

CANOpen Implementation Guide V1.0



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2 Introduction

2.1 Scope

This manual describes, in detail, the CANOpen implementation of Motor Power Company Devices.

2.2 CANopen

CANopen is a standard established by the association "CAN in Automation". A great number of device manufacturers are organized in this association. This standard has replaced most of all manufacturer-specific CAN protocols, now a manufacturer independent communication interface is available for the user:

CiA Draft Standard 201...207: In these standards the general network administration and the transfer of objects are determined. This book is rather comprehensive. The relevant aspects are treated in the CANopen manual in hand so that it is not necessary in general to acquire the DS201..207.

CiA Draft Standard 301: In this standard the basic structure of the object dictionary of a CANopen device and the access to this directory are described. Besides this the statements made in the DS201..207 are described in detail. The elements needed for the the object directory and the access methods which belong to them are described in the present manual. It is advisable to acquire the DS301 but not necessary.

CiA Draft Standard 402: This standard describes the concrete implementation of CANopen in servo controllers. Though all implemented objects are also briefly documented and described in this CANopen manual the user should own this book.

Any information on CANOpen protocol can be found at <http://www.can-cia.de>.

2.3 Cabling and pin assignment

Follow the installation Guide of each device to find out the correct pinout configuration.



Please carefully respect the following information and notes for the cabling of the controller to get a stable and undisturbed communication system. A non-professional cabling can cause malfunctions of the CAN bus which hence the controller to shut down with an error.

2.4 Cabling Hints

The CAN bus offers an easy and safe way to connect all parts of a plant. As condition all following instructions must be respected carefully.

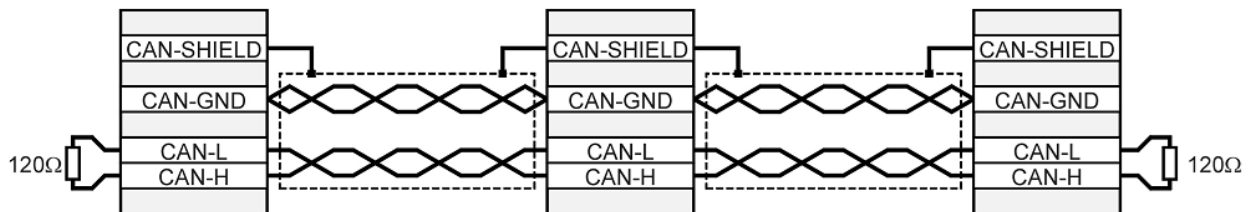


Image 1: Can Bus Cabling

- X All nodes of a network are principally connected in series, so that the CAN cable is looped through all controllers.
- X The two ends of the CAN cable must be terminated by a resistor of $120\Omega \pm 5\%$. Please note that such a resistor is often already installed in CAN cards or the PLC.
- X For cabling shielded cable with exactly two twisted pairs must be used.
 - One twisted pair is used for CAN-H and CAN-L.

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- One twisted pair is used commonly for CAN-GND.
- The shield of the cable is connected to CAN-SHIELD at all nodes.
- X A table with technical data of suitable cables can be found at the end of this chapter.
- X Recommended cables can be found in the product manual.
- X We dissuade from using connectors in between the CAN bus line. If it is still necessary to
 - X use connectors, assure that the connection of the shield is done by using metallic cases.
 - X For less noise injection principally
 - never place motor cables parallel to signal cables.
 - use only motor cables specified by Motor Power Company.
 - shield and earth motor cables correctly.
- X For further information refer to the Controller Area Network protocol specification, Ver. 2.0, Robert Bosch GmbH, 1991.
- X Technical data CAN bus cable:
 - 2 twisted pairs, $d \geq 0,22 \text{ mm}^2$ shielded
 - loop resistance $< 0,2 \text{ } \Omega/\text{m}$
 - char. impedance 100-120 Ω



120 Ω Termination resistor

No termination resistor is integrated in Motor Power Company Devices.

3 CANopen Basics

This chapter describes — in general — the CANopen communication features most relevant to Motor Power Company Devices. More detailed information is available in the specific CANopen documentation.

3.1 Physical Layer

CAN is a serial communication standard in which the transferred data is coded as electrical pulses on a two-wire communication line. The device that handles the CAN physical layer is

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called the CAN controller. The device that transmits data over the CAN lines is called the CAN transceiver.

For all the information regarding the connection, please check the Device Installation Guide Manual.

3.2 Client - Server relations

A CAN master (or client) is a controller that makes requests to nodes to respond to its commands. A CAN slave (or server) responds to the commands issued by the CAN master. The CAN protocol permits both single-master and multiple-master networks.

The Device assume a single-master network arrangement, in which the devices are the slaves and the machine controller or PLC is the master.

Every servo drive has a unique ID in the range [1...127]. The network master does not require an ID. As slave, the device never sends an unrequested message, other than emergencies. The drive responds only to messages addressed to its ID or to broadcast messages, which have an ID of 0. All messages sent by a servo drive are marked with its own ID.



If two servo drives have been assigned the same ID, the CAN network may crash.

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3.3 Object Dictionary

An object dictionary (OD) is a naming system that gives a unique identifier to each data item — or “object” — that is communicated over the CAN bus. An object is identified by an index and, if it is a complex object, also by a sub-index. A CANopen client can manipulate an object of a CANopen server by referring to its identifier, according to the access permission of the object. (An object’s access permission may be read-only, write-only, or read-write.)

CiA DS 301 requires a set of mandatory objects for all CANopen devices. Other OD items are predefined by CiA DS 301 to have fixed identifiers, if supported. The OD also accommodates manufacturer-specific objects.

3.4 Communication Objects

The data-byte units transported through a CAN network are called communication objects (COBs). The Device uses the following COB types:

COB Type	Description
Network Management (NMT)	NMT objects are used by CAN clients to initialize a servo drive as a server.
Emergency (EMCY)	Emergency messages are used by the servo drives to warn of an exception. The EMCY is the only COB type that a servo drive may transmit without first being explicitly asked. EMCY objects are like servo drive “interrupts”: they eliminate the need to poll the servo drive continuously for the emergency status.
Process data object (PDO)	PDO messages are used to manipulate OD objects without explicit reference to the object identifier, which is possible if there is an a-priori convention concerning the OD item referenced. Such conventions are called “PDO mappings”; these are actually OD objects themselves and may be defined and manipulated using an SDO.
Service data object (SDO)	SDO messages are used to manipulate OD objects according to their IDs. The server receives the SDO, which specifies in its message which object is to be dealt with. SDO messages can be chained to form a “domain transfer,” which is useful for sending large data items such as long strings. Domain transfers are time-consuming because the CAN bus is

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half-duplex. Each time a data segment is downloaded, a full-sized data segment is uploaded for verification, and vice versa.

Table 1: Communication Object used by Device

The type of COB transmitted is indicated in the arbitration field of the message, and thereby determines its priority. The relation between bits 8 to 11 of the arbitration field (COB-ID) and the COB type is presented in the following table:

COB Type	Bits 8-11 COB-ID	ID Range
NMT	0000	0
SYNC	0001	128 (80 _h)
Time Stamp	0010	256 (100 _h)
Emergency	0001	129 .. 255 (81 _h .. 255 _h)
PDO1 – Transmit	0011	513 .. 639 (181 _h .. 1FF _h)
PDO1 – Receive	0100	641 .. 767 (281 _h .. 2FF _h)
PDO2 – Transmit	0101	897 .. 1023 (381 _h .. 3FF _h)
PDO2 – Receive	0110	
PDO3 – Transmit	0111	
PDO3 – Receive	1000	
PDO4 – Transmit	1001	
PDO4 – Receive	1010	
SDO – Transmit	1011	
SDO – Receive	1100	
Error control (node guarding)	1110	1739 .. 1919 (701 _h .. 77FF _h)

3.5 Object Dictionary data types

The Device CAN controller supports the following data types:

Index	Object	Name
0002	DEFTYPE	Integer8
0003	DEFTYPE	Integer16

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0004	DEFTYPE	Integer32
0005	DEFTYPE	Unsigned8
0006	DEFTYPE	Unsigned16
0007	DEFTYPE	Unsigned32
0008	DEFTYPE	Floating Point(Float)
0009	DEFTYPE	Visible String
0020	DEFSTRUCT	PDO communication parameter
0021	DEFSTRUCT	PDO Mapping
0023	DEFSTRUCT	Identity
0081	DEFTYPE	DSP 402 Interpolated data record

Data Objects 0002 to 0004 are used as map able “dummy” entries.

3.6 The Object Dictionary

The most important part of a device profile is the Object Dictionary description. The Object Dictionary is essentially a grouping of objects accessible via the network in an ordered pre-defined fashion. Each object within the dictionary is addressed using a 16-bit index.

The overall layout of the standard Object Dictionary is shown below. This layout closely conforms with other industrial serial bus system concepts:

Index (hex)	Object
0000	Not used
0001-001F	Static data types
0020-003F	Complex data types
0040-005F	Manufacturer specific Complex data types
0060-007F	Device Profile Specific Static Data Types
0080-009F	Device Profile Specific Complex Data Types
00A0-0FFF	Reserved for further us
1000-1FFF	Communication Profile Area
2000-5FFF	Manufacturer Specific Profile Area
6000-9FFF	Standardized Device Profile Area

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A000-FFFF	Reserved for further use
-----------	--------------------------

The Object Dictionary may contain a maximum of 65536 entries which are addressed through a 16-bit index.

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3.7 Service data Objects SDO

Motor Power Company Devices use a single transmit server SDO (COB 581h-6ffh) and a single receive server SDO (COB601h-67fh). This is according to CiA definitions and priority allocations for 11-bit addressing.

When using SDOs, it is important to remember that:

- ✓ An SDO has a lower priority than a PDO.
- ✓ An SDO session is not complete until it is confirmed.

For example, if an SDO is used to change a PDO mapping, the SDO should be issued only after the last session in which the PDO is completed, and the newly-mapped PDO should not be used until the SDO mapping change is confirmed.

3.8 Initiate SDO Download Protocol

This protocol is used to implement the Initiate SDO Download service for SDOs.

Client to server:

Byte 0					Byte 1 – 3	Byte 4 - 7
7..5	4	3..2	1	0	-	-
css=1	x	N	e	s	m	d (data)

Server to client:

Byte 0		Byte 1 – 3	Byte 4 - 7
7..5	4..0	-	-
scs=3	x	m	reserved

Where:

css	Client command specifier 1: Initiate download request
scs	Server command specifier 3: Initiate download response
n	Number of bytes in d that do not contain data. Only valid if e = 1 and s = 1; otherwise it is 0. Bytes [8-n, 7] do not contain data.
e	Transfer type 0: Normal transfer 1: Expedited transfer
s	Size indicator 0: Data set size is not indicated 1: Data set size is indicated
m	Multiplexor. Represents index/sub-index of data to be transferred by SDO.
d	Data e = 0, s = 0: d is reserved for future use. e = 0, s = 1: d contains number of bytes to be downloaded. Byte 4 contains LSB and byte 7 contains MSB. e = 1, s = 1: d contains data of length 4-n to be downloaded. The encoding depends on the type of data referenced by index and sub-index. e = 1, s = 0: d contains an unspecified number of bytes to be downloaded.
x	Not used; always 0.
reserved	Reserved for future use; always 0.

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3.9 Download SDO Segment Protocol

This protocol is used to implement the Download SDO Segment service.

Client to server:

Byte 0				Byte 1 – 7
7..5	4	3..1	0	-
css=0	t	n	c	Segment - data

Server to client:

Byte 0				Byte 1 – 7
7..5	4	3..0		-
css=1	t	x		reserved

Where:

- ccs:** client command specifier
0: download segment request
- scs:** server command specifier
1: download segment response
- seg-data:** at most 7 bytes of segment data to be downloaded. The encoding depends on the type of the data referenced by index and sub-index
- n:** indicates the number of bytes in seg-data that do not contain segment data. Bytes [8-n, 7] do not contain segment data. n = 0 if no segment size is indicated.
- c:** indicates whether there are still more segments to be downloaded.
0 more segments to be downloaded
1: no more segments to be downloaded
- t:** toggle bit. This bit must alternate for each subsequent segment that is downloaded. The firstnsegment will have the toggle-bit set to 0. The toggle bit will be equal for the request and the response message.
- x:** not used, always 0

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reserved: reserved for further use, always 0

3.10 Initiate SDO Upload Protocol

This protocol is used to implement the Initiate SDO Upload service.

Client to server:

Byte 0		Byte 1 – 3	Byte 4 – 7
7..5	4..0	-	-
css=2	x	m	reserved

Server to client:

Byte 0					Byte 1 – 3	Byte 4 - 7
7..5	4	3..2	1	0	-	-
css=2	x	n	e	s	m	d (data)

Where:

ccs: client command specifier

2: initiate upload request

scs: server command specifier

2: initiate upload response

n: Only valid if e = 1 and s = 1, otherwise 0. If valid it indicates the number of bytes in d that do not contain data. Bytes [8-n, 7] do not contain segment data.

e: transfer type

0: normal transfer

1: expedited transfer

s: size indicator

0: data set size is not indicated

1: data set size is indicated

m: multiplexor. It represents the index/sub-index of the data to be transfer by the SDO.

