LUST

ServoOne

User Manual

CANopen

EtherCAT Technology Group

The bus modules for ServoOne

This guide is currently subject to approval testing and is therefore not yet final and complete.
The technical data and agreed properties are therefore provisional and still subject to change in line with further technical developments.

User Manual ServoOne CANopen/EtherCAT

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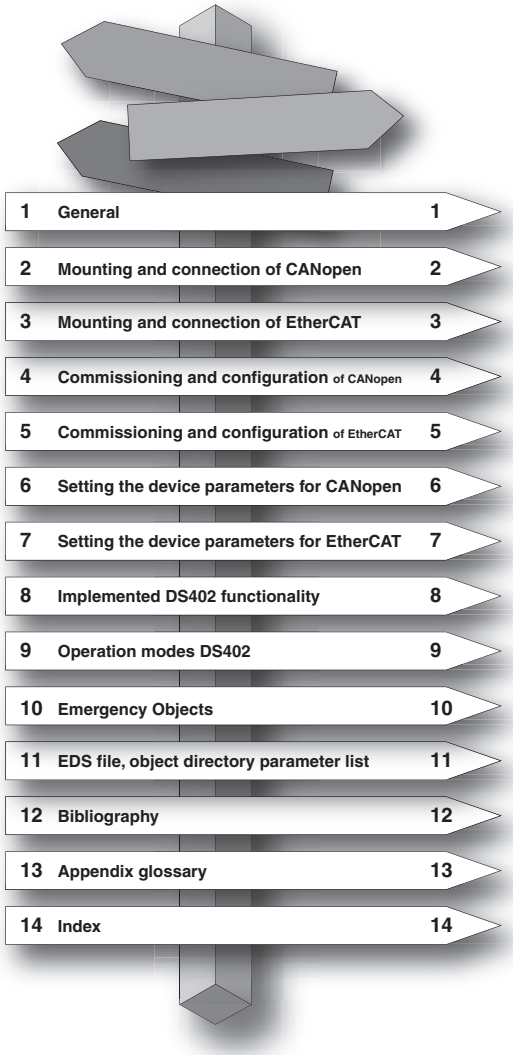
How to use the document

Dear User

This manual is intended for project engineers, commissioning engineers or programmers of drive and automation solutions on the CANopen and EtherCAT field bus. It is assumed that you are already familiar with these field bus systems through appropriate training and from reading the relevant literature. We assume that your drive is already in operation
– if not, you should first consult the Operation Manual.

This manual applies for the position controller system ServoOne, so you will see only the abbreviation SO below.



Pictograms

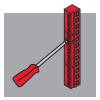
	Important! Misoperation may result in damage to the drive or malfunctions.
	Danger from electrical voltage! Improper behaviour may endanger human life.
	Danger from rotating parts! Drive may start up automatically.
	Note: Useful information

Contents

1 General Introduction

1.1 Measures for your safety

The ServoOne family drive devices are quick and safe to handle. For your own safety and for the safe functioning of your device, please be sure to observe the following points:

Read the Operation Manual first	
	• Follow the safety instructions
	Electric drives are dangerous: • Electrical voltages > 230 V/460 V: Dangerously high voltages may still be present 10 minutes after the power is cut. So always make sure the system is no longer live. • Rotating parts • Hot surfaces
	Your qualification: • In order to prevent personal injury and damage to property, only personnel with electrical engineering qualifications may work on the device. • Knowledge of national accident prevention regulations (e. g. VBG4 in Germany) • Knowledge of layout and interconnection with the CAN bus field bus
	During installation observe the following instructions: • Always comply with the connection conditions and technical specifications. • Electrical installation standards, e.g. for cable cross-section, shielding, etc. • Do not touch electronic components and contacts (electrostatic discharge may destroy components).

1.2 Introduction to CANopen

CANopen is an interconnection concept based on the CAN (Controller Area Network) serial bus system. CAN has many specific advantages, in particular multi-master capability, real-time capability, resistant response to electromagnetic interference and the high level of availability and low cost of controller chips. These advantages have resulted in CAN being introduced into widespread use in automation too.

Simplified cross-manufacturer communication

The integration of any number of devices in a manufacturer-specific network involves substantial expense. CANopen was developed to solve this problem. In CANopen the use of CAN identifiers (message addresses), the time response on the bus, the network management (e. g. system start and user monitoring) and coding of the data contents is specified in a uniform way. CANopen makes it possible for devices from different manufacturers to communicate in a network at minimal cost. CANopen uses a subset of the communication services offered by CAL to define an open interface. The selected CAL services are summarised in a kind of "user guide". This guide is called the CANopen Communication Profile.

CANopen functionality of ServoOne

The CANopen Communication Profile is documented in CiA DS-301 and regulates "how" communication is executed. It distinguishes between process data objects (PDOs) and service data objects (SDOs). The Communication Profile additionally defines a simplified network management system.

Based on the communication services of DS-301 (Rev. 4.01), the device profile for variable-speed drives DSP-402 (Rev2.0) was compiled. It describes the operation modes and device parameters supported.

The following sections will provide you with an overview of the CANopen functionality integrated in ServoOne. There then follows the information necessary for commissioning.

1.3 Introduction to EtherCAT

As far as real-time Ethernet systems are concerned, EtherCAT has become well established in the area of automation. The decisive factor here is not only the IEEE802.3/100BaseTX Ethernet physics known in the home office area, but also the excellent value for money with regard to implementation in the master and slave modules.

Interconnection can be optionally executed in a star, ring or line structure using standard patch or crossover cables and is therefore easily adapted to the machine infrastructure.

To reduce the amount of training required, familiar communication and device profiles were used as of the application layer. In this way, users familiar with CANopen profiles such as CiA DS301 or DSP402 can change over to this new field bus technology with minimal training.

In ServoOne we have combined all our past experiences in the CANopen area with this new field bus technology and achieved maximum compatibility and functionality.

1.4 System requirements

It is assumed you have a standard CANopen setup program and a CANopen interface driver.

For the precise protocol definitions refer to the CAL specification.

With the aid of these objects it is possible to configure the actual CANopen communication very flexibly and adapt it to the specific needs of the user.

1.5 Further documentation

- Operation Manual, for commissioning of the drive unit
- Application Manual, for additional parameter setting to adapt to the application. The Application Manual can be downloaded as a PDF file from our website at http://www.lust-tec.de. Follow the Service link.
- CiA DS-301 (Rev. 4.0): Application Layer and Communication Profile
- CiA DSP-402 (Rev. 2.0): Device Profile Drives and Motion Control
- EtherCAT Communication Specification Version 1.0 2004
- EtherCAT Indicator Specification Proposal V0.91 2005
- IEC61158-2-12 to IEC61158-6-12

2 Mounting and Connection of CANopen

Attention: Do NOT insert or remove the CANopenconnector during operation.

2.1 Setting the address

Step	Action	Note
1.	Find out which address is assigned to the module you are installing.	Ask your project engineer.
2.	Select the mode of addressing: • by bus address parameter • by DIP switch (S4) • by bus address parameter and DIP switch (S4)	See below
Address setting finished; for further procedure see Installation.		

Three possible methods of address assignment

1. Only using bus address parameter 2005-COM_CAN_Adr: You will find parameter 2005-COM_CAN_Adr (factory setting 1) in the “field bus“ subject area under CANopen.
2. Only using DIP switch S4
3. Combination of bus address parameter and DIP switch S4
   CAN address = hardware address (S4) + Parameter 2005-COM_CAN_Adr
   This option is advantageous, for example, if you intend always to use the same parameter set with up to 15 drives, but the lowest address is 30. Parameter 2005-COM_CAN_Adr is then set to 30. The device address is then defined using the coding switch, which ranges from 0-15.

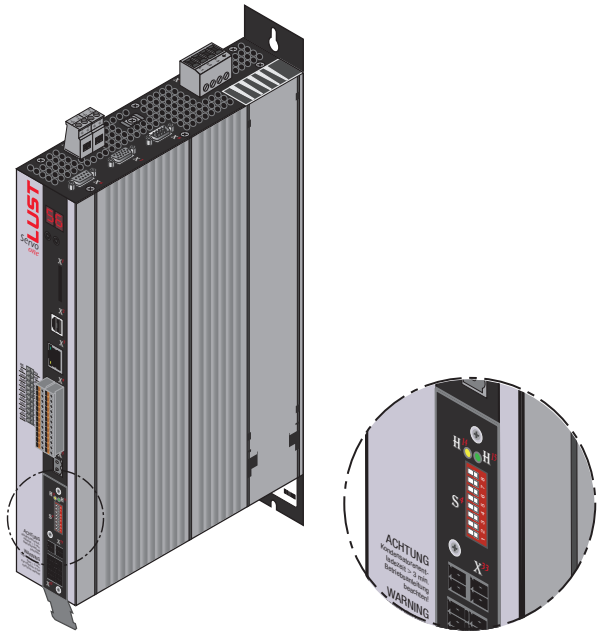


Figure Position of CAN connection on ServoOne

Address setting using DIP switch

An address between 0 and 127 can be decimally selected using DIP switch S4 on the position controller.

The DIP switch is assigned as follows: Positions 1-7 are reserved for the address setting, position 8 for the activation/deactivation of the 120 Ohm bus termination in the device.

Function/assignment:

Dip switch 1 - ⇨ significance 20 = 1
Dip switch 2 - ⇨ significance 21 = 2
Dip switch 3 - ⇨ significance 22 = 4
...
Dip switch 7 - ⇨ significance 26 = 64

Dip switch 8 = Bus termination ON/OFF

Figure DIP switch

Example of use of the DIP switches:

Setting address "3" using the Dip switch:
- ⇨ Set switch 1 and switch 2 to ON
- ⇨ 20 + 21 = 3
- ⇨ Resultant device address = 3
- ⇨ (If the software address = 0 is set)

IMPORTANT: Switch 8 = Bus termination!!!

Note: Changes to the CAN address are applied on a
- Reset node command
- Restart (device power-up).

Note: The active bus address can be found in the boot-up message.

2.2 Meanings of LEDs

The CAN option of ServoOne has two diagnosis LEDs (H14, H15).

Figure Device with CANopen option

The LEDs have the following function:

LED	Function	Meaning
H14 (yellow LED)	CANopen network state	The LED displays the current network state. • NMT STOPPED ⇨ flashing with 800 ms cycle • NMT PRE-OPERATIONAL ⇨ flashing with 1600 ms cycle • NMT OPERATIONAL ⇨ permanently lit.
H15 (green LED)	Voltage supply CAN option	Permanently lit, if the 24V supply of the option from CAN bus applies.

Table Meanings of LEDs

2.3 Installation

Step	Action	Note
1.	Make sure the hardware enable is wired on ServoOne (X4).	see Operation Manual
2.	Wire the CAN connection using connector X32 • Connection of CAN signal cables • Connection of interface power supply • Activation of the internal bus terminating resistor on the final drive controller	see Specification of CAN bus connection table and Assignment of connection X19 table
3.	Switch on the drive device.	
Electrical installation is finished; for how to proceed further, refer to section 4 “Commissioning and configuration”.		

The CANopen interface is integrated in ServoOne. The connection is made via connector X32. The interface is isolated from the drive controller electronics. The supply to the isolated secondary side is provided by the customer via connector X32.

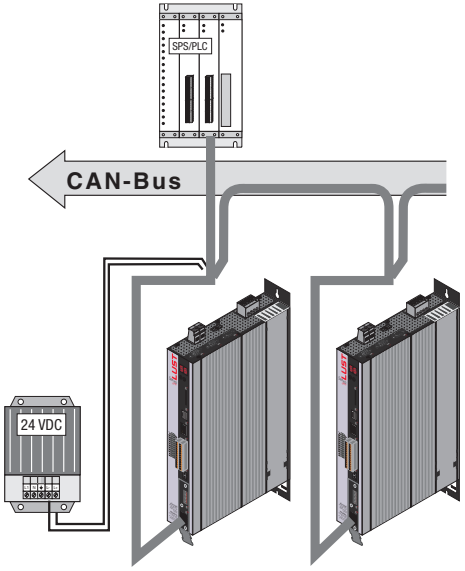


Figure System connection

Connection	Spring-type terminal
Wave terminating resistance - Bus termination -	120 W (internal) Activation of the bus termination in the device via switch 8 in the CAN option
Max. Input frequency	1 MHz
Ext. voltage supply	+24 V +25 %, 50 mA (isolated from drive controller)
Voltage ripple	Max. 3 Vss
Current consumption	Max. 50 mA per user
Cable type	4-wire, surge impedance 120 W

Table Specification of CAN bus connection

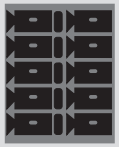
Terminal X32	PIN	PIN	Function	Description
	10	5	CAN_+24V	external 24V supply
	9	4	CAN_H	CAN High
	8	3	CAN_SHLD	CAN Shield (optional)
	7	2	CAN_L	CAN Low
	6	1	CAN_GND	CAN Ground (0V)

Table Assignment of connection X19

Note: Both connectors of terminal X32 are connected to each other in the device.

