checksum
0x5C0	Tx	8	0x42	0xFF	0x13	0x01	0xCD	0xC8	0x00	0x00	Response to Safety Config. checksum
Compare Safety relevant parameter incl. Checksum											
0x640	Rx	8	0x23	0xFE	0x13	0x00	0xA5	0x00	0x00	0x00	Configuration valid
0x5C0	Tx	8	0x60	0xFE	0x13	0x00	0x00	0x00	0x00	0x00	Response to Configuration valid
0x0	Rx	8	0x01	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Start Remote Node for all Nodes
MH CANopen Safety Sensor starts transmission of SRDO Data in the Refresh time intervall											
0x17F	Tx	8	Pos	Pos	Pos	Pos	Vel	Vel	Stat	Cnt	SRDO Data
0x180	Tx	8	Pos	Pos	Pos	Pos	Vel	Vel	Stat	Cnt	SRDO Data inverted
0x17F	Tx	8	Pos	Pos	Pos	Pos	Vel	Vel	Stat	Cnt	SRDO Data
0x180	Tx	8	Pos	Pos	Pos	Pos	Vel	Vel	Stat	Cnt	SRDO Data inverted
...
...
0x17F	Tx	8	Pos	Pos	Pos	Pos	Vel	Vel	Stat	Cnt	SRDO Data
0x180	Tx	8	Pos	Pos	Pos	Pos	Vel	Vel	Stat	Cnt	SRDO Data inverted

Figure 2 Start-up sequence without programming

If a change of the Node ID or a SRDO safety parameter is required a new checksum must be calculated and programmed by the user. The next example shows the sequence the start-up sequence of a MH CANopen Safety Sensor with additional parameter and checksum programming.

Node ID of the example sensor is 0x01.
SRDO Refresh time programmed to 10 ms. (Object Index 0x1301, Subindex 2)
Checksum for this example is 0xC4AF.

COB-ID	Rx/Tx	DLC	Data								Comment
			D0	D1	D2	D3	D4	D5	D6	D7	
0x701	Tx	1	0	-	-	-	-	-	-	-	Boot up message
Program Refresh time and Safety Configuration checksum											
0x601	Rx	8	0x2B	0x01	0x13	0x02	0x0A	0x00	0x00	0x00	Prog Refresh time
0x581	Tx	8	0x60	0x01	0x13	0x02	0x00	0x00	0x00	0x00	Response to Refresh time programming
0x601	Rx	8	0x2B	0xFF	0x13	0x01	0xAF	0xC4	0x00	0x00	Prog Checksum
0x581	Tx	8	0x60	0xFF	0x13	0x01	0x00	0x00	0x00	0x00	Response to Checksum programming
0x601	Rx	8	0x23	0x10	0x10	0x01	0x73	0x61	0x76	0x65	Store parameter
0x581	Tx	8	0x60	0x10	0x10	0x01	0x00	0x00	0x00	0x00	Response to Store parameter
Read Safety relevant parameter incl. Checksum											
0x601	Rx	8	0x40	0x01	0x13	0x01	0x00	0x00	0x00	0x00	Read Information direction
0x581	Tx	8	0x42	0x01	0x13	0x01	0x01	0x00	0x00	0x00	Response to Informatin direction
0x601	Rx	8	0x40	0x01	0x13	0x02	0x00	0x00	0x00	0x00	Read Refresh Time
0x581	Tx	8	0x42	0x01	0x13	0x02	0x0A	0x00	0x00	0x00	Response to Refresh Time
0x601	Rx	8	0x40	0x01	0x13	0x05	0x00	0x00	0x00	0x00	Read SRDO COB-ID1
0x581	Tx	8	0x42	0x01	0x13	0x05	0x01	0x01	0x00	0x00	Response SRDO COB-ID1
0x601	Rx	8	0x40	0x01	0x13	0x05	0x00	0x00	0x00	0x00	Read SRDO COB-ID2
0x581	Tx	8	0x42	0x01	0x13	0x06	0x02	0x01	0x00	0x00	Response SRDO COB-ID2
0x601	Rx	8	0x40	0xFF	0x13	0x01	0x00	0x00	0x00	0x00	Read Safety config. checksum
0x581	Tx	8	0x42	0xFF	0x13	0x01	0xAF	0xC4	0x00	0x00	Response to Safety Config. checksum
Compare Safety relevant parameter incl. Checksum											
0x601	Rx	8	0x2F	0xFE	0x13	0x00	0xA5	0x00	0x00	0x00	Configuration valid
0x581	Tx	8	0x60	0xFE	0x13	0x00	0x00	0x00	0x00	0x00	Response to Configuration valid
0x0	Rx	8	0x01	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Start Remote Node For all Nodes
MH CANopen Safety Sensor starts transmission of SRDO Data in the Refresh time intervall											
0x101	Tx	8	Pos	Pos	Pos	Pos	Vel	Vel	Stat	Cnt	SRDO Data
0x102	Tx	8	Pos	Pos	Pos	Pos	Vel	Vel	Stat	Cnt	SRDO Data inverted
0x101	Tx	8	Pos	Pos	Pos	Pos	Vel	Vel	Stat	Cnt	SRDO Data
0x102	Tx	8	Pos	Pos	Pos	Pos	Vel	Vel	Stat	Cnt	SRDO Data inverted
...
...
0x101	Tx	8	Pos	Pos	Pos	Pos	Vel	Vel	Stat	Cnt	SRDO Data
0x102	Tx	8	Pos	Pos	Pos	Pos	Vel	Vel	Stat	Cnt	SRDO Data inverted

Figure 3 Start-up sequence with programming

8. Network Management

The MH CANopen sensor is used in a CANopen network with a slave functionality, So, normally a CANopen master has the control over the MH CANopen sensor in a CANopen network.