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- d:** data
 $e = 0, s = 0$: d is reserved for further use.
 $e = 0, s = 1$: d contains the number of bytes to be uploaded.
 Byte 4 contains the lsb and byte 7 contains the msb.
 $e = 1, s = 1$: d contains the data of length 4-n to be uploaded,
 the encoding depends on the type of the data referenced by index and
 sub-index $e = 1, s = 0$: d contains unspecified number of bytes to be
 uploaded.
- x:** not used, always 0

reserved: reserved for further use , always 0

3.11 Upload SDO Segment Protocol

This protocol is used to implement the Upload SDO Segment service.

Client to server:

Byte 0			Byte 1 – 7
7..5	4	3..0	-
css=2	t	x	reserved

Server to client:

Byte 0				Byte 1 – 7
7..5	4	3..1	0	-
css=0	t	n	c	Segment - data

Where:

- ccs:** client command specifier
 3: upload segment request
- scs:** server command specifier
 0: upload segment response

- t:** toggle bit. This bit must alternate for each subsequent segment that is uploaded. The first segment will have the toggle-bit set to 0. The toggle bit will be equal for the request and the response message.
- c:** indicates whether there are still more segments to be uploaded.
 0: more segments to be uploaded
 1: no more segments to be uploaded
- seg-data:** at most 7 bytes of segment data to be uploaded. The encoding depends on the type of the data referenced by index and sub-index
- n:** indicates the number of bytes in seg-data that do not contain segment data. Bytes [8-n, 7] do not contain segment data. n = 0 if no segment size is indicated.
- x:** not used, always 0
- reserved:** reserved for further use, always 0

3.12 Abort SDO Transfer Protocol

This protocol is used to implement the Abort SDO Transfer Service.

Client to server:

	Byte 0	Byte 1 – 3	Byte 4 – 7
7..5	4..0	-	-
cs=4	x	m	d (data)

Where:

- cs:** command specifier
 4: abort transfer request
- x:** not used, always 0
- m:** multiplexor. It represents index and sub-index of the SDO.
- d:** contains a 4 byte abort code about the reason for the abort.

the abort code is encoded as UNSIGNED32 value.

Abort Code	Description
0503 0000h	Toggle bit not alternated.
0504 0000h	SDO protocol timed out.
0504 0001h	Client/server command specifier not valid or unknown.
0504 0002h	Invalid block size (block mode only).
0504 0003h	Invalid sequence number (block mode only).
0504 0004h	CRC error (block mode only)
0504 0005h	Out of memory.
0601 0000h	Unsupported access to an object.
0601 0001h	Attempt to read a write only object.
0601 0002h	Attempt to write a read only object.
0602 0000h	Object does not exist in the object dictionary.
0604 0041h	Object cannot be mapped to the PDO.
0604 0042h	The number and length of the objects to be mapped would exceed PDO length.
0604 0043h	General parameter incompatibility reason.
0604 0047h	General internal incompatibility in the device.
0606 0000h	Access failed due to an hardware error.
0607 0010h	Data type does not match, length of service parameter does not match
0607 0012h	Data type does not match, length of service parameter too high
0607 0013h	Data type does not match, length of service parameter too low
0609 0011h	Sub-index does not exist.
0609 0030h	Value range of parameter exceeded (only for write access).
0609 0031h	Value of parameter written too high.
0609 0032h	Value of parameter written too low.
0609 0036h	Maximum value is less than minimum value.
0800 0000h	general error
0800 0020h	Data cannot be transferred or stored to the application.
0800 0021h	Data cannot be transferred or stored to the application because of local control.
0800 0022h	Data cannot be transferred or stored to the application because of the present device state.
0800 0023h	Object dictionary dynamic generation fails or no object dictionary is present (e.g. object dictionary is generated from file and generation fails because of an file error).

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The abort codes not listed here are reserved.

3.13 Example using SDO expedited Transfer

Here below some sample for reading and writing different objects:

UINT8/INT8

Reading Object: 6061-00h

Returning data: 01h

Command:	40 _h	61 _h	60 _h	00 _h
Answer:	4F _h	61 _h	60 _h	00 _h 01 _h

Writing Object: 1401-02h

Data: EFh

Command:	2F _h	01 _h	14 _h	02 _h	EF _h
Answer:	60 _h	01 _h	14 _h	02 _h	

UINT16/INT16

Reading Object: 6041-00h

Returning data: 1234h

Command:	40 _h	41 _h	60 _h	00 _h
Answer:	4B _h	41 _h	60 _h	00 _h 34 _h 12 _h

Writing Object: 6040-00h

Data: 03E8h

Command:	2B _h	40 _h	60 _h	00 _h	E8 _h	03 _h
Answer:	60 _h	01 _h	60 _h	00 _h		

UINT32/INT32

Reading Object: 6093-01h

Returning data: 12345678h

Command:	40 _h	93 _h	60 _h	01 _h				
Answer:	43 _h	93 _h	60 _h	01 _h	78 _h	56 _h	34 _h	12 _h

Writing Object: 6093-01h
Data: 12345678h

Command:	23 _h	93 _h	60 _h	01 _h	78 _h	56 _h	34 _h	12 _h
Answer:	60 _h	93 _h	60 _h	01 _h				

Always wait for the acknowledge of the controller!
Only if a request has been acknowledged by the controller it can send the next request.

3.14 Process data Objects PDO

Process Data Objects (PDOs) are suitable to transmit data event-controlled, whereat the PDO contains one or more predefined parameters. In contrast to SDOs no handshake is used. So the receiver has to be able to handle an arriving PDO at any time. In most cases this requires a great deal of software in the host computer. This disadvantage is in contrast to the advantage that the host computer does not need cyclically inquiry of the objects embedded in a PDO, which means a strong reduction of bus load.

Following types of PDO can be used:

Transmit PDO (TPDO)	Device → Host	Servo controller sends PDO if a certain event occurs
Receive PDO (RPDO)	Host → Device	Servo controller evaluates PDO if a certain event occurs

The servo controller disposes of four Transmit- and four Receive-PDOs. Almost all parameters can be embedded (mapped) into a PDO, i.e. the PDO is for example composed of the velocity actual value, the position actual value or the like.

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3.15 Emergency Object (EMCY)

Emergency objects are triggered by the occurrence of a device internal error situation and are transmitted from an emergency producer on the device. Emergency objects are suitable for interrupt type error alerts. An emergency object is transmitted only once per 'error event'. As long as no new errors occur on a device no further emergency objects must be transmitted.

The emergency object may be received by zero or more emergency consumers. The reaction on the emergency consumer(s) is not specified and does not fall in the scope of this document.

By means of this specification emergency error codes and the error register are specified.

3.16 Emergency object data

The Emergency Telegram consists of 8 bytes with the data as shown below.

Byte	0	1	2	3	4	5	6	7
Content	Emergency Error Code		Error register (Object 1001H)	Manufacturer specific Error Field				

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3.17 Synchronization Object (SYNC)

The Synchronization Object is broadcasted periodically by the SYNC producer. This SYNC provides the basic network clock. The time period between the SYNCs is specified by the standard parameter communication cycle period (see Object 1006h: Communication Cycle Period), which may be written by a configuration tool to the application devices during the boot-up process. There can be a time jitter in transmission by the SYNC producer corresponding approximately to the latency due to some other message being transmitted just before the SYNC.

In order to guarantee timely access to the CAN bus the SYNC is given a very high priority identifier (1005h).

COB-ID=0080h	NO DATA
--------------	---------

3.18 Network Management (NMT)

NMT commands are used to control the communication state of the servo drive and to broadcast manufacturer messages to all other connected servo drives.

The NMT message contains only 2 data byte, with the following format:

COB-ID=0000h	NMT-command	node-id
--------------	-------------	---------

The following network communication states are supported, with the following communication type.

State	Description	SDO	PDO	NMT	SYNC
Inizialization	Servo drive is not ready, or it is booting. Drive will not respond to communication and will not transmit anything.	-	-	-	-
Pre-operational	Servo drive boot sequence is complete, but no command has been received to enter operational mode. The servo drive will	X	-	X	X

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	respond to SDO and NMT messages, but not to PDOs.				
Operational	Servo drive is fully operational, responding to PDO, SDO and NMT messages.	X	X	X	X
Stopped	Servo drive can respond only to NMT objects (including heartbeats).	-	-	X	-

Tabella 2: Network Management

Here below we can find the NMT state machine with all the allowed transitions.

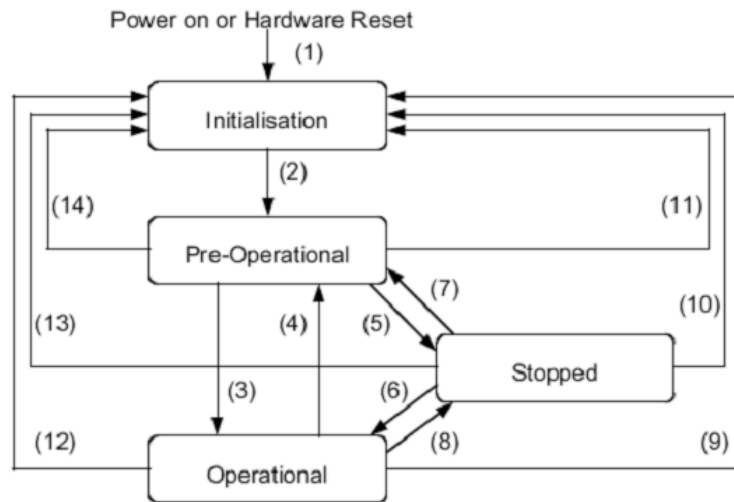


Image 2: State diagram

The transition (2) from Initialization state to Pre-Operational state is done automatically by the servo.

The following NMT commands are supported:

Command Specifier	Service
1 (01 _h)	Start Remote Node (3)(6)
2 (02 _h)	Stop Remote Node (8)(5)
128 (80 _h)	Enter Pre-Operational state (4)(7)
129 (81 _h)	Reset node (12)(13)(14)

130 (82h) Reset communication (9)(10)(11)

3.19 The Bootup protocol

This protocol is used to signal that an NMT slave has entered the pre-operational node state after the initializing state. The protocol uses the same identifier as the error control protocols.

COB-ID=1792+node-id	0
---------------------	---

Only one byte with 0 (zero) value is transmitted.

4 Communication Profile

This chapter define all the Device object available in the communication profile area of the Object Dictionary.

4.1 Object 1000h – Device Type

This object contains information about the device type and functionality. It is comprised of a 16-bit field that describes the device profile used, and a second 16-bit field that gives additional information about optional functionality of the device.

MSB		LSB	
BYTE 4	BYTE 3	BYTE 2	BYTE 1
Additional Information		Device profile Number	

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Index	1000h
Name	Device type
Object code	VAR
Data Type	UNSIGNED32
Category	Mandatory

Entry Description:

Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	0x191

4.2 Object 1001h – Error Register

This object is an error register for the device.

Object Description:

Index	1001h
Name	Error Register
Object code	VAR
Data Type	UNSIGNED8
Category	Mandatory

Entry Description:

Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED8
Default Value	0x0

Data description:

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bit	Meaning
0	Generic Error
1	Current
2	Voltage
3	Temperature
4	Communication Error
5	Device Profile Specific
6	Reserved
7	Manufacturer Specific

If a bit is set to 1, the specified error has occurred.

4.3 Object 1003h – Pre-defined error field

The object at index 1003h holds the errors that have occurred on the device and have been signaled via the Emergency Object. In doing so it provides an error history.

1. The entry at sub-index 0 contains the number of actual errors that are recorded in the array starting at sub-index 1.
2. Every new error is stored at sub-index 1, the older ones move down the list.
3. Writing a „0“ to sub-index 0 deletes the entire error history (empties the array).
4. The error numbers are of type UNSIGNED32 and are composed of a 16 bit error code and a 16 bit additional error information field which is manufacturer specific. The error code is contained in the lower 2 bytes (LSB) and the additional information is included in the upper 2 bytes (MSB). The Error list contain 8 elements.

MSB		LSB	
BYTE 4	BYTE 3	BYTE 2	BYTE 1
Additional Information		Error Code	

Object Description:

Index	1003h
Name	Pre-defined error field
Object code	ARRAY

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Data Type	UNSIGNED32
Category	Optional

Entry Description:

Sub-Index	0
Description	Number of actual error
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	0x0

Sub-Index	01 - 08
Description	Standard Error Field
Entry Category	Mandatory
Access	Read
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	0x0

4.4 Object 1005h - COB-ID SYNC message

This object defines the COB-ID of the synchronization object (SYNC).

