CiA Draft Standard Proposal DSP-402

CANopen

Device Profile for

Drives and Motion Control

Version 1.1

Date: October 8, 1998

not recommended for implementation
may be changed without notification

History

Changes made compared to revision 1.0
(old pages in brackets):

- page 57 (page 56)
  Bit 7 *Fault Reset* set to 0 except for the transition *Fault Reset*. See explanation page 54 *State Transition 15.*

- page 193 (page 183)
  Object 6058_h, Subindex 1: *vl_frequency_motor_**min**_amount*.

- page 24 (page 23)
  Object 1000h: *Device Type*.
  Adaption to DS301 for multi profile devices.
  Additional information bits 16..23 **bit-encoded**.

- page 62 (page 61)
  controlword bit 13, Profile Velocity mode: ***max_slippage_error***. See explenation page 161.

- page 161 (page 152)
  Object $60F8_h$:
  When the max_slippage has been reached, the corresponding bit 13 *max_slippage_error* in the status message will be set to one.

- page 78, 79 (page 76, 77)
  Object 6089_h, Object $608A_h$: ***software_position_limit*** added.

- page 124, 125, 126 ,128 (page 120, 121, 122, 123)
  Object 6062_h, Object 6064_h, Object 6065_h, Object 6067_h
  Units changed to *position units*.

- page 100, 101, 102 (page 98, 99, 100)
  Object $607F_h$, Object 6081_h, Object 6082_h
  Value Range changed to 0..($\mathbf{2^{31}}$-1).

- page 57 (page 56)
  controlword bit 6, Profile Position Mode: defined
  0: absolute
  1: relative

- page 94 (page 92)
  Figure 15: position_demand_value is index $60F2_h$.

- page 111, 114 (page 108, 111)
  Homing Methods: there is a new structure.
  Object 6098_h is adapted to the new structure.

- page 120 (page 117)
  Figure 31: Object 6063_h *position_actual_value** is a normalised parameter.

- page 178 (page 170)
  Figure 46: vl_velocity_target changed to ***vl_target_velocity*** see object 6042_h.

- page 38, 55 (page 37, 54)
  Object $603F_h$, Object 6040_h
  Data Type changed to ***Unsigned16***, therefore *Value Range* changed to 0..65553.

- page 129
  Object $60F4_h$: **New**
  following_error_actual_value: This object represents the actual value of the following error.

- page 19-26
  Index attached.

- page 153 (page 144)
  Figure 40: *target_velocity* indexnumber (60FFh) added. *Unit* changed to *velocity units*.

- page 154 (page 146)
  Output Data Description wrong text deleted.

- page 156 (page 148)
  velocity_sensor_actual_value formatted.

- page 156 (page 148)
  velocity_actual_value changed to *velocity_**sensor**_actual_value.*

- page 26,28 (page 25, 27)
  4^{th} RPDO second entry is **target_velocity** Index $60FF_h$.

- page 78, 79 (page 76, 77)
  target_velocity added.

Table of Contents

1 Scope

This document represents the standardised CANopen Device Profile for digital controlled motion products like servo controllers, frequency converters or stepper motors.

All the above devices use communication techniques which conform to those described in the CiA Draft Standard DS-301 (CAL based communication profile for industrial systems). This document should be consulted in parallel to this profile.

2 References

/1/: ISO 7498, 1984, Information Processing Systems - Open Systems Interconnection - Basic Reference Model

/2/: ISO 11898, November 1993, Road Vehicles, Interchange of Digital Information - Controller Area Network (CAN) for high-speed Communication

/3/: CiA/DS 102, CAN Physical Layer for Industrial Applications, April 1994

/4/: CiA/DS 201, CAN Reference Model, Version 1.1, Feb. 1996

/5/: CiA/DS 202-1, CMS Service Specification, Version 1.1, Feb. 1996

/6/: CiA/DS 202-2, CMS Protocol Specification, Version 1.1, Feb. 1996

/7/: CiA/DS 202-3, CMS Encoding Rules, Version 1.1, Feb. 1996

/8/: CiA/DS 203-1, NMT Service Specification, Version 1.1, Feb. 1996

/9/: CiA/DS 203-2, NMT Protocol Specification, Version 1.1, Feb. 1996

/10/: CiA/DS 204-1, DBT Service Specification, Version 1.1, Feb. 1996

/11/: CiA/DS 204-2, DBT Protocol Specification, Version 1.1, Feb. 1996

/12/: CiA/DS 207, Application Layer Naming Specification, Version 1.1, Feb. 1996

/13/: CiA/DS 205-1, LMT Service Specification, Version 1.1, Feb. 1996

/14/: CiA/DS 205-2, LMT Protocol Specification, Version 1.1, Feb. 1996

/15/: CiA/DS 206, Application Specific Data Types, Version 1.1, Feb. 1996

/16/: CiA/DS 301, CAL-based Communication Profile, Version 3.0, Oct. 1996

/17/: CiA/DS 401, CANopen Device Profile for I/O Modules, Version 1.4, Dec. 1996

/18/: DRIVECOM Profil Antriebstechnik/Profil 21

/19/: DRIVECOM Profil Antriebstechnik/Servo 22, Jan. 1994

3 Definitions, Acronyms and Abbreviation

CAN	Controller Area Network
CiA	CAN in Automation e. V. international users and manufactorers group.
CMS	CAN based Message Specification. One of the service elements of the application layer in the CAN Reference Model.
COB	Communication Object (CAN Message). A unit of transportation in a CAN network. Data must be sent across a network inside a COB.
COB-ID	COB-Identifier. Identifies a COB uniquely in a network. The identifier determines the priority of that COB in the MAC sub-layer too.
DBT	Distributor. One of the service elements of the application in the CAN Reference Model. It's the responsibility of the DBT to distribute COB-IDs to the COBs that are used by the CMS.
LMT	Layer Management. One of the service elements of the application in the CAN Reference Model. It serves to configure parameters of each layer in the CAN Reference Model.
MAC	Medium Access Control. One of the sub-layers of the Datalink Layer in the CAN Reference Model that controls who gets access to the medium to send a message.
NMT	Network Management. One of the service elements of the application in the CAN Reference Model. It performs initialisation, configuration and error handling in a CAN network.
PDO	Process Data Object. Object for data exchange between several devices.
SDO	Service Data Object. Peer to peer communication with access to the Object dictionary of a device.
pp	Profile Position Mode
pv	Profile Velocity Mode
vl	Velocity Mode
hm	Homing Mode
ip	Interpolated Position Mode
tq	Profile Torque Mode
all	mandatory for all modes 强制性
ce	Common Entries in the Object Dictionary
dc	Device Control
pc	Position Control Function

4 Overview

4.1 Access to the Drive

The access from the CAN network to the drive is done through data objects.

Data Objects of the Drive

PDO	SDO	IDO
Process Data Object	Service Data Object	Internal Data Object
described in chapters 9 to 18	described in chapter 7	manufacturer specific normally not accessible

Figure 1: Data Objects of the Drive

Process Data Object (PDO): PDOs are messages in an unconfirmed service (see /16/). They are used for the transfer of real-time data to and from the drive. The transfer is fast, because it is performed with no protocol overhead what means to transport eight application data bytes in one CAN-frame. The PDOs correspond to entries in the Object dictionary described in chapters 9 to 18. The data type and mapping of these objects into a PDO is described in chapter 7.

SDO需要进行握手

Service Data Object (SDO): SDOs are messages in a confirmed service with a kind of handshake (see /16/). They are used for the access to entries of the Object dictionary. Especially the configuration for the requested behaviour of the drive adapted to the various possible applications is done by these objects.

Internal Data Object (IDO): The internal data objects represent the adaptation of the manufacturer and device specific functionality to this profile. Normally these objects are not directly accessible; nevertheless a manufacturer can give the user access to the IDOs by SDO services.

4.2 Architecture of the Drive

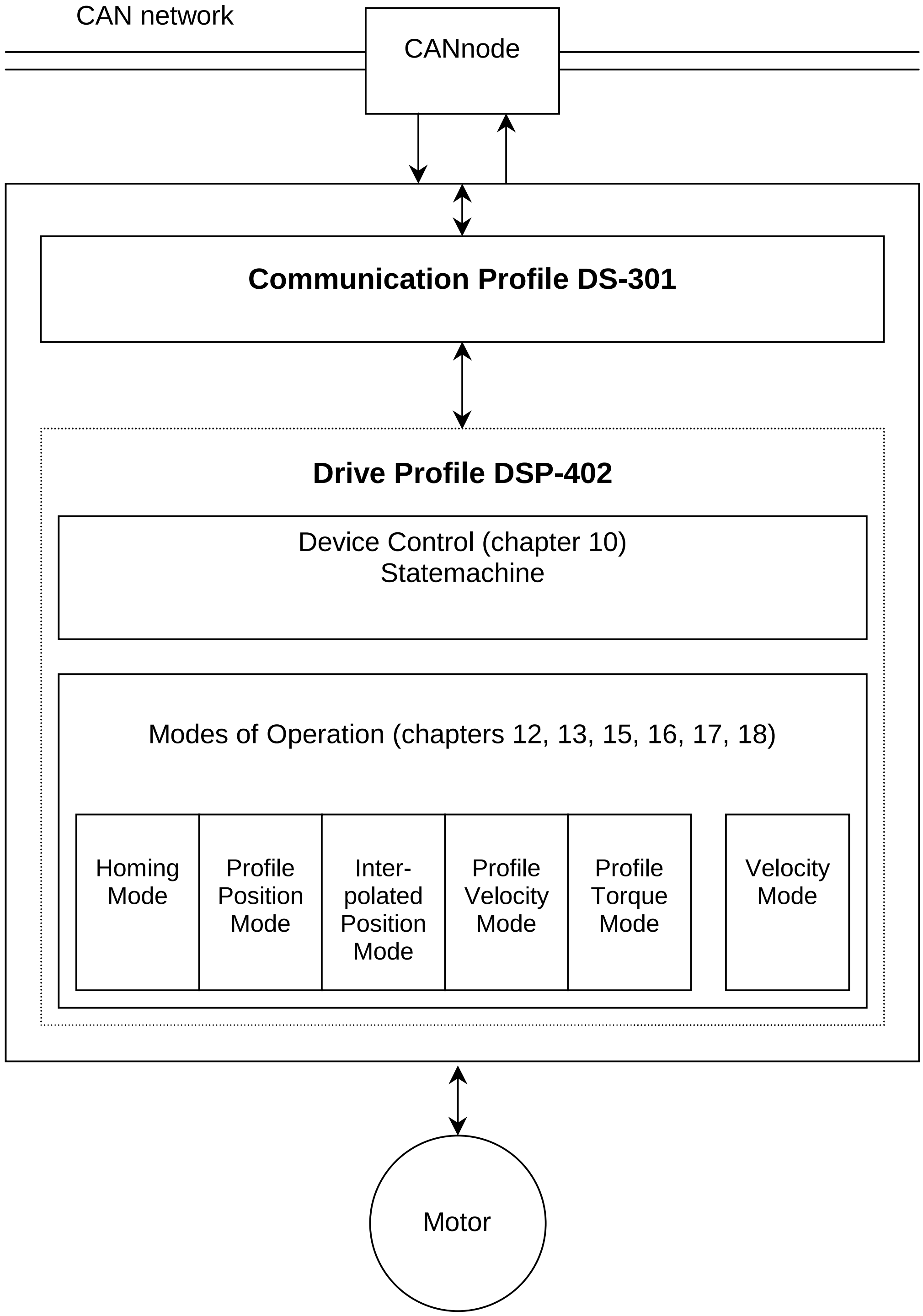


Figure 2: Communication Architecture

Device Control: The starting and stopping of the drive and several mode specific commands are executed by the statemachine. This is described in chapter 10. The mode specific actions are described in chapter 12 to 18.

Modes of Operation: The operation mode defines the behaviour of the drive. The following modes are defined in this profile:

Homing Mode (chapter 13)
This chapter describes the various methods to find a home position (also: reference point, datum, zero point). 参考位置，基准，零点

Profile Position Mode (chapter 12)
The positioning of the drive is defined in this mode. Speed, position and acceleration can be limited and profiled moves using a Trajectory Generator are possible as well.

Interpolated Position Mode (chapter 15)
This chapter describes the time interpolation of single axles and the spatial interpolation of co-ordinated axles. Synchronisation mechanisms and interpolation data buffers are covered by this chapter.

Profile Velocity Mode (chapter 16)
The Profile Velocity Mode is used to control the velocity of the drive with no special regard of the position. It supplies limit functions and trajectory generation.

Profile Torque Mode (chapter 17)
In this chapter the torque control with all related parameters is described.

Velocity Mode (chapter 18)
Many frequency inverters use this simple mode to control the velocity of the drive with limits and ramp functions.

The Velocity Mode (chapter 18) is rather separated from the other modes and does not interfere with them so much. For this reason, the naming of object dictionary entries differs a little bit from the other chapters.

The manufacturer commits in the manual which modes are supported by his device.

If more than one mode is supported, then the manufacturer also defines whether the change of operation mode is allowed while the drive is moving or only when the drive is stopped.