Note: The external 24 V supply for the option board is essential. It is not supplied by the device.

2.3 Transmission speeds

The CAN bus can be operated at the following Baud rates:

Transmission speed	Maximum line length across the complete network 1)	
1000 kBaud	25 m	Factory setting
500 KBaud	100 m	
250 kBaud 2)	250 m	
125 kBaud 2)	500 m	
50 kBaud 3)	1000 m	
25 kBaud 3)	2500 m	

1) Rounded bus length estimation (worst case) on basis 5 ns/m propagation delay and a total effective device internal in-out delay as follows:
1M-800 kbit/s: 210 ns
500 - 250 kbit/s: 300 ns (includes 2 * 40 ns for optocouplers)
125 kbit/s: 450 ns (includes 2 * 100 ns for optocouplers)
50 -10 kbit/s: Effective delay = delay recessive to dominant plus dominant to recessive divided by two.

2) For bus length greater than about 200 m the use of optocouplers is recommended. If optocouplers are placed between CAN Controller and transceiver this affects the maximum bus length depending upon the propagation delay of the optocouplers i.e. -4m per 10 ns propagation delay of employed optocoupler type.

3) For bus length greater than about 1 km bridge or repeater devices may be needed.

Table Transmission speeds

When selecting the transmission rate it should, however, be ensured that the line length does not exceed the permissible line length for the transmission rate in question.

2.4 Display of the operating states via 7-segment display

D1	D2	Meaning	Parameter
System states			
8.	8.	Device in reset state	
	0.	Auto-initialisation on device startup	(Start)
S. *)	1.	1) Not ready to switch on (no DC-link voltage)	(NotReadyToSwitchOn)
S. *)	2.	1) Switch-on inhibit (DC-link is OK, power stage not ready)	(SwitchOnDisabled)
	3.	Ready to switch on (power stage is ready)	(ReadyToSwitchOn)
	4.	On (power is connected to the device)2)	(SwitchedOn)
	5.	Drive ready (current applied to drive and drive ready for reference input) 2)	(OperationEnable)
	6.	Quick stop 2)	(QuickStopActive)
	7.	Fault response active 2)	(FaultReactionActive)
E	R	Fault (see below)	(Fault)
Displayed in the event of a fault			
E	R.	Display for errors or non-acknowledgeable errors	
X	X	Error number (decimal)	
Y	Y	Error localization (decimal)	

1) S. flashes, if the function STO (Safe Torque Off) is active, the display is not lit if the function is not active.
*) It does not involve a "safe display" under the terms of EN 61800-5-2.

2) The point flashes if the power stage is active.

Example of the flash sequence:

ER > 02 > 05 * ER > 02 > 05 ...

	Error:	ER = “Fault“
	Error name:	02 = “Error in the parameter list“
	Description of error:	05 = “Function for checking current parameter list“

2.5 Hardware enable

ServoOne has a control input for ENPO hardware enable on the control terminal.
This input must be configured to operate the power stage at 24 V.

The device also provides the function “STO (Safe Torque Off)“ (see Operation Manual or Application Manual ServoOne), category 3, control terminal ISDSH. For these devices the relevant function logic must be implemented by way of the higher-order controller as per the Application Manual.

Note: Without configuration of the inputs ENPO and ISDSH the device stays in state 1 = “Not Ready to Switch On“ or 2 = “Switch On Disabled“.
Only after correct configuration can the state be exited by a “Shutdown“ command via bus.

3 Mounting and Connection of EtherCAT

3.1 Installation and cabling

Setup of the EtherCAT network

In an EtherCAT network there is always one EtherCAT master (e. g. an industrial PC) and a variable number of slaves (e. g. servo controller, bus terminals etc.). Each EtherCAT slave has two Ethernet ports. Slave to slave cabling is thus possible. All EtherCAT users are generally put together in a line with the master at the beginning of the circuit. On the last slave in the line the second Ethernet port remains open.

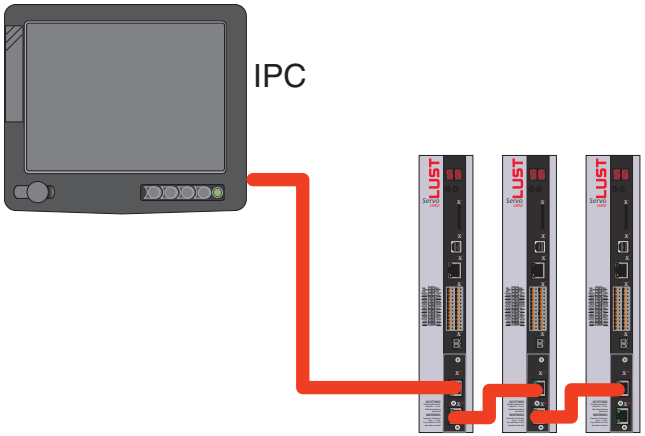


Figure EtherCAT connection

IN and OUT socket (RJ-45 input/output)

Each EtherCAT slave has two RJ-45 sockets. The upper port (X15) is the (IN) input and the lower port (X16) is the (OUT) output of the slave. The incoming cable (from the direction of the master) is connected using the IN port, the outgoing cable is connected to the next slave using the OUT port. The OUT port remains blank for the last slave in the series. In the case of a slave an open output leads internally to a logical short circuit of the transmit (Tx) and receive (Rx) cables. For this reason every EtherCAT network can be regarded as a logical ring in terms of its topology.

Figure EtherCAT option

upper RJ-45 port = input
lower RJ-45 port = output

IMPORTANT: Errors in cabling (incorrect connection of input and output) can lead to faulty addressing by the master.

Connecting cable

Ethernet patch cables or crossover cables are suitable connection cables as per the CAT5e specification. Cables lengths of 0.3 to a max. 100 m are permissible.

3.2 Pin assignment of the RJ-45 socket

The RJ-45 socket is assigned as follows:

PIN	Colour	Cable wire pairs	Function
1	white/orange	2	TxData +
2	orange	2	TxData -
3	white/green	3	RecvData +
4	blue	1	Unused
5	white/blue	1	Unused
6	green	3	RecvData -
7	white/brown	4	Unused
8	brown	4	Unused

Table Pin assignment

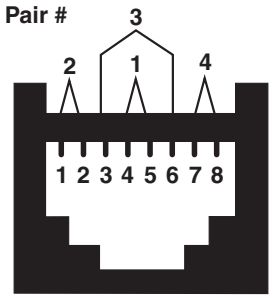


Figure RJ-45 socket

NOTE: Ethernet cables are available in the IT specialist trade in various lengths. Use CAT5e cable or better.

3.3 Meanings of LEDs

There are 2 LEDs on each RJ-45 socket.

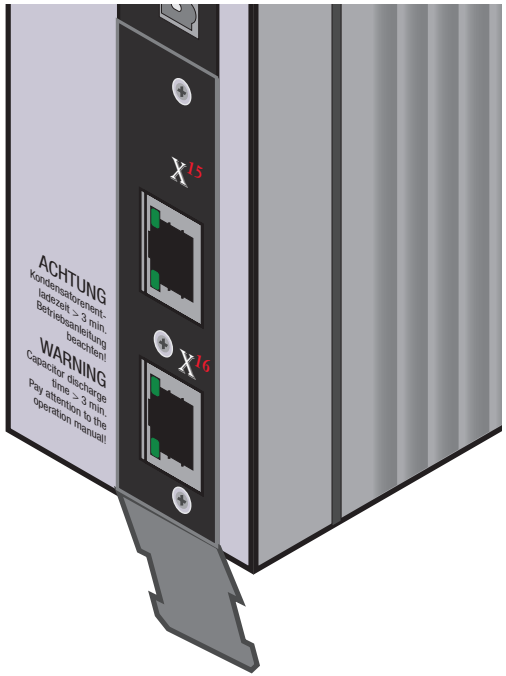


Figure Device with EtherCAT option

They have the following meanings:

LED	Function	Meaning
Upper LED	Link LED	off = no Link ⇨ No connection with another user
		on = Link ⇨ Connection with another user exists. Currently no data exchange.
		toggle = activity ⇨ Flashing of the LED signals that data is being exchanged.
Lower LED	Speed LED	off = 10 mbit/s ⇨ There is a connection with a transmission rate of 10 mbit/s.
		on = 100 mbit ⇨ There is a connection with a transmission rate of 100 mbit/s.

Table LED meanings

3.4 Display of operating states via 7-segment display

D1	D2	Meaning	Parameter
System states			
8.	8.	Device in reset state	
	0.	Auto-initialization on device startup	(Start)
S. *)	1.	1) Not ready to switch on (no DC-link voltage)	(NotReadyToSwitchOn)
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	5.	Drive ready (current applied to drive and ready for reference input) 2)	(OperationEnable)
	6.	Emergency stop 2)	(QuickStopActive)
	7.	Fault response active 2)	(FaultReactionActive)
E	R	Fault (see below)	(Fault)
Appears in the event of error			
E	R.	Display for errors or non-acknowledgeable errors	
X	X	Error number (decimal)	
Y	Y	Error localization (decimal)	

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Example of the flash sequence:

➢ ER > 02 > 05 * ER > 02 > 05 ...

Er	Error:	ER = "Fault"
02	Error name:	02 = "Error in the parameter list"
05	Description of error:	05 = "Function for checking current parameter list"

3.5 Hardware enable

ServoOne has a control input for ENPO hardware enable on the control terminal. This input must be configured to operate the power stage at 24 V.

The device also provides the function "STO (Safe Torque Off)" (see Operation Manual or Application Manual ServoOne), category 3, control terminal ISDSH. For these devices the relevant function logic must be implemented by way of the higher-order controller as per the Application Manual.

Note: Without configuration of the inputs ENPO and ISDSH the device stays in state 1 = "Not Ready to Switch On" or 2 = "Switch On Disabled". Only after correct configuration can the state be exited by a "Shutdown" command via bus.

4 Commissioning and Configuration of CANopen

4.1 Commissioning

The DriveManager user interface is used for general commissioning of the drive system. The DriveManager includes tools to identify motor data, provide access to a motor database for servo motors, and for general device configuration.

Initial commissioning is a separate subject with regard to operation via the user interface, and is detailed in the device's Application Manual.

4.2 Commissioning sequence

Preconditions:

- The drive device is wired as specified in the Operation Manual and first commissioning is complete. (To test CAN communication, it is sufficient to connect the voltage supply of the CAN option and the control voltage).
- If current is to be applied to the motor, the hardware enable (ENPO) and the "STO (Safe Torque Off)" must also be correctly configured.

Note: For more detailed information on optimisation of the software functions and control circuits refer to the device application manual.

Step	Action	Note
1.	Check the wiring. Please note that hardware enable ENPO (X4) is not configured.	
2.	Switch on the mains power and the 24 V supply to the CAN interface.	
3.	Configure the drive unit using the Application Manual.	(Inputs/outputs, software functions, etc.)
4.	Test the control quality and optimise the controller settings as necessary using the Operation Manual.	
5.	Set the parameters for the CAN communication. The Baud rate and the device address are required. The address can be selected by software and hardware. The mapping must also be completed and the active operation mode selected as per DS301/402.	Software and hardware address are added...
6.	Test the drive on the higher-order controller - see section 3.4.	
7.	Finally, save the setting.	Save device setting ⇨ Non volatile in device

Note: For more information on the subject of "Units and scalings" refer to section 5.4.

4.2.1 Setting the software address and Baud rate

The software address and Baud rate can be set using the following device parameters via DriveManager:

Parameter	Function	Description
2005-COM_CAN_Adr	CANopen address	Address assignment via parameter For more information on setting the address, see section 2.1
2006-COM_CAN_Baudrate	Baud rate	Permissible Baud rates - see section 2.3

Table Parameters on the Bus Systems function screen

Note: ServoOne has a default Baud rate of 1 mbit.

4.3 Commissioning instructions

For a variety of reasons, it may be that a drive device does not respond to a telegram:

- There is no reply if the telegram frame (Baud rate, data length) on the master computer is not correct.
- There is no reply if a drive device is addressed with the wrong bus address.
- There is no reply if the serial connection between the master computer and the drive device is not correctly set up.
- There is no reply if the 24 V supply to the CAN connection is missing or the cabling is faulty.
- There is no valid reply if several devices with the same device address are connected to the bus.
- There is no reply if the device has certain network states.

4.4 Testing the higher-order controller

To activate changed settings the device must be switched off and back on again. When the power is connected, after an initialisation period of a few seconds the device must transmit a one-off boot-up message (ID 700h + node ID = 701h for device address 1). If this happens, the communication is OK.

Note: During transfer of data to the device via SDO telegrams the number of data bytes transferred should be taken into account. For this the correct length information must be transferred in the control byte.
Alternatively, however, an SDO transfer without specification of the data length is also possible. The correct operation of the control byte in the SDO telegram should also be observed.

4.5 Data handling

4.5.1 Saving the settings

All configuration data can be backed up by the DriveManager.