The following description is part of the CANopen communication profile DS301.

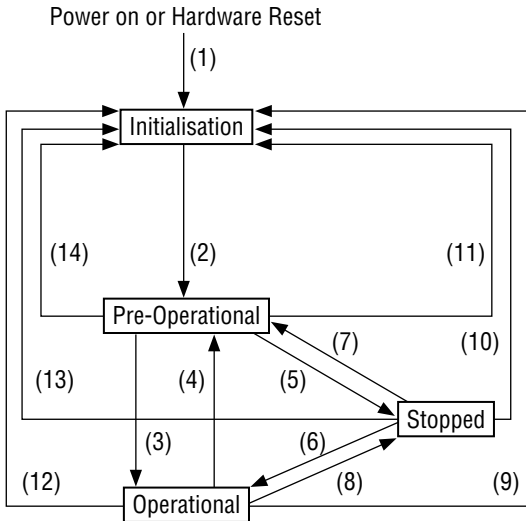


Figure 4 MNT State machine

(1)	At Power on the initialisation state is entered autonomously
(2)	Initialisation finished - enter PRE-OPERATIONAL automatically
(3),(6)	Start_Remote_Node indication
(4),(7)	Enter_PRE-OPERATIONAL_STATE
(5),(8)	Stop_Remote_Node indication
(9),(10),(11)	Reset_Node indication
(12),(13),(14)	Reset Communication indication

Table 1 Trigger for State Transition

8.1 Module Control Protocol

The following messages are not confirmed by the MH CANopen sensor.

8.1.1 Start_Remote_Node Indication (3),(6)

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

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x000	Rx	2	0x01	PAR	-	-	-	-	-	-

Figure 5 Start Node message

PAR - 0 All devices
PAR - Node ID This device

8.1.2 Enter_PRE-OPERATIONAL_STATE Indication (4),(7)

Through this service the NMT Master sets the state of the selected NMT slave(s) to “PREOPERATIONAL”.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x000	Rx	2	0x80	PAR	–	–	–	–	–	–

Figure 6 Enter Pre-Operational message

PAR - 0 All devices

PAR - Node ID This device

8.1.3 Stop_Remote Indication (5),(8)

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

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x000	Rx	2	0x02	PAR	–	–	–	–	–	–

Figure 7 Stop Node message

PAR - 0 All devices

PAR - Node ID This device

8.1.4 Reset_Node Indication (9),(10),(11)

Through this service the NMT Master sets the state of the selected NMT Slave(s) from any state to the “reset application” sub-state.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x000	Rx	2	0x81	PAR	-	-	-	-	-	-

Figure 8 Reset Node message

PAR - 0 All devices
PAR - Node ID This device

8.1.5 Reset_Communication Indication (12),(13),(14)

Through this service the NMT Master sets the state of the selected NMT Slave(s) from any state to the “reset communication” sub-state. After completion of the service, the state of the selected remote nodes will be RESET COMMUNICATION.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x000	Rx	2	0x82	PAR	-	-	-	-	-	-

Figure 9 Reset Communication message

PAR - 0 All devices
PAR - Node ID This device

8.2 Network Initialisation

When powering the sensor or after a NMT Reset command (8.1.4 and 8.1.5) or after an internal Reset the sensor enters automatically the NMT Initialisation state. In this state the MH CANopen sensor loads all parameter from the non-volatile memory into the RAM of the internal microcontroller. Also the microcontroller performs several test function and configuration tasks. In this state is no communication with the MH CANopen sensor possible. After finishing the NMT Initialisation state the MH CANopen sensor enters automatically the NMT Pre-Operational state. During that state transition the MH CANopen sensor sends automatically its Boot-up protocol message.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x700 + Node-ID	Tx	2	0x00	-	-	-	-	-	-	-

Figure 10 Boot-up protocol message

Note:

The COB-ID of the Boot-up protocol is the same as for the heartbeat message.
This COB-ID can be individually programmed with Index 100E. (see 11.2)
So the COB-ID of the Boot-up message can be different.

8.3 Network Pre-Operational State

In the PRE-OPERATIONAL state, the communication via Service Data Objects (see 11.2 SDO Objects) with the MH CANopen Sensor is possible. Process Data Objects (see 12.1 PDOs) do not exist, so PDO communication is not allowed. Configuration of PDOs, and device parameters may be performed by a configuration application. Also the Emergency Objects and Error Control Service like the MH CANopen Sensors 'Heartbeat message' are allowed in this state. The node may be switched into the Operational state directly by sending a Start_Remote_Node (3) (8.1.1)

8.4 Network Operational State

In the OPERATIONAL state all communication objects are active. Transitioning to OPERATIONAL creates all PDOs and (see 12.1). The constructor uses the parameters as described in the Object Dictionary. Object Dictionary Access via SDO is possible.