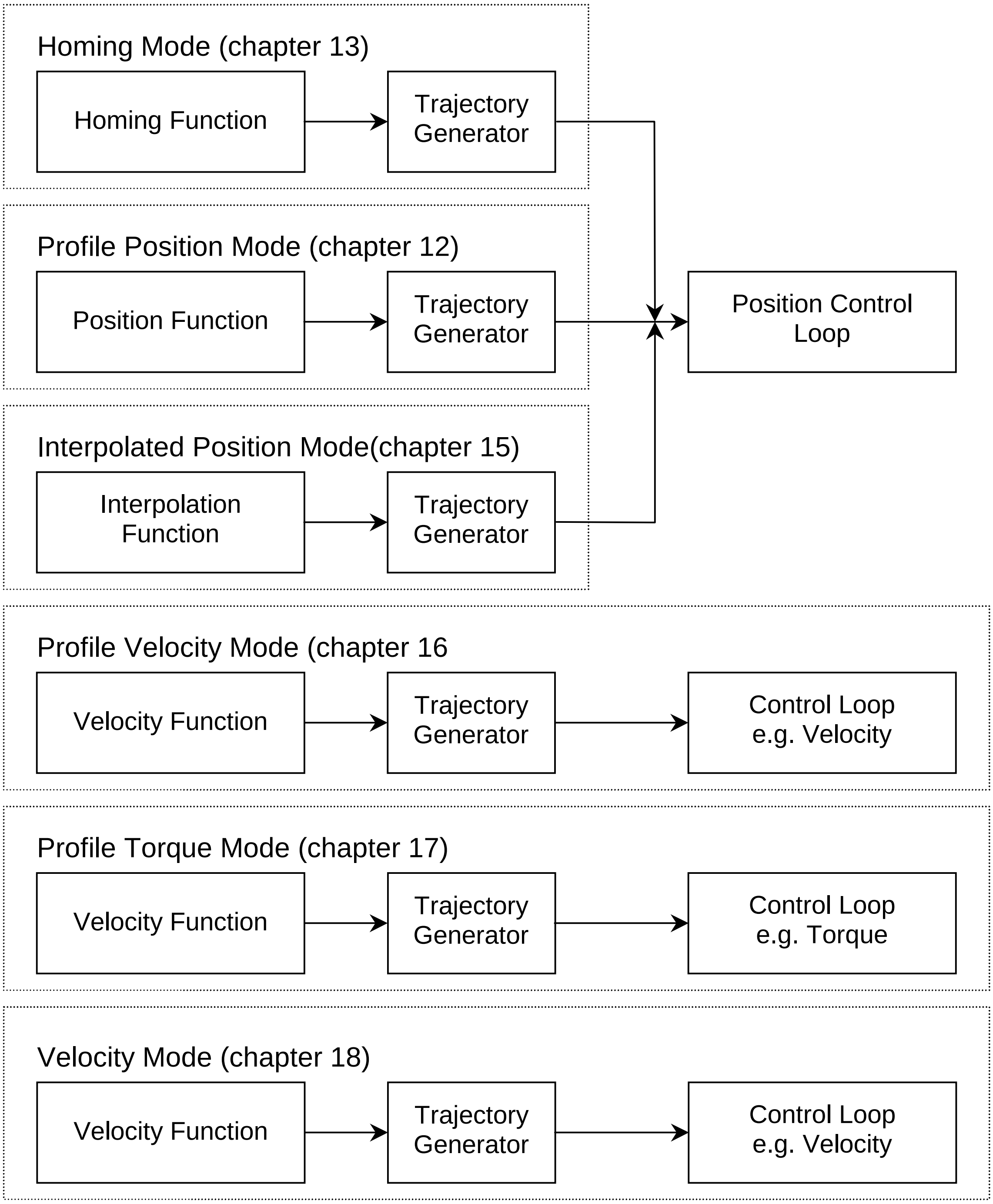


Figure 3: Functional Architecture

Trajectory Generator: The chosen operation mode and the corresponding parameters (objects) define the input of the Trajectory Generator. The Trajectory Generator supplies the control loop(s) with the demand values. They are generally mode specific.

Each Mode may use its own Trajectory Generator. A general description of its functionality is given in chapter 12, which is related to the Profile Position Mode.

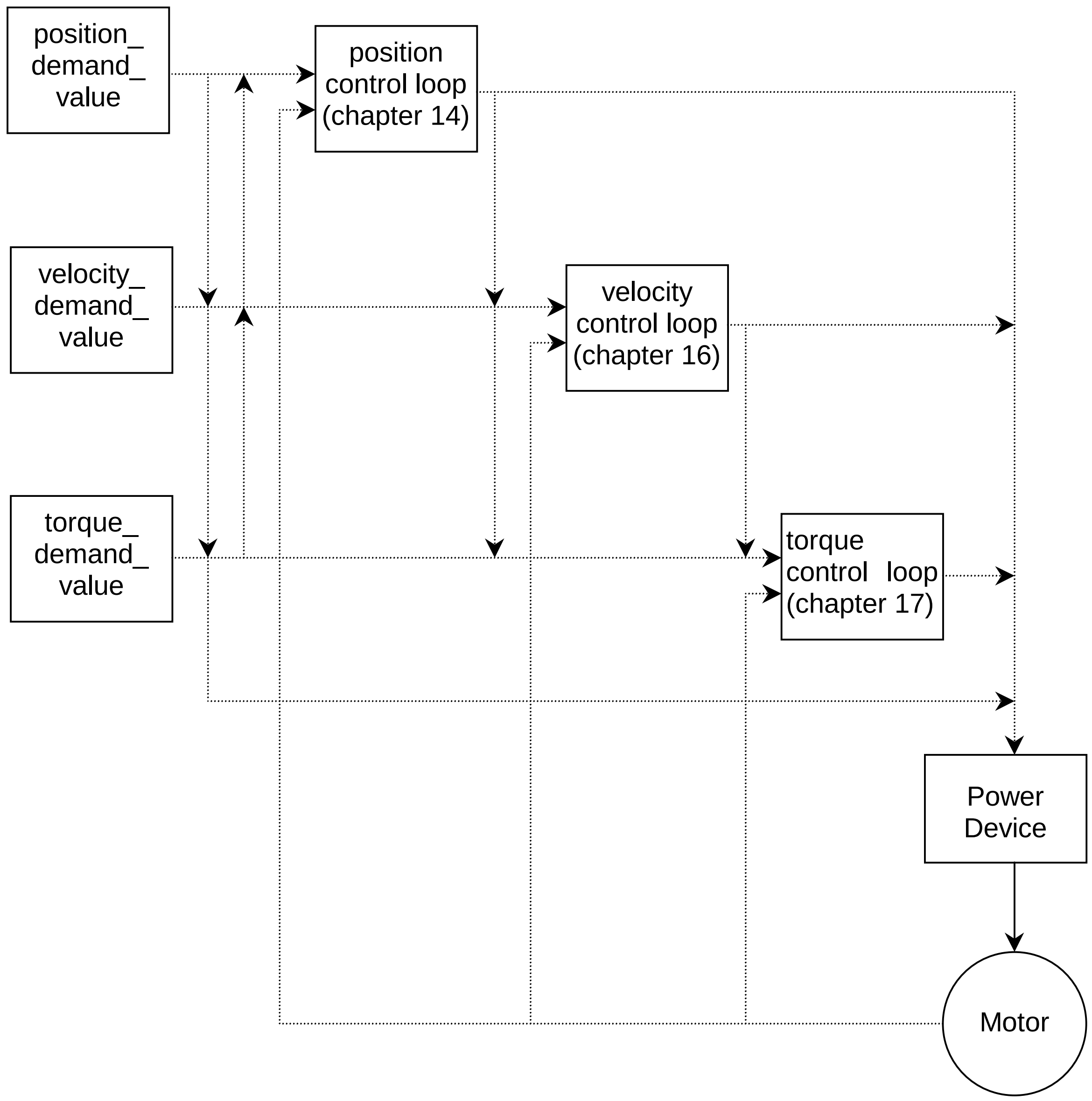


Figure 4: Possible Structures of the Control Loop

Control Loop: The implementation of the control loop is highly manufacturer specific and not described in this profile. Possible control loop structures are shown in the picture above.

The control loop can be open or closed and it can be operation mode specific or fixed. The objects which are described in chapter 12 to 18 must be implemented, if the corresponding mode is supported and if they are mandatory. But it is allowed that the manufacturer uses objects of the velocity controller in the Profile Position Mode; for example the control loop structure consists of a position controller producing a velocity demand value and a velocity controller using this as a demand value.

5 Operating Principle

5.1 Introduction

The purpose of this profile is, to give drives an understandable and unique behaviour on the CAN network. The CANopen Device Profile for Drives and Motion Control is built on top of a CAN communication profile, called CANopen, describing the basic communication mechanisms common to all devices at the CAN-network.

The purpose of drive units is to connect axle controllers or other motion control products to the CAN bus. They can receive configuration information what is done via service data objects normally for I/O configurations, limit parameters for scaling or application specific parameters. At run time, data can be obtained from the drive unit via CAN bus by either polling or event driven (interrupt).

The motion control products have a process data object mapping for real time operation, which may be configured using service data objects (see /16/). This communication channel is used to interchange real-time data like setpoints or actual values like a *position_actual_value* e.g.

5.2 Standardisation via Profiling

The two principal advantages of the profile approach for device specification are in the areas of system integration and device standardisation.

If two independent device manufacturers design products that have to communicate, then both manufacturers must be provided with a device specification from the other one. These specifications will widely differ in formal and terminological aspects from one company to another. The concept of device profiling provides a standard for producing such specifications. By adopting this approach, all manufacturers will specify their devices in a similar fashion, what greatly reduces the effort involved in system integration.

The other obvious advantage of the profile approach for device specification is, that it can be used to guide manufacturers into producing standardised devices. The advantages of standardised devices are numerous. Perhaps most important is the idea, that a standardised device decouples a system integrator from a specific supplier. If one supplier cannot meet special application demands, a system designer can use devices from another supplier with reduced effort. On the other hand the device manufacturers are not forced any more to implement private protocols for each customer.

A device profile defines a ‘standard’ device. This standard device represents really basic functionality, every device within this device class must support. This mandatory functionality is necessary to ensure, that at least simple non-manufacturer-specific operation of a device is possible. For example the standard drive unit provides a 'quickstop' function to stop a drive. This function is defined as mandatory, such that any drive unit supporting the CANopen Device Profile for Drives and Motion Control, can be halted using the same message.

The concept of device standardisation is extended by the notion of optional functionality defined within the standardised device profile. Such optional functionality does not have to be implemented by all manufacturers. However, if a manufacturer implements such functionality he must do so in a fixed manner.

Providing optional functionality is a very powerful mechanism to ensure all manufacturers implementing particular functionality in a defined fashion. For example, the device profile covers multi-axles modules as well, which are still not very common. By defining a standardised access to the different axles, interchanging devices from different manufacturers becomes easier.

The device profiles provide a mechanism by which manufacturers wishing to implement truly manufacturer specific functionality can do so as well. This is clearly necessary since it would be impossible to anticipate all possible device functionality and define this in the optional category of each device class. This concept guarantees that the standard device profiles are 'future-proof'.

By defining mandatory device characteristics, basic network operation is guaranteed. By defining optional device features a degree of defined flexibility can be built in. By leaving 'hooks' for manufacturer specific functionality, manufacturers will not be constrained to an out-of-date standard.

5.3 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 so that the object dictionary may contain a maximum of 65536 entries.

The overall layout of the standard object dictionary is shown below. This layout closely conforms with device profiles for other fieldbus systems :

Index (hex)	**Object**
0000	not used
0001-001F	Static Data Types
0020-003F	Complex Data Types
0040-005F	Manufacturer Specific Data Types
0060-0FFF	Reserved for further use
1000-1FFF	Communication Profile Area
2000-5FFF	Manufacturer Specific Profile Area
6000-9FFF	Standardised Device Profile Area
A000-FFFF	Reserved for further use

Table 1: Object Dictionary Structure

The static data types at indices 0001_h through $001F_h$ contain type definitions for standard data types like boolean, integer, floating point, string, etc. These entries are included for reference only, they cannot be read or written.

Complex data types at indices 0020_h through $003F_h$ are pre-defined structures that are composed out of standard data types and are common to all devices.

Manufacturer Specific Data Types at indices 0040_h through $005F_h$ are also structures composed of standard data types but are specific to a particular device.

The Communication Profile Area at indices 1000_h through $1FFF_h$ contains the parameters for the communication profile on the CAN network. These entries are common to all devices.

The standardised device profile area at indices 6000_h through $9FFF_h$ contains all data objects common to a class of devices that can be read or written via the network. The drives profile uses entries from 6000_h to $9FFF_h$ to describe the drive parameters and the drive functionality. Within this range up to 8 axles can be realised. Additional it is possible to describe optional I/O modules combined with the drive. These I/O modules must conform to DS-401 (see /17/) and can be implemented instead of an axle. For standard drives only the range 6000_h to $67FF_h$ is mandatory. There are also two reserved areas at indices 060_h through $0FFF_h$ and $A000_h$ through $FFFF_h$ for future use by the communication or drive profile.

For multi axles devices the object range 6000_h to $67FF_h$ is shifted as follows:

6000_h to $67FF_h$	axle 0
6800_h to $6FFF_h$	axle 1
7000_h to $77FF_h$	axle 2
7800_h to $7FFF_h$	axle 3
8000_h to $87FF_h$	axle 4
8800_h to $8FFF_h$	axle 5
9000_h to $97FF_h$	axle 6
9800_h to $9FFF_h$	axle 7

5.3.1 Index and sub-index usage

A 16-bit index is used to address all entries within the object dictionary. In case of a simple variable this references the value of this variable directly. In case of records and arrays however, the index addresses the whole data structure. To allow individual elements of structures of data to be accessed via the network a sub-index has been defined. For single object dictionary entries such as an Unsigned8, Boolean, Integer32 etc. the value for the sub-index is always zero. For complex object dictionary entries such as arrays or records with multiple data fields the sub-index refers to fields within a data-structure pointed to by the main index. Index counting starts with one. For example in the chapter Factor Group exists the object $608F_h$ named *position_encoder_resolution*. Because this may be a fraction, two integers in an array are used to describe it. The drive uses the two values in the following manner:

$$\text{position\_encoder\_resolution} = \frac{\text{encoder\_increments}}{\text{motor\_revolutions}}$$

The sub-index concept can be used to access these individual fields which may be of different data type as shown below:

Main Index	Sub Index	Variable Accessed	Data Type
648F	0	Number of elements	Unsigned8
	1	Encoder_increments	Unsigned32
	2	Motor_revolutions	Unsigned32

Table 2: Usage of index and sub-index

6 Emergency Messages

6.1 Principle

Emergency messages are triggered by internal errors in the device and they are assigned the highest possible priority to ensure that they get access to the bus without latency. By default, the emergency messages contain an error field with pre-defined error numbers and additional information.

The error number is of Unsigned32 type. The lower two bytes contain the error code, the upper two bytes may contain additional error information. The high byte of the error code is used for an error classification while the low byte contains the error number for this class (see also /16/).

Error numbers from $xx00_h$ to $xx7F_h$ are defined in the communication profile DS-301 or in this profile DSP402. Not defined error numbers within this range are reserved. Error numbers between $xx80_h$ and $xxFF_h$ can be used manufacturer specific.