NOTE: Please note, however, that some objects are RAM variables, which must be correctly operated and initialised by the controller. This includes, for example, object 6060h Modes of Operation.

4.5.2 Restoring factory defaults

There are two possible ways of restoring the factory defaults of the devices:

- Via field bus
  Write value 1 to the subindex 3 of object 200BH-PARA_SetCmd. The complete device is then set to factory settings.

Note: Please note that this also effects the settings for the Baud rate/device address. The changes take effect after a "Reset node" command or device restart.

- Via DriveManager
  In the DriveManager tree structure, select the relevant ServoOne. A pop-up menu can be opened using the right-hand mouse button and you can select the "Reset Device Setting" entry.

Note: In both cases it takes around approx. 10 s for the device to signal that it is ready again. During this time the device performs a self-test and changes all its settings to the factory setting. However, this setting is only retained if the data is backed up in the device. Data backup is initiated by way of the DriveManager user interface or by writing to object 200BH-PARA_SetCmd Subindex 1 = 1 by way of the bus system. The save operation can also be executed by way of object 1010 hex.

Attention: Data backup takes a few 100 ms. During that time the device must not be switched off, otherwise the settings will be lost.

Object 200BH-PARA_SetCmd Subindex 1 is automatically set to 0 by the device after the save operation. This process can be used for timeout monitoring of the function.

4.6 Commissioning via DriveManager

Procedure for commissioning with the aid of the Application Manual

1.	Initial commissioning based on Operation Manual	
	↓	A precondition for this is initial commissioning with the aid of the Operation Manual. The User Manual only covers adjustment of the software functions.
2.	Commissioning as per Application Manual	
	↓	Setting the drive controller parameters using the Application Manual. This includes, for example, the configuration of technology functions.
3.	Commissioning based on CANopen User Manual	
	↓	Configuration of field bus-specific settings (e. g. Baud rate) using this document.
4.	Checking the set application solution	
	↓	To preserve the safety of personnel and machinery, the application solution should only be checked at low speed. Make sure the direction of rotation is correct. In case of emergency the controller power stage can be disabled, and the drive stopped, by removing the ENPO signal.

	Completing commissioning	
5.	↓	When you have successfully completed commissioning, save your settings (using DriveManager) and store the data set in the device.

4.7 Control functions

Control functions can be optimally adapted to the relevant application. Consequently, several control formats are offered. The appropriate formats can be selected by the master during the setup phase over the bus, or by adjusting the relevant device parameters.

The drive devices' state machine has a cycle time of 1 ms.

All control commands and reference values are processed within that cycle time by the drive device.

Note: Control PDOs are processed in a minimum cycle time of 1 ms. If protocols arrive at the device faster, the telegram that arrived most recently overwrites the previous one.
An error message is not generated if telegrams are overwritten as a result of insufficient cycle time.

4.8 Operation mode selection (Modes of operation)

There are different control modes for operation of the devices via CANopen. The active operation mode is always selected via DS402 object 6060h (Modes of Operation).

ServoOne supports the operation modes as per the DS402:

- Profile Position Mode
- Profile Velocity Mode
- Homing Mode
- Interpolated Position Mode
- Cyclic Synchronous Position Mode (EtherCAT only)
- Cyclic Synchronous Velocity Mode (EtherCAT only)
- Cyclic Synchronous Torque Mode (EtherCAT only)

In the course of initial commissioning the user implements the settings of the drive using motor data, loop control settings, I/O configuration etc.

A relevant control mode is also directly connected with the respective operation mode. By switching modes of operation via CANopen, it is possible to switch directly between position control, speed control and torque control.

The drive is thus in speed control for Profile Velocity Mode and in position control for Profile Position Mode.

4.8.1 Functionality of operation modes

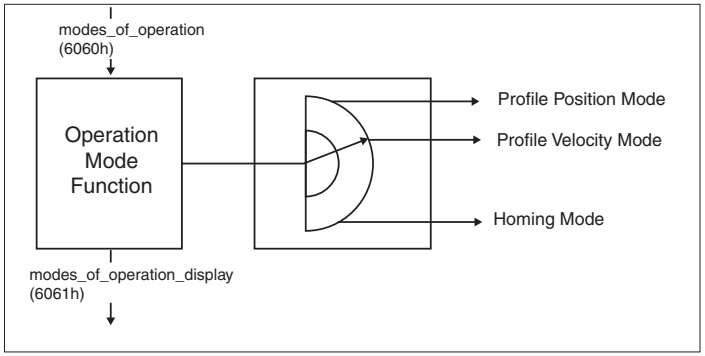

Figure Functionality of operation modes Change modes in the diagram

Users can switch between the various operation modes, as long as these are supported by the device.

The status word contains bits, the meaning of which depends on the operation mode. For monitoring, it is necessary for the bits to change their meaning when modes are switched, see also Chapter 6.

5 Commissioning and Configuration of EtherCAT

Commissioning via EtherCAT is possible using the XML file supplied on your controller. All further commissioning and configuration steps are independent of the controller used. For notes on this refer to the documentation provided by your control manufacturers.

6 Setting the Device Parameters for CANopen

6.1 Implemented DS301 functionality

6.1.1 Communication objects

- Boot-up to DS301 V4.01 (Guarding boot-up via identifier 700h)
- Four variably mappable TxPDOs (transmission type 1 to 240, 254 and 255dec possible).
- Four variably mappable RxPDOs (transmission type 1 to 240, 254 and 255dec possible).
- An SDO server - Pay attention to definition of time conditions (typical processing time in device approx. 5 ms, depending on capacity utilisation)
- One emergency object error code to DS402 plus manufacturer-specific error location and number, operating hours of the device
- One Sync object
- NMT state machine to DS301
- Node guarding and heartbeat (see below)
- Processing cycle:
  PDO protocols can be processed in a minimum cycle time of 1ms. If protocols arrive faster, previous protocols are overwritten.
- SDO protocols and NMT services are processed acyclically. Typical processing times lie between 1 and 5 ms.
- Initialisation values of the COB IDs based on Predefined Connection Set
- Access to device parameters 2000h - 5FFFh (expedited/non-expedited).

6.1.2 Object directory of DS301

For a full overview of the supported CAN objects of ServoOne refer to the EDS file.

Here you can refer to both the CANopen objects of DS301, DS402 and also the manufacturer-specific objects of the device.

The following list shows an extract of the object directories with important DS301 objects. For these objects the transmission types or mapping, for example, are explained below.

Object No.	Object name	Object Code	Type	Attr.
0x1000	Device_Type	VAR	Unsigned32	ro
0x1001	Error_Register	VAR	Unsigned8	ro
0x1003	Pre-Defined_Error_Field One subentry	ARRAY	Unsigned32	ro
0x1005	COB-ID_SYNC	VAR	Unsigned32	rw
0x1006	Communication_Cycle_Period	VAR	Unsigned32	rw
0x1007	Synchronous_Window_Length	VAR	Unsigned32	rw
0x1008	Manufacturer device name	String		
0x1009	Manufacturer hardware version	String		
0x100A	Manufacturer software version	String		
0x100C	Guard_Time	VAR	Unsigned16	
0x100D	Life_Time_Factor	VAR	Unsigned8	
0x1014	COD-ID_EMCY	VAR	Unsigned32	
0x1017	Producer_Heartbeat_Time	VAR	Unsigned16	rw
0x1018	Identity_Object support all 4 entries (serial number, etc.)	RECORD	Identity (23h)	ro

Table Object directory

Object No.	Object name	Object Code	Type	Attr.
0x1400	1st_Receive_PDO_Parameter	RECORD	PDO CommPar	rw
0x1401	2nd_Receive_PDO_Parameter	RECORD	PDO CommPar	rw
0x1402	3rd_Receive_PDO_Parameter	RECORD	PDO CommPar	rw
0x1403	4th_Receive_PDO_Parameter	RECORD	PDO CommPar	rw
0x1600	1st_Receive_PDO_Mapping max 8 objects	RECORD	PDO Mapping (21h)	rw
0x1601	2nd_Receive_PDO_Mapping max 8 objects	RECORD	PDO Mapping	rw
0x1602	3rd_Receive_PDO_Mapping max 8 objects	RECORD	PDO Mapping	rw
0x1603	4th_Receive_PDO_Mapping max 8 objects	RECORD	PDO Mapping	rw
0x1800	1st_Transmit_PDO_Parameter	RECORD	PDO CommPar (20h)	rw
0x1801	2nd_Transmit_PDO_Parameter	RECORD	PDO CommPar (20h)	rw
0x1802	3rd_Transmit_PDO_Parameter	RECORD	PDO CommPar	rw
0x1803	4th_Transmit_PDO_Parameter	RECORD	PDO CommPar	rw
0x1A00	1st_Transmit_PDO_Mapping max 8 objects	RECORD	PDO Mapping	rw
0x1A01	2nd_Transmit_PDO_Mapping max 8 objects	RECORD	PDO Mapping	rw
0x1A02	3rd_Transmit_PDO_Mapping max 8 objects	RECORD	PDO Mapping	rw
0x1A03	4th_Transmit_PDO_Mapping max 8 objects	RECORD	PDO Mapping	rw

Table Object directory

6.2 Parameter channel (Service Data Objects)

The Service Data Object (SDO) permits write and read access to the object directory. This SDO is implemented according to the CAL specification by the Multiplexed Domain CMS object. The protocol is designed for the transfer of data of any length. For SDO transfer, an SDO server is integrated into the device. Communication is by way of two reserved identifiers.

Receive SDO: 600 h

Transmit SDO: 580 h

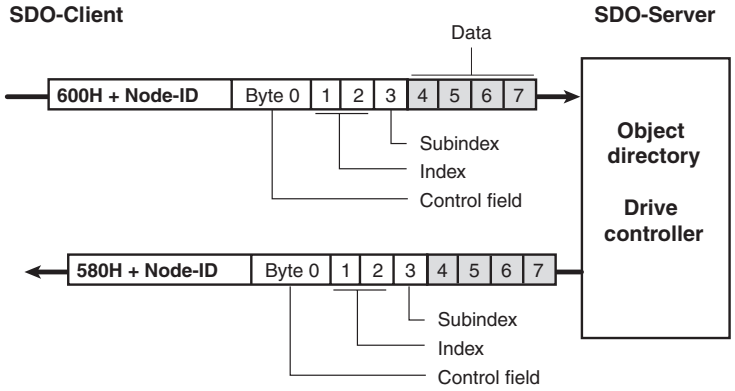

Figure Example of SDO data transfer in Expedited Mode

The CAL specification makes a basic distinction between three protocol services:

- Download protocol (Write)
- Upload protocol (Read)
- Abort protocol (Error)

The upload and download protocols also differentiate between:

- Expedited Multiplexed Domain Protocol for access to objects with a data length of up to 4 bytes (shown above) and
- Multiplexed Domain Protocol, for access to objects of any length

The entries in the "Control field" area are generated by the CANopen driver. They are only included to fully document the examples cited. The entries are dependent on the transferred data.

The control field is described in the DS301 profile.

6.2.1 Data types

Note: Via the DriveManager user interface many parameter settings are displayed in the form of value substitution texts.
Example: Parameter 450-MOT_Type = PSM

When writing and reading over the field bus the corresponding numerical values for these value substitution texts must be used. These values are displayed in brackets ( ) when the parameter is opened in DriveManager.

Example:
Parameter 450-MOT_Type = PSM (1)

The drive units support the following parameter data formats:

Data type	Value range	Function
USIGN8	0...255	Unsigned
USIGN16	0...65535	
USIGN32	0...4294967295	
INT8	-128...127	Integer, signed
INT16	-32768...32767	
INT32	-2147483648...2147483647	
FLOAT32	see IEEE	32-bit floating point number in IEEE format
STRING		ASCII characters, max. 100 bytes in bus mode incl. zero terminator

Table Data types

6.2.2 Representation of data types in the control protocol

All data types are represented appropriate to their preceding sign as 32-bit variables in Intel format.

Data bytes of the control protocol	3	4	5	6
USIGN8/INT8* USIGN16/INT16* USIGN32/INT32	Low Word Low Byte	Low Word High Byte	High Word Low Byte	High Word High Byte
FLOAT32	IEEE format			
STRING	See examples,			
* Filled out appropriate to preceding sign (00H or FFH)				

Table Assignment of data types in the data field

6.2.3 Access to device parameters

Where can I find the device parameters?

All device parameters are addressed by way of a parameter number.

In addition to the standard objects, the CANopen profile provides an area for manufacturer-specific entries. This area lies between 2000 h and 5FFF h. If you then want to read or write parameter 455-MOT_FNOM (rated frequency of the motor) of the device, the object index is formed from 2000 h + parameter number (Hex).

In our example: Index = 2000 h + 1C7 H

Note: Profile-specific parameters are visible in DriveManager, but only in area 1000H... (DS301 objects)/6000H... (DS402 objects) writeable/readable. This means parameters stored both as device parameters (area 2xxxH) and also as profile parameters (DS301/DS402), can only be read and written to via their object number (DS301/DS402 profile).