8.5 Network Stopped State

By switching a device into the Stopped state it is forced to stop the communication altogether (except node guarding and heartbeat, if active). Furthermore, this state can be used to achieve certain application behaviour. The definition of this behaviour falls into the scope of device profiles.

9. Emergency Object / Mal Function

Emergency objects are triggered by the occurrence of a MH CANopen Sensor internal error situation. An emergency object is transmitted only once per 'error event'.

If one or all errors are repaired, the device transmits an emergency object with the error code 'reset error / no error'. This message contains also Error register with the remaining Errors. For the MH CANopen Sensor are two Error conditions defined. This is the 'Device Hardware Error' and the 'Data Set Error'.

The 'Data Set Error' is send by the MH CANopen Sensor when internal test function detects a mismatch between the new calculated and the stored checksum of the non-volatile memory of the sensor. The checksum is checked during the NMT Initialisation state. The checksum is also checked when the LSS Store Configuration Data command 11.1.4) or a valid SDO download to Object 1010h – Store parameters is received. This Error can only be cleared by a reset of the device and a successful checksum comparison in the new initialisation state.

The 'Device Hardware Error' is send when the Microcontroller detects more or less Stop pulses during one measuring cycle and when the Error Counter runs out.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x80 + Node-ID	Tx	8	Emergency Error Code	Error Register Object 1001h	0x00	0x00	0x00	0x00	0x00	0x00

Figure 11 Emergency Object message

The possible Error Codes are:

Error Code (hex)	Meaning
0x0000	Error Reset or No Error
0x5000	Device Hardware
0x6300	Data Set

Table 2 Error Code

The Error Register can contain the following data:

Error Code (hex)	Meaning
0x00	No Error
0x01	Data Set Error
0x81	Device Hardware Error or Device Hardware Error and Data Set Error

Table 3 Error Register

Note:

The COB-ID of the Emergency Object message can be individually programmed with Index 1014. (see 11.2) So the COB-ID of the Emergency message can be different.

10. Error Control Service

Through Error control services the NMT detects failures in a CAN-based Network. When the Error Control service is enabled the MH CANopen Sensor transmits a Heartbeat message cyclically. One or more Heartbeat Consumer receives the indication. The relationship between producer and consumer is configurable via the object dictionary by SDO. By default the Heartbeat is disabled. The first byte of the Heartbeat message contains the actual Network Management State of the MH CANopen Sensor.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x700 + Node-ID	Tx	1	STATE	-	-	-	-	-	-	-

Figure 12 Heartbeat Protocol message

STATE	Meaning
0x00	Bootup
0x04	Stopped
0x05	Operational
0x7F	Pre-Operational

Table 4 Heartbeat Protocol Data

Note:

This COB-ID can be individually programmed with Index 100E. (see 11.2)
So the COB-ID of the Heartbeat Protocol message can be different.

11. Configuration

The complete configuration of the MH CANopen Sensor is done through the CAN Bus interface.

11.1 LSS Protocol for CANopen

Every CANopen Device must have a unique Node-Identifier in the actual CANopen network. The Node Id and the Baud rate can be programmed by using the LSS Protocol DS305 published by the CiA. To program the Node ID and/or the Baud rate the MH CANopen Sensor has change to the LSS Configuration State. There are two ways to switch the MH CANopen Sensor to the LSS Configuration State.

- **LSS Switch Mode Selective**

In this case only the addressed device is switched to the LSS Configuration State. The configuration tool uses the unique LSS Address. The MH CANopen LSS Address has the following structure:

LSS Address	Meaning
Vendor-ID	0x40
Product Code	0x53787800
Revision Number	0x322E3030
Serial Number	Actual MH CANopen Sensors Serial Number

Table 5 LSS Address

With the following sequence you can switch the MH CANopen sensor to the LSS Configuration State

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x7E5	Rx	8	0x40	0x40	0x00	0x00	0x00	0x00	0x00	0x00
0x7E5	Rx	8	0x41	0x00	0x78	0x78	0x43	0x00	0x00	0x00
0x7E5	Rx	8	0x42	0x31	0x30	0x2E	0x31	0x00	0x00	0x00
0x7E5	Rx	8	0x43	0x34	0x12	0x50	0x09	0x00	0x00	0x00
0x7E5	Tx	8	0x44	0x00	0x00	0x00	0x00	0x00	0x00	0x00

Figure 13 LSS Switch Mode Selective sequence

■ - Serial Number in this example: 0x09501234

- **LSS Switch Mode Global**

In this case all CANopen devices supporting the LSS Service are switched to the LSS Configuration State.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x7E5	Rx	8	0x04	0x01	0x00	0x00	0x00	0x00	–	–

Figure 14 LSS Switch Mode Global

When the CANopen devices are in Configuration State the Node ID and/or the Baud rate can be changed.