MSB				LSB	
31	30	29	28-11	10-0	
x	0	0	0	11-bit identifier	

Object Description:

Index	1005h
Name	COB-ID SYNC message

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Object code	VAR
Data Type	UNSIGNED32
Category	Mandatory

Entry Description:

Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	0x80

4.5 Object 1006h - Communication Cycle Period

This object defines the communication cycle period in μs . This period defines the SYNC interval. It is 0 if not used. If the communication cycle period on sync producer is changed to a new value unequal 0 the transmission of sync object resumes within 1 sync cycle of the new value.

Object Description:

Index	1006h
Name	Communication Cycle Period
Object code	VAR
Data Type	UNSIGNED32
Category	Conditional; Mandatory for sync producers

Entry Description:

Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	0x0

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4.6 Object 1007h - Synchronous Window Length

Contains the length of the time window for synchronous PDOs in ms. It is 0 if not used.

Object Description:

Index	1007h
Name	Communication Cycle Period
Object code	VAR
Data Type	UNSIGNED32
Category	Optional

Entry Description:

Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	0x0

4.7 Object 1008h: Manufacturer Device Name

Contains the manufacturer device name.

Object Description:

Index	1008h
Name	Manufacturer Device Name
Object code	VAR
Data Type	Visible String
Category	Optional

Entry Description:

Access	Read Only
PDO Mapping	NO
Value Range	-

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Default Value	-
---------------	---

4.8 Object 1009h: Manufacturer Hardware Version

Contains the manufacturer hardware version description.

Object Description:

Index	1009 _h
Name	Manufacturer Hardware Version
Object code	VAR
Data Type	Visible String
Category	Optional

Entry Description:

Access	Read Only
PDO Mapping	NO
Value Range	-
Default Value	-

4.9 Object 100Ah: Manufacturer Software Version

Contains the manufacturer software version description.

Object Description:

Index	1008 _h
Name	Manufacturer Software Version
Object code	VAR
Data Type	Visible String
Category	Optional

Entry Description:

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Access	Read Only
PDO Mapping	NO
Value Range	-
Default Value	-

4.10 Object 1010h - Save parameters

This object is used to save parameters in non-volatile memory. Through read access, the drive provides information about its save capabilities, using:

- (a) *f*Sub-index 0: Largest supported sub-index
- (b) Sub-index 1: Save all parameters

In order to avoid accidental storage, storage is only executed when a specific signature "save" is written to the appropriate sub-index.

MSB			LSB	
BYTE 4	BYTE 3	BYTE 2	BYTE 1	
"e"	"v"	"a"	"s"	
65h	76h	61h	73h	

Object Description:

Index	1010 _h
Name	Save parameters
Object code	ARRAY
Data Type	UNSIGNED32
Category	Optional

Entry Description:

Sub-Index	0
Description	largest sub-index supported
Entry Category	Mandatory
Access	Read Only

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PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	1

Sub-Index	1
Description	Save all parameters
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	-

4.11 Object 1011h - Restore default parameters

This object is used to restore parameters from non-volatile memory. Through read access, the drive provides information about its restore capabilities, using:

- (a) f Sub-index 0: Largest supported sub-index
- (b) f Sub-index 1: Restore all parameters

In order to avoid accidental storage, restore is only executed when a specific signature "load" is written to the appropriate sub-index.

MSB		LSB	
BYTE 4	BYTE 3	BYTE 2	BYTE 1
"d"	"a"	"o"	"l"
64h	61h	6Fh	6Ch

4.12 Object 1014h - COB-ID Emergency Object

Index 1014h defines the COB-ID of the Emergency Object (EMCY).

UNSIGNED32

MSB			LSB	
31	30	29	28-11	10-0
Reserved (=0)		0	0	11-bit identifier

Object Description:

Index	1014 _h
Name	COB-ID Emergency Object
Object code	VAR
Data Type	UNSIGNED32
Category	Optional

Entry Description:

Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	0x08+Node-ID

4.13 Object 1015h - Inhibit Time EMCY

The inhibit time for the EMCY message can be adjusted via this entry. The time has to be a multiple of 100µs.

Object Description:

Index	1014 _h
Name	Inhibit Time EMCY
Object code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry Description:

Access	Read/Write
--------	------------

PDO Mapping	NO
Value Range	UNSIGNED16
Default Value	0x00

4.14 Object 1016h - Consumer Heartbeat Time

The consumer heartbeat time defines the expected heartbeat cycle time and thus has to be higher than the corresponding producer heartbeat time configured on the device producing this heartbeat.

Monitoring starts after the reception of the first heartbeat. If the consumer heartbeat time is 0 the corresponding entry is not used. The time has to be a multiple of 1ms.

UNSIGNED32

	MSB		
	LSB		
bits	31-24	23-16	15-0
value	reserved (value: 00h)	Node-ID	heartbeat time
encoded as	-	UNSIGNED8	UNSIGNED16

Object Description:

Index	1016_h
Name	Consumer Heartbeat Time
Object code	ARRAY
Data Type	UNSIGNED32
Category	Optional

Entry Description:

Sub-Index	0
Description	number entries
Entry Category	Mandatory

Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	0x1

Sub-Index	1
Description	Consumer Heartbeat Time
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	0

This object is not active and reserved for future implementation.

4.15 Object 1017h: Producer Heartbeat Time

The producer heartbeat time defines the cycle time of the heartbeat. The producer heartbeat time is 0 if it not used. The time has to be a multiple of 1ms.

Object Description:

Index	1017_h
Name	Producer Heartbeat Time
Object code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry Description:

Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED16
Default Value	0x00

This object is not active and reserved for future implementation.

4.16 Object 1018h: Identity Object

The object at index 1018h contains general information about the device.

The Vendor ID (sub-index 1h) contains a unique value allocated to each manufacturer. The manufacturer-specific Product code (sub-index 2h) identifies a specific device version.

The manufacturer-specific Revision number (sub-index 3h) consists of a major revision number and a minor revision number. The major revision number identifies a specific CANopen behavior. If the CANopen functionality is expanded, the major revision has to be incremented. The minor revision number identifies different versions with the same CANopen behavior.

Object Description:

Index	1018h
Name	Identity Object
Object code	ARRAY
Data Type	Identity
Category	Optional

Entry Description:

Sub-Index	0
Description	number entries
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	0x4

Sub-Index	1
Description	Vendor ID
Entry Category	Mandatory
Access	Read Only

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PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	-

Sub-Index	2
Description	Product code
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	-

Sub-Index	3
Description	Revision Number
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	-

Sub-Index	4
Description	Serial Number
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	-

4.17 Object 1029h - Error behavior

This object reports the CAN communication state after a heartbeat failure. The value of the object asserts that after such a failure, the CAN communication state is:

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- 0: Pre-operational (only if current state is operational)
- 1: No state change
- 2: Stopped

The default value is 1 (no state change).

Object Description:

Index	1029h
Name	Error behavior
Object code	ARRAY
Data Type	UNSIGNED8
Category	Optional

Entry Description:

Sub-Index	0
Description	Number of error classes
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED8
Default Value	0x1

Sub-Index	1
Description	Communication error
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED8
Default Value	1

4.18 Object 1200h - Server SDO Parameter

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This object is used to describe the SDO used on a device. The data type has the index 22h in the object dictionary. The number of supported entries in the SDO object record is specified by sub-index 0h. The values at 1h and 2h specify the COB-ID for this SDO. Sub-index 3 gives the server of the SDO if the record describes an SDO for which the device is a client, and it gives the client of the SDO if the record describes an SDO for which the device is the server. The structure of the SDO COB-ID entry is as follows:

	MSB			LSB	
bits	31	30	29	28-11	10-0
11-bit ID	0/1	0	0	0	11-bit identifier

Bit number	Value	Meaning
31	0/1	1 = SDO Enabled, 0 = SDO not Enabled
30	0	Reserved (always 0)
29	0	11-bit ID (CAN 2.0A)
28-11	0	(Always 0)
10-0	x	SDO COB-ID

Object Description:

Index	1200 _h
Name	Server SDO Parameter
Object code	RECORD
Data Type	SDO Parameter
Category	Optional

Entry Description:

Sub-Index	0
Description	Number of entries
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED8

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Default Value	0x2
---------------	-----

Sub-Index	1
Description	COB-ID Client->Server (rx)
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	601h...67Fh
Default Value	600h+Node-ID

Sub-Index	2
Description	COB-ID Server -> Client (tx)
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	581h ... 5FFh
Default Value	580h+Node-ID

4.19 Object 1400h:1403h - Receive PDO communication parameter

Contains the communication parameters for the PDOs the device is able to receive.

	MSB			LSB	
bits	31	30	29	28-11	10-0
11-bit ID	0/1	0	0	0	11-bit identifier

Bit number	Value	Meaning
31	0/1	1 = PDO Enabled, 0 = PDO not Enabled
30	0	No RTR is allowed
29	0	11-bit ID (CAN 2.0A)
28-11	0	(Always 0)

10-0	x	PDO COB-ID
------	---	------------

The transmission type (sub-index 2) defines the transmission/reception character of the PDO. Table following Table describes the usage of this entry. On an attempt to change the value of the transmission type to a value that is not supported by the device an abort message (abort code: 0609 0030h) is generated.

Transmission type	PDO transmission			
	cyclic	acyclic	synchronous	Asynchronous
0		x	x	
1-240	x		x	
241-251	Reserved			
254			x	
255			x	

Synchronous (transmission types 0-240 and 252) means that the transmission of the PDO shall be related to the SYNC object as described in 9.3. Preferably the devices use the SYNC as a trigger to output or actuate based on the previous synchronous Receive PDO respectively to update the data transmitted at the following synchronous Transmit PDO. Details of this mechanism depend on the device type and are defined in the device profile if applicable.

Asynchronous means that the transmission of the PDO is not related to the SYNC object. A transmission type of zero means that the message shall be transmitted synchronously with the SYNC object but not periodically.

A value between 1 and 240 means that the PDO is transferred synchronously and cyclically, the transmission type indicating the number of SYNC which are necessary to trigger PDO transmissions/receptions.

Object Description:

Index	1400h - 1403h
Name	Receive PDO parameter
Object code	RECORD
Data Type	PDO CommPar (object 0x20)
Category	Mandatory for supported PDO

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Entry Description:

Sub-Index	0
Description	Number of entries
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED8
Default Value	0x2

Sub-Index	1
Description	COB-ID used by PDO
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	Index 1400h: 200h+NODE-ID Index 1401h: 300h+NODE-ID Index 1402h: 400h+NODE-ID Index 1403h: 500h+NODE-ID

Sub-Index	2
Description	transmission type
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED8
Default Value	0

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4.20 Object 1600h - 17FFh: Receive PDO Mapping Parameter

Contains the mapping for the PDOs the device is able to receive. The sub-index 0h contains the number of valid entries within the mapping record. This number of entries is also the number of the application variables which shall be transmitted/received with the corresponding PDO. The sub-indices from 1h to number of entries contain the information about the mapped application variables. These entries describe the PDO contents by their index, sub-index and length. All three values are hexadecimal coded. The length entry contains the length of the object in bit (1..8h). This parameter can be used to verify the overall mapping length. It is mandatory.

The structure of the entries from sub-index 1h – 8h is as follows:

Byte:	MSB		LSB
	Index (16 bit)	Sub-index (8 bit)	Object length (8 bit)

If the change of the PDO mapping cannot be executed (e.g. the PDO length is exceeded or the SDO client attempts to map an object that cannot be mapped) the device responds with an Abort SDO Transfer Service.

Sub-index 0 determines the valid number of objects that have been mapped. For changing the PDO mapping first sub-index 0 must be set to 0 (mapping is deactivated). Then the objects can be remapped. When a new object is mapped by writing a sub-index between 1 and 8, the device may check whether the object specified by index /sub-index exists. If the object does not exist or the object cannot be mapped, the SDO transfer must be aborted with the Abort SDO Transfer Service with one of the abort codes 0602 0000h or 0604 0041h.

After all objects are mapped sub-index 0 is set to the valid number of mapped objects. When sub-index 0 is set to a value >0 the device may validate the new PDO mapping before transmitting the response of the SDO service. If an error is detected the device has to transmit the Abort SDO Transfer Service with one of the abort codes 0602 0000h, 0604 0041h or 0604 0042h.

A device that supports dynamic mapping of PDOs must support this during the state PRE-OPERATIONAL state. If dynamic mapping during the state OPERATIONAL is supported, the SDO client is responsible for data consistency.

Object Description:

Index	1600h - 1603h
Name	Receive PDO mapping parameters

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Object code	RECORD
Data Type	PDO Mapping
Category	Mandatory for each supported PDO

Entry Description:

Sub-Index	0
Description	Number of entries
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	0 deactivated ; 1-8 activated
Default Value	0

Sub-Index	N (1-8)
Description	PDO mapping for the nth
Entry Category	Conditional
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	0

4.21 Object 1800h - 1803h: Transmit PDO Communication Parameter

Contains the communication parameters for the PDOs the device is able to transmit. The type of the PDO communication parameter (20h). A detailed description of the entries is done in the section for the Receive PDO Communication Parameter (1400h – 1403h).