Example:

The object 1000h Device Type exists both in the DS301 profile and also as a device parameter with parameter number 2011. Simultaneous two-way access would therefore be possible via CANopen or EtherCAT. In order to clearly configure the access, the read/write access for this object is only possible via profile-specific object number 1000h (as per DS301).

6.3 Examples of SDO handling

By way of the Receive SDO (COB IDs: 600 h + Node-ID) the CANopen objects and the parameters of the drive controller can be accessed.

In a data transfer protocol a maximum of 4 data bytes can be transferred in Expedited mode. This means all device parameters, apart from string parameters, can be written to with a single transfer protocol.

String parameters can be written to using the Multiplexed Domain protocol.

Example of read access to string parameters (parameter 3 DV_DeviceAliasName)

Note:
- All numeric values are hexadecimal
- The string "X-axis" is to be transferred
- This text is entered in ServoOne parameter 3 DV_DeviceAliasName

TIME	ID	Direction	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Comments
18.992445	Tx	601	8	40	03	20	00	00	00	00	00	Read object 2003h (= parameter 3)
18.992972	Rx	581	8	41	03	20	00	64	00	00	00	Reply: 64h --> 100bytes to be transferred
35.514341	Tx	601	8	60	00	00	00	00	00	00	00	Requirement Segment 1
35.514594	Rx	581	8	00	58	2d	41	78	69	73	00	Reply Segment 1 - contains "X-axis"
36.269620	Tx	601	8	70	00	00	00	00	00	00	00	Requirement Segment 2
36.270175	Rx	581	8	10	00	00	00	00	00	00	00	Reply Segment 2
36.982385	Tx	601	8	60	00	00	00	00	00	00	00	Requirement Segment 3
36.982664	Rx	581	8	00	00	00	00	00	00	00	00	Reply Segment 3
37.686447	Tx	601	8	70	00	00	00	00	00	00	00	Requirement Segment 4
37.686706	Rx	581	8	10	00	00	00	00	00	00	00	Reply Segment 4
38.421344	Tx	601	8	60	00	00	00	00	00	00	00	Requirement Segment 5
38.421604	Rx	581	8	00	00	00	00	00	00	00	00	Reply Segment 5
39.053526	Tx	601	8	70	00	00	00	00	00	00	00	Requirement Segment 6
39.053787	Rx	581	8	10	00	00	00	00	00	00	00	Reply Segment 6
39.749081	Tx	601	8	60	00	00	00	00	00	00	00	Requirement Segment 7
39.749347	Rx	581	8	00	00	00	00	00	00	00	00	Reply Segment 7
40.428981	Tx	601	8	70	00	00	00	00	00	00	00	Requirement Segment 8
40.429249	Rx	581	8	10	00	00	00	00	00	00	00	Reply Segment 8
41.085839	Tx	601	8	60	00	00	00	00	00	00	00	Requirement Segment 9
41.086198	Rx	581	8	00	00	00	00	00	00	00	00	Reply Segment 9

TIME	ID	Direction	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Comments
41.740755	Tx	601	8	70	00	00	00	00	00	00	00	Requirement Segment 10
41.741148	Rx	581	8	10	00	00	00	00	00	00	00	Reply Segment 10
42.514034	Tx	601	8	60	00	00	00	00	00	00	00	Requirement Segment 11
42.514294	Rx	581	8	00	00	00	00	00	00	00	00	Reply Segment 11
43.172512	Tx	601	8	70	00	00	00	00	00	00	00	Requirement Segment 12
43.172787	Rx	581	8	10	00	00	00	00	00	00	00	Reply Segment 12
43.908571	Tx	601	8	60	00	00	00	00	00	00	00	Requirement Segment 13
43.908831	Rx	581	8	00	00	00	00	00	00	00	00	Reply Segment 13
44.668466	Tx	601	8	70	00	00	00	00	00	00	00	Requirement Segment 14
44.668740	Rx	581	8	10	00	00	00	00	00	00	00	Reply Segment 14
53.884044	Tx	601	8	60	00	00	00	00	00	00	00	Requirement Segment 15
53.884414	Rx	581	8	0b	00	00	00	00	00	00	00	Reply Segment 15 - No further segments

Translation of transferred values (ASCII):

The string “X-Axis“ at 6 bytes is so short that it can be completely transferred with the first segment.

The following segments (of 100 bytes of parameter) therefore only include zeroes.

Transmitted bytes (HEX)	58	2d	41	78	69	73
Interpretation (ASCII)	X	-	A	x	i	s

6.3.1 Parameter set download

The following data can be transferred to ServoOne via the CANopen interface:

- Parameter set
- A parameter data set can be downloaded by an SDO transfer or by way of the DriveManager user interface version 5 or higher. All manufacturer-specific device parameters are additionally accessible via objects 2000h- 5FFFh.

If a unified valid data set - that is, not just individual parameters - needs to be transferred from the CAN master to the device, the following points must be considered:

On every transfer of an individual parameter the drive controller checks whether the parameter matches its existing data set. The check of the new parameter value includes existing parameter values in some cases. This means it is possible that the drive controller may reject a parameter, even though it originates from a valid parameter data set, because the parameter is not yet complete in the device.

Since a simple error reset may not eliminate the cause of the error, it may be necessary to reset to the factory defaults.

Remedy:

The parameter data set is transferred to the drive controller without a logic check. At the end of the download, the logic check is reactivated and the drive controller checks the transferred parameters for plausibility. During this check parameter settings that do not functionally match are reported as errors.

Download procedure of a completed parameter data set:

1. Reporting a download without logic check
   To deactivate the logic check and to report the download of a data set, parameter 11 subindex 4 value 1 is written.
2. Downloading the parameter data to the drive controller
   In this step the individual parameters of the data set are sequentially transferred to the drive. Despite the deactivated logic check basic checking mechanisms are still active. These monitor, for example, the maintenance of parameter limits and become active if these are infringed. Thus if a value range limit is infringed by the download of a parameter, then this SDO protocol is directly rejected (Abort message).
3. Completing download and activating plausibility check
   Once all parameter data has been transferred to the drive controller, parameter 11 subindex 4 is reset to value 0. Then a logic check of the device parameters is carried out. In cases of error the user receives an Emergency message.

Note: The download of a complete parameter data set is only possible when the system is at a standstill. Make sure the drive controller is not switched on for the duration of the download.

6.4 PDO transmission types

In connection with the PDO transfer, various transmission types are defined in CANopen profile DS301. The transmission type and event control can be set separately for all supported RXPDOs and TXPDOs. The drive controller supports the following transmission types:

Cyclic Synchronous Types No. 1-F0 h

Meaning: The difference between this and the acyclic synchronous transmission type is that RXPDOs are only evaluated after receipt of 1-F0 h Sync objects and TxPDOs are only transmitted every 1-F0 h Sync objects.

Asynchronous Types No. FE h and FF h

Meaning: RxPDOs are evaluated immediately on receipt; TxPDOs are transmitted by a device-specific event. The Sync object is irrelevant to this mode of transfer. Special feature type FF h:
In this case the event is defined in the associated device profile.

Note: The desired transmission types are set by way of the corresponding CANopen objects 1400h for RxPDOs and 1800h for TxPDOs.

6.5 Event-controlled TxPDO transmission

Note: Event control is only active when the relevant "transmission type" is set to asynchronous (FEh or FFh).

Functions of event control:

Any bit changes within the TxPDO can serve as an event for the sending of a TxPDO. Thus only the mapped contents of this TXPDO are relevant as an event for the sending of a TxPDO. Accordingly it is not possible to send a TxPDO dependent on the changes to the content of another TxPDO.

Example:
The status word 6041h is mapped in TxPDO1. TxPDO2 contains the current actual position. A change to the status word in TxPDO1 can therefore not be used as an event for the sending of the TxPDO2. If this is required, however, the status word 6041h can also be mapped in TxPDO2.

Selecting the events:
In ServoOne every bit (or a change to it) in a TxPDO can be defined as an event. By default all bits (max. 64bit = 8byte) are monitored for changes and are evaluated as events. Individual bits can be displayed via screens, however, and therefore are no longer used for event generation.

There are screens defined in field parameter 2007 enabling the display of individual bits of TxPDOs. Subindexes are respectively relevant for a TxPDO. Each subindex is responsible for 32 bits of the TxPDO. The structure is thus as follows:

Parameter 2007 - COM_301_EvMask
"Event mask for asynchronous transmit pdos"

Sub Id	Name	Value	Description	Type
0	EvMsk_TxPdo1L	FFFFFFFFh	Event mask for txpdo 1 byte 0-3	uint32
1	EvMsk_TxPdo1H	FFFFFFFFh	Event mask for txpdo 1 byte 4-8	uint32
2	EvMsk_TxPdo2L	FFFFFFFFh	Event mask for txpdo 2 byte 0-3	uint32
3	EvMsk_TxPdo2H	FFFFFFFFh	Event mask for txpdo 2 byte 4-8	uint32
4	EvMsk_TxPdo3L	FFFFFFFFh	Event mask for txpdo 3 byte 0-3	uint32
5	EvMsk_TxPdo3H	FFFFFFFFh	Event mask for txpdo 3 byte 4-8	uint32
6	EvMsk_TxPdo4L	FFFFFFFFh	Event mask for txpdo 4 byte 0-3	uint32
7	EvMsk_TxPdo4H	FFFFFFFFh	Event mask for txpdo 4 byte 4-8	uint32

Table Field parameter 2007

Example of application of screens:
To only allow the lower 16 bits of the TxPDO1 as an event, the subindexes of parameter 2007 are described as follows:

- Subindex 0 (Event screen TxPDO1 bytes 0 – 3) = 0000FFFFh
- Subindex 1 (Event screen TxPDO1 bytes 4 – 7) = 00000000h

Note: The cyclic sending of the Tx PDOs is activated by setting a cycle time in ms in the objects 0x1800 (TxPDO1) 0x1801(TxPDO2), 0x1802 (TxPDO3) and 0x1803 (TxPDO4) subindex 5 (event timer).

6.6 PDO mapping

6.6.1 Mapping - general

Variable mapping of parameters is possible on ServoOne for all 4 Rx and TxPDOs. Mapping works as defined in the CANopen communication profile DS301.

Most device-specific parameters form part of the manufacturer-specific area (2001h-5FFFh) and can also be mapped in the PDOs. For these parameters (objects), refer to the EDS file of the drive controller.

6.6.2 Mapping notes

In contrast to earlier devices ServoOne no longer has predefined mapping or mapping selectors. This means that prior to communication via PDO the mapping must be written to the drive controller by the controller. Transfer of the data set is also possible.

By default all mapping settings are set to 0, i. e. the PDOs do not contain any mapping.

The communication settings (mapping/transmission types etc.) can be saved in the device however, and are subject to data set handling. This means they must be rewritten each time and can be transferred with the data set.

The following objects are relevant for mapping:

RxPDOs:
1600h RxPDO1 mapping
1601h RxPDO2 mapping
1602h RxPDO3 mapping
1603h RxPDO4 mapping

TxPDOs:
1A00h TxPDO1 mapping
1A01h TxPDO2 mapping
1A02h TxPDO3 mapping
1A03h TxPDO4 mapping

Notes: A maximum of 8 objects can be mapped per PDO.
In a PDO a maximum of 8 bytes can be mapped.

6.7 Heartbeat function

The Heartbeat function to DS301 (V4.01) is supported. ServoOne can only be used as heartbeat producer, i.e. it sends heartbeat telegrams to the controller. To this end object 1017H Producer Heartbeat Time is implemented.

A time value (in ms) is entered as a value for this object. The time value represents the cyclic interval during which the drive controller sends its heartbeat telegrams.

Heartbeat protocol

The Heartbeat protocol defines an ERROR CONTROL SERVICE without using REMOTE FRAMES.
A HEARTBEAT PRODUCER sends a cyclic HEARTBEAT MESSAGE. One or more HEARTBEAT CONSUMERS receive this message. The relationship between the PRODUCER and the CONSUMER can be configured by way of the objects described below. The HEARTBEAT CONSUMER monitors receipt of the HEARTBEAT PROTOCOL taking account of the preset HEARTBEAT CONSUMER TIME.

If the HEARTBEAT PROTOCOL is not received within the HEARTBEAT CONSUMER TIME, a HEARTBEAT event is generated.

The HEARTBEAT PROTOCOL starts directly after entry of the HEARTBEAT PRODUCER TIME.
If the device is powered up with a HEARTBEAT PRODUCER TIME setting not equal to 0, the HEARTBEAT PROTOCOL starts with the state transition INITIALISING -> PREOPERATIONAL.

In this case the BOOTUP MESSAGE is classed as the first HEARTBEAT MESSAGE.