6.2 Error Code Meanings

Error Code (hex)	Meaning	Defined By
0000	no error	Comm. Prof.
1000	generic error	Comm. Prof.
2000	current	Comm. Prof.
2100	current on device input side	
2110	short circuit/earth leakage	Drives Prof.
2120	earth leakage	Drives Prof.
2121	earth leakage phase L1	Drives Prof.
2122	earth leakage phase L2	Drives Prof.
2123	earth leakage phase L3	Drives Prof.
2130	short circuit	Drives Prof.
2131	short circuit phases L1-L2	Drives Prof.
2132	short circuit phases L2-L3	Drives Prof.
2133	short circuit phases L3-L1	Drives Prof.
2200	internal current	Drives Prof.
2211	internal current No.1	Drives Prof.
2212	internal current No.2	Drives Prof.
2213	over-current in ramp function	Drives Prof.
2214	over-current in the sequence	Drives Prof.
2220	continuous over current	Drives Prof.
2221	continuous over current No.1	Drives Prof.
2222	continuous over current No.2	Drives Prof.
2230	short circuit/earth leakage	
2240	earth leakage	Drives Prof.
2250	short circuit	Drives Prof.

Error Code (hex)	Meaning	Defined By
2300	current on device output side	Drives Prof.
2310	continuous over current	Drives Prof.
2311	continuous over current No.1	Drives Prof.
2312	continuous over current No.2	Drives Prof.
2320	short circuit/earth leakage	Drives Prof.
2330	earth leakage	Drives Prof.
2331	earth leakage phase U	Drives Prof.
2332	earth leakage phase V	Drives Prof.
2333	earth leakage phase W	Drives Prof.
2340	short circuit	Drives Prof.
2341	short circuit phases U-V	Drives Prof.
2342	earth leakage phase V-W	Drives Prof.
2343	earth leakage phase W-U	Drives Prof.
3000	voltage	Comm. Prof.
3100	mains voltage	Drives Prof.
3110	mains over-voltage	Drives Prof.
3111	mains over-voltage phase L1	Drives Prof.
3112	mains over-voltage phase L2	Drives Prof.
3113	mains over-voltage phase L3	Drives Prof.
3120	mains under-voltage	Drives Prof.
3121	mains under-voltage phase L1	Drives Prof.
3122	mains under-voltage phase L2	Drives Prof.
3123	mains under-voltage phase L3	Drives Prof.
3130	phase failure	Drives Prof.
3131	phase failure L1	Drives Prof.
3132	phase failure L2	Drives Prof.
3133	phase failure L3	Drives Prof.
3134	phase sequence	Drives Prof.
3140	mains frequency	Drives Prof.
3141	mains frequency too great	Drives Prof.
3142	mains frequency too small	Drives Prof.
3200	DC link voltage	Drives Prof.
3210	DC link over-voltage	Drives Prof.
3211	over-voltage No. 1	Drives Prof.
3212	over voltage No. 2	Drives Prof.
3220	DC link under-voltage	Drives Prof.
3221	under-voltage No. 1	Drives Prof.
3222	under-voltage No. 2	Drives Prof.
3230	load error	Drives Prof.
3300	output voltage	Drives Prof.
3310	output over-voltage	Drives Prof.
3311	output over-voltage phase U	Drives Prof.
3312	output over-voltage phase V	Drives Prof.
3313	output over-voltage phase W	Drives Prof.
3320	armature circuit	Drives Prof.
3321	armature circuit interrupted	Drives Prof.
3330	field circuit	Drives Prof.
3331	field circuit interrupted	Drives Prof.

Error Code (hex)	Meaning	Defined By
4000	temperature	Comm. Prof.
4100	ambient temperature	Drives Prof.
4110	excess ambient temperature	Drives Prof.
4120	too low ambient temperature	Drives Prof.
4130	temperature supply air	Drives Prof.
4140	temperature air outlet	Drives Prof.
4200	temperature device	Drives Prof.
4210	excess temperature device	Drives Prof.
4220	too low temperature device	Drives Prof.
4300	temperature drive	Drives Prof.
4310	excess temperature drive	Drives Prof.
4320	too low temperature drive	Drives Prof.
4400	temperature supply	Drives Prof.
4410	excess temperature supply	Drives Prof.
4420	too low temperature supply	Drives Prof.
5000	device hardware	Comm. Prof.
5100	supply	Drives Prof.
5110	supply low voltage	Drives Prof.
5111	U1 = supply +/- 15V	Drives Prof.
5112	U2 = supply +24 V	Drives Prof.
5113	U3 = supply +5 V	Drives Prof.
5114	U4 = manufacturer specific	Drives Prof.
5115	U5 = manufacturer specific	Drives Prof.
5116	U6 = manufacturer specific	Drives Prof.
5117	U7 = manufacturer specific	Drives Prof.
5118	U8 = manufacturer specific	Drives Prof.
5119	U9 = manufacturer specific	Drives Prof.
5120	supply intermediate circuit	Drives Prof.
5200	control	Drives Prof.
5210	measurement circuit	Drives Prof.
5220	computing circuit	Drives Prof.
5300	operating unit	Drives Prof.
5400	power section	Drives Prof.
5410	output stages	Drives Prof.
5420	chopper	Drives Prof.
5430	input stages	Drives Prof.
5440	contacts	Drives Prof.
5441	contact 1 = manufacturer specific	Drives Prof.
5442	contact 2 = manufacturer specific	Drives Prof.
5443	contact 3 = manufacturer specific	Drives Prof.
5444	contact 4 = manufacturer specific	Drives Prof.
5445	contact 5 = manufacturer specific	Drives Prof.
5450	fuses	Drives Prof.
5451	S1 = L1	Drives Prof.
5452	S2 = L2	Drives Prof.
5453	S3 = L3	Drives Prof.
5454	S4 = manufacturer specific	Drives Prof.
5455	S5 = manufacturer specific	Drives Prof.
5456	S6 = manufacturer specific	Drives Prof.
5457	S7 = manufacturer specific	Drives Prof.

Error Code (hex)	Meaning	Defined By
5458	S8 = manufacturer specific	Drives Prof.
5459	S9 = manufacturer specific	Drives Prof.
5500	data storage	Drives Prof.
5510	RAM	Drives Prof.
5520	EPROM	Drives Prof.
5530	EEPROM	Drives Prof.
6000	device software	Comm. Prof.
6010	software reset (watchdog)	Drives Prof.
6100	internal software	Drives Prof.
6200	user software	Drives Prof.
6300	data record	Drives Prof.
6301	data record No. 1	Drives Prof.
	.....	Drives Prof.
630F	date record No.15	Drives Prof.
6310	loss of parameters	Drives Prof.
6320	parameter error	Drives Prof.
7000	additional modules	Comm. Prof.
7100	power	Drives Prof.
7110	brake chopper	Drives Prof.
7111	failure brake chopper	Drives Prof.
7112	over current brake chopper	Drives Prof.
7113	protective circuit brake chopper	Drives Prof.
7120	motor	Drives Prof.
7121	motor blocked	Drives Prof.
7122	motor error or commutation malfunc.	Drives Prof.
7123	motor tilted	Drives Prof.
7200	measurement circuit	Drives Prof.
7300	sensor	Drives Prof.
7301	tacho fault	Drives Prof.
7302	tacho wrong polarity	Drives Prof.
7303	resolver 1 fault	Drives Prof.
7304	resolver 2 fault	Drives Prof.
7305	incremental sensor 1 fault	Drives Prof.
7306	incremental sensor 2 fault	Drives Prof.
7307	incremental sensor 3 fault	Drives Prof.
7310	speed	Drives Prof.
7320	position	Drives Prof.
7400	computation circuit	Drives Prof.
7500	communication	Drives Prof.
7510	serial interface No. 1	Drives Prof.
7520	serial interface No. 2	Drives Prof.
7600	data storage	Drives Prof.

Error Code (hex)	Meaning	Defined By
8000	monitoring	Comm. Prof.
8100	communication	Drives Prof.
8110	process data monitoring	Drives Prof.
8120	host monitoring	Drives Prof.
8200	control	Drives Prof.
8300	torque control	Drives Prof.
8311	excess torque	Drives Prof.
8312	difficult start up	Drives Prof.
8313	standstill torque	Drives Prof.
8321	insufficient torque	Drives Prof.
8331	torque fault	Drives Prof.
8400	velocity speed controller	Drives Prof.
8500	position controller	Drives Prof.
8600	positioning controller	Drives Prof.
8611	following error	Drives Prof.
8612	reference limit	Drives Prof.
8700	sync controller	Drives Prof.
8800	winding controller	Drives Prof.
9000	external error	Comm. Prof.
F000	additional functions	Comm. Prof.
F001	deceleration	Drives Prof.
F002	sub-synchronous run	Drives Prof.
F003	stroke operation	Drives Prof.
F004	control	Drives Prof.
FF00 .... FFFF	device specific	Comm. Prof.

Table 3: Error Codes

7 Predefinitions

7.1 Naming conventions

The first three characters of a CMS name is a device profile identification (see /16/) and is defined for this device profile as: <402> (according to the number of this standard).

7.2 Predefined Objects

The default values for communication objects 1000_h to $1FFF_h$ which are not defined by the communication profile (see /16/) are mentioned below.

7.2.1 Object 1000_h: Device Type

The object at index 1000_h describes the type of a device and its functionality.

For multi device modules the additional information parameter contains FFFh and the device profile number referenced by object 1000h is the device profile of the first device in the object dictionary. All other devices of a multiple device module identify their profiles at object 67FFh + x * 800h with x = internal number of the device (0..7).

MSB ... LSB

additional information		device profile number
mode bits	type	
31 ... 24	23 ... 16	15 ... 0

For devices in this device profile the following assignment exists:

Device Profile Number:	**402**	
additional information		
drive type bit encoded:	Bit 16 = 1	Frequency Converter
bits 16...23	Bit 17 = 1	Servo Drive
	Bit 18 = 1	Stepper Motor
	Bit 23 = 1	I/O module (only multi device modules)
manufacturer specific		
bits 24...31	0	

Table 4: Structure of the Device Type Entry in the Object Dictionary

7.2.2 Object 1001_h: Error Register

All bits are defined as in /16/. The device specific bit in the status word is used by the CANopen Device Profile for Drives and Motion Control. The error code can be read from the predefined error field at object 1003_h and to be compatible with device profiles for drives available for other fieldbus systems from object $603F_h$ as well.

7.2.3 Object $67FF_h$: Single Device Type

The object at index $67FF_h$ and multiples with an offset of 800_h describe the type of each device within one drive unit and its functionality. The object structure is the same as defined in Object 1000_h.

For a multi device module, there must be defined the *device_type* at index 1000_h with the value $FFFF_h$ instead.

7.3 PDO Mapping

A drive supporting more then one mode will mostly use more than one standard PDO. Therefore a lot of PDOs are predefined in respect to the different possible modes of operation for drives.

The hereafter described PDO distribution should be used for every axle of a multi-device module with an offset of 64, e.g. the first PDO of the second axle gets the number 65. In this way a system with a maximum of 8 axles is supported.

It is open to a manufacturer to specify additional entries in the mapping table or define absolutely new PDO mappings and it is also open to a user to change these default settings by changing the mapping structure, if the module supports variable mapping on these PDOs.

7.3.1 Receive PDOs

PDO No.	Mapping Object Index	Mapping Object Name	M/O	Comment
1	6040_h	controlword	M	controls the state machine
2	6040_h 6060_h	controlword modes_of_operation	O	controls the state machine and mode of operation
3	6040_h $607A_h$	controlword target_position	O	controls the state machine and the target position (pp)
4	6040_h $60FF_h$	controlword target_velocity	O	controls the state machine and the target velocity (pv)
5	6040_h 6071_h	controlword target_torque	O	controls the state machine and the target torque (tq)
6	6040_h 6042_h	controlword vl_target_velocity	O	controls the state machine and the nominal speed (vl)
7	6040_h $60FE_h$	controlword digital_outputs	O	controls the state machine and the digital outputs
8	6040_h 6060_h	controlword modes_of_operation	O	controls the state machine and mode of operation (Broadcast PDO)
9 - 20			O	reserved
21 - 64			O	manufacturer specific

7.3.1.1 1st Receive PDO

Index	Subindex	Comment	Default Value
1400_h	0	number of entries	see /16/
	1	COB-ID used by PDO	see /16/
	2	transmission type	255
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
1600_h	0	number of mapped objects	1
	1	controlword	60400010_h

7.3.1.2 2nd Receive PDO

Index	Subindex	Comment	Default Value
1401 h	0	number of entries	see /16/
	1	COB-ID used by PDO	see /16/
	2	transmission type	255
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
1601 h	0	number of mapped objects	2
	1	controlword	60400010 h
	2	modes_of_operation	60600008 h

7.3.1.3 3rd Receive PDO

Index	Subindex	Comment	Default Value
1402 h	0	number of entries	see /16/
	1	COB-ID used by PDO	not defined
	2	transmission type	255
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
1602 h	0	number of mapped objects	2
	1	controlword	60400010 h
	2	target_position	607A0020 h

7.3.1.4 4th Receive PDO

Index	Subindex	Comment	Default Value
1403_h	0	number of entries	see /17/
	1	COB-ID used by PDO	not defined
	2	transmission type	255
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
1603_h	0	number of mapped objects	2
	1	controlword	60400010_h
	2	profile_velocity	$60FF0020_h$

7.3.1.5 5th Receive PDO

Index	Subindex	Comment	Default Value
1404_h	0	number of entries	see /16/
	1	COB-ID used by PDO	not defined
	2	transmission type	255
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
1604_h	0	number of mapped objects	2
	1	controlword	60400010_h
	2	target_torque	60710010_h

7.3.1.6 6th Receive PDO

Index	Subindex	Comment	Default Value
1405_h	0	number of entries	see /16/
	1	COB-ID used by PDO	not defined
	2	transmission type	255
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
1605_h	0	number of mapped objects	2
	1	controlword	60400010_h
	2	nominal_speed_value	60420010_h

7.3.1.7 7th Receive PDO

Index	Subindex	Comment	Default Value
1406_h	0	number of entries	see /16/
	1	COB-ID used by PDO	not defined
	2	transmission type	255
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
1606_h	0	number of mapped objects	2
	1	controlword	60400010_h
	2	digital_outputs	$60FE0020_h$

7.3.1.8 8th Receive PDO

Index	Subindex	Comment	Default Value
1407_h	0	number of entries	see /16/
	1	COB-ID used by PDO	not defined
	2	transmission type	255
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
1607_h	0	number of mapped objects	2
	1	controlword	60400010_h
	2	modes_of_operation	60600008_h

7.3.2 Transmit PDOs

The task of the transmit PDOs is the monitoring of the drives behaviour. The TPDO 1,2 and 7 are event driven. The other PDOs can be implemented as synchronous or remotely requested (RTR) PDO.