Index	1400_h - 1403_h
Name	Transmit PDO parameter
Object code	RECORD
Data Type	PDO CommPar (object 0x20)

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Category	Mandatory for supported PDO
----------	-----------------------------

Entry Description:

Sub-Index	0
Description	Number of entries
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED8
Default Value	0x2

Sub-Index	1
Description	COB-ID used by PDO
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	Index 1800h: 180h+NODE-ID Index 1801h: 280h+NODE-ID Index 1802h: 380h+NODE-ID Index 1803h: 480h+NODE-ID

Sub-Index	2
Description	transmission type
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED8
Default Value	0

Sub-Index	3
Description	inhibit time
Entry Category	Optional
Access	Read/Write

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PDO Mapping	NO
Value Range	UNSIGNED16
Default Value	0

Sub-Index	4
Description	reserved
Entry Category	optional
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED8
Default Value	0

Sub-Index	5
Description	Event timer
Entry Category	Optional
Access	Read/Write
PDO Mapping	NO
Value Range	0 not used - UNSIGNED16
Default Value	0

4.21.1 Event time

When a TPDO transmission type is 254 an event time can be used. The event occurs when the time is elapsed. The event time elapse is a multiple of 1 millisecond of sub-index 5. It causes the transmission of this PDO in addition to other asynchronous events. The occurrence of an event sets the timer again. A value of 0 disables this function.

4.21.2 Inhibit time

Inhibit time specifications do not relate to the generating event but to the transmission of the TPDO. The inhibit time resolution is 100 microseconds. The exact inhibit times are not very accurate and can actually be up to 2 milliseconds (20 units of inhibit time) longer than defined by sub-index 3 of this object. For example, if an inhibit time is specified as 10 milliseconds, its actual inhibit time length may vary in the range of [10...12] milliseconds.

4.22 Object 1A00h - 1A03h: Transmit PDO Mapping Parameter

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Contains the mapping for the PDOs the device is able to transmit. The type of the PDO mapping parameter (21h). A detailed description of the entries is done in the section for the Receive PDO Mapping Parameter (1600h – 1603h).

Object Description:

Index	1A00h - 1A03h
Name	Transmit PDO mapping parameters
Object code	RECORD
Data Type	PDO Mapping
Category	Mandatory for each supported PDO

Entry Description:

Sub-Index	0
Description	Number of entries
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	0 deactivated ; 1-8 activated
Default Value	0

Sub-Index	N (1-8)
Description	PDO mapping for the nth
Entry Category	Conditional
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	0

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5 Manufacturer-specific Objects

5.1 Object 2100h – Manufacturer specific error register

This object show the status of internal Drive error register.

Object Description:

Index	2100h
Name	Manufacturer specific error register
Object code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry Description:

Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED16
Default Value	0x0

5.2 Object 2F80h – Boot NMT Status

With this object is possible to select the Boot NMT status.

Object Description:

Index	2F80 _h
Name	Boot NMT Status
Object code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry Description:

Access	Read/Write
PDO Mapping	NO
Value Range	-
Default Value	0

List of possible values:

Value	Description
0x00	Pre-operational
0x04	Operational

5.3 Object 2F81_h – Status word masking

For compatibility reasons it is possible to use this mask to hide the Manufacturer specific bit of the Status word. The mask affects all status word, please change only the 2 most significant bits if needed.

Object Description:

Index	2F81 _h
Name	Status word masking
Object code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry Description:

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Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED16
Default Value	65535

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6 Device Control

6.1 General Information

The device control function block controls all functions of the drive (drive function and power section).

It is divided into:

- device control of the state machine
- operation mode function

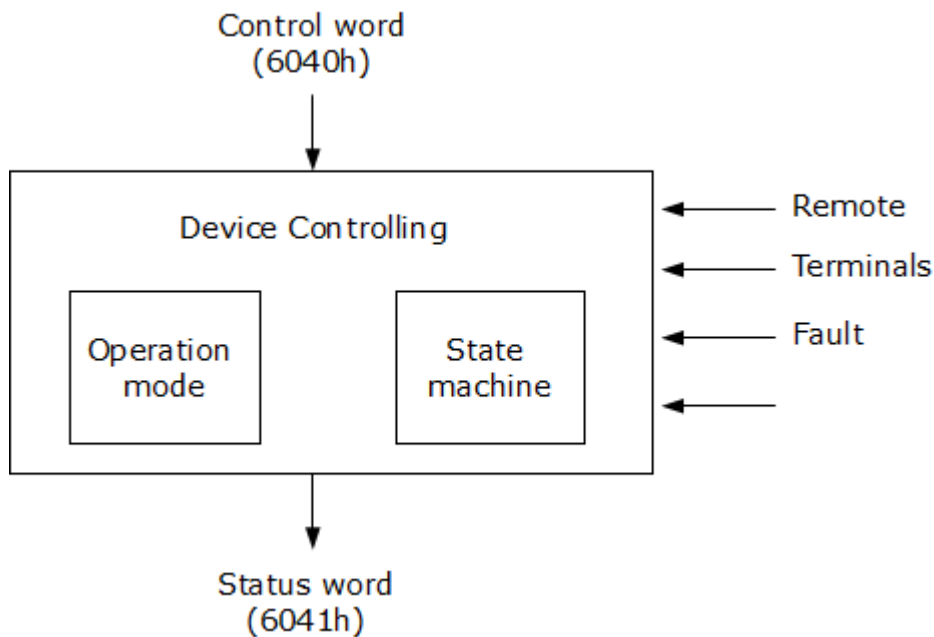


Image 3: Device Control

The state of the device can be controlled by the *controlword*.

The state of the device is shown in the *statusword*.

In remote mode the device is controlled directly from the CANopen network by PDO and SDO.

The state machine is controlled externally by the controlword and external signals. The state machine is also controlled by internal signals like faults and modes of operation.

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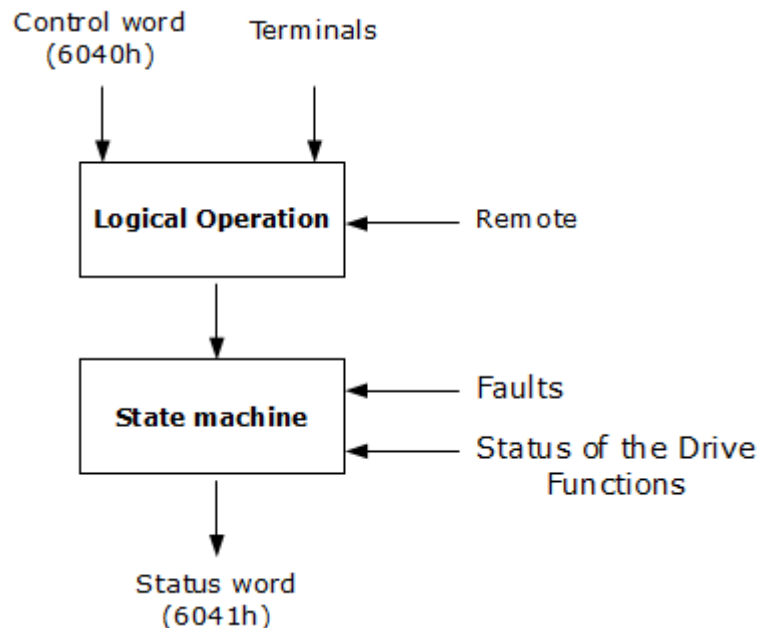


Image 4: Device Control Flow

The Device is always in remote mode, thus the relative bit in the status word is always set to 1.

6.2 State machine

The state machine describes the device status and the possible control sequence of the drive. A single state represents a special internal or external behavior. The state of the drive also determines which commands are accepted. E.g. it is only possible to start a point-to-point move when the drive is in state OPERATION ENABLE.

States may be changed using the controlword and/or according to internal events. The current state can be read using the statusword.

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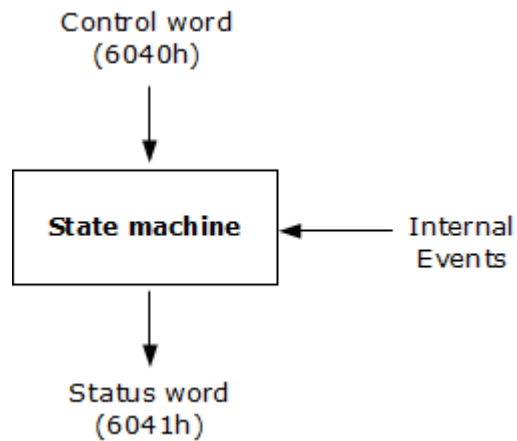


Image 5: Flow Diagram

The state machine describes the state machine of the device with respect to control of the power electronics because of user commands and internal drive faults.

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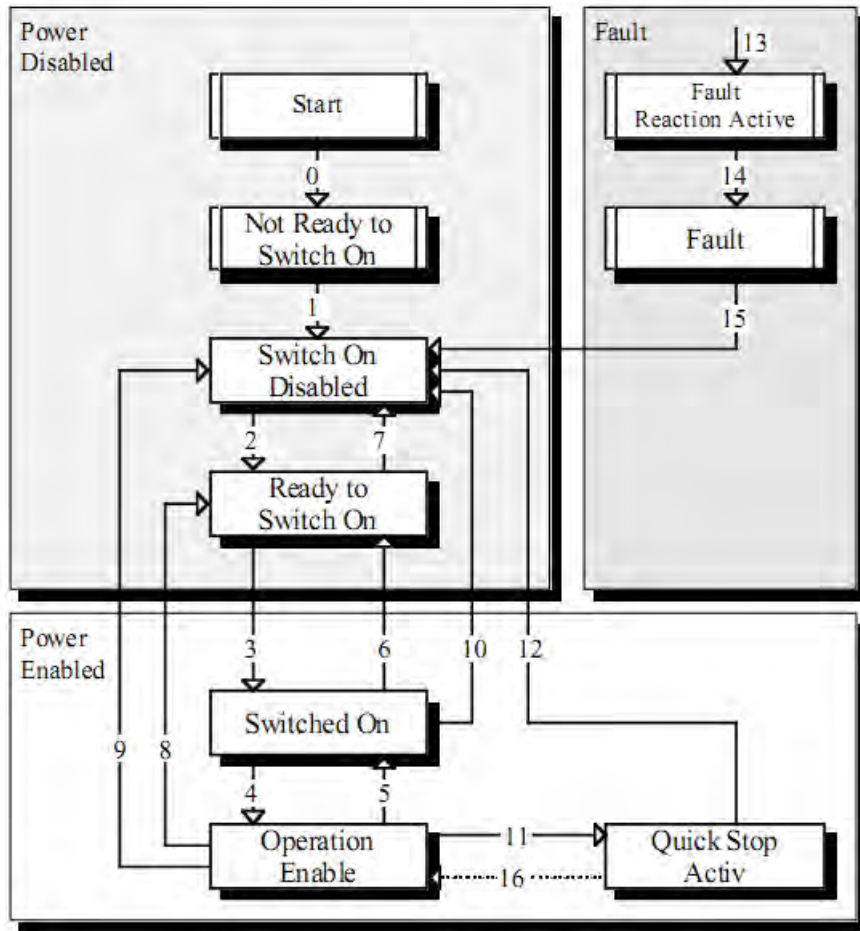


Image 6: State Machine

The following states of the device are possible:

➤ **NOT READY TO SWITCH ON:**

Low level power (e.g. $\pm 15V$, $5V$) has been applied to the drive.
 The drive is being initialized or is running self test.
 A brake, if present, has to be applied in this state.
 The drive function is disabled.

➤ **SWITCH ON DISABLED:**

Drive initialization is complete.
 The drive parameters have been set up.
 Drive parameters may be changed.
 High voltage may not be applied to the drive, (e.g. for safety reasons).
 The drive function is disabled.

➤ **READY TO SWITCH ON:**

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High voltage may be applied to the drive.
 The drive parameters may be changed.
 The drive function is disabled.

➤ **SWITCHED ON:**

High voltage has been applied to the drive.
 The power amplifier is ready.
 The drive parameters may be changed.
 The drive function is disabled.

➤ **OPERATION ENABLE:**

No faults have been detected.
 The drive function is enabled and power is applied to the motor.
 The drive parameters may be changed.
 (This corresponds to normal operation of the drive.)

➤ **QUICK STOP ACTIVE:**

The drive parameters may be changed.
 The quick stop function is being executed.
 The drive function is enabled and power is applied to the motor.
 o If the quick stop option code is switched to 5 (stay in the state QUICK STOP ACTIVE), you can't leave the state QUICK STOP ACTIVE, but you can transmit to the state OPERATION ENABLE with the command 'Enable Operation'.