11.1.1 Node ID

With the following command the Node ID can be programmed.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x7E5	Rx	8	0x11	N ID	0x00	0x00	0x00	0x00	0x00	0x00
0x7E4	Tx	8	0x11	Err Code	0x00	0x00	0x00	0x00	0x00	0x00

Figure 15 Configure Node ID protocol

N ID The new Node ID in the range of 1 to 127
Err Code 0 - protocol successfully completed
 1 - Node ID out of range

Note:

The new Node ID gets immediately active after a successful Response message of the MH CANopen sensor. The following COB-IDs are automatically updated according to the Pre-defined Connection Set of the #2 DS301. SDO(Tx); SDO(Rx); Emergency; Error control; PDO1(Tx)

11.1.2 Baud Rate

With the following command the Baud rate can be programmed.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x7E5	Rx	8	0x13	0x00	Table Index	0x00	0x00	0x00	0x00	0x00
0x7E4	Tx	8	0x13	Err Code	0x00	0x00	0x00	0x00	0x00	0x00

Figure 16 Configure Bit-timing parameters protocol

Table index	Bit rate
0	1000 kbit/s
1	800 kbits
2	500 kbit/s
3	250 kbit/s
4	125 kbit/s
5	Reserved
6	50 kbit/s
7	20 kbit/s
8	10 kbit/s

Table 6 Baud rate indices

Err Code: 0 - protocol successfully completed
 1 - bit timing not supported

Note:

The Baud rate gets active after receiving the 'Activate Bit timing parameters' command or after the 'Store Configuration Data' command with the next Power on Reset.

11.1.3 Activate Bit Timing Parameter

With the following command the LSS master shall activate the bit timing defined by the configure bit timing parameters service.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x7E5	Rx	8	0x15	Switch delay	0x00	0x00	0x00	0x00	0x00	0x00

Figure 17 Activate Bit timing protocol

Switch delay: Time in ms internal multiplied by 2 when the new Bit timing parameters become active.

Note:

No communication should be performed until the (2*Switch delay) time runs out.

11.1.4 Store Configuration Data

With the following command the LSS Configuration Data (Node ID and Baud rate) is stored to the nonvolatile memory of the MH CANopen sensor.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x7E5	Rx	8	0x17	0x00	0x00	0x00	0x00	0x00	0x00	0x00
0x7E4	Tx	8	0x17	Err Code	0x00	0x00	0x00	0x00	0x00	0x00

Figure 18 Store LSS Configuration protocol

Err Code: 0 - Protocol successfully completed
2 - Storage media access error

11.1.5 Inquiry and Identification Services

The MH CANopen sensor supports also the inquiry and identification services described in the LSS protocol. (See #1 DS 305 for details).

11.2 SDO Services

With Service Data Objects (SDO) the access to entries of a device Object Dictionary is provided.

11.2.1 SDO Download

The SDO Download service is used to configure the communication, device and manufacturer specific parameters of the MH CANopen sensor.

COB-ID	Rx/Tx	DLC	Data						
			D0	D1	D2	D3	D4	D5	D6
0x600 + Node ID	Rx	8	0x2x	Index	Subindex	Data LSB	Data	Data	Data MSB
0x580 + Node ID	Tx	8	0x60	Index	Subindex	0x00	0x00	0x00	0x00

Figure 19 SDO Download protocol

D0 0x2x: x depends upon the data size of the transferred data (see #2 DS301)
 Index: Object dictionary parameter index
 Subindex: Object dictionary parameter subindex

11.2.2 SDO Upload

The SDO Upload service is used to read the communication, device and manufacturer specific parameters of the MH CANopen sensor.

COB-ID	Rx/Tx	DLC	Data						
			D0	D1	D2	D3	D4	D5	D6
0x600 + Node ID	Rx	8	0x40	Index	Subindex	0x00	0x00	0x00	0x00
0x580 + Node ID	Tx	8	0x42	Index	Subindex	Data LSB	Data	Data	Data MSB

Figure 20 SDO Upload protocol

Index: Object dictionary parameter index
 Subindex: Object dictionary parameter subindex

11.2.3 SDO Abort

If the SDO Download or SDO Upload service fails for any reason the MH CANopen sensor responds not with the corresponding SDO message. The MH CANopen sensor responds with a SDO Abort protocol.

COB-ID	Rx/Tx	DLC	Data						
			D0	D1	D2	D3	D4	D5	D6
0x580 + Node ID	Tx	8	0x80	Index	Subindex	Abort code			

Figure 21 SDO Abort protocol

Abort Code	Meaning
0x06090011	Subindex does not exist
0x06090030	Value exceeded
0x06020000	Object does not exist
0x06010001	Object is write only
0x06010002	Object is read only
0x08000020	Data transport error
0x08000000	General error
0x08000022	Wrong state

Table 7 SDO abort codes

11.3 Object Dictionary

The following table shows all parameters implemented in the MH CANopen sensor.

Communication Profile Area

Index	Subindex	Name	Typ	Attribute	Default value	Comment
1000	0	device type	unsigned32	ro	x196 x0A	device profile 406 multi-sensor encoder interface
1001	0	error register	unsigned8	ro	0	0x00: No error 0x81: transducer error
1002	0	manufacturer status register	unsigned8	ro	1	Additional status register
1005	0	COB-ID SYNC-message	unsigned32	rw	80h	COB-ID SYNC-message
1008	0	manufacturer device name	visible string	const	Sxx	device name
1009	0	manufacturer hardware version	visible string	const	1.00	hardware version release
100A	0	manufacturer software version	visible string	const	1.00	software version release
100B	0	Node-ID	unsigned32	ro	127	Node-ID can be changed via LSS protocol
100E	0	COB-ID Error Control	unsigned32	rw	700h + Node ID	error control identifier (should not be changed)
1010	0	store parameters	unsigned8	ro	1	number of largest sub-index writing the signature 'save' will store all parameters into EEPROM (73, 61, 76, 65)
	1		unsigned32	rw	1	
1011	0	restore default parameters	unsigned8	ro	1	number of largest sub-index writing the signature 'load' will load all parameters with default values (6C, 6F, 61, 64)
	1		unsigned32	rw	1	
1014	0	COB-ID emergency	unsigned32	rw	80h + Node ID	COB-ID emergency message
1017	0	producer heartbeat time	unsigned16	rw	0	time period in ms
1018	0	identity object	unsigned8	ro	4	number of entries
	1		unsigned32	ro	0x40	Vendor-ID
	2		unsigned32	ro	0x53787800	product code (ASCII Sxx)
	3		unsigned32	ro	xxxx	revision number
	4		unsigned32	ro	xxxx	serial number
1200	0	1 st server SDO parameter	unsigned8	ro	2	number of largest sub-index
	1		unsigned32	ro	600h + Node ID	COB-ID client > server (Rx)
	2		unsigned32	ro	580h + Node ID	COB-ID server > client (Tx)