PDO No.	**Mapping Object Index**	Mapping Object Name	M/O	Comment
1	6041_h	statusword	M	shows status
2	6041_h 6061_h	statusword modes_of_operation_display	O	shows status and the actual mode of operation
3	6041_h 6064_h	statusword position_actual_value	O	shows the status and the actual position (pp)
4	6041_h $606C_h$	statusword velocity_actual_value	O	shows the status and the actual velocity (pv)
5	6041_h 6077_h	statusword torque_actual_value	O	shows the status and the actual torque (tq)
6	6041_h 6044_h	statusword vl_control_effort	O	shows the status and the actual speed (vl)
7	6041_h $60FD_h$	statusword digital_inputs	O	shows the status and the digital inputs
8 – 20			O	reserved
21 - 64			O	manufacturer specific

7.3.2.1 1st Transmit PDO

Index	Subindex	Comment	Default Value
1800_h	0	number of entries	see /16/
	1	COB-ID used by PDO	see /16/
	2	transmission type	255
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
$1A00_h$	0	number of mapped objects	1
	1	statusword	60410010_h

7.3.2.2 2nd Transmit PDO

Index	Subindex	Comment	Default Value
1801_h	0	number of entries	see /16/
	1	COB-ID used by PDO	see /16/
	2	transmission type	255
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
$1A01_h$	0	number of mapped objects	2
	1	statusword	60410010_h
	2	modes_of_operation_display	60610008_h

7.3.2.3 3rd Transmit PDO

Index	Subindex	Comment	Default Value
1802_h	0	number of entries	see /16/
	1	COB-ID used by PDO	not defined
	2	transmission type	not defined
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
$1A02_h$	0	number of mapped objects	2
	1	statusword	60410010_h
	2	position_actual_value	606400020_h

7.3.2.4 4th Transmit PDO

Index	Subindex	Comment	Default Value
1803_h	0	number of entries	see /16/
	1	COB-ID used by PDO	not defined
	2	transmission type	not defined
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
$1A03_h$	0	number of mapped objects	2
	1	statusword	60410010_h
	2	velocity_actual_value	$606C0020_h$

7.3.2.5 5th Transmit PDO

Index	Subindex	Comment	Default Value
1804_h	0	number of entries	see /16/
	1	COB-ID used by PDO	not defined
	2	transmission type	not defined
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
$1A04_h$	0	number of mapped objects	2
	1	statusword	60410010_h
	2	torque_actual_value	60770010_h

7.3.2.6 6th Transmit PDO

Index	Subindex	Comment	Default Value
1805_h	0	number of entries	see /16/
	1	COB-ID used by PDO	not defined
	2	transmission type	not defined
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
$1A05_h$	0	number of mapped objects	2
	1	statusword	60410010_h
	2	vl_control_effort	60440010_h

7.3.2.7 7th Transmit PDO

Index	Subindex	Comment	Default Value
1806_h	0	number of entries	see /16/
	1	COB-ID used by PDO	not defined
	2	transmission type	255
	3	inhibit time	see /16/
	4	CMS priority group	3

Index	Subindex	Comment	Default Value
$1A06_h$	0	number of mapped objects	2
	1	statusword	60410010_h
	2	digital_inputs	$60FD0020_h$

8 Object Dictionary

Each drive shares the dictionary entries from 6000_h to $63FF_h$. These entries are common to all drive modules and each module implements only the dictonary parts which are relevant for its functions.

Drives having also digital or analog I/O are using dictionary entries from 8000_h to $83FF_h$as described in /19/ for the objects from 6000_h to $63FF_h$ with an offset of 2000_h.

Meaning of the Table Rows:	
Index	the 16-bit index to the object dictionary used by a module to represent a special function, data or task
Name	short description of the usage
Object Code	object type which represents the data, e.g. VAR, ARRAY, RECORD, etc.
Data Type	data type which represents the information, e.g. Unsigned32, Unsigned8 etc.
Object Class	entries in this row indicates wether an object is mandatory or not: M this object is mandatory for all drives O this object is optional Dependent on the mode of operation
Access	description how the object might be accessed: ro read only wo write only rw read and write
PDO mapping	indicates the manner of PDO mapping for an object. No mapping is not allowed Possible mapping is allowed for the manufacturer Yes this object is mapped by default
Units	physical units of the object value
Value Range	the value range allowed and requested for an object
Default Value	default value of the object after device initialization.
Substitute Value	if the object doesn’t exist in the object dictionary description, this value will be used for internal calculations
Device Mode Abbreviations:	
pp	mandatory (m), optional (o) or not used (-) for the Profile Position Mode
pv	mandatory (m), optional (o) or not used (-) for the Profile Velocity Mode
vl	mandatory (m), optional (o) or not used (-) for the Velocity Mode
hm	mandatory (m), optional (o) or not used (-) for the Homing Mode
ip	mandatory (m), optional (o) or not used (-) for the Interpolated Position Mode
tq	mandatory (m), optional (o) or not used (-) for the Profile Torque Mode
all	mandatory for all modes
Chapter Titel Abbreviations	
ce	Common Entries in the Object Dictionary
dc	Device Control
pc	mandatory (m), optional (o) or not used (-) for the Position Control Function

9 Common Entries in the Object Dictionary

9.1 General Information

9.1.1 Motor Data

The objects 6402_h to $64FF_h$ serve as a database for motor parameters. The values are typically found on the motor's nameplate or the manufacturer's motor catalog and are used to maintain a service database within the controlling device of the drive. Most of the entries are typically entities from the manufacturer's motor catalog. Future drives should at least contain an entry to the electronically available catalog via a common net address, like a HTTP link to the manufactorers database, *http_motor_catalog_address*.

The objects 6402_h to $640F_h$ are highly recommended.

Some objects are available in the object dictionary of other fieldbus systems, so their indices are not in the default range from 6400_h to $64ff_h$.

There is one manufacturer specific data RECORD at object 6410_h. It should contain as much as possible entries for the used motor. The structure of this record is described in the manufacturer`s data sheet for the drive unit.

9.1.2 Drive Data

The objects 6500_h to $65FF_h$ serve as a database for drive parameters.

There is one manufacturer specific data RECORD at object 6510_h. It should contain as much as possible entries for the used drive. The structure of this record is described in the manufacturer's handbook. The data must be filled in while in commissioning. The values are typically found on the drive's datasheet or the manufacturer's drives catalog and are used to maintain a service database within the controlling device of the drive.

Most of the entries are typically entities from the manufacturer's drive catalog. Future drives should at least contain an entry to the electronically available catalog via a common net address, like a HTTP link to the manufactorers database, *http_drive_catalog_address*.

In /16/ three optional objects for a CANopen device are recommended:

Index	**Name**
1008_h	manufacturer device name
1009_h	manufacturer hardware version
$100A_h$	manufacturer software version

9.2 Object Dictionary Entries

9.2.1 Objects defined in this Chapter

Index	Object	Name	Type	Attr.	M/O
6007_h	VAR	abort_connection_option_code	Integer16	rw	O
$603F_h$	VAR	error_code	Unsigned16	ro	O
6402_h	VAR	motor_type	Unsigned16	rw	O
6403_h	VAR	motor_catalogue_number	Visible String	rw	O
6404_h	VAR	motor_manufacturer	Visible String	rw	O
6405_h	VAR	http_motor_catalog_address	Visible String	rw	O
6406_h	VAR	motor_calibration_date	Date	rw	O
6407_h	VAR	motor_service_period	Unsigned32	rw	O
6410_h	RECORD	motor_data	-	rw	O
6502_h	VAR	supported_drive_modes	Unsigned32	ro	O
6503_h	VAR	drive_catalogue_number	Visible String	ro	O
6504_h	VAR	drive_manufacturer	Visible String	ro	O
6505_h	VAR	http_drive_catalog_address	Visible String	rw	O
6510_h	RECORD	drive_data	-	rw	O
$60FD_h$	VAR	digital_inputs	Unsigned32	rw	O
$60FE_h$	RECORD	digital_outputs	-	rw	O

9.3 Object Description

9.3.1 Object 6007_h: abort_connection_option_code

The content of this object selects the function to be performed when the connection to the network is lost.

Index	**6007_h**
Name	abort_connection_option_code
Object Code	VAR
Data type	Integer16

Value description

Object Class	M: -	O: all
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-32768..32767	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

Data Description

Option Code	**Meaning of the Option Code**
0	No action
1	Malfunction
2	Device control command „disable_voltage“
3	Device control command „quick_stop“
4..32767	reserved
-32768..–1	manufacturer specific

9.3.2 Object 603F$_h$: error_code

The *error_code* captures the code of the last error that occured in the drive. It corresponds to the value of the lower 16 bits of object 1003$_h$ *pre_defined_error_field*.

Index	**603F$_h$**
Name	error_code
Object Code	VAR
Data type	Unsigned16

Value description

Object Class	M: -	O: all
Access	ro	
PDO Mapping	Possible	
Units	-	
Value Range	0..65535	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

9.3.3 Object 6402$_h$: motor_type

The type of motor driven by the controller.

Index	**6402$_h$**
Name	motor_type
Object Code	VAR
Data type	Unsigned16

Value Description

Object Class	M: -	O: -
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..65535	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

Data Description

Value	Motor Type
0	Non-Standard Motor
1	Phase Modulated DC Motor
2	Frequency Controlled DC Motor
3	PM Synchronous Motor
4	FC Synchronous Motor
5	Switched Reluctance Motor
6	Wound Rotor Induction Motor
7	Squirrel Cage Induction Motor
8	Stepper Motor
9	Micro-Step Stepper Motor
10	Sinusoidial PM BL Motor
11	Trapezoidal PM BL Motor

9.3.4 Object 6403_h: motor_catalogue_number

The manufacturer's motor catalog number (nameplate number).

Index	**6403_h**
Name	motor_catalogue_number
Object Code	VAR
Data type	Visible String

Value Description

Object Class	M: -	O: -
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

9.3.5 Object 6404_h: motor_manufacturer

The motor manufacturer's name.

Index	**6404_h**
Name	motor_manufacturer
Object Code	VAR
Data type	Visible String

Value Description

Object Class	M: -	O: -
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

9.3.6 Object 6405_h: http_motor_catalog_address

Index	**6405_h**
Name	http_motor_catalog_address
Object Code	VAR
Data type	Visible String

Value Description

Object Class	M: -	O: -
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

9.3.7 Object 6406_h: motor_calibration_date

Date of the last motorbject 6406_h inspection.

Index	**6406_h**
Name	motor_calibration_date
Object Code	VAR
Data type	Date

Value Description

Object Class	M: -	O: -
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

9.3.8 Object 6407_h: motor_service_period

Value in hours of the nominal motor lifetime.The motor needs service after this time.

Index	**6407_h**
Name	motor_service_period
Object Code	VAR
Data type	Unsigned32

Value Description

Object Class	M: -	O: -
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

9.3.9 Object 6410_h: motor_data

This object contains as much as possible information about the connected motor. The structure of this record is described in the drive manufacturer's handbook.

Index	**6410_h**
Name	motor_data
Object Code	RECORD
Number of Elements	0..255

Value Description

Sub-Index	01_h..$255h_h$	
Description	Manufacturer specific	
Object Class	M: -	O: all
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	
Data Type	manufacturer defined	

9.3.10 Object 6502_h: supported_drive_modes

A drive can support more then one and several distinct modes of operation. Many of them are described in this document. This object is read only.

Index	**6502_h**
Name	supported_drive_modes
Object Code	VAR
Data type	Unsigned32

Value Description

Object Class	M: -	O: -
Access	ro	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

Data Description

Bit number	Description
0	Profile Position Mode
1	Velocity Mode
2	Profile Velocity Mode
3	Profile Torque Mode
4	reserved
5	Homing Mode
6	Interpolated Position Mode
7	reserved
8	reserved
9	reserved
10...15	reserved
16 ... 31	manufacturer specific

9.3.11 Object 6503$_h$: drive_catalogue_number

The manufacturer's drive catalog number (nameplate number).

Index	**6503$_h$**
Name	drive_catalogue_number
Object Code	VAR
Data type	Visible String

Value Description

Object Class	M: -	O: -
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

9.3.12 Object 6504$_h$: drive_manufacturer

The drive manufacturer's name.

Index	**6504$_h$**
Name	drive_manufacturer
Object Code	VAR
Data type	Visible String

Value Description

Object Class	M: -	O: -
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

9.3.13 Object 6505_h: http_drive_catalog_address

The internet address of the manufacturer.

Index	**6505_h**
Name	http_drive_catalog_address
Object Code	VAR
Data type	Visible String

Value Description

Object Class	M: -	O: -
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

9.3.14 Object 6510_h: drive_data

This object contains as much as possible information about the drive unit. The structure of this record is described in the drive manufacturer's handbook.

Index	**6510_h**
Name	drive_data
Object Code	RECORD
Number of Elements	0..255

Value Description

Sub-Index	01_h..$255h_h$	
Description	Manufacturer specific	
Object Class	M: -	O: all
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	
Data Type	manufacturer defined	

9.3.15 Object $60FD_h$: digital_inputs

This index defines simple digital inputs for drives. The user may apply any signals to these inputs for special purposes like limit or reference switches.

Index	**$60FD_h$**
Name	digital_inputs
Object Code	VAR
Data type	Unsigned32

Value Description

Object Class	M: -	O: all
Access	ro	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

Data Description

Bit No	**Digital Input Assignment**
0	negative limit switch position switch is "active high"
1	positive limit switch position switch is "active high"
2	home switch
3	interlock (enable) switch is "active high"
4..15	reserved
16..31	manufacturer specific

9.3.16 Object 60FE$_h$: digital_outputs

This index defines simple digital outputs for drives.