➤ **FAULT REACTION ACTIVE:**

The drive parameters may be changed.
 A fault has occurred in the drive.
 The quick stop function is being executed.
 The drive function is enabled and power is applied to the motor.

➤ **FAULT:**

The drive parameters may be changed.
 A fault has occurred in the drive.
 High voltage switch-on/-off depends on the application.
 The drive function is disabled.

State transitions are caused by internal events in the drive or by commands from the host via the controlword.

State Transition 0: START ⇒ NOT READY TO SWITCH ON

Event: Reset.

Action: The drive self-tests and/or self-initializes.

State Transition 1: NOT READY TO SWITCH ON ⇒ SWITCH ON DISABLED

Event: The drive has self-tested and/or initialized successfully.

Action: Activate communication.

State Transition 2: SWITCH ON DISABLED ⇒ READY TO SWITCH ON

Event: 'Shutdown' command received from host.

Action: None

State Transition 3: READY TO SWITCH ON ⇒ SWITCHED ON

Event: 'Switch On' command received from host.

Action: The power section is switched on if it is not already switched on.

State Transition 4: SWITCHED ON ⇒ OPERATION ENABLE

Event: 'Enable Operation' command received from host.

Action: The drive function is enabled.

State Transition 5: OPERATION ENABLE ⇒ SWITCHED ON

Event: 'Disable Operation' command received from host.

Action: The drive operation will be disabled.

State Transition 6: SWITCHED ON ⇒ READY TO SWITCH ON

Event: 'Shutdown' command received from host.

Action: The power section is switched off.

State Transition 7: READY TO SWITCH ON ⇒ SWITCH ON DISABLED

Event: 'Quick Stop' and 'Disable Voltage' command received from host.

Action: None

State Transition 8: OPERATION ENABLE ⇒ READY TO SWITCH ON

Event: 'Shutdown' command received from host.

Action: The power section is switched off immediately, and the motor is free to rotate if unbraked.

State Transition 9: OPERATION ENABLE ⇒ SWITCH ON DISABLED

Event: 'Disable Voltage' command received from host.

Action: The power section is switched off immediately, and the motor is free to rotate if unbraked.

State Transition 10: SWITCHED ON ⇒ SWITCH ON DISABLED

Event: 'Disable Voltage' or 'Quick Stop' command received from host.

Action: The power section is switched off immediately, and the motor is free to rotate if unbraked.

State Transition 11: OPERATION ENABLE ⇒ QUICK STOP ACTIVE

Event: 'Quick Stop' command received from host.

Action: The quick stop function is executed.

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State Transition 12: QUICK STOP ACTIVE ⇒ SWITCH ON DISABLED

Event: 'Quick Stop' is completed or 'Disable Voltage' command received from host. This transition is possible, if the Quick-Stop-Option-Code is different 5 (stay in the state 'Quick Stop Active').

Action: The power section is switched off.

State Transition 13: All states ⇒ FAULT REACTION ACTIVE

A fault has occurred in the drive.

Action: Execute appropriate fault reaction.

State Transition 14: FAULT REACTION ACTIVE ⇒ FAULT

Event: The fault reaction is completed.

Action: The drive function is disabled. The power section may be switched off.

State Transition 15: FAULT ⇒ SWITCH ON DISABLED

Event: 'Fault Reset' command received from host.

Action: A reset of the fault condition is carried out if no fault exists currently on the drive. After leaving the state Fault the Bit 'Fault Reset' of the controlword has to be cleared by the host.

State Transition 16: QUICK STOP ACTIVE ⇒ OPERATION ENABLE

Event: 'Enable Operation' command received from host. This transition is possible if the Quick-Stop-Option-Code is 5, 6, 7 or 8 (→ Chapter 10.3.5).

Action: The drive function is enabled.

6.3 Object Description

6.3.1 Object 6040h: Controlword

The controlword consist of bits for:

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

Object Description:

Index	6040h
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Name	Control word
Object code	VAR
Data Type	UNSIGNED16
Category	Mandatory

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED16
Default Value	-

The bits of the controlword are defined as follows:

15-11	10-9	8	7	6-4	3	2	1	0
Manufacturer specific	reserved	halt	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

Bits 0-3 and 7:

Device control commands are triggered by the following bit patterns in the controlword:

Command	Bits of the Controlword					Transitions
	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**

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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 with X are not relevant.

f * The drive executes the functionality of SWITCH_ON.

f ** The drive does nothing in this state, which is treated the same as in *

Bits 4,5,6 and 8:

Bit	Operation mode					
	Velocity mode	Profile position mode	Profile velocity mode	Profile torque mode	Homing mode	Interpolation position mode
4	rfg enable	New set-point	Reserved	Reserved	Homing operation start	Enable ip mode
5	rfg unlock	Change set immediately	Reserved	Reserved	Reserved	Reserved
6	rfg use ref	abs/rel	Reserved	Reserved	Reserved	Reserved
8	Halt	Halt	Halt	Halt	Halt	Halt

Bits: 9,10:

These bits are reserved for further use. They are inactive by setting to zero. If they have no special function, they must be set to zero.

Bits 11, 12, 13, 14 and 15:

These bits are manufacturer specific.

6.3.2 Object 6041h: Statusword

The statusword indicates the current state of the drive. No bits are latched. The statusword consist of bits for:

- the current state of the drive,

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- the operating state of the mode and
- manufacturer specific options.

Object Description:

Index	6041 _h
Name	Status word
Object code	VAR
Data Type	UNSIGNED16
Category	Mandatory

Entry Description:

Access	Read Only
PDO Mapping	YES
Value Range	UNSIGNED16
Default Value	-

The bits in the status word has the following meaning:

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	Operation mode specific	M
13	Operation mode specific	M

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14	MS – not used	0
15	MS – Homing reached	0

Bits 0-3, 5 and 6:

The following bits indicate the status of the device:

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

Bit 4: VOLTAGE ENABLED

High voltage is applied to the drive when this bit is set to 1.

Bit 5: QUICK STOP

When reset, this bit indicates that the drive is reacting on a quick stop request. Bits 0, 1 and 2 of the statusword must be set to 1 to indicate that the drive is capable to regenerate. The setting of the other bits indicates the status of the drive (e.g. the drive is performing a quick stop as result of a reaction to a non-fatal fault. The fault bit is set as well as bits 0, 1 and 2).

Bit 7: WARNING

A drive warning is present if bit 7 is set. The cause means no error but a state that has to be mentioned, e.g. temperature limit, job refused. The status of the drive does not change. The cause of this warning may be found by reading the fault code parameter. The bit is set and reset by the device.

Bit 8: MANUFACTURER SPECIFIC

Not used.

Bit 9: REMOTE

Always set to 1.

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Bit 10: TARGET REACHED

If bit 10 is set by the drive, then a set-point has been reached. The set-point is dependent on the operating mode. The description is situated in the chapter of the special mode. The change of a target value by software alters this bit.

If quick stop option code is 5, 6, 7 or 8, this bit must be set, when the quick stop operation is finished and the drive is halted.

If halt occurred and the drive has halted then this bit is set too.

Bit 11: INTERNAL LIMIT ACTIVE

This bit set by the drive indicates, that an internal limitation is active (e.g. position range limit).

Bit 12 and 13:

These bits are operation mode specific. The description is situated in the chapter of the special mode.

The following table gives an overview:

Bit	Operation mode					
	vl	pp	pv	tq	hm	ip
12	reserved	Set point acknowledge	Speed	reserved	Homing attained	Ip mode active
13	reserved	Following error	Following error	reserved	Homing error	reserved

Bit 14 and 15:

14 - Not used

15 - Homing is Valid.

6.3.3 Object 6060h: Modes of operation

The parameter modes of operation switches the actually chosen operation mode.

Object Description:

Index	6060h
Name	Modes of operation
Object code	VAR

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Data Type	INTEGER8
Category	Mandatory

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	INTEGER8
Default Value	-

List of possible operation modes:

Value	Description
-4	Tuning Current Mode
0	Reserved
1	Profile Position Mode
3	Profile Velocity Mode
4	Torque Profile Mode
5	Reserved
6	Homing Mode
7	Interpolated Position Mode

Note:

A read of modes of operation shows only the value of modes of operation. The actual mode of the drive is reflected in the object modes of operation display. It may be changed by writing to modes of operation.

6.4 Object 6061h: Modes of operation display

The modes of operation display show the current mode of operation. The meaning of the returned value corresponds to that of the modes of operation option code (index 6060h).

Object Description:

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Index	6061_h
Name	Modes of operation display
Object code	VAR
Data Type	INTEGER8
Category	Mandatory

Entry Description:

Access	Read Only
PDO Mapping	YES
Value Range	INTEGER8
Default Value	-

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7 Profile Position Mode

7.1 General Information

This chapter describes how to set a point-to-point (PTP) movement under a profiled position where a target position is applied to the trajectory generator. It generates a position demand value to the control loop. The trajectory generator input includes profiled velocity, acceleration, deceleration, and selection of motion type, motion polarity and stopping option. The inputs to the trajectory are given in user units and are limited before being normalized to internal increments.

7.2 Objects

7.2.1 Object 607Ah: Target Position

The target position is the position that the drive should move to in position profile mode using the current settings of motion control parameters such as velocity, acceleration, deceleration, motion profile type etc. The target position is given in user defined position units. It is converted to position increments using the position factor. The target position will be interpreted as absolute or relative depending on the 'abs / rel' flag in the control word.

Object Description:

Index	607Ah
Name	Target position
Object code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry Description:

Access	Read/Write
PDO Mapping	YES

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Value Range	INTEGER32
Default Value	-

7.2.2 Object 607Bh: Position range limit

Position range limit contains two sub-parameters, min position range limit and max position range limit. These limit the numerical range of the input value. On reaching or exceeding these limits, the input value automatically wraps to the other end of the range. Wrap-around of the input value can be prevented by setting software position limits.

Object Description:

Index	607B _h
Name	Position range limit
Object code	ARRAY
Data Type	INTEGER32
Category	Mandatory

Entry Description:

Sub-Index	0
Description	Number of entries
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	2
Default Value	2

Sub-Index	1
Description	Min position range limit
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	INTEGER32
Default Value	-2 ³¹

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Sub-Index	2
Description	Max position range limit
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	INTEGER32
Default Value	2 ³¹ -1

7.2.3 Object 607Dh: Software position limit

Software position limit contains the sub-parameters min position limit and max position limit. These parameters define the absolute position limits for the position demand value and the position actual value. Every new target position must be checked against these limits. The limit positions are specified in position units (same as target position) and are always relative to the machine home position.

Object Description:

Index	607Dh
Name	Software position limit
Object code	ARRAY
Data Type	INTEGER32
Category	Mandatory

Entry Description:

Sub-Index	0
Description	Number of entries
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	2
Default Value	2

Sub-Index	1
------------------	----------

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Description	Min position limit
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	INTEGER32
Default Value	-2^{31}

Sub-Index	2
Description	Max position limit
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	INTEGER32
Default Value	$2^{31}-1$

7.2.4 Object 6081h: Profile velocity

The profile velocity is the velocity normally attained at the end of the acceleration ramp during a profiled move and is valid for both directions of motion. The profile velocity is given in user defined speed units. It is converted to position increments per second using the velocity encoder factor.

Object Description:

Index	6081h
Name	Profile velocity
Object code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	INTEGER32
Default Value	0

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7.2.5 Object 6083h: Profile acceleration

The profile acceleration is given in user defined acceleration units. It is converted to position increments per second² using the normalizing factors (see chapter 11).

Object Description:

Index	6083 _h
Name	Profile acceleration
Object code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	INTEGER32
Default Value	0

7.2.6 Object 6084h: Profile deceleration

The profile deceleration is given in the same units as profile acceleration. If this parameter is not supported, then the profile acceleration value is also used for deceleration.

Object Description:

Index	6084 _h
Name	Profile deceleration
Object code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry Description:

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Access	Read/Write
PDO Mapping	YES
Value Range	INTEGER32
Default Value	0

7.2.7 Object 6085h: Quick stop deceleration

The quick stop deceleration is the deceleration used to stop the motor if the 'Quick Stop' command is given. The quick stop deceleration is given in the same units as the profile acceleration.

Object Description:

Index	6085h
Name	Quick stop deceleration
Object code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	INTEGER32
Default Value	0

7.2.8 Object 6086h: Motion profile type

The motion profile type is used to select the type of motion profile used to perform a profiled move.

Object Description:

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Index	6086 _h
Name	Motion profile type
Object code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	INTEGER32
Default Value	0

List of possible values:

Value	Description
-32768 -1	Manufacturer specific
0	Linear ramp (trapezoidal profile)
1	Not used
2	Not used
3	Not used
4 .. 32767	reserved

• Functional Description

Two different ways to apply target positions to a drive, are supported by this device profile.