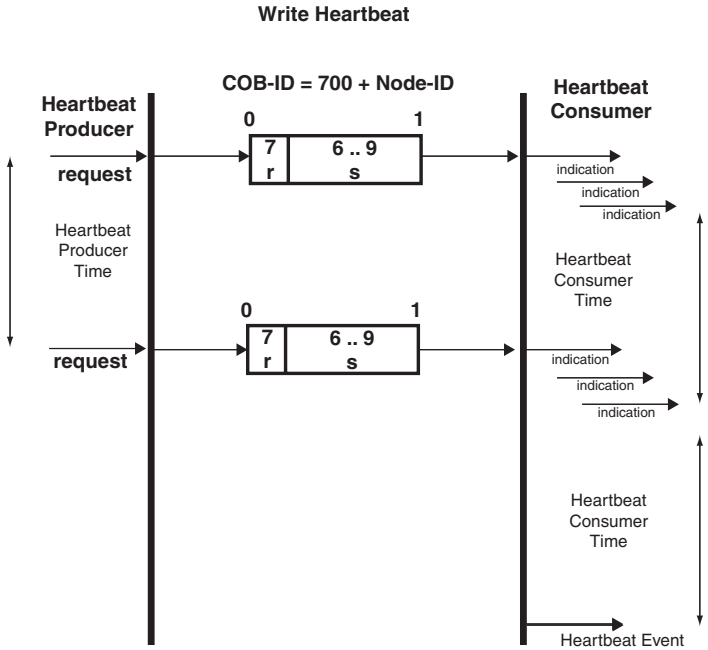

Figure Heartbeat protocol

r: reserved (always 0)
s: the state of the Heartbeat producer
0: BOOTUP
4: STOPPED
5: OPERATIONAL
127: PRE-OPERATIONAL

The NODE GUARDING and HEARTBEAT functions cannot be used in a device simultaneously. If the HEARTBEAT PRODUCER TIME is not equal to 0, the HEARTBEAT PROTOCOL is used.

7 Setting the Device Parameters for EtherCAT

7.1 Supported EtherCAT functionality

Below you will find an overview of the EtherCAT functionality implemented in ServoOne. The next diagram shows the basis for the following description. It shows the structure of EtherCAT based on the OSI 7 layer model.

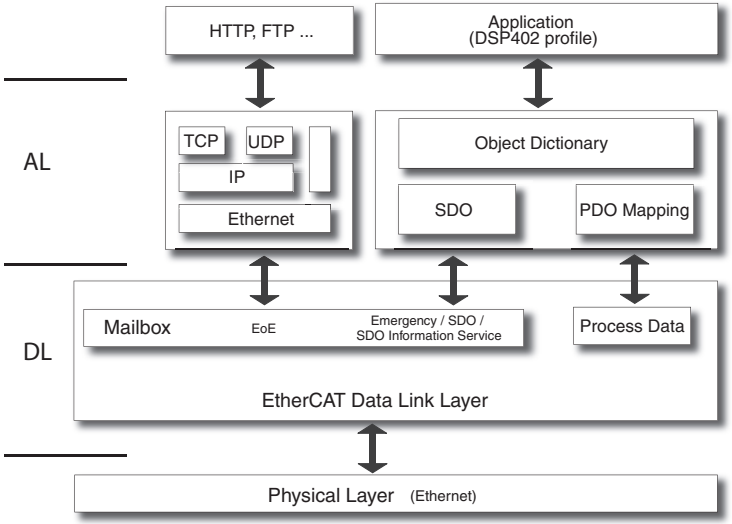

Figure Structure EtherCAT

The physical layer of EtherCAT based on IEEE802.3/100 BaseTX Ethernet physics. Based on this the EtherCAT Data Link Layer (DL) follows, which is split into mailbox and process data. The following layer is termed as AL (Application Layer) and includes the services of CoE (CAN over EtherCAT) and EoE (Ethernet over EtherCAT).

All services that are not time-critical, i. e. their execution/contents do not critically intervene in process data in terms of time, are grouped together in the mailbox. The mailbox is used as a service data channel and thus also enables access to drive parameters. This is done via the SDO (Service Data Objects) channel. The mailbox service also provides the basis for the services of EoE (Ethernet over EtherCAT) and the error handling (emergency telegrams).

The process data is designed on the basis of CANopen (CiA DS301). This means there is mapping of objects in PDOs (Process Data Objects) that are cyclically transferred. This process data includes, for example, cyclic position, speed or torque reference values and actual values.

The basis for both SDO and PDO accesses to the drive is always the object directory, which is realised based on CANopen. For the user this means that these objects can be accessed both via CANopen and via EtherCAT.

In the case of ServoOne the DS402 profile is again set up on the application layer.
For information on this layer refer to the sections "Implemented DS402 functionality" and "DS402 operation modes".

An overview of the EtherCAT functionality of ServoOne is provided below:

Process Data

- 4 RxPDOs
- 4 TxPDOs
- Transfer length = max. 8 bytes per PDO
- Variable mapping as per DS301 (cf. CANopen)

Attention: The PDO must have an even number of bytes assigned. If an uneven number is required, this must be filled up with a "Dummy Byte" for example...

- Cycle times
  Transfer cyclic position references with max. 8 kHz (125µs)
  Transfer cyclic speed reference with max. 8 kHz (125µs)
  Transfer cyclic torque references with max. 8 kHz (125µs)

Mailbox

ServoOne supports the CAN over EtherCAT (CoE) and Ethernet over EtherCAT (EoE) protocol. The following functions/services are implemented:

CoE

- Sdo/Abort
  - Initiate SDO Download
  - Download SDO Segment
  - Initiate SDO Upload
  - Upload SDO Segment
  - Abort SDO Transfer
  - All device parameters are accessible via object ID 2000H + x

Note: Profile-specific parameters are visible in DriveManager, but only in range 1000H... (DS301 objects)/6000H... (DS402 objects) writeable/readable. This means parameters stored both as device parameters (range 2xxxH) and also as profile parameters (DS301/DS402) can only be read and written to via their object number (DS301/DS402 profile).

Example:

The object 1000h Device Type exists both in the DS301 profile and also as device parameters with parameter number 2011. Simultaneous two-way access would therefore be possible via CANopen or EtherCAT. In order to uniquely configure the access, the read/write-access for this object is only possible via profile-specific object number 1000h (as per DS301).

Emergency

The Emergency service is designed for the transfer of error messages. In contrast to CANopen, emergency messages in EtherCAT are not autonomously sent from the slave but are retrieved by the master.

Functionality in ServoOne:

- ErrorCodes as per the DS402 device profile are supported.
- For the structure/content of the emergency message refer to the section “Emergency Objects“

SDO Information Service

The SDO Information Service allows the master to read the object directory of the slave. In this way, the master can determine the supported objects of the slave with the required additional information (e. g. data type/access rights etc.). The SDO Information Service therefore represents an alternative in the use of EDS files known to CANopen.

Functionality in ServoOne:

- Access to the object list and description
- Alternatives for integrating the EDS file

EoE

Functions such as the tunnelling of standard Ethernet frames in EtherCAT generally fall under Ethernet over EtherCAT. This enables protocols, for example TCP/IP to be transferred via EtherCAT.

Implemented functionality in ServoOne:

- Initiate EoE request
- Initiate EoE response
- EoE fragment request
- EoE fragment response

Distributed clocks

Synchronization in the case of EtherCAT is implemented on the basis of distributed clocks. Each slave has its own clock, which is synchronized with the others using a synchronisation pulse. The reference clock with which users are synchronized is accommodated in a slave.

Notes on ServoOne:
- The complete configuration of distributed clocks takes place in the controller.
- Multiples of 125µs (time basis of the control) must always be used as cycle times.

XML file

The XML file helps to integrate an EtherCAT slave into an EtherCAT master (control). It includes the configuration (mapping etc.) for the respective operation modes.

Notes on ServoOne:
- The XML file is provided with the firmware.
- The integration of this file is control-specific....

NMT (Network Management)

The Network Management is essentially based on the network management of CANopen. The Stopped (CANopen) state was replaced by the Safe Operational (EtherCAT) state however.

Depending on the scope of functions of the control software, individual state transitions can be executed automatically or via the PLC.

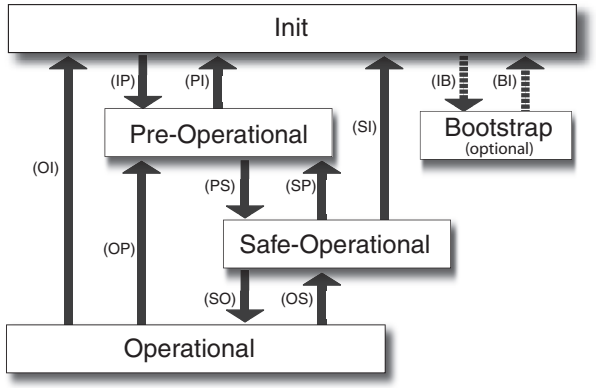

Figure EtherCAT state machine

State	Description
Init	Initialisation, the device starts up.
Pre-Operational	The device is ready to be configured. Mailbox communication is possible.
Safe-Operational	PDO input data (TxPDO device) can be read. PDO output data (RxPDO device is ignored.
Operational	Cyclic I/O communication PDO output data (RxPDO device) is processed.

Transitions	Actions
IP	Start Mailbox Communication
PI	Stop Mailbox Communication
PS	Start Input Update
SP	Stop Input Update

Table State transitions

Transitions	Actions
SO	Start Output Update
OS	Stop Output Update
OP	Stop Output Update/Stop Input Update
SI	Stop Input Update/Stop Mailbox Communication
OI	Stop Output Update/Stop Input Update/Stop Mailbox Communication

Table State transitions

7.2 Configuration for the operation in a controller

The services described in the previous section (e. g. PDO mapping etc.) are all operated by the controller (EtherCAT master). The communication-specific parameter setting of ServoOne is performed on the basis of the supplied XML files by the Master.

The parameter setting of control settings, scaling etc. can also be performed via the DriveManager. Alternatively all parameters can also be configured via the object directory.

8 Implemented DS402 Functionality

The functions in this section relate to activation in the modes of operation of DS402 profile

1 - Profile Position Mode
3 - Profile Velocity Mode
6 - Homing Mode
7 - Interpolated Position Mode
8 - Cyclic Synchronous Position Mode (only EtherCAT)
9 - Cyclic Synchronous Velocity Mode (only EtherCAT)
10 - Cyclic Synchronous Torque Mode (only EtherCAT)

8.1 Device control and state machine

The drive is controlled by way of the DRIVECOM state machine defined in DS402 (see DS402 10.1.1 state machine). No remote signal is planned.

8.1.1 General information

The DEVICE CONTROL FUNCTION monitors all the functions of the controller. This function is subdivided into

- device control of the state machine
- operation mode function

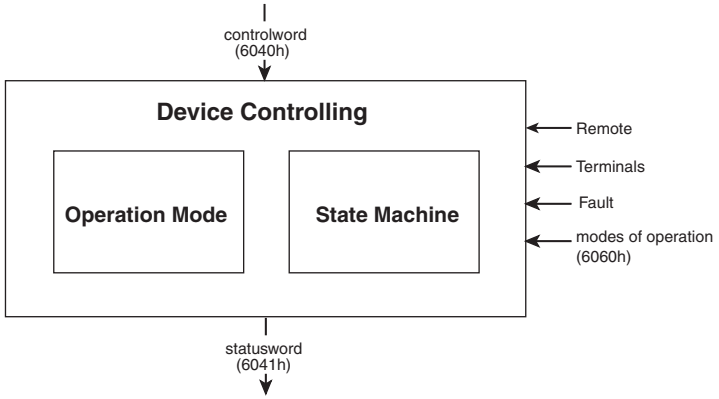

Figure Device controlling

The status of the controller is controlled by way of the control word. The status of the controller is displayed in the STATUS WORD. In REMOTE MODE the controller is controlled directly from the CANopen network by PDO and SDO.

The state machine is controlled by the control word. The state machine is also influenced by internal events, such as errors.

8.1.2 State machine

The state machine describes the CONTROLLER STATUS and the possible options for control by the master. A single status indicates a specific internal or external response. At the same time, the status of a controller restricts the possible control commands. For example, initiating a point-to-point positioning operation is only possible in the OPERATION ENABLE state.

States may change because of the control word or other internal events. The current status is displayed in the STATUS WORD. The state machine describes the state of the controller with regard to user commands and internal error messages.

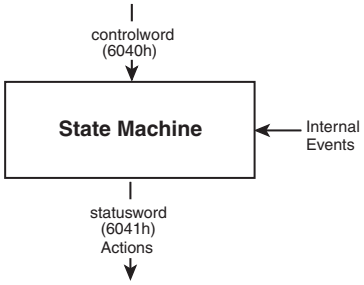

Figure State machine

8.1.3 Device states

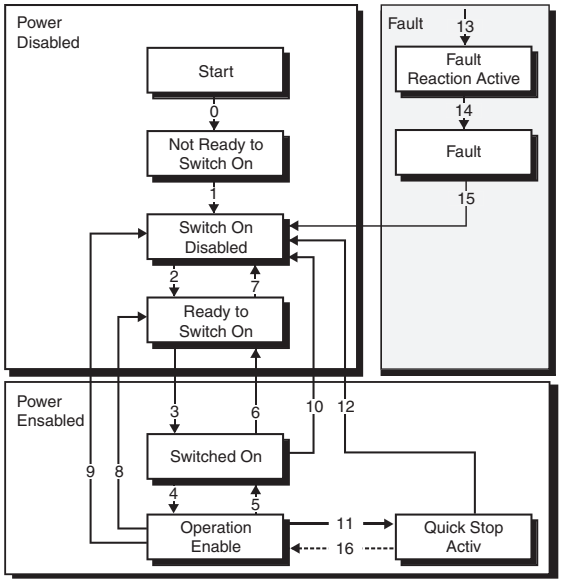

Figure State machine

The following device states are possible:

NOT READY TO SWITCH ON:
Only control voltage is connected to the drive.
The drive is initialised or is performing a self-test.
If installed, the brake engages in this state.
The drive function is deactivated.