Index	**60FE$_h$**
Name	digital_outputs
Object Code	RECORD
Number of Elements	2

Value Description

Sub-Index	01$_h$	
Description	physical_outputs	
Object Class	M: -	O: all
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	
Data Type	Unsigned32	

Data Description

Bit No	**Assigned Digital Outputs**
0	set brake
1..15	reserved
16..31	manufacturer specific

This second sub-index describes a mask to specify which of the outputs shall be used, where a "1" selects and a "0" deselects an output.

Sub-Index	02_h	
Description	bitmask	
Object Class	M: -	O: all
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0, 1	
Mandatory Range	0, 1	
Default Value	0	
Substitute Value	-	
Data Type	Unsigned32	

10 Device Control

10.1 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 Statemachine

Operation Mode Function

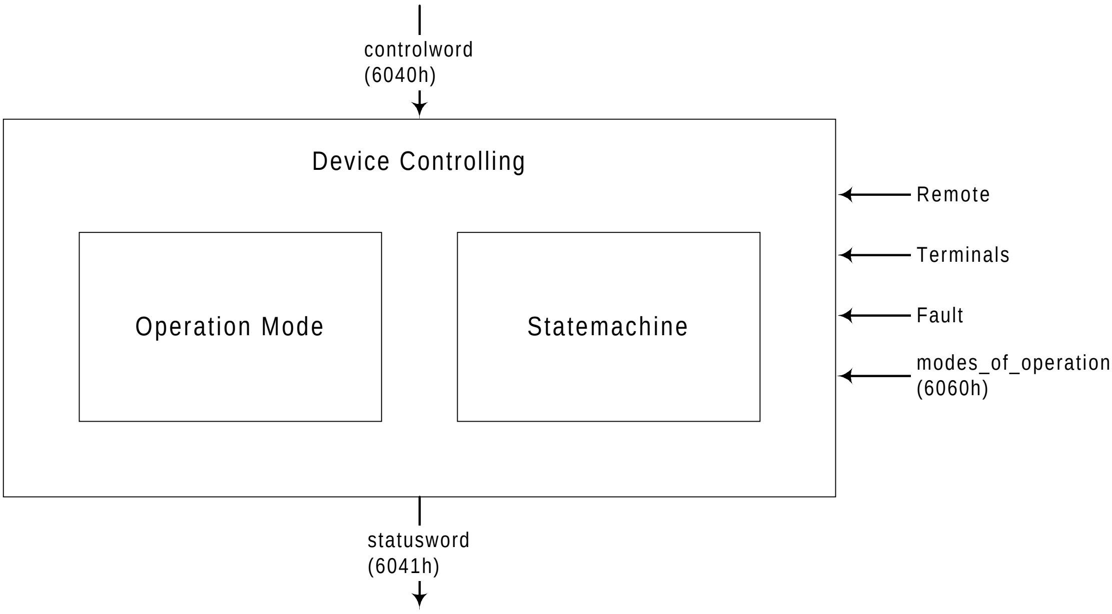


Figure 5: Device-Controlling

The state of the drive can be controlled by the *controlword*

The state of the drive is shown in the *statusword*

In remote mode the device is controlled directly from the CAN-network by Process Data Objects (PDOs) and Service Data Objects (SDOs).

The statemachine is controlled externally by the *controlword* and external signals. The write access to the *controlword* is controlled by the optional hardware signal 'Remote'. The statemachine is also controlled by internal signals like faults and *modes_of_operation*.

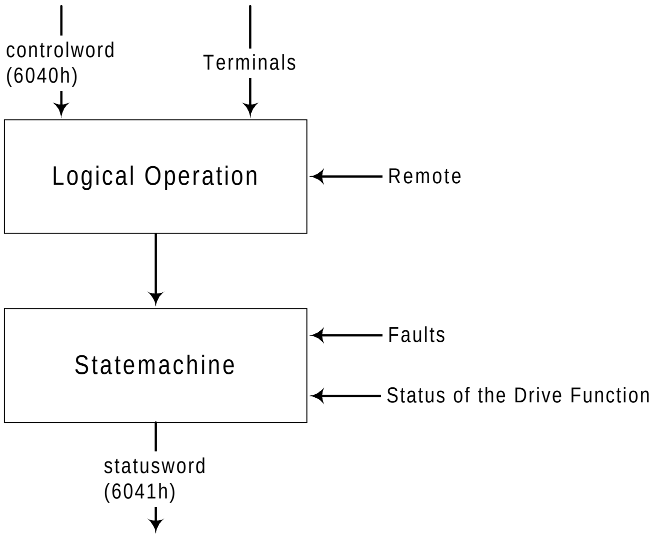


Figure 6: Remote Mode

10.1.1 Statemachine

The Statemachine describes the device status and the possible control sequence of the drive. A single state represents a special internal or external behaviour. 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 ENABLED.

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

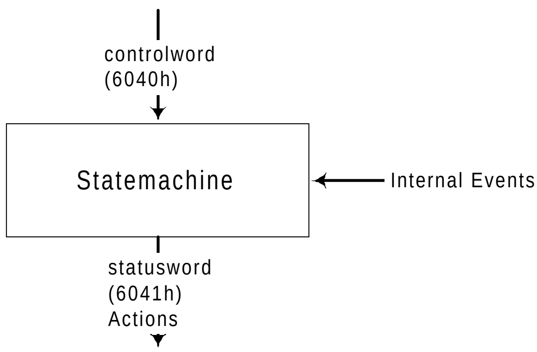


Figure 7: Statemachine

The state diagram in Figure 7 describes the state machine of the device with respect to control of the power electronics as a result of user commands and internal drive faults.

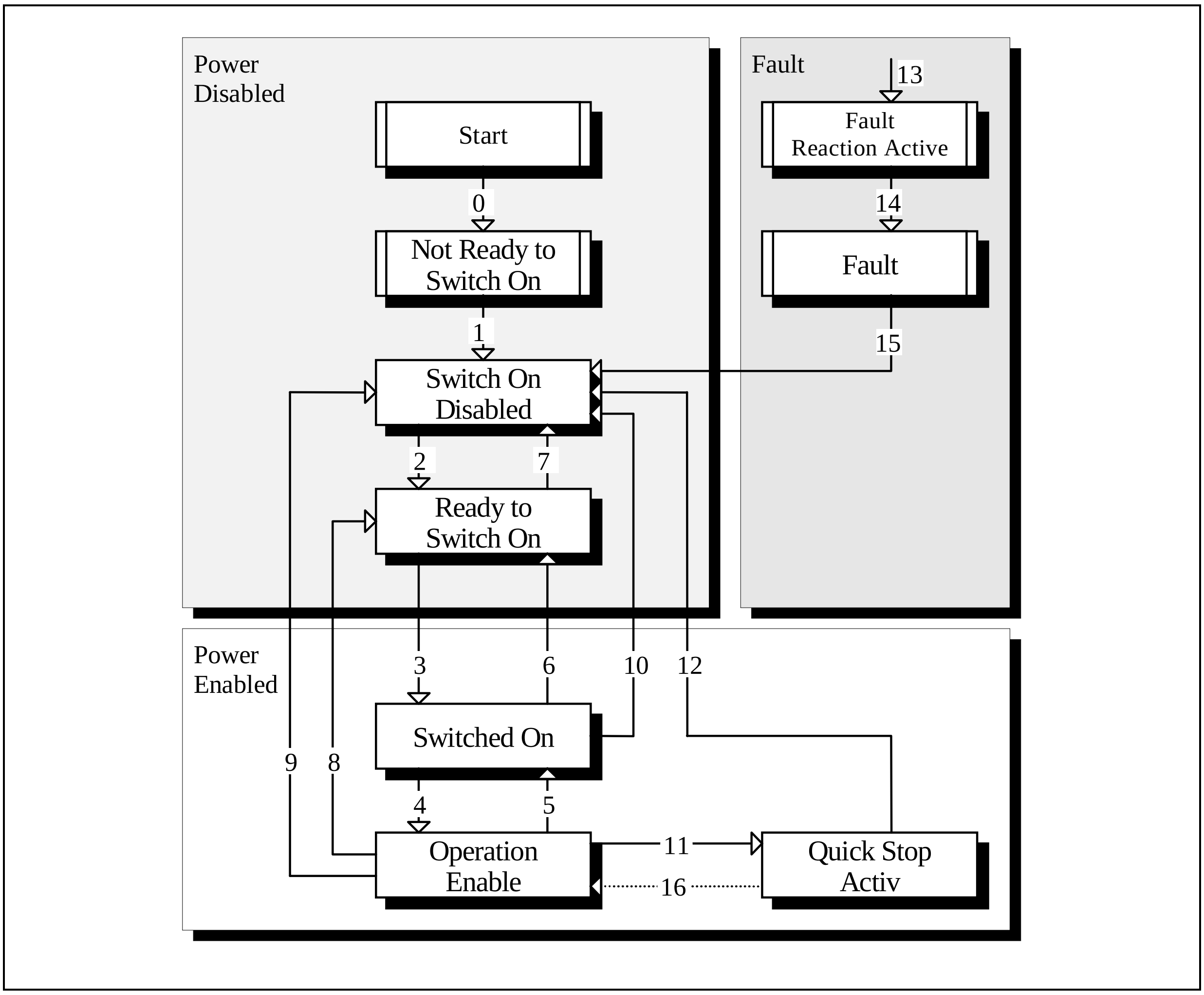


Figure 8: State Diagram

10.1.1.1 Drive States

The drive states may become more evident when considering the following (generic) block diagram of a drive:

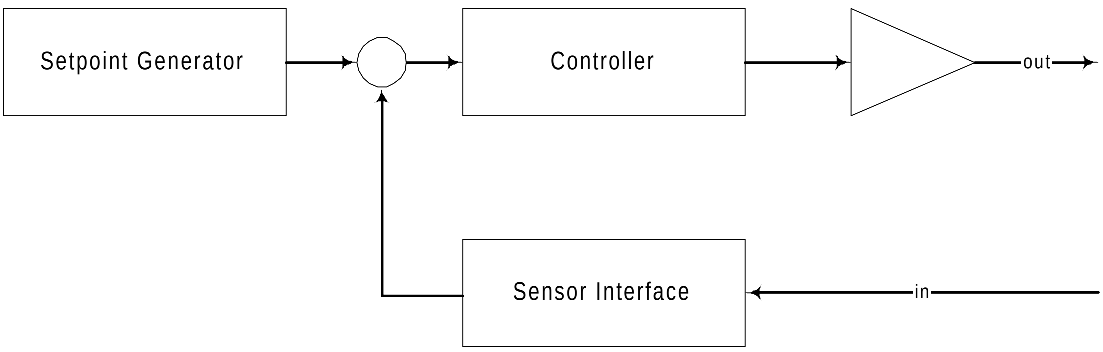


Figure 9: Generic Control Loop Block Diagram

The sensor interface and the “in”-terminal are only present in drives with a feedback path. Normally the setpoint generator, the controller and the power amplifier can be disabled.

The following states of the device are possible:

- *Not Ready to Switch On:*
  Low level Power (e.g. ±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 Initialisation 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:*
  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.

  If the ‘Quick-Stop-Option-Code’ is switched to 5 (Stay in Quick-Stop), you can’t leave the Quick-Stop-State, but you can transmit to ‘Operation Enable’ with the command ‘Enable Operation’.

- *Fault Reaction Active:*
  The drive parameters may be changed.
  A non-fatal fault has occured 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 occured in the drive.
  The drive function is disabled.

10.1.1.2 State Transitions of the Drive Supervisor

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

- *State Transition 0: Startup ⇒ Not Ready to Swich On*
  Event: Reset.
  Action: The drive self-tests and/or self-initialises.

- *State Transition 1: Not Ready to Swich On ⇒ Switch On Disabled*
  Event: The drive has self-tested and/or initialised sucessfully.
  Action: Activate communisation and process data monitoring

- *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 Enabled*
  Event: 'Enable Operation' command received from host.
  Action: The drive function is enabled.

- *State Transition 5: Operation Enabled ⇒ 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 Disable*
  Event: 'Quick stop' 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 immediatly, and the motor is free to rotate if unbraked

- *State Transition 9: Operation Enable ⇒ Switch On Disable*
  Event: 'Disable Voltage' command received from host.
  Action: The power section is switched off immediatly, and the motor is free to rotate if unbraked

- *State Transition 10: Switched On ⇒ Switched On Disable*
  Event: 'Disable Voltage' or 'Quick Stop' command received from host.
  Action: The power section is switched off immediatly, and the motor is free to rotate if unbraked

- *State Transition 11: Operation Enabled ⇒ Quick Stop Active*
  Event: 'Quick Stop' command received from host.
  Action: The Quick Stop function is executed.

- *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 Quick-Stop)
  Action: The power section is switched off.

- *State Transition 13: All states ⇒ Fault Reaction Active*
  A fatal 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 'Fault' state 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.

Notes:
If a command is received which causes a change of state, this command must be processed completely and the new state attained before the next command can be processed.

'Drive function is disabled' implies no energy is supplied to the motor. This may be achieved by different manufacturers in different ways. Reference values are not processed.

'Drive function is enabled' implies that energy can be supplied to the motor. The reference values (Torque, Velocity, Position) are processed.

'Fault occurred' implies that a fault in the drive has occurred. In this case there is a transition to the state 'Fault Reaction Active'. In this state the device will execute a special fault reaction. After the execution of this fault reaction the device will switch to the state 'Fault'. This state can only be left by the command 'Fault reset', but only if the fault is not active any more.