➤ Set of set-points:

After reaching the target position the drive unit immediately processes the next target position which results in a move where the velocity of the drive normally is not reduced to zero after achieving a set-point.

➤ Single set-point:

After reaching the target position the drive unit signals this status to a host computer and then receives a new set-point. After reaching a target position the velocity normally is reduced to zero before starting a move to the next set-point.

The two modes are controlled by the timing of the bits 'new set-point' and 'change set immediately' in the controlword and 'set-point acknowledge' in the statusword. These bits allow to set up a request-response mechanism in order to prepare a set of set-points while another set still is processed in the drive unit. This minimizes reaction times within a control program on a host computer.

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8 Homing Mode

8.1 General information

This chapter describes the method by which a drive seeks the home position (also called, the datum, reference point or zero point). There are various methods of achieving this using limit switches at the ends of travel or a home switch (zero point switch) in mid-travel, most of the methods also use the index (zero) pulse train from an incremental encoder.

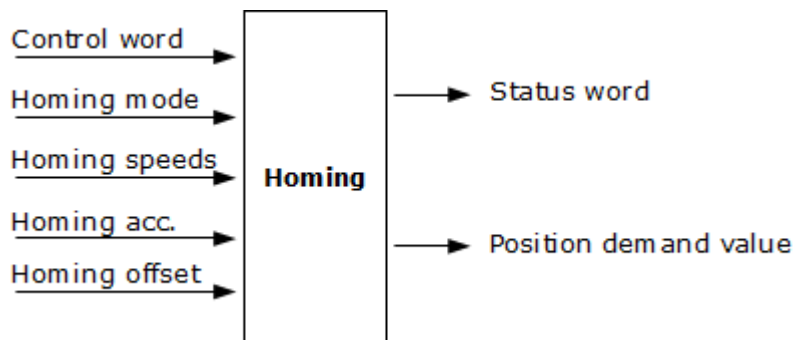


Image 7: Homing function

8.2 Object description

8.2.1 Object 607Ch: Home offset

The home offset object is the difference between the zero position for the application and the machine home position (found during homing), it is measured in position units. During homing the machine home position is found and once the homing is completed the zero position is offset from the home position by adding the home offset to the home position. All subsequent absolute moves shall be taken relative to this new zero position. This is illustrated in the following diagram.

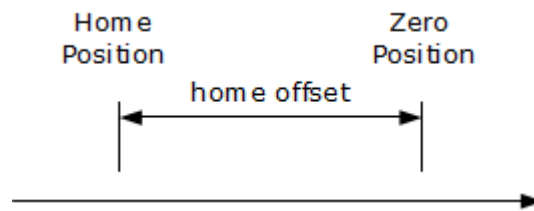


Image 8: Home Offset description

If the home offset is not implemented, then it shall be zero.

Object Description:

Index	607Ch
Name	Home offset
Object code	VAR
Data Type	INTEGER32
Category	Optional

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	INTEGER32
Default Value	0

8.2.2 Object 6098h: Homing method

The homing method object determines the method that will be used during homing.

Object Description:

Index	6098h
Name	Homing method
Object code	VAR
Data Type	INTEGER8

Category	Optional
----------	----------

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	INTEGER8
Default Value	0

List of possible values:

Value	Description
-17	See the functional description
-18	See the functional description
0	No homing operation required
1 - 35	See the functional description
36 - 127	reserved

8.2.3 Object 6099h: Homing speeds

This entry in the object dictionary defines the speeds used during homing and is given velocity units.

Object Description:

Index	6099 _h
Name	Homing speeds
Object code	ARRAY
Data Type	UNSIGNED32
Category	Mandatory

Entry Description:

Sub-Index	0
------------------	----------

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Description	Number of entries
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	2
Default Value	2

Sub-Index	1
Description	Speed during search for switch
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED32
Default Value	0

Sub-Index	2
Description	Speed during search for zero
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED32
Default Value	0

8.2.4 Object 609Ah: Homing acceleration

The homing acceleration establishes the acceleration to be used for all accelerations and decelerations with the standard homing modes and is given in acceleration units.

Object Description:

Index	609Ah
Name	Homing acceleration
Object code	VAR
Data Type	UNSIGNED32

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Category	Optional
----------	----------

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED32
Default Value	0

8.3 Functional description

By choosing a method of homing by writing a value to homing method will clearly establish:

- ✓ the homing signal (positive limit switch, negative limit switch, home switch)
- ✓ the direction of actuation and where appropriate
- ✓ the position of the index pulse.

The home position and the zero position are offset by the home offset, see the definition of home offset for how this offset is used. Various homing positions are illustrated in the following diagrams. An encircled number indicates the code for selection of this homing position. The direction of movement is also indicated.

There are five sources of homing signal available, these are the negative and positive limit switches, the home switch and the index pulse from an encoder and the hard-home.

In the diagrams of homing sequences shown below, the encoder count increases as the axis position moves to the right, in other words the left is the minimum position and the right is the maximum position. For the operation of positioning drives, an exact knowledge of the absolute position is normally required. Since for cost reasons, drives often do not have an absolute encoder, a homing operation is necessary. There are several, application-specific methods. The homing method is used for selection.

The exact sequence of the homing operation is clearly described by the method. In some circumstances, a device has several methods to choose from, using the homing method.

8.4 Homing methods

The following sub-sections describe the details of how each of the homing modes shall function.

8.4.1 Method 1: Homing on the negative limit switch and index pulse

Using this method the initial direction of movement is leftward if the negative limit switch is inactive (here shown as low). The home position is at the first index pulse to the right of the position where the negative limit switch becomes inactive.

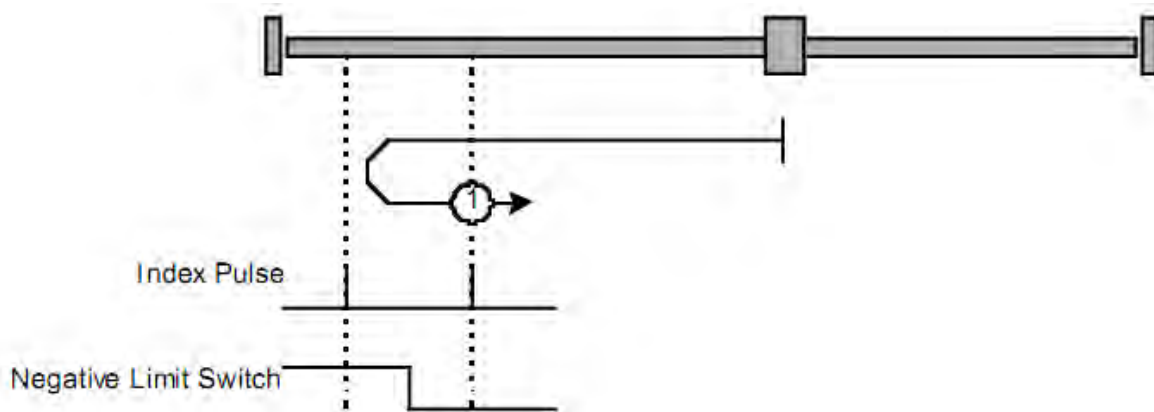


Image 9: Homing on negative Limit switch and index pulse

8.4.2 Method 2: Homing on the positive limit switch and index pulse

Using this method the initial direction of movement is rightward if the positive limit switch is inactive (here shown as low). The position of home is at the first index pulse to the left of the position where the positive limit switch becomes inactive.

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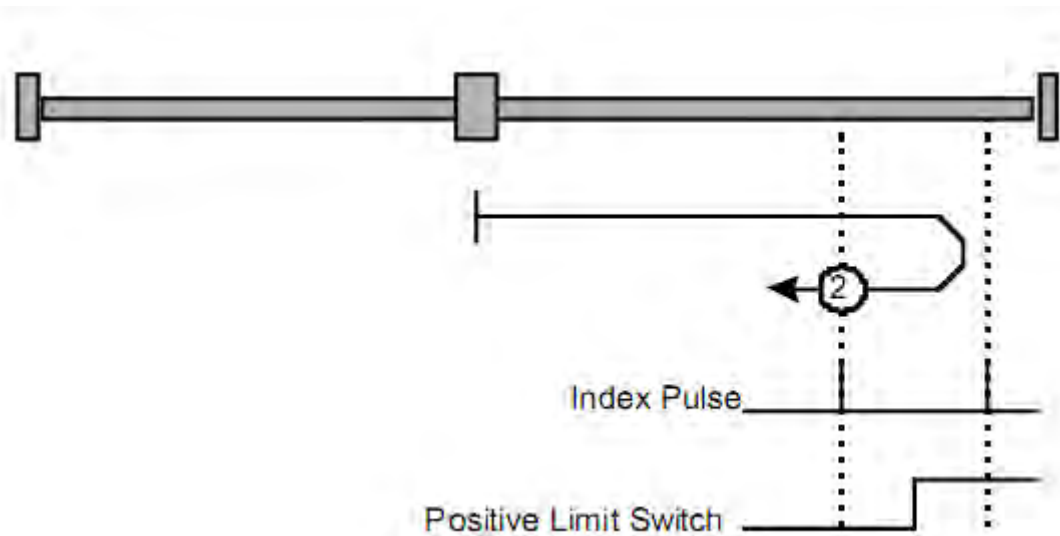


Image 10: Homing on positive Limit switch and index pulse

8.4.3 Methods 3 and 4: Homing on the positive home switch and index pulse

Using methods 3 or 4 the initial direction of movement is dependent on the state of the home switch. The home position is at the index pulse to either to the left or the right of the point where the home switch changes state. If the initial position is sited so that the direction of movement must reverse during homing, the point at which the reversal takes place is anywhere after a change of state of the home switch.

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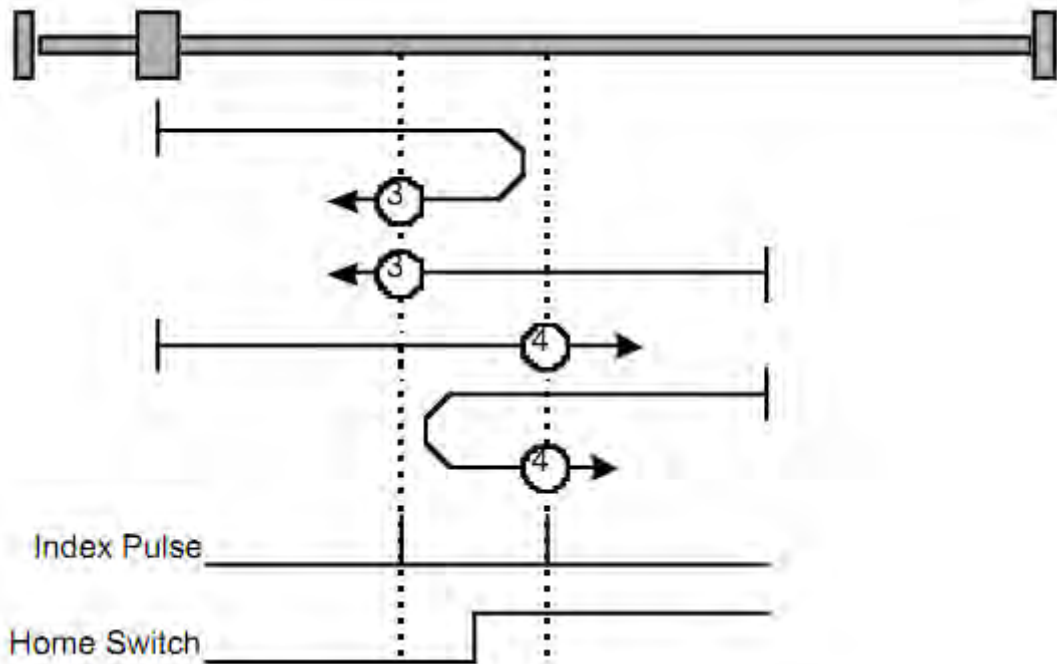


Image 11: Homing on positive home switch and index pulse

8.4.4 Methods 5 and 6: Homing on the negative home switch and index pulse

Using methods 5 or 6 the initial direction of movement is dependent on the state of the home switch. The home position is at the index pulse to either to the left or the right of the point where the home switch changes state. If the initial position is sited so that the direction of movement must reverse during homing, the point at which the reversal takes place is anywhere after a change of state of the home switch.