SWITCH ON DISABLED: (Switch-on inhibit)
Drive initialisation is complete.
Drive parameters have been set.
Drive parameters have been changed.
No power to device (for safety reasons).
The drive function is deactivated.
"STO (Safe Torque Off)" Standstill and/or ENPO not active.

READY TO SWITCH ON:
Power is connected to the device.
Drive parameters have been changed.
Drive function is deactivated.

SWITCHED ON:
Power is connected to the device.
POWER AMPLIFIER is ready.
Drive parameters have been changed.
The drive function is deactivated.

OPERATION ENABLE:
No errors were detected.
Drive function is enabled and power is connected to motor.
Drive parameters have been changed.
(Relates to standard application of the drive.)

QUICK STOP ACTIVE:
Drive parameters have been changed.
QUICK STOP function being executed.
Drive function is enabled and power is connected to motor.
If the QUICK STOP OPTION CODE is set to 5 (remain at

QUICK STOP ACTIVE status), you cannot quit the QUICK STOP ACTIVE status, but you can switch to OPERATION ENABLE status with the ENABLE OPERATION command.

FAULT REACTION ACTIVE:
Drive parameters have been changed.
An error has occurred.
The QUICK STOP function has been executed.
Drive function is enabled and power is connected to motor.

FAULT:
Drive parameters have been changed.
An error has occurred, the error response has been executed.
Power disconnection and connection depends on the application.
The drive function is deactivated.

Bit combinations of the DRIVECOM state machine

Device control commands

The following bit combinations of control bits 0-3 and 7 form the device control commands for the state transitions of the state machine:

	Control word					
Command	7	3	2	1	0	Transitions
SHUTDOWN	0	X	1	1	0	2, 6, 8
POWER-UP	0	X	1	1	1	3
DISABLE POWER	0	X	X	0	X	7, 9, 10, 12
QUICK STOP	0	X	0	1	X	11
DISABLE OPERATION	0	0	1	1	1	5
ENABLE OPERATION	0	1	1	1	1	4
RESET FAULT	0>1	X	X	X	X	15

Device status table

The bits of the DRIVECOM status word presented below indicate the current system state:

	Status bit					
State	6	5	3	2	1	0
NOT READY	0	X	0	0	0	0
SWITCH-ON INHIBIT	1	X	0	0	0	0
READY	0	1	0	0	0	1
ON	0	1	0	0	1	1
OPERATION ENABLED	0	1	0	1	1	1
FAULT	0	X	1	0	0	0
FAULT REACTION ACTIVE	0	X	1	1	1	1
QUICK STOP ACTIVE	0	0	0	1	1	1

Table Bit combinations of the DRIVECOM state machine

8.2 Option codes

The devices support option codes for four different options for shutting down the drive. The four options are :

- HALT function - interrupt an ongoing movement
- Controller disable function - stop movement by cancelling the controller enable (software)
- Quick-stop function - stop movement by initiating a quick stop
- Error reaction function - stop movement in case of an error

For all variants, the option code sets the parameters for the desired device response.

CANopen	Function	Supported settings
Object 605Ah	Quick stop option code	0 to 8
Object 605Bh	Shutdown option code	-1 to 1
Object 605Ch	Disable operation option code	0 and 1
Object 605Dh	Halt Option Code	0 to 4
Object 605Eh	Fault Reaction Option Code	0 to 4

Table Option codes

The objects form part of the data set as standard parameters of the devices.

Note: The quick-stop ramp is always executed with the smoothing preset for the driving profile ramps. The error stop ramp is always executed without smoothing, even when smoothing is programmed.

8.3 Device control objects

The following table lists the implemented objects to control the drive:

Object No.	Object Name	Object Code	Type	Attr
0x6040	Control word	VAR	Unsigned16	rw
0x6041	Statusword	VAR	Unsigned16	ro
0x605A	Quick_Stop_Option_Code 0: disable drive function 1: slow down on slow down ramp 2: slow down on quick stop ramp 3: slow down on the current limit 4: slow down on the voltage limit 5: slow down on slow down ramp and stay in QUICK STOP 6: slow down on quick stop ramp and stay in QUICK STOP 7: slow down on the current limit and stay in QUICK STOP 8: slow down on the voltage limit and stay in QUICK STOP	VAR	Integer16	rw
0x605B	Shutdown_Option_Code -1: Response as per Quick_Stop_Option_Code 0: Disable Drive Function 1: slow down with slow down ramp; disable of the drive	VAR	Integer16	rw
0x605C	Disable_Operation_Option_Code 0: Disable Drive Function 1: Slow down with slow down ramp and then disabling of the Drive Function	VAR	Integer16	rw
0x605D	Halt_Option_Code 0: disable drive, motor is free to rotate 1: slow down on slow down ramp 2: slow down on quick stop ramp 3: slow down on the current limit 4: slow down on the voltage limit	VAR	Integer16	rw
0x605E	Fault_Reaction_Option_Code 0: disable drive, motor is free to rotate 1: slow down on slow down ramp 2: slow down on quick stop ramp 3: slow down on the current limit 4: slow down on the voltage limit	VAR	Integer16	rw
0x6060	Modes_Of_Operation 1: profile position mode 3: profile velocity mode 6: homing mode 7: Interpolated position mode 8: Cyclic sync position mode (ONLY EtherCAT) 9: Cyclic sync velocity mode (ONLY EtherCAT) 10: Cyclic sync torque mode (ONLY EtherCAT)	VAR	Integer8	wo
0x6061	Modes_Of_Operation_Display see 0x6060	VAR	Integer8	ro

Table Device control objects

8.4 Units and scalings, factor group

The DriveManager user interface offers a Scaling Wizard as a user-friendly means of configuring the scaling of mechanical and electrical units of variables necessary for control. The Wizard translates the application variables into representation of the parameters from the DS402 factor group. The parameters from the factor group are listed below, and can also be set directly by the user.

Correlations must be calculated externally and the final results entered in the relevant factor group parameter.

It is generally easier to have the Scaling Wizard calculate the parameter settings.

Note: The following objects are directly calculated in ServoOne:
- Position Factor
- Velocity Encoder Factor
- Acceleration Factor

The calculation is based on the objects stored in the formulae (e. g. feed constant, gear ratio etc.).
It is in fact possible to change these variables in DriveManager or via the bus, but they will be overwritten by the internal calculation as part of the control initialisation.

Note: In this section you will find an overview of the objects from the factor group and the underlying formulae for the calculation.
You will find practical examples for the implementation of scaling in the Application Manual.

Factor group as per DS402:

Object No.	Object Name	Object Code	Type	Attr.
0x607E	Polarity	VAR	Unsigned8	rw
0x6089	Position_Notation_Index	VAR	Integer8	rw
0x608A	Position_Dimension_Index Only display for scaling block	VAR	Unsigned8	rw
0x608B	Velocity_Notation_Index	VAR	Integer8	rw
0x608C	Velocity_Dimension_Index Only display for scaling block	VAR	Unsigned8	rw
0x608D	Acceleration_Notation_Index	VAR	Integer8	rw
0x608E	Acceleration_Dimension_Index Only display for scaling block	VAR	Unsigned8	rw
0x608F	Position_Encoder_Resolution	VAR	Unsigned8	rw
0x6090	Velocity_Encoder_Resolution	ARRAY	Unsigned32	rw
0x6091	Gear_Ratio	ARRAY	Unsigned32	rw
0x6092	Feed_Constant	ARRAY	Unsigned32	rw
0x6093	Position_Factor	ARRAY	Unsigned32	rw
0x6094	Velocity_Encoder_Factor	ARRAY	Unsigned32	rw
0x6097	Acceleration_Factor	ARRAY	Unsigned32	rw

Table Factor group

The objects of the factor group can be calculated and entered directly by the user, independently of the DriveManager Scaling Wizard. The corresponding encoder settings must be made however.

Calculation correlations factor group parameters

Object 608Fh: Position Encoder Resolution
The position encoder resolution defines the relationship between the encoder and motor revolutions

$$\text{Position Encoder Resolution} = \frac{\text{Encoder increments}}{\text{Motor revolutions}}$$

Object 6090h: Velocity Encoder Resolution
The velocity encoder resolution defines the relationship between the encoder increments per second and motor revolutions per second

$$\text{Velocity Encoder Resolution} = \frac{\text{Encoder } \frac{\text{Increments}}{\text{Seconds}}}{\text{Motor } \frac{\text{Revolutions}}{\text{Seconds}}}$$

Object 6091h: Gear Ratio
Gear ratio defines the transmission ratio of a gear in relation to the motor. It is defined as follows:

$$\text{Gear Ratio} = \frac{\text{Motor shaft revolutions}}{\text{Drive shaft revolutions}}$$

Object 6092h: Feed Constant
The feed constant defines the ratio of feed in position units per driving shaft revolutions. This includes the gear if present.

$$\text{Feed Constant} = \frac{\text{Feed}}{\text{Drive shaft revolutions}}$$

Object 6093h: Position Factor
The position factor converts the desired position (in position units) into the internal format (in increments).

$$\text{Position Factor} = \frac{\text{Position Encoder Resolution} \cdot \text{Getriebeübersetzung}}{\text{Feed constant}}$$

Object 6094h: Velocity Encoder Factor
The velocity encoder factor converts the desired velocity (in velocity units) into the internal format (in increments).

$$\text{Velocity Encoder Factor} = \frac{\text{Velocity Encoder Resolution} \cdot \text{Position encoder resolution} \cdot \text{Position unit} \cdot F_{\text{velocity (Notationsindex)}}}{\text{Feed constant} \cdot \text{Velocity unit} \cdot \text{Seconds} \cdot F_{\text{positon (Notationsindex)}}}$$

An example of $F_{\text{velocity (Notationsindex)}}$ or $F_{\text{positon (Notationsindex)}}$ would be 10^2 or 10^{-6}

Object 6097h: Acceleration Factor
The acceleration factor converts the acceleration (in acceleration unit/s) into the internal format (in increments).

$$\text{Acceleration Factor} = \frac{\text{Velocity unit} \cdot \text{Velocity Encoder Factor}}{\text{Acceleration unit} \cdot \text{Seconds}}$$

Object 607Eh: Polarity
The position reference value and position actual value are multiplied by 1 or -1 depending on the value of the polarity flag.

The same applies to the speed reference and actual speed value.

Please observe the operation of the object polarity as per DS402 V2.0.

Bits 0 to 5 = reserved (don't use)
Bit 6 = velocity polarity
Bit 7 = position polarity

Note: As in the case of the other objects in the factor group, changes in polarity only take effect if the control is switched off.

8.5 I/O map, object 60FDH

The status of inputs and outputs of the drive controller can be determined using various objects. Object 60FDh from device profile DS402 is implemented, as well as two manufacturer-specific objects.

8.5.1 Object 60FDh – Digital inputs

This object is implemented in compliance with device profile DS402. It allows digital input functions defined in the profile to be evaluated. That is, it offers no input map of existing physical inputs, but rather a function-related input map.

So it is irrelevant to which input, for example a limit switch is connected. Within the object the bit that defines the state of the limit switch is permanently defined.

Bit	Assignment
0	Negative limit switch
1	Positive limit switch
2	Home switch
3 to 15	Reserved
16 to 31	Manufacturer-specific (curr. not implemented)
18	"STO (Safe Torque Off)" input
19	ENPO

Table Object 60FDh – Digital inputs

8.5.2 Object 2079h – MPRO_INPUT_STATE

This manufacturer-specific object delivers an input map of all the digital inputs of ServoOne. The object is mappable and transferable by PDO. The assignment is as follows:

Bit	Assignment
0	State input ENPO
1	State input ISD00
2	State input ISD01
3	State input ISD02
4	State input ISD03
5	State input ISD04
6	State input ISD05
7	State input ISDSH
8 to 15	Don't use
16	State input ISD06
17	Don't use
18	State input ISA00
19	State input ISA01
30 to 31	Don't use

Table Object 2079h – MPRO_INPUT_STATE

9 Operation modes DS402

9.1 DS402 compatible operation modes

Devices of the ServoOne families support DS402 operation modes

- Profile position mode
- Profile velocity mode
- Homing mode
- Interpolated Position Mode
- Cyclic Synchronous Position Mode (EtherCAT only)
- Cyclic Synchronous Velocity Mode (EtherCAT only)
- Cyclic Synchronous Torque Mode (EtherCAT only)

The mode is switched by way of the CANopen object 6060h modes of operation. This switch is possible in the "Operation enable" (power to motor) state. The current operation mode is indicated in the CANopen object 6061h modes of operation display.