10.2 Object Dictionary Entries

10.2.1 Objects defined in this Chapter

Index	**Object**	**Name**	**Type**	**Attr.**	**M/O**
6040_h	VAR	controlword	Unsigned16	rw	M
6041_h	VAR	statusword	Unsigned16	rw	M
$605B_h$	VAR	shutdown_option_code	Integer16	rw	O
$605C_h$	VAR	disable_operation_option_code	Integer16	rw	O
$605A_h$	VAR	quick_stop_option_code	Integer16	rw	O
$605D_h$	VAR	stop_option_code	Integer16	rw	O
$605E_h$	VAR	fault_reaction_option_code	Integer16	rw	O
6060_h	VAR	modes_of_operation	Integer8	wo	M
6061_h	VAR	modes_of_operation_display	Integer8	ro	M

10.3 Object Description

10.3.1 Object 6040_h: controlword

The logical addition of several bits in the *controlword* and the external signals (transitions) results in the device-control-command. The *controlword* is always mapped into the first two bytes of the drive's command Message. The bits of the *controlword* are defined as follows:

Index	**6040_h**
Name	controlword
Object Code	VAR
Data Type	Unsigned16

Value Description

Object Class	M: all O: -I
Access	rw
PDO Mapping	Possible
Units	-
Value Range	0..65535
Mandatory Range	-
Default Value	-
Substitute Value	-

Data Description

MSB								LSB							
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High-Byte								Low-Byte							

Bit	Name	Mandatory
0	Switch On	√
1	Disable Voltage	√
2	Quick Stop	√
3	Enable Operation	√
4	Operation Mode Specific	
5	Operation Mode Specific	
6	Operation Mode Specific	
7	Reset Fault	√
8	Halt	
9	Reserved	
10	Reserved	
11	Manufacturer Specific	
12	Manufacturer Specific	
13	Manufacturer Specific	
14	Manufacturer Specific	
15	Manufacturer Specific	

Table 5 Bits in the *controlword*

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

command/ Bit of the *controlword*	**Bit 7 Fault Reset**	**Bit 3 Enable Operation**	**Bit 2 Quick Stop**	**Bit 1 Disable Voltage**	**Bit 0 Switch On**	**Transitions**
Shutdown	0	X	1	1	0	2,6,8
Switch On	0	X	1	1	1	3
Disable Voltage	0	X	X	0	X	7,9,10,12
Quick Stop	0	X	0	1	X	7,10,11
Disable Operation	0	0	1	1	1	5
Enable Operation	0	1	1	1	1	4,16
Fault Reset		X	X	X	X	15

Table 6: Device Control Commands

10.3.1.1 Description of the remaining Bits of the *controlword*

Bits 4, 5 and 6 are operation mode specific

Bit	**Operation Mode**					
	Velocity Mode	**Profile Position Mode**	**Profile Velocity Mode**	**Profile Torque Mode**	**Homing Mode**	**Interpol. Position Mode**
4	RFG disable	new_set-point	reserved	reserved	Homing Operation Start	enable_ip_mode
5	RFG stop	change_set_immediatly	reserved	reserved	reserved	reserved
6	RFG zero	0: absolute 1: relative	reserved	reserved	reserved	reserved
8	Halt	Halt	Halt	Halt	Halt	Halt

Table 7: Mode specific Bits in the *controlword*

RFG: **R**unning up **F**requency **G**enerator (see chapter 18, Velocity Mode)
Halt: Interrupts the move of a drive, and wait for release to continue.

Bits 9, 10 are reserved

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 are manufacturer specific

10.3.2 Object 6041$_h$: statusword

The *statusword* indicates the current status of the drive and is always mapped into the first two bytes of the actual message. The following bits are defined in the statusword.

Index	**6041$_h$**
Name	statusword
Object Code	VAR
Data Type	Unsigned16

Value Description

Object Class	M: all	O: -
Access	ro	
PDO Mapping	Possible	
Units	-	
Value Range	0..65535	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

Data Description

MSB								LSB							
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
High-Byte								Low-Byte							

Bit	Name	Mandatory
0	Ready to Switch On	√
1	Switched On	√
2	Operation Enabled	√
3	Fault	√
4	Voltage Disabled	√
5	Quick Stop	√
6	Switch On Disabled	√
7	Warning	
8	Manufacturer Specific	
9	Remote	√
10	Target Reached	√
11	Internal Limit Active	√
12	Operation Mode Specific	
13	Operation Mode Specific	
14	Manufacturer Specific	
15	Manufacturer Specific	

Table 8: Bits in the *statusword*

Device Status Bit Meanings

The following bits indicate the status of the device:

State	Bit 6 Switch On Disable	Bit 5 Quick Stop	Bit 3 Fault	Bit 2 Operation Enable	Bit 1 Switched On	Bit 0 Ready to Switch On
Not Ready to Switch On	0	X	0	0	0	0
Switch On Disabled	1	X	0	0	0	0
Ready to Switch On	0	1	0	0	0	1
Switched On	0	1	0	0	1	1
Operation Enabled	0	1	0	1	1	1
Fault	0	X	1	1	1	1
Fault Reaction Active	0	X	1	1	1	1
Quick Stop Active	0	0	0	1	1	1

Table 9: Device State Bits

Bits marked X are irrelevant for that state. Other bit combinations are not allowed.

10.3.2.1 Description of the remaining Bits of the *statusword*

Bit 4: voltage_disable

The Disable Voltage request is active when the *voltage_disabled* bit is cleared to 0.

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 is manufacturer specific

This bit may be used by a drive manufacturer to implement any manufacturer specific functionality.

Bit 9: remote

If bit 9 is set, then parameters may be modified via the CAN-network, and the drive executes the content of a command message. If the bit *remote* is reset, then the drive is in local mode and will not execute the command message. The drive may transmit messages containing valid actual values like a *position_actual_value*, depending on the actual drive configuration. The drive will accept accesses via service data objects (SDOs) in local mode.

Bit 10: target_reached

If bit 10 is set by the drive, then a setpoint has been reached (torque, speed or position depending on the *modes_of_operation*). The change of a target value by software alters this bit.

If *quickstop_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 occured 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, 13 are operation mode specific

Bit	Velocity mode	Profile Position Mode	Profile Velocity mode	Profile Torque mode	Homing mode	Interpol. Position mode
12	reserved	setpoint acknowledge	Speed = 0	reserved	Homing attained	Ip-Mode active
13	reserved	following error	max_slippage error	reserved	Homing error	reserved

Table 10: Mode specific bits in the *statusword*

Bit 14, 15 are manufacturer specific

These bits may be used by a drive manufacturer to implement any manufacturer specific functionality.

Note:

All bits reflect the actual/current state of the drive. No bits are latched.

10.3.3 Object $605B_h$: shutdown_option_code

The parameter *shutdown_option_code* determines what action should be taken if there is a transition 'OPERATION ENABLE' ⇒ 'READY TO SWITCH ON'

Index	**$605B_h$**
Name	shutdown_option_code
Object Code	VAR
Data Type	Integer16

Value Description

Object Class	M: -	O: all
Access	rw	
PDO Mapping	No	
Units	-	
Value Range	-32768..32767	
Mandatory Range	Profile Specific Code	
Default Value	0	
Substitute Value	-	

Data description

reset_option_code	**Action**
-32768 ... –1	Manufacturer Specific
0	Disable drive function
1	Slow down with slow down ramp disable of the drive function
2 ... 32767	reserved

10.3.4 Object 605C$_h$: disable_operation_option_code

The parameter *disable_operation_option_code* determines what action should be taken if there is a transition 'OPERATION ENABLE' ⇒ 'SWITCHED ON'.

Index	**605C$_h$**
Name	disable_operation_option_code
Object Code	VAR
Data Type	Integer16

Value Description

Object Class	M: - O: all
Access	rw
PDO Mapping	No
Units	-
Value Range	-32768..32767
Mandatory Range	-
Default Value	1
Substitute Value	-

Data description

disable_operation_option_code	**Action**
-32768 ... -1	Manufacturer Specific
0	disable drive function
1	Slow down with slow down ramp and then disabling of the drive function
2 ... 32767	reserved

10.3.5 Object 605A$_h$: quick_stop_option_code

The parameter *quick_stop_option_code* determines what action should be taken if the Quick Stop Function is executed.

Index	**605A$_h$**
Name	quick_stop_option_code
Object Code	VAR
Data Type	Integer16

Value Description

Object Class	M: - O: all
Access	rw
PDO Mapping	No
Units	-
Value Range	-32768..32767
Mandatory Range	-
Default Value	2
Substitute Value	-

Data description

quick_stop_option_code	**Action**
-32768 ... -1	Manufacturer Specific
0	Disable drive function
1	Slow down on slow down ramp
2	Slow down on quick stop ramp
3	Slow down on the current limit
4	Slow down on the voltage limit
5	Slow down on slow down ramp and stay in Quick-Stop
6	Slow down on quick stop ramp and stay in Quick-Stop
7	Slow down on the current limit and stay in Quick-Stop
8	Slow down on the voltage limit and stay in Quick-Stop
9 ... 32767	reserved

10.3.6 Object 605D$_h$: stop_option_code

The parameter *stop_option_code* determines what action should be taken if the Stop Function is active.

Index	**605D$_h$**
Name	stop_option_code
Object Code	VAR
Data Type	Integer16

Value Description

Object Class	M: -	O: all
Access	rw	
PDO Mapping	No	
Units	-	
Value Range	-32768..32767	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

Data description

stop_option_code	**Action**
-32768 ... -1	Manufacturer Specific
0	Disable drive, Motor is free to rotate
1	Slow down on slow down ramp
2	Slow down on quick stop ramp
3	Slow down on the current limit
4	Slow down on the voltage limit
5 ... 32767	reserved

10.3.7 Object 605E$_h$: fault_reaction_option_code

The parameter *fault_reaction_option_code* determines what action should be taken if a fault occurs in the drive.

Index	**605E$_h$**
Name	fault_reaction_option_code
Object Code	VAR
Data Type	Integer16

Value Description

Object Class	M: -	O: all
Access	rw	
PDO Mapping	No	
Units	-	
Value Range	-32768..32767	
Mandatory Range	-	
Default Value	2	
Substitute Value	-	

Data description

fault_reaction_option_code	**Action**
-32768 ... -1	Manufacturer specific
0	Disable drive, motor is free to rotate
1	Slow down on slow down ramp
2	Slow down on quick stop ramp
3	Slow down on the current limit
4	Slow down on the voltage limit
5 ... 32767	reserved

10.3.8 Object 6060_h: modes_of_operation

The parameter *modes_of_operation* switches the actually choosen operation-mode.

Index	**6060_h**
Name	modes_of_operation
Object Code	VAR
Data Type	Integer8

Value Description

Object Class	M: all O: -
Access	wo
PDO Mapping	Possible
Units	-
Value Range	-128..127
Mandatory Range	-
Default Valu	-
Substitute Value	-

Data description

Modes of Operation	**Action**
-1 ... -128	Manufacturer specific modes of operation
0	reserved
1	Profile Position Mode
2	Velocity Mode
3	Profile Velocity Mode
4	Torque Profile Mode
5	reserved
6	Homing Mode
7	Interpolated Position Mode
8 ... 127	reserved

Note:

The actual mode is reflected in the *modes_of_operation_display* (index $6061_{h)}$, and not in the m*odes_of_operation* (index 6060_h). It may be changed by writing to *modes_of_-operation*

10.3.9 Object 6061h: modes_of_operation_display

The *modes_of_operation_display* shows the current mode of operation. The meaning of the returned value corresponds to that of the *modes_of_operation* option code (index 6060_h)

Index	**6061_h**
Name	modes_of_operation_display
Object Code	VAR
Data Type	Integer8

Value Description

Object Class	M: all O: -
Access	ro
PDO Mapping	Possible
Units	-
Value Range	-128..127
Mandatory Range	-
Default Value	-
Substitute Value	-

Data description

Same as for Object 6060_h *modes_of_operation*.

Note:

The actual mode is reflected in the *modes_of_operation_display* (index 6061_h), and not in the m*odes_of_operation* (index 6060_h).

10.4 Functional Description

10.4.1 Modes of Operation Function

The device behaviour depends on the activated modes of operation.

It is possible to implement different device modes. Since it is not possible to operate the modes in parallel, the user is able to activate the required function by selecting a mode of operation. An example of exclusive functions are those for position and torque control, which can only control one variable at any one time. The variables can perform at most a limited function. Such hybrids are regarded as the particular characteristics of a mode of operation. Position control operation and encoder profile support can be active at the same time, for example. Consequently encoder profile support is not regarded as a mode of operation.

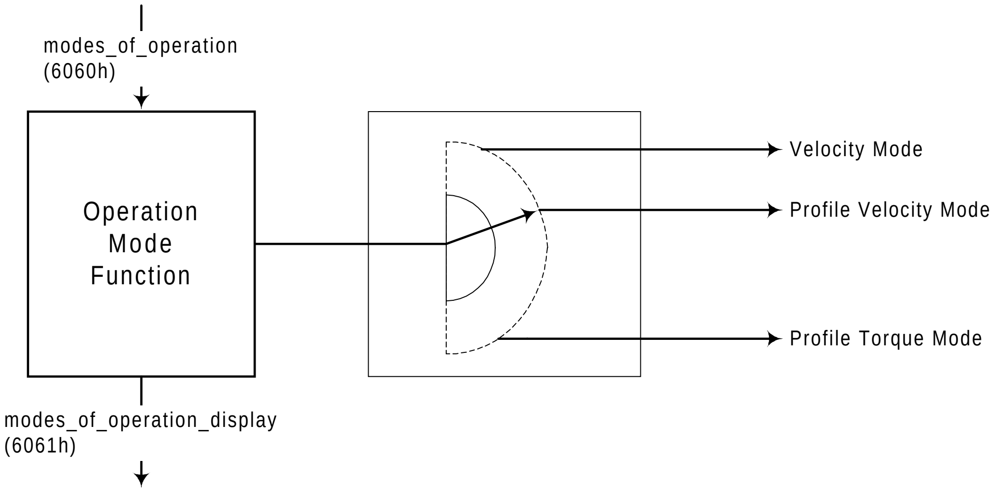


Figure 10: Operation Mode Function

It is possible for the user to switch between the various modes of operation as long as this is supported by the device. It is possible for the manufacturer to allow dynamic switching between different modes of operation at any time or to limit switching for example to the state 'SWITCH ON'. Switching can also be limited to the state 'local control'; i.e. not possible via the CAN-network. A device characteristic listed in the device function list can possible have several modes of operation.

The following modes of operation are listed:

- ❍ Velocity Mode (AC/DC drives, no feedback)
- ❍ Profile Velocity Mode (servo drives, feedback)
- ❍ Torque Profile Mode
- ❍ Homing Mode
- ❍ Profile Position Mode
- ❍ Interpolated Position Mode

With the exception of the ‘Homing Mode’, these listed modes of operation can all be put under the heading of 'setpoint setting'.