Index	Subindex	Name	Typ	Attribute	Default value	Comment
1301	0	SRDO	Unsigned8	ro	6	Highest Subindex supported
	1	Communication parameter		rw	1	Information direction
	2		Unsigned16	rw	25	Refresh time
	3		Unsigned16	rw	20	Not used
	4			ro	254	Transmission type
	5		Unsigned32	rw	0x0FF+2*NodeID	SRDO COB-ID 1
	6		Unsigned32	rw	0x100+2*NodeID	SRDO COB-ID 2
1381	0	SRDO	Unsigned8	ro	8	Highest Subindex supported
	1	Mapping parameter	Unsigned32	ro	60200120	1 st mapping parameter
	2		Unsigned32	ro	60200120	2 nd mapping parameter
	3		Unsigned32	ro	60300110	3 rd mapping parameter
	4		Unsigned32	ro	60300110	4 th mapping parameter
	5		Unsigned32	ro	30000008	5 th mapping parameter
	6		Unsigned32	ro	30000008	6 th mapping parameter
	7		Unsigned32	ro	30010008	7 th mapping parameter
	8		Unsigned32	ro	30010008	8 th mapping parameter
13FE	0	Configuration valid	Unsigned8	rw	0	0xA5: Valid All other values: Not valid
13FF	0	Safety configuration checksum	Unsigned8	rw	1	Highest Subindex supported
	1		Unsigned16	rw	0	Checksum

Device Profile Area - DS406

Index	Subindex	Name	Typ	Attribute	Default value	Comment
6000	0	operating parameter	unsigned16	rw	0	operating parameters
6005	0	linear encoder	unsigned8	ro	2	number of objects
	1	measuring step	unsigned32	ro	100000	position measuring step in 0.001 μm
	2	settings	unsigned32	ro	100	speed measuring step in 0.01 μm
6010	0	present value	unsigned8	rw	1	number of available channels
	1		integer32	rw	xxxx	present value channel 1
6020	0	position value	unsigned8	ro	1	number of available channels
	1		integer16	ro	no	position value channel 1
6030	0	speed value	unsigned8	ro	1	number of available channels
	1		integer16	ro	no	speed value channel 1
6200	0	cyclic timer	unsigned16	rw	1	cyclic timer value in ms if value > 0
6500	0	operating status	unsigned16	ro	no	operating status
6501	0	measuring step	unsigned32	ro	100000	position measuring step in 0.001 μm

Manufacturer Area

Index	Subindex	Name	Typ	Attribute	Default value	Comment
3000*	0*	Manufacturer Status register	Unsigned8	ro	1	This object contains additional error information (same as Index 1002h)
3001*	0*	Working counter	Unsigned8	ro	–	The working counter is incremented at each SRDO data transmission in the Operational state.

* This object is mapped to the SRDO.

11.3.1 SDO Objects

Object 1000_h - Device Type

Index	Sub	Name	Data type	Access	Range/Value	Default
1000 _h	0	Device type	unsigned32	ro	0x000A0196	0x000A0196

Object 1001_h - Error Register

Index	Sub	Name	Data type	Access	Range/Value	Default
1001 _h	0	Error register	unsigned8	ro	0	0

For details see 9. emergency object / mal function

Object 1002_h - Manufacture Status Register

Index	Sub	Name	Data type	Access	Range/Value	Default
1002 _h	0	Manufacture Status Register	unsigned32	ro		1

The content of this register is the same as the index 3000 in the manufacturer area.
The definition of the Manufacturer Status Register is as follows:

D31-D8	D7	D6	D5	D4	D3	D2	D1	D0
0	V	T	E3	E2	E1	E0	S	N

Figure 22 Manufacturer status register definition

N:	Status	0 = sensor in error state 1 = normal running state valid position and velocity data transmitted
S:	Start up	0 = normal running state 1 = start up or internal test mode
E0:	Magnet Error	0 = one magnet detected 1 = no or more than one magnet detected
E1:	Range Error	0 = no error 1 = the calculated position is out of range when also the position and velocity value is set to zero 1 = the velocity value maybe not correct
E2:	Data flash error	0 = no error 1 = the CRC check of data flash parameter memory failed
E3:	Controller error	0 = no error 1 = the internal test routines detects an error
T:	Temperature μ C	0 = T < max temperature 1 = T > max temperature
V:	SRDO Valid	0 = no Error 1 = The SRDO checksum comparion failed