9.1.1 Parameter setting of ServoOne for activation via DS402:

For activation via CANopen (or CoE - EtherCAT) as per DS402 profile the following parameters must be set in the device:

No.	Name	Function	Setting
159	MPRO_CTRL_SEL	Control location selector	DS402
165	PRO_REF_SEL	Reference selector	DS402

Table Parameter setting of ServoOne

These parameters can be found under "Motion Profile" --> "Basic Settings"

If the drive is operated in a mode in which the internal profile generator is inactive and cyclic reference value are transferred (e. g. Cyclic Synchronous Position Mode), the interpolation time must be configured.

No.	Name	Function
306	CON_IpRefTs	Cycle time of the references in IP mode

Table Parameter setting of ServoOne

The interpolation time CON_IpRefTs represents the cycle time in which reference values from a higher-level controller are expected.

9.1.2 Control word DS402

Object 6040h-control word

The object is also mapped in the parameter 2208-MP_Controlword. The control word contains bits for:

- the controlling of the state,
- the controlling of operating modes and
- manufacturer-specific options.

The bits of the control word are defined as follows:

15 11	10 9	8	7	6 4	3	2	1	0
Manufacturer-specific	reserved	Stop	Fault reset	Operation mode specific	Enable operation	Quick stop	Enable voltage	Switch on
O	O	O	M	O	M	M	M	M

MSB LSB

O - Optional M - Mandatory

Table Control word DS402

Bits 0 - 3 and 7:
DEVICE CONTROL COMMANDS are triggered by the following schema in the control word:

Command	Bit of the control word					Transi-tions
	Fault reset	Enable operation	Quick-Stop	Enable-voltage	Switch on	
Shutdown	0	X	1	1	0	2, 6, 8
Switch on	0	0	1	1	1	3*
Switch on	0	1	1	1	1	3**
Disable voltage	0	X	X	0	X	7, 9, 10, 12
Quick Stop	0	X	0	1	X	7, 10, 11
Disable operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4, 16
Fault reset		X	X	X	X	15

bits marked X are irrelevant,
* ... In the state SWITCHED ON the drive executes the functionality of this state.
** .. There is no functionality in the state SWITCHED ON. The drive does not do anything in this state.

Table Device control commands

Bits 4 - 6 and 8

The bits 4 - 6 and 8 are interpreted differently depending on the active operation mode (object "modes of operation display").

Bit	Operation mode						
	Profile-position mode	Profile velocity-mode	Homing-mode	Inter-polated position mode	Cyclic synchro-nous position mode (Ether-CAT)	Cyclic synchro-nous velocity mode (Ether-CAT)	Cyclic synchro-nous torque mode (Ether-CAT)
4	New setpoint	reserved	Homing operation start	Enable IP mode	reserved	reserved	reserved
5	Change set immedia-tely	reserved	reserved	reserved	reserved	reserved	reserved
6	abs/rel	reserved	reserved	reserved	reserved	reserved	reserved
8	Stop	Stop	Stop	Stop	reserved	reserved	reserved

Table Mode-specific bits in the control word

Use of the specific bits is explained in more detail in the sections on the operation modes.

Bits 7 and 11- 15

Bit	Name	Value	Description
7	Fault reset	0 ⇨ 1	Fault reset
11			No function
. . .			No function
15			No function

9.1.3 Status word DS402

Object 6041h-status word

The content of the object is also mapped in parameter 2209 - MP_Statusword. The status word indicates the current status of the drive. It contains the following bits for:

- current state of the device,
- operating state of the mode and
- manufacturer-specific options.

Status word bits

Bit	Description	M/O
0	Ready to switch on	M
1	Switched on	M
2	Operation enabled	M
3	Fault	M
4	Voltage enabled	M
5	Quick stop	M
6	Switch on disabled	M
7	Warning	O
8	Manufacturer-specific	O
9	Remote	M
10	Target reached	M
11	Internal Limit active	M
12 - 13	Operation mode specific	O
14 - 15	Manufacturer-specific	O

Table Bits in the status word

Bits 0 - 3, 5 and 6:
These BITS indicate the STATUS of the controller.

Value (binary)	State
xxxx xxxx x0xx 0000	Not ready to switch on
Xxxx xxxx x1xx 0000	Switch on disabled
Xxxx xxxx x01x 0001	Ready to switch on
Xxxx xxxx x01x 0011	Switched on
Xxxx xxxx x01x 0111	Operation enabled
Xxxx xxxx x00x 0111	Quick stop active
Xxxx xxxx x0xx 1111	Fault reaction active
Xxxx xxxx x0xx 1000	Fault

Table Device state bits in the status word

Bit 4: Voltage enabled
Power supply connected.

Bit 5 Quickstop
In the LOW state this bit indicates that the controller is executing a “quick stop“. Bits 0, 1 and 2 of the status word are set to 1 when the drive is ready for operation. The other bits indicate additional states of the drive, such as execution of a “quick stop“. In the event of an error the FAULT bit is set.

Bit 7: Warning
Warnings such as temperature limits, are indicated in bit 7. In response to warnings the device state does not change. For more information on the warning given, refer to the FAULT CODE.

Bit 8: Manufacturer-specific
Currently not used.

Bit 9: Remote
Currently not used.

Bit 10: Target Reached
The bit is automatically set when a SETPOINT is reached. The setpoint depends on the OPERATING MODE. A change to the setpoint by the master changes this bit. With “quick stop“ OPTION CODE 5, 6, 7 or 8, this bit is set when the “quick stop“ ends. In response to a STOP request this bit is also set at a standstill.

Bit 11: Internal Limit active
This bit is set when internal limits are reached. This bit is dependent on OPERATION MODE.

Bits 12 and 13:
These bits are dependent on OPERATION MODE - see section 6.

The following table provides an overview:

Bit	Operation mode						
	Profile-position mode	Profile velocity-mode	Homing-mode	Inter-polated position mode	Cyclic synchro-nous position mode (Ether-CAT)	Cyclic synchro-nous velocity mode (Ether-CAT)	Cyclic synchro-nous torque mode (Ether-CAT)
12	Setpoint acknow-ledge	Speed	Homing attained	IP mode active	Target position ignored	Target velocity ignored	Target torque ignored
13	Following error	Max slippa-ge error	Homing error	reserved	Following error	reserved	reserved

Table Mode-specific bits in the control word

Bits 14 and 15:
These bits are implemented specific to manufacturer; explanatory notes to them are given in the sections on the various operation modes.

9.2 Profile Velocity Mode

This operation mode (mode of operation = 3) is used to activate the device at a velocity setpoint as per the DS402 profile. The drive is in speed control in this mode of operation.

The units, the reference and ramp variable are produced from the settings of the factor group. Also refer to the section 5.4 “Units and scalings“ in this regard.

The device supports the following objects for this mode:

Object No.	Object Name	Object Code	Type
0x606C	Velocity actual value	VAR	Int32
0x60FF	Target velocity	VAR	Int32
0x6094	Velocity encoder factor	ARRAY	Int32
0x6083	Profile acceleration	VAR	Int32
0x6084	Profile deceleration	VAR	Int32
0x6085	Quick Stop deceleration	VAR	UInt32
0x607E	Polarity	VAR	UInt8

Table Profile Velocity Mode

Structure of operation mode

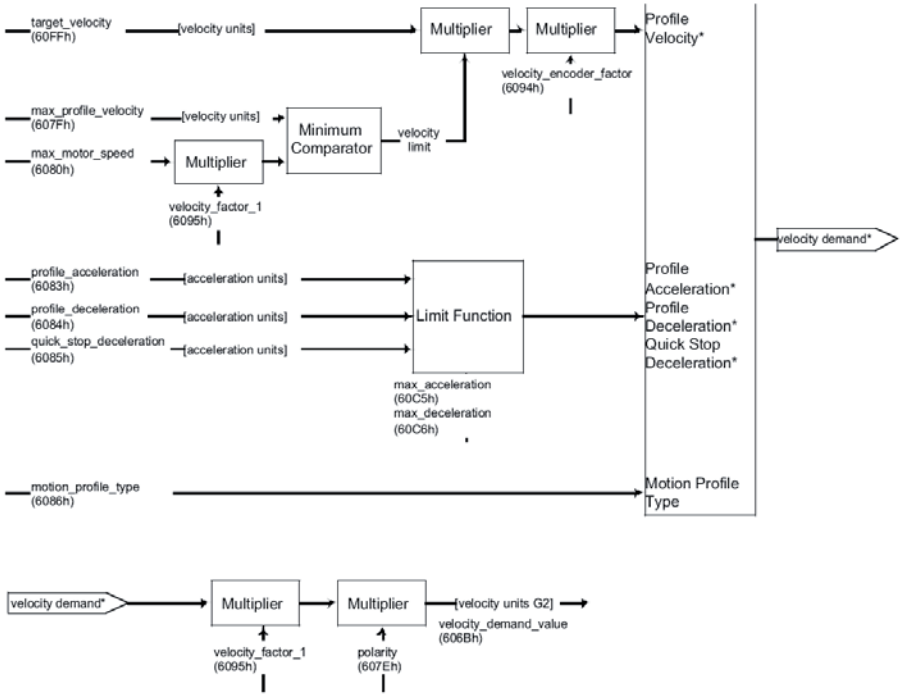

Figure Structure Profile Velocity Mode

9.2.1 Mode-dependent bits in the control word

The structure presented below is based on this operation mode:

Object No.	Object Name	Object Code	Type
8	Stop	0	Execute the motion
		1	Stop axle

Table Profile velocity mode bits of the status word

9.2.2 Mode-dependent bits in the status word

Object No.	Object Name	Object Code	Type
10	Target reached	0	Stop = 0: Target velocity not (yet) reached Stop = 1: Axle decelerates
		1	Stop = 0: Target velocity reached Stop = 1: Axle has velocity 0
12	Speed	0	Speed is not equal to 0
		1	Speed is equal to 0
13	Max. Slippage error	0	Maximum slippage not reached
		1	Maximum slippage reached
14	Rot 0	1	Axle at standstill Speed is much lower than parameter 745 MON_REFWINDOW

Table Profile velocity mode bits of the status word

9.3 Homing mode

This mode (Mode of operation = 6) is used to perform a homing of a position-controlled axle. The drive executes a movement according to the programmed reference run type (homing method).

The various homing methods differ in the integration of hardware limit switch, reference cam and zero pulse into the encoder system. It should be noted in this that, for limit switch and reference cam functionality, appropriate digital inputs should be configured:

Limit switch function
LCW - right side HW limit switch
LCCW - left side HW switch
HOMSW - reference cam

The following objects are supported by the device for this operation mode:

Object No.	Object Name	Object Code	Type	Attr.
0x607C	Home_Offset	VAR	Integer32	rw
0x6098	Homing_Method	VAR	Integer8	rw
0x6099	Homing_Speeds *	ARRAY	Unsigned32	rw
0x609A	Homing_Acceleration	VAR	Unsigned32	rw
* 0x6099.01 - Quick jog speed 0x6099.02 - Slow jog speed				

Table Homing mode

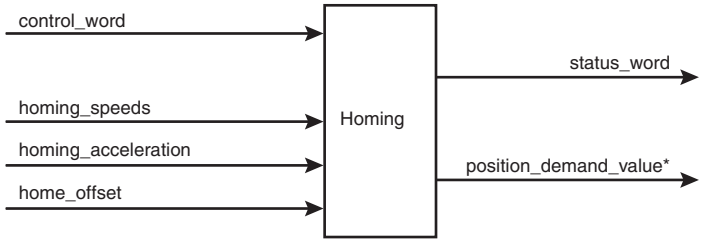

Figure Homing function

ServoOne supports all 35 homing methods defined in DS402.

The individual homing methods are described in the device application manuals with regard to their function and movement sequencing.

Home Offset:

The HOME OFFSET object is the difference between position 0 of the application and the HOME POSITION found during homing. It is represented in position units. At the end of a homing run the HOME OFFSET is added to the HOME POSITION found. All subsequent absolute positioning operations relate to this new home position.

A change in the referencing run type and the associated properties is possible in two ways. The reference run can be changed either via DriveManager or CAN.

For configuration via CANopen the objects of the homing mode can be directly addressed. For example, for a change to the reference run type, object 0x6098 can be changed.