In parallel to this, manufacturer-specific modes of operation may also be available. These are not limited to setpoint settings.

The reference operation is regarded as a special form of a program function. The program function allows the user to run complex of time-critical sequence, e. g. tool change or special reference operations, directly in the device.

The switching between the modes of operation listed above should not incur any automatic reconfiguration of the process data channel. Problems which occur through switching of setpoint values during change of mode of operation must be monitored by the user. If necessary they can be rectified by prior reconfiguration of the process data channel.

Two objects are defined for management of the modes of operation.

- *modes_of_operation*
- *modes_of_operation_display*

The *statusword* contains bits, whose meaning is dependent on the mode of operation. When switching the mode of operation, the bits changing their meaning need to be monitored.

10.4.2 Drive Disabeling Function

The drive disabeling function defines the behaviour of the drive when transitioning from the 'OPERATION ENABLED' state to the 'READY TO SWITCH ON' (Shutdown command) or 'SWITCH ON' (Disable operation command) state.

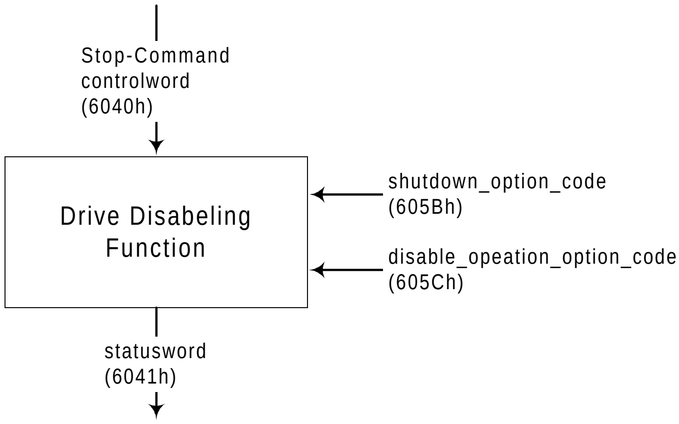


Figure 11: Modes of Operation Function

10.4.3 Quick Stop Function

The Quick Stop Function is triggered by the Quick Stop command.

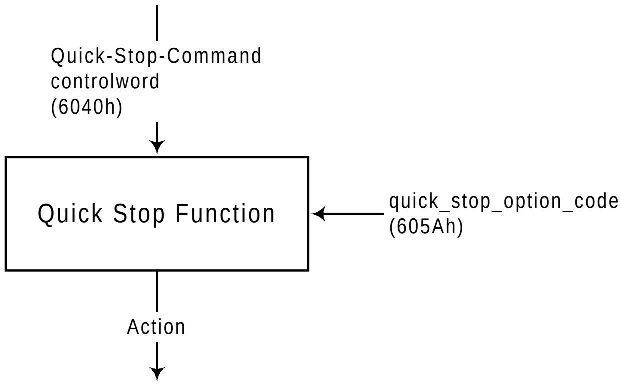


Figure 12: Quick-Stop-Function

10.4.4 Stop Function

The Stop Function may be triggered by resetting the bit 'RFG-disable' in the *controlword*.

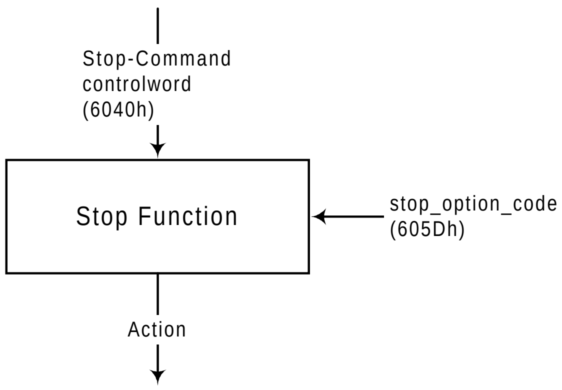


Figure 13: Stop-Function

10.4.5 Fault Reaction

Drive faults may be classified as fatal or non-fatal faults.

10.4.5.1 Fatal Faults

When a fatal fault occures, the drive is no longer able to control the motor, so an immediate switch-off of the drive is necessary.

10.4.5.2 Non-Fatal Faults

When a non-fatal fault occures, the drive can run the motor in a controlled fashion. The actions which are executed depend on the *fault_reaction_option_code*.

Once a fault occures the drive will always enter the FAULT state, even if the fault clears before the drive enters the FAULT state. The FAULT state may only be left if the 'Fault Reset' command is received from a host, and no further fault is present in the drive.

11 Factor Group

11.1 General Information

11.1.1 Factors

There is a need to interchange physical dimensions and sizes into the device internal units. To implement the interchange, several factors are necessary. This chapter describes how these factors have an influence on the system, how they are calculated and which data is necessary to build them. Normalised parameters are denoted with an asterisk *.

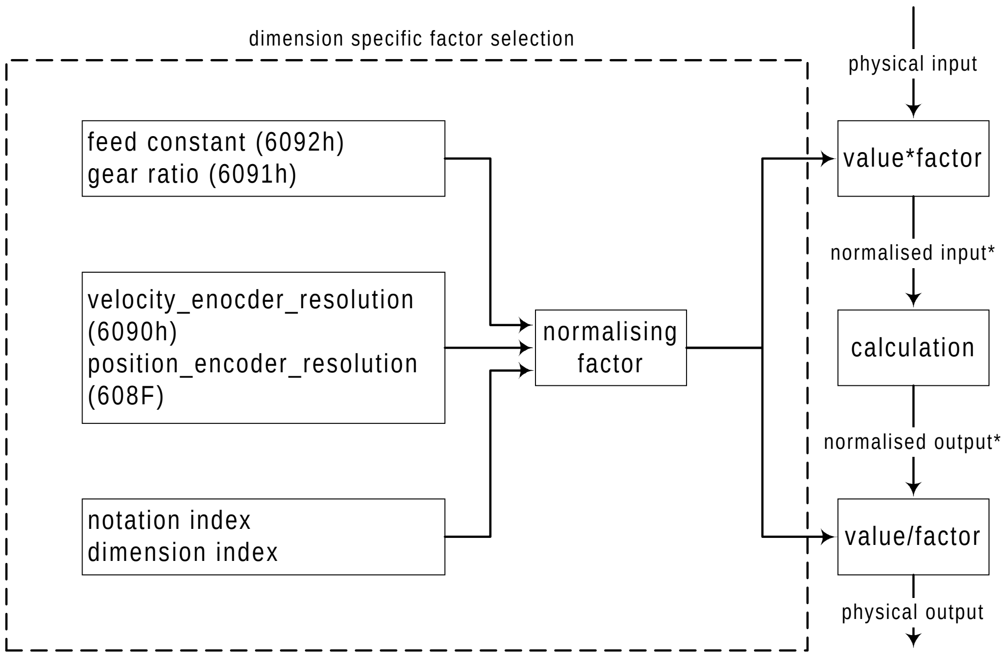


Figure 14: Influence of Factors

11.1.2 Relationship between Physical and Internal Units

The factors defined in the factor group set up a relationship between device internal units and physical units.

The factors are result of the calculation of two parameters called dimension index and notation index, which are defined in **Table D (see appendix** Definiton of Dimension Indices**)**. One parameter indicates the physical dimension, the other the physical unit and a decimal exponent for the values. These factors are directly used to normalise the physical values.

The application specific parameters will be used in the corresponding mode of operation to build the described factors.

Parameters that are commonly used will be integrated in the object dictionary without defining their junctions. This guaranties a common parameter number for further use without the need for a predefinition.

parameter	typical values
feed_constant	0.1 .... 1000 position units
position_encoder_resolution	50 .... 10^6 inc
velocity_encoder_resolution	0 .... 10^6 inc/s
gear_ratio	0.1 1000
position_dimension_index	mm, inch, grade
position_notation_index	-3
velocity_dimension_index	m/s, 1/min
velocity_notation_index	-3
acceleration_dimension_index	1/s²
acceleration_notation_index	0

constants	value
torque resolution	0.001

The dimension index defines the physical dimension of the parameter. The notation index can be used in two ways:

- For a unit with decimal scaling and notation index < 64
  the notation index defines the exponent/decimal place of the unit.

- or a unit with non-decimal scaling and notation index > 64
  the notation index defines the sub-index of the physical dimension of the unit.

Examples for notation indices < 64:

For notation index <64 the value is used as an exponent. The unit is defined by the physical dimension and calculated by unit type and exponent, all declared in the dimension/notation index table **Table D (see appendix** Definiton of Dimension Indices**)**.

position unit
dimension index = 1: length
notation index = -6: micro meter

position_units = $10^{notation\_index}$ x f(dimension_index)
= 10^{-6} m

dimension index = 12: angle
notation index = 0: radian

position_units = $10^{notation\_index}$ x f(dimension_index)
= radian

velocity unit
dimension index = 13: velocity
notation index = -3: milli metre per second

velocity_units = $10^{notation\_index}$ x f(dimension_index)
= 10^{-3} m/s

frequency units
dimension index = 28: frequency
notation index = 3: kilo hertz

frequency_units = $10^{notation\_index}$ x f(dimension_index)
= 10^{3} Hz

Examples for notation indices > 64:

The unit is defined by the physical dimension and unit type, both declared in the dimension/notation index table **Table D (see appendix** Definiton of Dimension Indices**)**

time units
dimension index = 4: time
notation index = 77: day

time_units = f(dimension_index,notation_index)
= day

position unit
dimension index = 12: angle
notation index = 76: minute

position_units = f(dimension_index,notation_index)
= minute

11.2 Object Dictionary Entries

11.2.1 Objects defined in this Chapter

Index	Object	Name	Type	Attr.	M/O
6089_h	VAR	position_notation_index	Integer8	rw	O
$608A_h$	VAR	position_dimension_index	Unsigned8	rw	O
$608B_h$	VAR	velocity_notation_index	Integer8	rw	O
$608C_h$	VAR	velocity_dimension_index	Unsigned8	rw	O
$608D_h$	VAR	acceleration_notation_index	Integer8	rw	O
$608E_h$	VAR	acceleration_dimension_index	Unsigned8	rw	O
$608F_h$	ARRAY	position_encoder_resolution	Unsigned32	rw	O
6090_h	ARRAY	velocity_encoder_resolution	Unsigned32	rw	O
6091_h	ARRAY	gear_ratio	Unsigned32	rw	O
6092_h	ARRAY	feed_constant	Unsigned32	rw	O
6093_h	ARRAY	position_factor	Unsigned32	rw	O
6094_h	ARRAY	velocity_encoder_factor	Unsigned32	rw	O
6095_h	ARRAY	velocity_factor_1	Unsigned32	rw	O
6096_h	ARRAY	velocity_factor_2	Unsigned32	rw	O
6097_h	ARRAY	acceleration_factor	Unsigned32	rw	O
$607E_h$	VAR	polarity	Unsigned8	rw	O

11.3 Object Description

Objects in this group represent factors which are necessary to normalise the physical inputs and outputs. The user has to consider that the correct dimension and unit are used.

11.3.1 Object 6089_h: position_notation_index

The *position_notation_index* is used to scale the following objects:

position_actual_value
position_demand_value
target_position
position_window
following_error_window
home_offset
position_range_limit
software_position_limit
target_velocity

Index	**6089_h**
Name	position_notation_index
Object Code	VAR
Data type	Integer8

Value Description

Object Class	M: -	O: pc pp ip hm pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-128..127	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

11.3.2 Object $608A_h$: position_dimension_index

The *position_dimension_index* is necessary for:

position_actual_value
position_demand_value
target_position
position_window
following_error_window
home_offset
position_range_limit
software_position_limit
target_velocity

Index	**$608A_h$**
Name	position_dimension_index
Object Code	VAR
Data type	Unsigned8

Value Description

Object Class	M: -	O: pc pp ip hm pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..255	
Mandatory Range	0..32	
Default Value	-	
Substitute Value	-	

11.3.3 Object 608B$_h$: velocity_notation_index

The *velocity_notation_index* is necessary for:

velocity_actual_value
velocity_demand_value
end_velocity
profile_velocity
velocity_window
max_profile_velocity
velocity_threshold
homing_speeds

Index	**608B$_h$**
Name	velocity_notation_index
Object Code	VAR
Data Type	Integer8

Value Description

Object Class	M: -	O: pc pp ip hm pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-128..127	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

11.3.4 Object 608C$_h$: velocity_dimension_index

The *velocity_dimension_index* is necessary for:

velocity_actual_value
velocity_demand_value
end_velocity
profile_velocity
velocity_window
max_profile_velocity
velocity_threshold
homing_speeds

Index	**608C$_h$**
Name	velocity_dimension_index
Object Code	VAR
Data Type	Unsigned8

Value Description

Object Class	M: -	O: pc pp ip hm pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..255	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

11.3.5 Object 608D$_h$: acceleration_notation_index

The *acceleration_notation_index* is necessary for:

profile_acceleration
profile_deceleration
quick_stop_deceleration
homing_acceleration

Index	**608D$_h$**
Name	acceleration_notation_index
Object Code	VAR
Data type	Integer8

Value Description

Object Class	M: -	O: pc pp ip hm pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-128..127	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

11.3.6 Object 608E$_h$: acceleration_dimension_index

The *acceleration_dimension_index* is necessary for:

profile_acceleration
profile_deceleration
quick_stop_deceleration
homing_acceleration

Index	**608E$_h$**
Name	acceleration_dimension_index
Object Code	VAR
Data type	Unsigned8

Value Description

Object Class	M: -	O: pc pp ip hm pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..255	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

11.3.7 Object $608F_h$: position_encoder_resolution

The *position_encoder_resolution* defines the ratio of encoder increments per motor revolution.

$$\text{position\_encoder\_resolution} = \frac{\text{encoder\_increments}}{\text{motor\_revolutions}}$$

Index	**$608F_h$**
Name	position_encoder_resolution
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value Description

Sub-Index	01_h	
Description	encoder_increments	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	inc	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

Sub-Index	02_h	
Description	motor_revolutions	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	inc	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

11.3.8 Object 6090_h: velocity_encoder_resolution

The *velocity_encoder_resolution* defines the ratio of encoder increments/sec. per motor revolutions/sec.