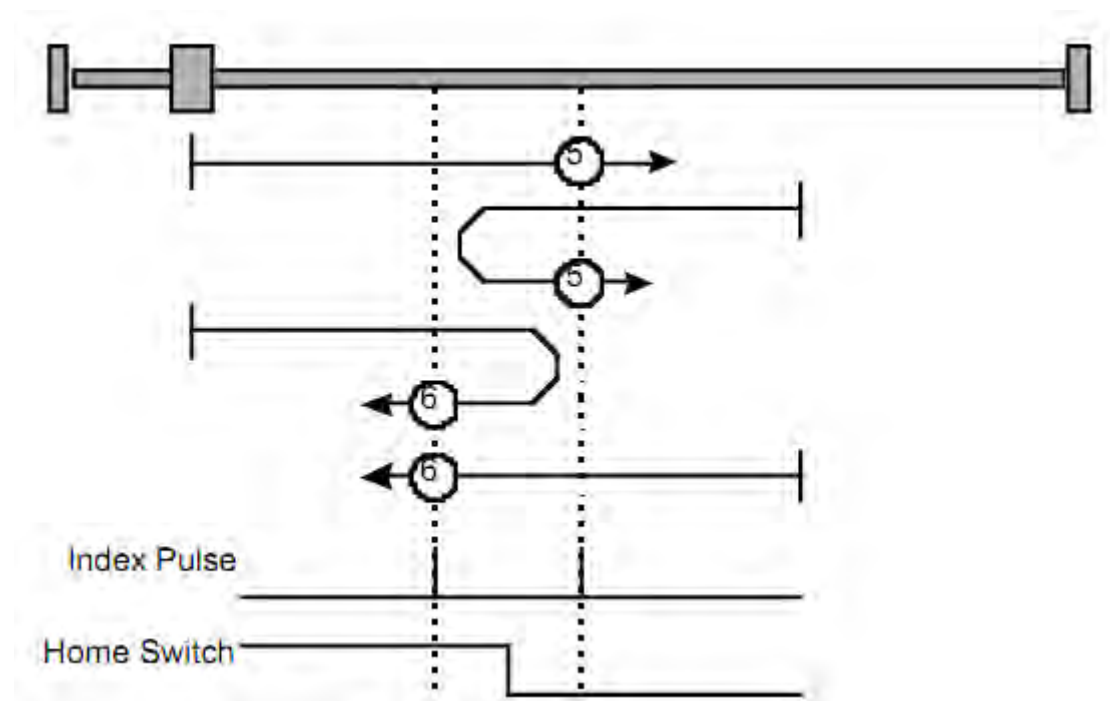


Image 12: Homing on negative home switch and index pulse

8.4.5 Methods 7 to 14: Homing on the home switch and index pulse

These methods use a home switch which is active over only portion of the travel, in effect the switch has a 'momentary' action as the axle's position sweeps past the switch. Using methods 7 to 10 the initial direction of movement is to the right, and using methods 11 to 14 the initial direction of movement is to the left except if the home switch is active at the start of the motion.

In this case the initial direction of motion is Dependent on the edge being sought. The home position is at the index pulse on either side of the rising or falling edges of the home switch, as shown in the following two diagrams. If the initial direction of movement leads away from the home switch, the drive must reverse on encountering the relevant limit switch.

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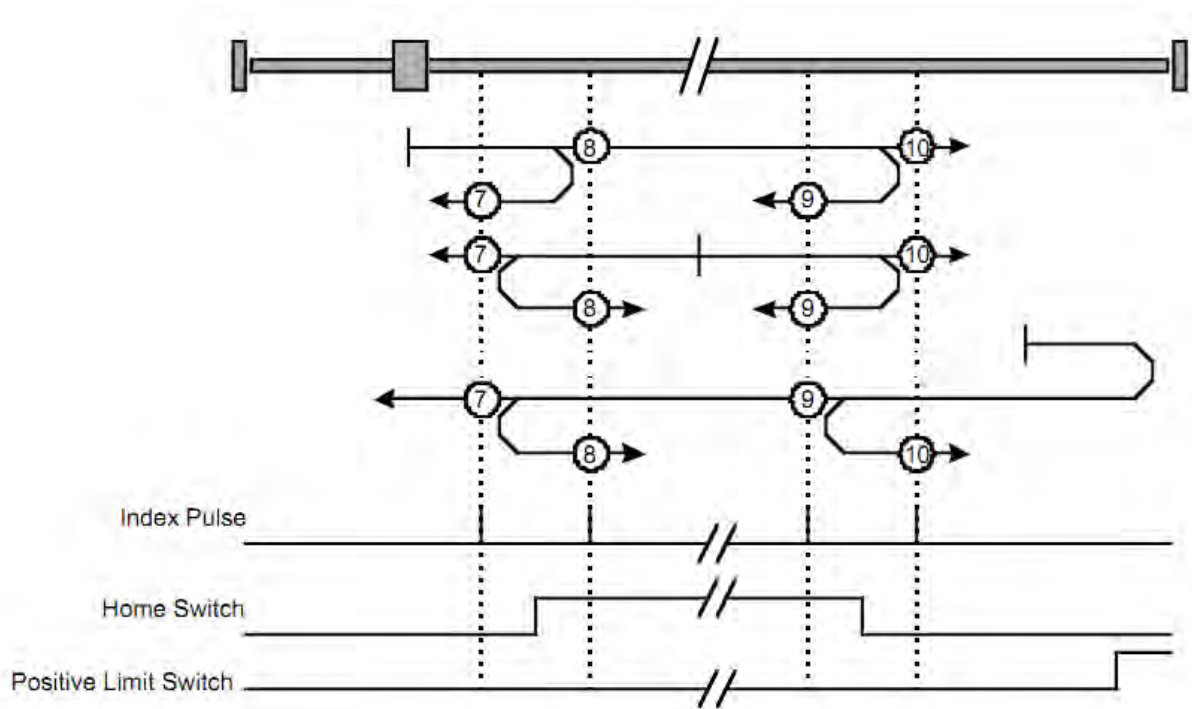


Image 13: Homing on the home switch and index pulse - positive initial move

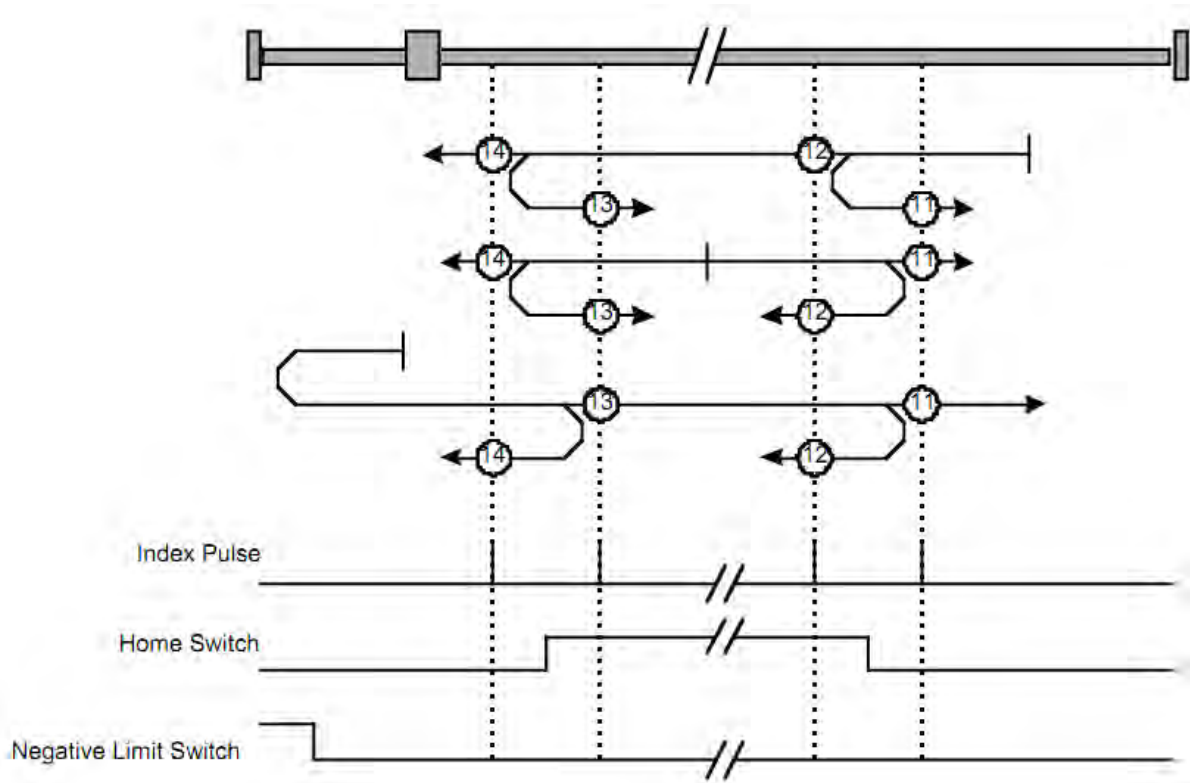


Image 14: Homing on the home switch and index pulse - negative initial move

8.4.6 Methods 17 to 30: Homing without an index pulse

These methods are similar to methods 1 to 14 except that the home position is not dependent on the index pulse but only dependent on the relevant home or limit switch transitions. For example methods 19 and 20 are similar to methods 3 and 4 as shown in the following diagram.

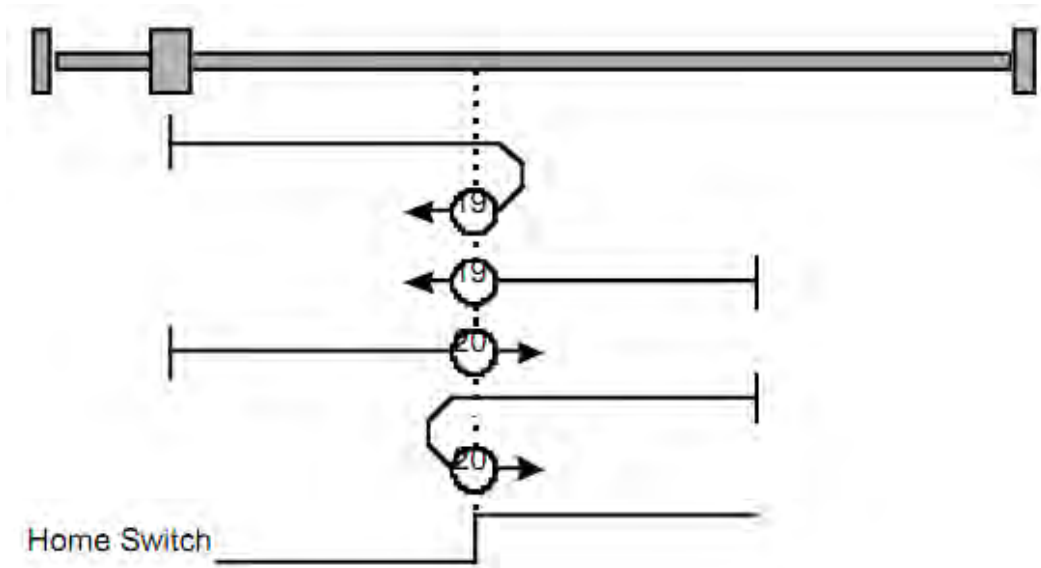


Image 15: Homing without and index pulse

8.4.7 Methods 33 to 34: Homing on the index pulse

Using methods 33 or 34 the direction of homing is negative or positive respectively. The home position is at the index pulse found in the selected direction.

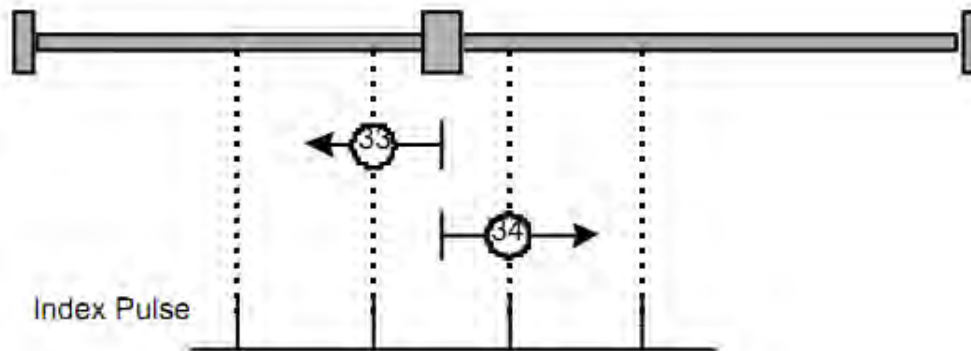


Image 16: Homing on index pulse

8.4.8 Method 35: Homing on the current position

In method 35 the current position is taken to be the home position.

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9 Position control function

9.1 General information

In this chapter, all parameters are described which are necessary for a closed loop position control. The control loop is fed with the position demand value as one of the outputs of the trajectory generator and with the output of the position detection unit (position actual value) of encoder as input parameters. The behavior of the control may be influenced by control parameters which are externally applicable. To keep stable the loop, a relative limitation of the output using the previous control effort is possible. In order not to exceed physical limits of a drive, an absolute limit function is implemented for the control effort. The control effort may be a velocity demand value, a position demand value or any other output value, depending on the modes of operation implemented by a manufacturer. Especially in cascaded control structures, where a position control is followed by a torque control, e.g. the control effort of the position control loop is used as an input for a further calculation.