9.3.1 Mode-specific bits in the control word

Bit 4 - HOMING OPERATION START
Bit 8 - STOP

Bit	Name	Value	Description
4	Homing operation start	0	Homing mode inactive
		0 ⇨ 1	Start homing mode
		0	Homing mode active
		1 ⇨ 0	Interrupt homing mode
8	Stop	0	Execute the instructions of bit 4
		1	Stop axle with profile deceleration

Table Homing Mode Bits of the control word

9.3.2 Mode-specific bits in the status word

Bit 10 - TARGET REACHED
Bit 12 - HOMING ATTAINED
Bit 13 - HOMING ERROR
Bit 14 - ROT_0

Bit	Name	Value	Description
10	Target reached	0	Stop = 0: Home position not reached Stop = 1: Axle decelerates
		1	Stop = 0: Home position reached Stop = 1: Axle has velocity 0
12	Homing attained	0	Homing mode not yet completed
		1	Homing mode carried out successfully
13	Homing error	0	No homing error
		1	Homing error occurred; Homing mode not carried out successfully The error cause is found by reading the error code
14	ROT_0	1	Axle at standstill Speed is much lower than parameter 745 MON_REFWINDOW

Table Homing Mode bits of the status word

9.4 Profile position mode

In this operation mode (mode of operation =1) the axle executes relative or absolute single positioning movements.

Object No.	Object Name	Object Code	Type	Attr.
0x607A	Target_Position	VAR	Integer32	rw
0x607d	Software Position Limit	ARRAY	Integer32	rw
0x6081	Profile_Velocity	VAR	Unsigned32	rw
0x6083	Profile_Acceleration	VAR	Unsigned32	rw
0x6084	Profile_Deceleration	VAR	Unsigned32	rw
0x6085	Quick Stop deceleration	VAR	Unsigned32	rw
0x6064	Position actual value	VAR	Integer32	r
0x607E	Polarity	VAR	UInt8	rw

Table Profile Position Mode

Units of the parameters are set by way of the Scaling Wizard or the objects from the factor group.

Structure of operation mode

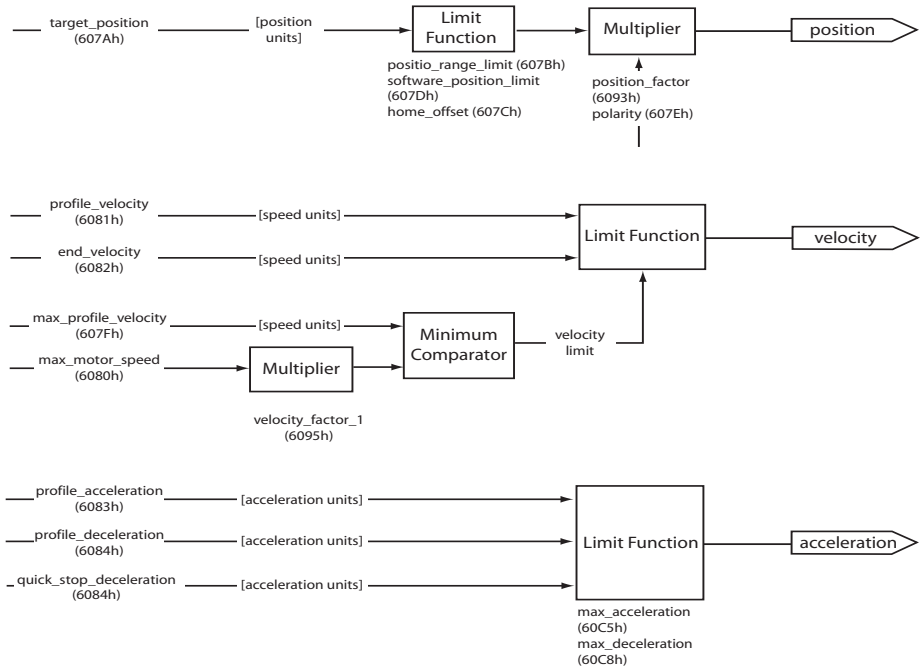

Figure Structure Profile Position Mode

9.4.1 Mode-specific bits in the control word

Bit 4 - New setpoint
Bit 5 - Change set immediately
Bit 6 - abs/rel
Bit 8 - Stop

Bit	Name	Value	Description
4	New setpoint	0	Does not assume target position
		1	Assume target position
5	Change set immediately	0	Finish the current positioning and then start the next positioning
		1	Interrupt the actual positioning and start the next positioning
6	abs/rel	0	Target position is an absolute value
		1	Target position is a relative value
8	Stop	0	Execute positioning
		1	Stop axle with profile deceleration (if not supported with profile acceleration)

Table Profile position mode bits of the control word

9.4.2 Mode-specific bits in the status word

Bit 10 - Target reached
Bit 12 - Set-point acknowledge
Bit 13 - Following error
Bit 14 - ROT_0

Bit	Name	Value	Description
10	Target reached	0	Stop = 0: Target position not reached Stop = 1: Axle decelerates
		1	Stop = 0: Target position reached Stop = 1: Velocity of axle is 0
12	Setpoint acknowledge	0	Trajectory generator has not assumed the positioning values (yet)
		1	Trajectory generator has assumed the positioning values
13	Following error	0	No following error
		1	Following error
14	ROT_0	1	Axle at standstill speed is much lower than parameter 745 MON_REFWINDOW

Table Profile Position Mode bits of the status word

9.4.3 Functional description

In this OPERATION MODE two different options for target position input are supported.

SET OF SETPOINTS:

When the target position is reached, the drive directly approaches the next target position; the axle is not stopped when the first target position is reached.

SINGLE SETPOINT:

When the target position is reached the drive indicates the fact to the master. Then the drive receives a new setpoint. At each target position the drive is stopped before being moved on to the next target position.

The two options are controlled by way of the timing of the NEW SETPOINT and CHANGE SET IMMEDIATELY bits in the control word and the SETPOINT ACKNOWLEDGE bit in the status word. These bits allow a new positioning operation to be initiated even while the current one is ongoing.

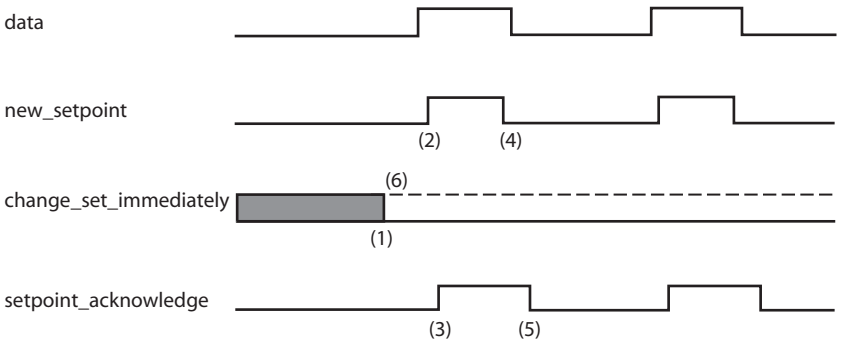

Figure Setpoint transmission from a host computer

If the "CHANGE SET IMMEDIATELY" bit is set to "0" (solid line in above diagram) a SINGLE SETPOINT is expected by the drive (1).

When the setpoint has been transmitted to the drive, the master activates the positioning by setting the ‚New setpoint' bit in the control word (2). The drive responds by setting the "Setpoint acknowledge" bit in the status word (3) once the new data has been detected and saved. Now the master can delete the "New setpoint" bit (4). Then the drive signals by deleting the "set-point acknowledge" bit that a new setpoint is accepted (5). In the diagram the mechanism initiates a speed 0 on reaching the target position at time t1. After the message indicating the target position has been reached, the next target position can be initiated at time t2.

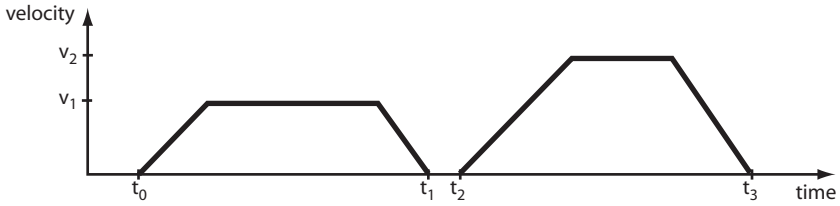

Figure Single setpoint

If the "CHANGE SET IMMEDIATELY" bit is set to "1" (broken line in Figure "Setpoint transmission"), the new target position is adopted immediately. In the Figure "Change Set Immediately" the drive receives the first target position at the time t0. At the time t1 the drive receives the second target position. The drive immediately implements the movement to the second target position.

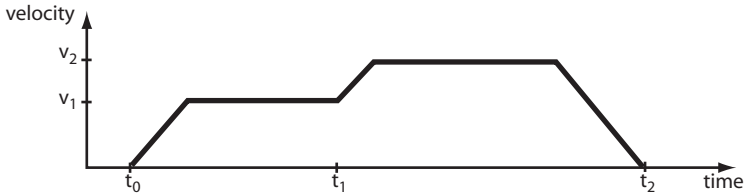

Figure Change set immediately

10 Emergency Objects

byte	0	1	2	3	4	5	6	7
Bit:	0 ... 15	16 ... 23	24 ... 39	40 ... 47		40 ... 47	48 ... 63	
Profile	Device Profile DS402			Drive controller				
Error	Emergency error code as per DS402		Error register (Object 1001 h)	Error number	Error location	Operating hours meter (in full hours)		

Table Emergency telegram

The decisive factors for rapid localization are the error code and error location. In byte 3 of the emergency telegram you will find the error code, which provides an initial categorisation of the cause of the error. The precise cause of the error is specified by the error location in byte 4. Bytes 5, 6 and 7 contain the internal operating hours meter of the device.

CANopen errors - i.e. incorrect configurations, bus disturbances etc. - are indicated by error code 0xFF00.

Note: When an error occurs the controller executes a response as per the parameterised error response. These can be set separately for individual errors.

Note: The state displays of the 7-segment display are explained in the Application Manual.

10.1 Error acknowledgement, general

Device errors can be acknowledged by the following mechanisms:

- Control word bit 7, edge-controlled
- Control input with programmed reset functionality
- Hardware enable ENPO to control terminal
- Operation via two buttons
- Drive Manager user interface
- Writing the value 1 to parameter 153 MPRO_DRVCOM_FaultReset by way of the control unit or bus system

Note: For a detailed list of all error messages together with remedial messages refer to the Application Manual ServoOne on our product CD.

10.2 Error acknowledgment via bus system

Another possibility is offered by the object 6040 h Control Word:

Draft 402	6040h	VAR	Control word	Integer16	rw	M

An error acknowledgement is executed by a rising edge at bit 7 in the control word. Resetting of the error is signalled by transmission of the following emergency message:

ID	Data bytes	Description
Emergency	00 00 00 00 00 00 00 00	Emergency message acknowledgment error

Table Error acknowledgement

If the cause of the error is not eliminated, the drive controller returns to the error state after transmission of another emergency message.

11 EDS File, Object Directory Parameter List

11.1 EDS file, object directory

An EDS file is available for the devices to integrate them into the CAN master. The file is shipped with the firmware. It contains all the CAN objects of the drive controllers.

Note: ServoOne has parameters with default values in the device that may deviate from the default values in the EDS file. These are power-stage specific parameters with contents that are dependent on the size. Examples of such parameters are:
Para 302 – CON_SwitchFreq
Para 307 – CON_VoltageSupply
Para 651 – DV_CAL_VDC

12 Bibliography

Operation Manual ServoOne	LUST Antriebstechnik GmbH Gewerbestrasse 5 - 9 35633 Lahnau http://www.lust-antriebstechnik.de
User Manual ServoOne	LUST Antriebstechnik GmbH Gewerbestrasse 5 - 9 35633 Lahnau http://www.lust-antriebstechnik.de
CiA DS-301 (Rev. 4.0): Application Layer and Communication Profile	http://www.can-cia.org/
CiA DSP-402 (Rev. 2.0): Device Profile Drives and Motion Control	http://www.can-cia.org/
EtherCAT Communication Specification Version 1.0 2004	http://www.ethercat.org/
EtherCAT Indicator Specification Proposal V0.91 2005	http://www.ethercat.org/
IEC61158-2-12 to IEC61158-6-12	

13 Appendix Glossary

CiA:	(“CAN in Automation”). CAN bus user group, generally defines a protocol for automation.
CAL:	(CAN Application Layer) CiA protocol, primarily describes the way in which variables are transmitted without defining their function or content. Subsets: CMC: (CAN based Message Specification). Sets out the definition described above. Is accepted by most CAN suppliers. LUST conforms to this definition. NMT: (Network Management). Required for masters in the CAN system. Not implemented by LUST because drive controllers are always slaves and have no “control function“. LMT: (Layer Management). See NMT DBT: (Identifier Distributor). See NMT
CANopen:	Based on CAL definition Corresponds to CiA Draft Standard 301 Extends the CAL definition to include function and unit assignment of the predefined variables This definition is being drafted by CiA and various user groups (MOTION for drive technology and I/O for inputs/outputs) (e. g. variable for torque in Nm).

General points on the various protocol definitions

CAL:	Mainly in use in Europe, LUST has currently implemented a protocol which can be activated by a CAL master. The initialisation is simpler than CAL (CCDA), for example addressing by way of jumper, which has no influence on operation.
DeviceNet:	Mainly in the USA (corresponds to CAL definition).

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