Object 1008_h - Manufacturer Device Name

Index	Sub	Name	Data type	Access	Range/Value	Default
1008 _h	0	Manufacturer Device Name	Visible String	const		Sxx

Object 1009_h - Manufacturer Hardware Version

Index	Sub	Name	Data type	Access	Range/Value	Default
1009 _h	0	Manufacturer Hardware Version	visible string	const		1.00

Object 100A_n - Manufacturer Software Version

Index	Sub	Name	Data type	Access	Range/Value	Default
100A _n	0	Manufacturer Software Version	visible string	const		2.00

Object 100B_n - Node ID

Index	Sub	Name	Data type	Access	Range/Value	Default
100B _n	0	Node ID	unsigned32	rw	1...127	127

Object 100E_n - COB-ID Error Control

Index	Sub	Name	Data type	Access	Range/Value	Default
100E _n	0	COB-ID error control	unsigned32	rw	0...0x7FF	0x700 + Node ID

This object defines the COB-ID of the heartbeat and boot-up message (see 10 error control service).

Object 1010_n - Store parameters

Index	Sub	Name	Data type	Access	Range/Value	Default
1010 _n	0	Store parameters	unsigned8	ro	1	1
	1	All parameters	unsigned32	rw	0x73617665	0x73617665

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x600 + Node ID	Rx	8	0x23	0x10	0x10	0x01	0x73	0x61	0x76	0x65
0x580 + Node ID	Tx	8	0x60	0x10	0x10	0x01	0x00	0x00	0x00	0x00

Figure 23 Store all parameters command

A valid SDO download to this objects stores all changeable parameters of the communication and device profile to the non-volatile memory of the MH CANopen sensor.

Object 1011_n - Restore default parameters

Index	Sub	Name	Data type	Access	Range/Value	Default
1011 _n	0	Restore default parameters	unsigned8	ro	1	1
	1	All parameters	unsigned32	rw	0x6C6F6164	0x6C6F6164

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x600 + Node ID	Rx	8	0x23	0x11	0x10	0x01	0x6C	0x6F	0x61	0x64
0x580 + Node ID	Tx	8	0x60	0x11	0x10	0x01	0x00	0x00	0x00	0x00

Figure 24 Restore default parameters command

A valid SDO Download to this Object restores all changeable parameters of the Communication and Device profile in the non-volatile memory of the MH CANopen Sensor. The new restored values become active after any Reset of the MH CANopen Sensor. The restore values are defined in the # 2 DS301 and # 4 DS406.

Object 1014_h - COB-ID emergency

Index	Sub	Name	Data type	Access	Range/Value	Default
1014 _h	0	COB-ID emergency	unsigned32	rw	0...0x7FF	0x80 + Node ID

This object defines the COB-ID of the emergency message (see 9 emergency object / mal function).

Object 1017_h - Producer heartbeat time

Index	Sub	Name	Data type	Access	Range/Value	Default
1017 _h	0	Producer heartbeat time	unsigned16	rw	0...65535	0

With this object you can set the producer heartbeat time of the error control function of the MH CANopen sensor. The value is given in ms. Value 0 disables the heartbeat function. (see 10 Error Control Service)

Object 1018_h - Identity object

Index	Sub	Nadme	Data type	Access	Range/Value	Default
1018 _h	0	Number of entires	unsigned8	ro	4	4
	1	Vendor-ID	unsigned32	rw	0x40	0x40
	2	Product code	unsigned32	rw	0x53787800	0x53787800
	3	Revision number	unsigned32	rw	0x322E3030	0x322E3030
	4	Serial number	unsigned32	rw		

The identity object contains general information about the MH CANopen sensor. This information are also used as the LSS address when using the 'Switch mode selective' command.

Object 1200_h - 1st Server SDO parameter

Index	Sub	Name	Data type	Access	Range/Value	Default
1200 _h	0	Number of entires	unsigned8	ro	2	2
	1	COB-ID client -> server (Rx)	unsigned32	ro		0x600 + Node ID
	2	COB-ID server -> client (Tx)	unsigned32	ro		0x580 + Node ID

Object 6000_h - Operating parameter

Index	Sub	Name	Data type	Access	Range/Value	Default
6000 _h	0	Operating parameter	unsigned16	rw		0

This object is not supported by the MH CANopen sensor.

Object 6005_h - Measuring steps

Index	Sub	Name	Data type	Access	Range/Value	Default
6500 _h	0	Largest Subindex	unsigned8	ro	2	2
	1	Position measuring steps	unsigned32	ro		100000
	2	Speed measuring steps	unsigned16	ro		100

The Position measuring steps are given in 0.001 µm. The default resolution of the MH CANopen Sensor is 100 µm. The Speed measuring steps are given in 0.01 mm/s. This Object is for user information.

Object 6010_n - Present value

Index	Sub	Name	Data type	Access	Range/Value	Default
6010 _n	0	Number of available channels	unsigned8	rw	1	1
	1	Present value channel 1	integer32	rw		

With the Preset function you can change the position output value of the actual magnet position to the downloaded preset value. The preset value can be read until the next reset. The preset value is not stored in the non-volatile memory. Only the calculated offset is stored in the non-volatile memory.