9.2 Object description

9.2.1 Object 6062h: Position demand value

The position demand value is given in position units.

Object Description:

Index	6062h
Name	Position demand value
Object code	VAR
Data Type	UNSIGNED32
Category	Optional

Entry Description:

Access	Read Only
PDO Mapping	YES

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Value Range	UNSIGNED32
Default Value	0

9.2.2 Object 6063h: Position actual value

The actual value of the position measurement device is one of the two input values of the closed loop position control. The data unit is defined as increments.

Object Description:

Index	6063h
Name	Position actual value
Object code	VAR
Data Type	UNSIGNED32
Category	Optional

Entry Description:

Access	Read Only
PDO Mapping	YES
Value Range	UNSIGNED32
Default Value	0

9.2.3 Object 6064h: Position actual value

The actual value of the position measurement in user units.

Object Description:

Index	6064h
Name	Position actual value
Object code	VAR
Data Type	UNSIGNED32
Category	Mandatory

Entry Description:

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Access	Read Only
PDO Mapping	YES
Value Range	UNSIGNED32
Default Value	0

9.2.4 Object 6065h: Following error window

The following error window defines a range of tolerated position values symmetrically to the position demand value. As it is in most cases used with user defined units, a transformation into increments with the position factor is necessary. If the position actual value is out of the following error window, an error occur.

Object Description:

Index	6065h
Name	Following error window
Object code	VAR
Data Type	UNSIGNED32
Category	Optional

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED32
Default Value	0

9.2.5 Object 6066h: Following error time out

When a following error occurs longer than the defined value of the time-out given in multiples of milliseconds, the corresponding bit 13 following error in the status word will be set to one. The reaction of the drive when a following error occurs, is manufacturer specific.

Object Description:

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Index	6066 _h
Name	Following error time out
Object code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED16
Default Value	0

9.2.6 Object 6067_h: Position window

The position window defines a symmetrical range of accepted positions relatively to the target position. If the actual value of the position encoder is within the position window, this target position is regarded as reached. As the user mostly prefers to specify the position window in his application in user defined units, the position factor must be used to transform this value into increments. The target position has to be handled in the same manner as in the Trajectory Generator concerning limiting functions and transformation into internal machine units before it can be used with this function.

Object Description:

Index	6067 _h
Name	Position window
Object code	VAR
Data Type	UNSIGNED32
Category	Optional

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED32

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Default Value	0
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9.2.7 Object 6068 : Position window time

When the actual position is within the position window during the defined position window time which is given in multiples of milliseconds, the corresponding bit 10 target reached in the statusword will be set to one.

Object Description:

Index	6068 _h
Name	Position window time
Object code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED16
Default Value	0

9.2.8 Object 60F4h: Following error actual value

This object represents the actual value of the following error, it is given in user defined position units.

Object Description:

Index	60F4 _h
Name	Following error actual value
Object code	VAR

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Data Type	UNSIGNED32
Category	Optional

Entry Description:

Access	Read Only
PDO Mapping	YES
Value Range	UNSIGNED32
Default Value	0

9.2.9 Object 60FAh: Control effort

The output of the position control loop is the control effort. It is particular to the Position control function that the notation of the control effort is mode dependent and therefore not specified in the object description.

Object Description:

Index	60FA _h
Name	Control effort
Object code	VAR
Data Type	INTEGER32
Category	Optional

Entry Description:

Access	Read Only
PDO Mapping	YES
Value Range	INTEGER32
Default Value	0

9.2.10 Object 60FBh: Position control parameter set

The object define the manufacturer-specific object for the position control loop

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Object Description:

Index	60FB_h
Name	Position control parameter set
Object code	ARRAY
Data Type	UNSIGNED16
Category	Optional

Entry Description:

Sub-Index	0
Description	Number of entries
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	2
Default Value	2

Sub-Index	1
Description	KP Position loop
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED16
Default Value	0

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10 Interpolated Position Mode

The interpolated position mode is used to control multiple coordinated axis or a single axis with the need for time-interpolation of set-point data. The interpolated position mode use time synchronization mechanisms for a time coordination of the related drive units.

10.1 Object description

10.1.1 Object 60C0_h: Interpolation Sub Mode Select

This object reflects or changes the actual chosen interpolation mode, selected by the user. The interpolation sub-modes can be changed only when the interpolated mode is inactive.

Object Description

Index	60C0 _h
Name	Interpolated Sub Mode Select
Object code	VAR
Data Type	INTEGER16
Category	Optional

Entry Description

Access	Read/Write
PDO Mapping	NO
Value Range	0
Default Value	0 (Linear Interpolation)

Data Description

Value	Description
-------	-------------

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-3,...,-32768	Reserved
-2	Linear Interpolation no Buffering
-1	Reserved
0	Linear Interpolation

10.1.2 Object 60C1_h: Interpolation data record

This object is the data words, which are necessary for performing the interpolation algorithm. The interpretation of the data words may vary with the different possible interpolation modes as set by 60C0_h.

Object Description

Index	60C0 _h
Name	Interpolation data record
Object code	60C0 _h = 0 : INTEGER32 60C0 _h > 0 : not defined
Data Type	INTEGER16
Category	Optional

Entry Description

Sub-Index	0
Description	Number of Entries
Entry Category	mandatory
Access	Read/Write
PDO Mapping	YES
Value Range	1
Default Value	1

Sub-Index	1
Description	Parameter of IP Function
Entry Category	mandatory
Access	Read/Write
PDO Mapping	YES

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Value Range	60C0h = 0 : INTEGER32 60C0h > 0 : not defined
Default Value	No

10.2

10.2.1 Object 60C2_h: Interpolation time period

This object is used to define the relative time taken between two set points for the interpolation position modes. The interpolation time unit is given in $10^{\text{interpolation time index}}$ seconds.

The interpolation time period can be changed only when the interpolated mode is inactive.

Object Description

Index	60C2 _h
Name	Interpolation time period
Object code	RECORD
Data Type	Interpolation time period record (0080h)
Category	Optional

Entry Description

Sub-Index	0
Description	Number of Entries
Entry Category	mandatory
Access	Read Only
PDO Mapping	YES
Value Range	2
Default Value	2

Sub-Index	1
Description	Interpolation time units
Entry Category	mandatory

Access	Read/Write
PDO Mapping	YES
Value Range	0,26
Default Value	1

Sub-Index	2
Description	Interpolation time index
Entry Category	mandatory
Access	Read/Write
PDO Mapping	YES
Value Range	-128,63 (-3 ONLY)
Default Value	-3

10.2.2 Object 60C3_h: Interpolation sync definition

Devices in the interpolation position mode often interact with other devices. Therefore it is necessary to define a communication object which is used to synchronize these interactions.

This can be done by the general Sync, or a specific group-sync-signal. Each reception of this trigger-signal or a specified number of occurrences of the trigger-signal can synchronize the devices; a second opportunity is to use fixed time slices for synchronization.

Object Description

Index	60C3 _h
Name	Interpolation sync definition
Object code	ARRAY
Data Type	UNSIGNED8
Category	Optional

Entry Description

Sub-Index	0
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Description	Number of Entries
Entry Category	mandatory
Access	Read Only
PDO Mapping	YES
Value Range	2
Default Value	2

Sub-Index	1
Description	Synchronize on Group
Entry Category	mandatory
Access	Read Only
PDO Mapping	NO
Value Range	0 .. 255
Default Value	0

Sub-Index	2
Description	IP Sync every n event
Entry Category	mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	0 .. 255
Default Value	1

Description of synchronize on group:

Value	Description
0	General Sync is Used
1 .. 255	Reserved

10.2.3 Object 60C_{4h}: Interpolation data configuration

It is possible to offer different algorithms of interpolation. Most of them need a larger number of position to calculate the actual position the axles should reach. To enable

the device to receive the needed data in advance a data space is used to store the positions and further data send by the host.

Object Description

Index	60C4_h
Name	Interpolation data configuration
Object code	RECORD
Data Type	Interpolation data configuration record (0081h)
Category	Optional

Entry Description

Sub-Index	0
Description	Number of Entries
Entry Category	mandatory
Access	Read Only
PDO Mapping	NO
Value Range	6
Default Value	6

Sub-Index	1
Description	Maximum buffer size
Entry Category	mandatory
Access	Read Only
PDO Mapping	NO
Value Range	UNSIGNED32
Default Value	1

Sub-Index	2
Description	Actual buffer size
Entry Category	mandatory
Access	Read/Write

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PDO Mapping	YES
Value Range	UNSIGNED32
Default Value	0

Sub-Index	3
Description	Buffer organization
Entry Category	mandatory
Access	Read/Write
PDO Mapping	YES
Value Range	0 .. 255
Default Value	0

Possible values for Buffer organization:

Value	Description
0	FIFO buffer
1	RING Buffer
2 .. 255	Reserved

Sub-Index	4
Description	Buffer position
Entry Category	mandatory
Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED16
Default Value	0

Sub-Index	5
Description	Size of data record
Entry Category	mandatory
Access	Write Only
PDO Mapping	YES
Value Range	1 .. 254
Default Value	1

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Sub-Index	6
Description	Buffer clear
Entry Category	mandatory
Access	Write Only
PDO Mapping	YES
Value Range	UNSIGNED8
Default Value	0

Possible values for Clear buffer:

Value	Description
0	Clear Input Buffer Access disabled Clear all ip data records
1	Enable access to the input buffer for the drive functions
2 .. 255	Reserved

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11 Profile Velocity Mode

The profile velocity mode allow the user to run the motor with a controlled speed profile.

11.1 Object description

11.1.1 Object 6069h: Velocity sensor actual value

The velocity sensor actual value describes the value read from a velocity encoder.

Object Description:

Index	6069h
Name	Velocity sensor actual value
Object code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry Description:

Access	Read Only
PDO Mapping	YES
Value Range	INTEGER32
Default Value	0

11.1.2 Object 606Bh: Velocity demand value

The output value of the trajectory generator may be corrected by the output value of the position control function. It is then provided as a demand value for the velocity controller and given in the velocity units.

Object Description:

Index	606B_h
Name	Velocity demand value
Object code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry Description:

Access	Read Only
PDO Mapping	YES
Value Range	INTEGER32
Default Value	0

11.1.3 Object 606C : Velocity actual value

The velocity actual value is also represented in velocity units and is coupled to the velocity used as input to the velocity controller.

Object Description:

Index	606C_h
Name	Velocity actual value
Object code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry Description:

Access	Read Only
PDO Mapping	YES
Value Range	INTEGER32
Default Value	0

11.1.4 Object 606D_h: Velocity window

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The velocity window monitors whether the required process velocity has been achieved after an eventual acceleration or deceleration (braking) phase. It is given in velocity units.

Object Description:

Index	606D _h
Name	Velocity window
Object code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED16
Default Value	0

11.1.5 Object 606E_h: Velocity window time

The corresponding bit 10 target reached is set in the statusword when the difference between the target velocity and the velocity actual value is within the velocity window longer than the velocity window time. The value of the velocity window time is given in multiples of milliseconds.

Object Description:

Index	606E _h
Name	Velocity window time
Object code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry Description:

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Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED16
Default Value	0

11.1.6 Object 606F: Velocity threshold

As soon as the velocity actual value exceeds the velocity threshold longer than the velocity threshold time bit 12 velocity = 0 is reset in the statusword. Below this threshold the bit is set and indicates that the axle is stationary. The value is given in velocity units.

Object Description:

Index	606F _h
Name	Velocity threshold
Object code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED16
Default Value	0

11.1.7 Object 6070h: Velocity threshold time

The velocity threshold time is given in multiples of milliseconds.

Object Description:

Index	606F _h
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Name	Velocity threshold time
Object code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	UNSIGNED16
Default Value	0

11.1.8 Object 60FFh: Target velocity

The target velocity is the input for the trajectory generator and the value is given in velocity units.

Object Description:

Index	60FF _h
Name	Target velocity
Object code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry Description:

Access	Read/Write
PDO Mapping	YES
Value Range	INTEGER32
Default Value	0

11.1.9 Object 60F9h: Velocity control parameter set

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In order to control the behavior of the velocity control loop, one or more parameters are necessary.

This object defines a rudimentary set of three parameters for a PI-control which may be enlarged by the manufacturer up to 255 parameters.

Object Description:

Index	60F9_h
Name	Velocity control parameter set
Object code	ARRAY
Data Type	UNSIGNED16
Category	Optional

Entry Description:

Sub-Index	0
Description	Number of entries
Entry Category	Mandatory
Access	Read Only
PDO Mapping	NO
Value Range	2
Default Value	2

Sub-Index	1
Description	KP Velocity loop
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO
Value Range	UNSIGNED16
Default Value	0

Sub-Index	2
Description	KI Velocity loop
Entry Category	Mandatory
Access	Read/Write
PDO Mapping	NO

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Value Range	UNSIGNED16
Default Value	0

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