Object 6020_n - Position value

Index	Sub	Name	Data type	Access	Range/Value	Default
6020 _n	0	Number of available channels	unsigned8	ro	1	1
	1	Position value channel 1	integer32	ro		

This object contains the position value of the MH CANopen sensor and is mapped in the PDO.

Object 6030_n - Speed value

Index	Sub	Name	Data type	Access	Range/Value	Default
6030 _n	0	Number of available channels	unsigned8	ro	1	1
	1	Speed value channel 1	integer16	ro		

This object contains the speed value of the MH CANopen sensor and is mapped in the PDO.

Object 6500_n - Operating status

Index	Sub	Name	Data type	Access	Range/Value	Default
6500 _n	0	Operating status	unsigned16	ro		0

This object is not supported by the MH CANopen sensor.

Object 6501_n - Measuring step

Index	Sub	Name	Data type	Access	Range/Value	Default
6501 _n	0	Measuring step	unsigned32	ro		100000

This object has the same functionality as object 6005_n subindex 1.

The measuring step is given in 0.001 µm. The default resolution of the MH CANopen sensor is 100 µm.

Object 3000_h - Manufacturer Status Register

Index	Sub	Name	Data type	Access	Range/Value	Default
3000 _h	0	Manufacture Status Register	unsigned8	ro		1

The content of this register is the same as the index 1002 in the communication profile. This object is the status value of the MH CANopen Sensor and is mapped in the SRDO. The definition of the Manufacturer Status Register is as follows:

D31-D8	D7	D6	D5	D4	D3	D2	D1	D0
0	V	T	E3	E2	E1	E0	S	N

- N: Status
 0 = sensor in error state
 1 = normal running state
 valid position and velocity data transmitted
- S: Start up
 0 = normal running state
 1 = start up or internal test mode
- E0: Magnet Error
 0 = one magnet detected
 1 = no or more than one magnet detected
- E1: Range Error
 0 = no error
 1 = the calculated position is out of range when also the position and velocity value is set to zero
 1 = the velocity value maybe not correct
- E2: Data flash error
 0 = no error
 1 = the CRC check of data flash parameter memory failed
- E3: Controller error
 0 = no error
 1 = the internal test routines detects an error
- T: Temperature μ C
 0 = T < max temperature
 1 = T > max temperature
- V: SRDO Valid
 0 = no Error
 1 = The SRDO checksum comparion failed

Object 3001_h - Working counter

Index	Sub	Name	Data type	Access	Range/Value	Default
3001 _h	0	Working counter	Unsigned8	ro		-

This object is a counter for the SRDO transmission. The counter is incremented at every SRDO transmission.

11.3.2 SRDO Objects

Object 1301_n - SRDO Communication parameter

Index	Sub	Name	Data type	Access	Range/Value	Default
1301 _n	0	Largest Subindex	unsigned8	ro	6	6
	1	Information direction	unsigned8	rw	0...2	1
	2	Refresh time	unsigned16	rw	0...65535	25
	3	Safety-relevant object Validation time Not used (if info-dir is tx)	unsigned16	rw	0...65535	20
	4	Transmission type	unsigned8	ro	254	254
	5	COB-ID 1	unsigned32	rw		FFh+(2*Node ID)
	6	COB-ID 2	unsigned32	rw		100h+(2*Node ID)

Note:

These parameters can only be changed in the NMT Pre-Operational state.

Information Direction	Meaning
0	Does not exist / not valid
1	Exists / is valid for transmit (tx)
2	Exists / is valid for receive (rx)
3 to 255	reserved

Table 8 SRDO Information Direction

Note:

To use the SRDO transmission the Information Direction must be programmed to 1.

The Refresh time at Subindex 2 is the value for the SRDO message transmission rate in ms.

Event Timer	Meaning
0	SRDO Transmission disabled
1 - 65535	SRDO Transmission in [ms]

Table 9 Refresh Time

At Subindex 3 the Safety-relevant data object is not used for the MH CANopen Sensor. The default value of 20 is fixed but the parameter is used for the Safety configuration checksum.

Also the Subindex 4, parameter transmission type is fixed to 254.

The Subindex 5 contains the COB-ID for the non-inverted SRDO message and Subindex 6 contains the COB-ID for the inverted SRDO message.

Object 1381_h - SRDO mapping

Index	Sub	Name	Data type	Access	Range/Value	Default
1381 _h	0	Largest Subindex	unsigned8	ro	8	8
	1	1 st mapping parameter	unsigned32	ro	60200120h	60200120h
	2	2 nd mapping parameter	unsigned32	ro	60200120h	60200120h
	3	3 rd mapping parameter	unsigned32	ro	60300110h	60300110h
	4	4 th mapping parameter	unsigned32	ro	60300110h	60300110h
	5	5 th mapping parameter	unsigned32	ro	30000008h	30000008h
	6	6 th mapping parameter	unsigned32	ro	30000008h	30000008h
	7	7 th mapping parameter	unsigned32	ro	30010008h	30010008h
	8	8 th mapping parameter	unsigned32	ro	30010008h	30010008h

Object 13FE_h - Configuration valid

Index	Sub	Name	Data type	Access	Range/Value	Default
13FE _h	0	Configuration valid	Unsigned8	rw		0

Configuration valid	Meaning
A5h	Configuration is valid
All other values	Configuration is invalid

Table 10 SRDO Configuration valid

This object shall contain an acknowledgement flag for a valid configuration. After write access to any of the safety-relevant parameter, this object shall be automatically set to invalid configuration (00h). If the configuration is finished, the user writes the "valid" value to this object.

Object 13FF_h - Safety configuration checksum

Index	Sub	Name	Data type	Access	Range/Value	Default
13FF _h	0	Largest Subindex	unsigned8	rw	1	1
	1	Checksum-1	unsigned16	rw		0

The generator polynomial shall be: $G(x) = X_{16} + X_{12} + X_5 + 1$

The order for data, which are checked by the CRC, shall be as follows:

SRDO communication parameter

a) Information direction 1 byte = $a_7 \dots a_0$

b) Refresh time or SCT 2 byte = $b_{15} \dots b_0$

c) SRVT 1 byte = $c_7 \dots c_0$

d) COB-ID 1 4 byte = $d_{31} \dots d_0$

e) COB-ID 2 4 byte = $e_{31} \dots e_0$

SRDO mapping parameter

f) Sub-index 00_h 1 byte (Number of mapped application objects in SRDO) = $f_7 \dots f_0$

g₁) Sub-index 1 byte (SRDO mapping for the nth application object to be mapped) = $g_7^1 \dots g_0^1$

h₁) Mapping data 4 byte (2 byte index, 1 byte sub-index, 1 byte data length) = $h_{131}^1 \dots h_0^1$

to

g₈) Sub-index 1 byte (SRDO mapping for the 8th application object to be mapped) = $g_7^8 \dots g_0^8$

h₈) Mapping data 4 byte (2 byte index, 1 byte Sub-index, 1 byte data length) = $h_{31}^8 \dots h_0^8$

$D(x) = X_n + \dots + X_0$

$D(x) = a_7 + \dots + a_0 + b_{15} + \dots + b_0 + c_7 + \dots + c_0 + d_7 + \dots + d_0 + d_{15} + \dots + d_8 + d_{23} + \dots + d_{16} + d_{31} + \dots + d_{24} + \dots$ etc.

The CRC shall start with the value 0000_h.

Note:

This Checksum must be written by the user. The checksum is compared by the MH CANopen Sensor when entering the NMT Operational state. If the comparison fails the MH CANopen Sensor still transmits the SRDO messages, but the SRDO VALID bit is set in the Manufacturer Status Register (Index 1002h and Index 3000h).

12. Process data

Transmission the data with SRDOs

12.1 Asynchronous Mode

This is the only transmission mode for the SRDO.

The SRDO is transmitted by the MH CANopen Sensor after the Refresh time (Index 1301,2) is expired. The value of the timer is given in ms.

12.2 SRDO Message Format

An SRDO shall consist of two CAN data frames with identifiers, which shall be different in at least two bit positions. The user data in both transmissions is redundant, i.e. the meaning of the data is the same, but the data on the 2nd transmission is inverted bitwise. SRDOs are transmitted periodically defined by the Refresh time at Index 1301 Subindex 2. SRDOs shall be only allowed in the NMT state operational. The redundant transmission is sent after the first transmission to the CAN controller with minimum delay.

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x0FF+2*Node ID	Tx	8	Pos LSB	Pos	Pos	Pos MSB	Speed LSB	Speed MSB	Status	Working Counter

Figure 25 SRDO format 1st message - non-inverted

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
0x100+2*Node ID	Tx	8	Pos LSB	Pos	Pos	Pos MSB	Speed LSB	Speed MSB	Status	Working Counter

Figure 26 SRDO format 2nd message - bit wise inverted

For SRDOs the actual measuring steps for the position (Pos) and Speed values can be read with Object linear encoder measuring step settings (Index 6005). The Status is defined at Index 3000. The working counter is defined at Index 3001.

Note:

The COB-ID of the SRDO messages can be individually programmed with Index 1301,5/6. (see 11.3.2)
So the COB-ID of the SRDO messages can be different.

13. Literature

- # 1 CiA DS305 CANopen Layer Setting Service (LSS) V2.1.1
- # 2 CiA DS301 CANopen Application Layer and Communication Profile V4.02
- # 3 DIN EN 50325-5 Industrial communications subsystem based on ISO 11898 (CAN)
- # 4 CiA DS406 CANopen Device profile for encoders V3.1



Temposonics

AN AMPHENOL COMPANY

UNITED STATES
Temposonics, LLC
Americas & APAC Region
3001 Sheldon Drive
Cary, N.C. 27513
Phone: +1 919 677-0100
E-mail: info.us@temposonics.com

GERMANY
Temposonics
GmbH & Co. KG
EMEA Region & India
Auf dem Schüffel 9
58513 Lüdenscheid
Phone: +49 2351 9587-0
E-mail: info.de@temposonics.com

ITALY
Branch Office
Phone: +39 030 988 3819
E-mail: info.it@temposonics.com

FRANCE
Branch Office
Phone: +33 6 14 060 728
E-mail: info.fr@temposonics.com

UK
Branch Office
Phone: +44 79 44 15 03 00
E-mail: info.uk@temposonics.com

SCANDINAVIA
Branch Office
Phone: + 46 70 29 91 281
E-mail: info.sca@temposonics.com

CHINA
Branch Office
Phone: +86 21 2415 1000 / 2415 1001
E-mail: info.cn@temposonics.com

JAPAN
Branch Office
Phone: +81 3 6416 1063
E-mail: info.jp@temposonics.com

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