$$\text{velocity\_encoder\_resolution} = \frac{\text{encoder\_increments / sec}}{\text{motor\_revolutions / sec.}}$$

Index	**6090_h**
Name	velocity_encoder_resolution
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value Description

Sub-Index	01_h	
Description	encoder_increments_per_second	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	inc/sec	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

Sub-Index	02_h	
Description	motor_revolutions_per_second	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	inc/sec	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

11.3.9 Object 6091_h: gear_ratio

The *gear_ratio* defines the ratio of feed in position units per driving shaft revolutions. This includes the gear if present.

$$\text{gear\_ratio} = \frac{\text{motor\_shaft\_revolutions}}{\text{driving\_shaft\_revolutions}}$$

Index	**6091_h**
Name	gear_ratio
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value description

Sub-Index	01_h	
Description	motor_revolutions	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

Sub-Index	02_h	
Description	shaft_revolutions	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

11.3.10 Object 6092_h: feed_constant

The *feed_constant* defines the ratio of feed in position units per driving shaft revolutions. This includes the gear if present.

$$\text{feed\_constant} = \frac{\text{feed [position\_units]}}{\text{driving\_shaft\_revolutions}}$$

Index	**6092_h**
Name	feed_constant
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value description

Sub-Index	01_h	
Description	feed	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

Sub-Index	02_h	
Description	shaft_revolutions	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

11.3.11 Object 6093_h: position_factor

The *position_factor* converts the desired position (in position units) into the internal format (in increments). This parameter may be calculated internally in the drive; nevertheless it is specified as read-writeable as the objects necessary for the calculation are defined as optional too and need not to be present in an implementation.

$$\text{position\_factor} = \frac{\text{position\_encoder\_resolution} * \text{gear\_ratio}}{\text{feed\_constant}}$$

Index	**6093_h**
Name	position_factor
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value description

Sub-Index	01_h	
Description	numerator	
Object Class	M: -	O: pc pp ip
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

Sub-Index	02_h	
Description	feed_constant	
Object Class	M: -	O: pc pp ip
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

11.3.12 Object 6094$_h$: velocity_encoder_factor

The *velocity_encoder_factor* converts the desired velocity (in velocity units) into the internal format (in increments).

$$\text{velocity\_encoder\_factor} = \frac{\text{velocity\_encoder\_resolution} * \text{gear\_ratio} * \text{position\_unit} * F_{velocity}(\text{notation\_index})}{\text{feed\_constant} * \text{velocity\_unit} * \text{sec} * F_{position}(\text{notation\_index})}$$

Index	**6094$_h$**
Name	velocity_encoder_factor
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value description

Sub-Index	01$_h$	
Description	numerator	
Object Class	M: -	O: pv
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

Sub-Index	02$_h$	
Description	divisor	
Object Class	M: -	O: pv
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

11.3.13 Object 6095_h: velocity_factor_1

The *velocity_factor_1* is used to convert motor data (e.g. maximum motor revolutions) into velocity data (e.g. maximum velocity), because both data items are based on different physical dimensions.

$$\text{velocity\_factor\_1} = \frac{\text{feed\_constant} * \text{velocity\_unit} * \text{sec} * F_{\text{position\_unit}}(\text{notation\_index})}{60\ \text{sec/min} * \text{gear\_ratio} * \text{velocity\_unit} * F_{\text{velocity\_unit}}(\text{notation\_index})}$$

Index	**6095_h**
Name	velocity_factor_1
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value description

Sub-Index	01_h	
Description	numerator	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

Sub-Index	02_h	
Description	divisor	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

11.3.14 Object 6096_h: velocity_factor_2

The *velocity_factor_2* is used to convert encoder data for positions into encoder data for velocity, because both data items are based on different physical dimensions. The velocity encoder system is transformed to the position encoder.

$$\text{velocity\_factor\_2} = \frac{\text{position\_encoder\_resolution}}{\text{velocity\_encoder\_resolution}}$$

Index	**6096_h**
Name	velocity_factor_2
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value description

Sub-Index	01_h	
Description	numerator	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

Sub-Index	02_h	
Description	divisor	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

11.3.15 Object 6097$_h$: acceleration_factor

The acceleration_factor converts the acceleration (in acceleration units/sec²) into the internal format (in increments/sec²).

$$\text{acceleration\_factor} = \frac{\text{velocity\_units} \quad * \quad \text{velocity\_encoder\_factor}}{\text{acceleration\_units} * \text{sec}}$$

Index	**6097$_h$**
Name	acceleration_factor
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value description

Sub-Index	01$_h$	
Description	numerator	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

Sub-Index	02$_h$	
Description	divisor	
Object Class	M: -	O: pc pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	

11.3.16 Object $607E_h$: polarity

Position_demand_value and *position_actual_value* are multiplied by 1 or -1 depending on the value of the polarity flag.

Index	**$607E_h$**
Name	polarity
Object Code	VAR
Data type	Unsigned8

Value Description

Object Class	M: -	O: pc pp pv tq ip
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..255	
Mandatory Range	0..192	
Default Value	0	
Substitute Value	-	

Bit	Meaning
7	Position polarity 0 => multiply by 1 (default) 1 => multiply by -1
6	Velocity polarity 0 => multiply by 1 (default) 1 => multiply by -1

12 Profile Position Mode

12.1 General Information

The overall structure for this mode is shown in Figure 15. A *target_position* is applied to the Trajectory Generator. It is generating a *position_demand_value* for the position control loop described in the Position Control Function (chapter 14). These two function blocks are optionally controlled by individual parameter sets.

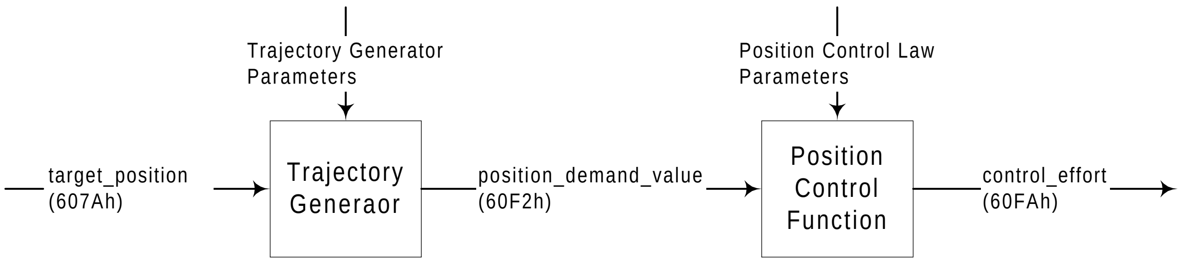
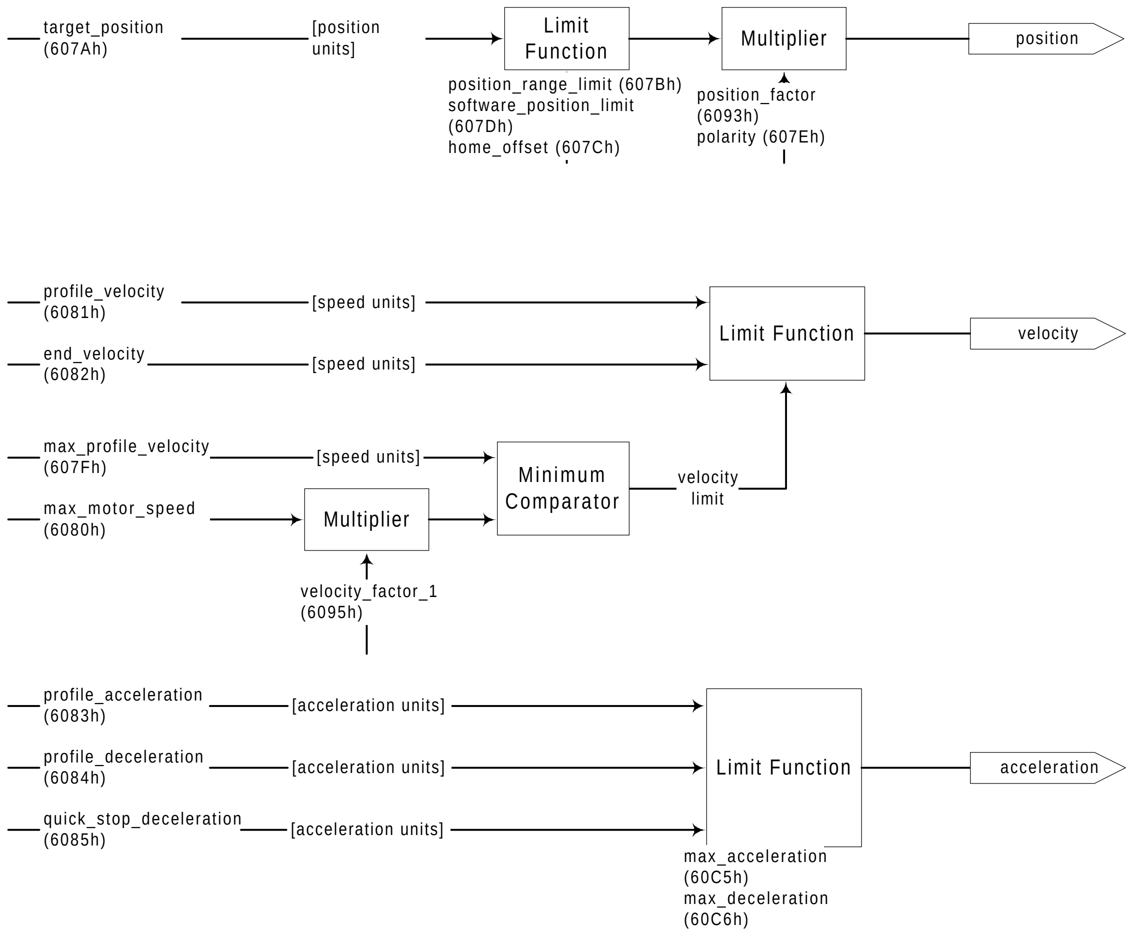


Figure 15: Overall Structure for the Profile Position Mode



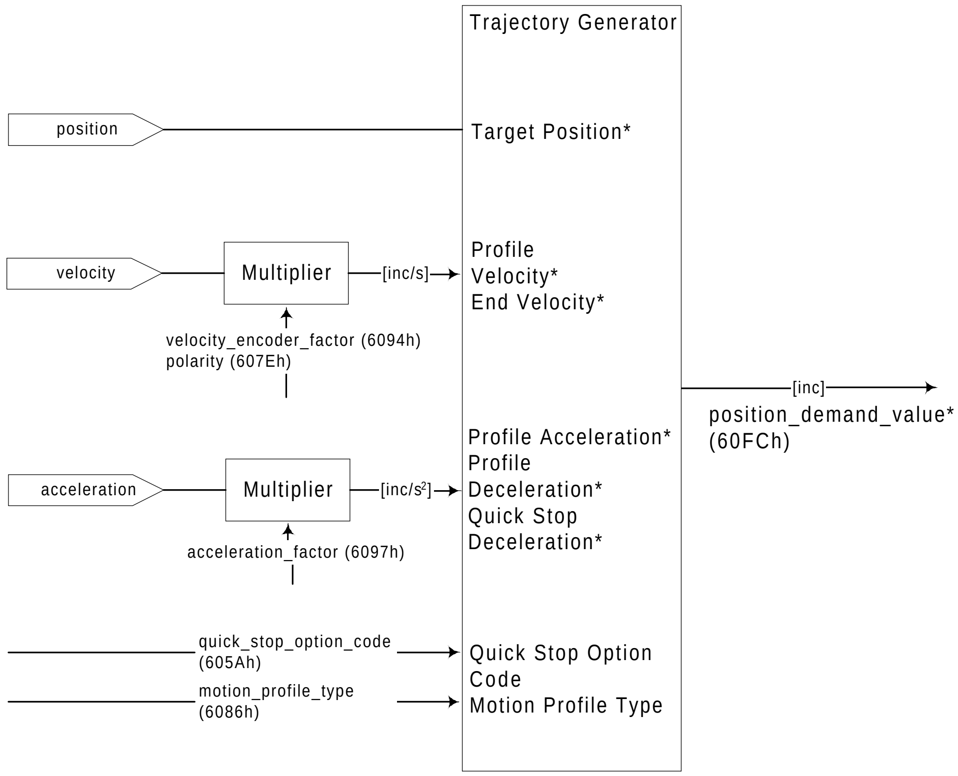


Figure 16: The Trajectory Generator

At the input to the Trajectory Generator, parameters may have optional limits applied before being normalised to internal units. Normalised parameters are denoted with an asterisk. The simpliest form of a Trajectory Generator is just to pass through a *target_position* and to transform it to a *position_demand_value** with internal units (increments) only.

12.1.1 Input Data Description

Operating Mode	**Input Parameters Used**
Profile Position Mode	target_position, profile_velocity, end_velocity, profile_acceleration, profile_deceleration, quick_stop_deceleration, position_factor, quick_stop_option_code, polarity, velocity_encoder_factor, motion_profile_type, max_profile_velocity, max_motor_speed, position_range_limit, software_position_limit, acceleration_factor

12.1.2 Output Data Description

The output value provided by the Trajectory Generator is the input for Position Control Function. In that chapter the remotely accessible parameters of the device for a position control are described.

Operating Mode	Output Parameters Used
Profile Position Mode	position_demand_value*

12.2 Object Dictionary Entries

12.2.1 Objects defined in this Chapter

Index	Object	Name	Type	Attr.	M/O
$607A_h$	VAR	target_position	Integer32	rw	M
$607B_h$	ARRAY	position_range_limit	Integer32	rw	O
$607D_h$	ARRAY	software_position_limit	Integer32	rw	O
$607F_h$	VAR	max_profile_velocity	Unsigned32	rw	O
6080_h	VAR	max_motor_speed	Unsigned16	rw	O
6081_h	VAR	profile_velocity	Unsigned32	rw	M
6082_h	VAR	end_velocity	Unsigned32	rw	O
6083_h	VAR	profile_acceleration	Unsigned32	rw	M
6084_h	VAR	profile_deceleration	Unsigned32	rw	M
6085_h	VAR	quick_stop_deceleration	Unsigned32	rw	O
6086_h	VAR	motion_profile_type	Integer16	rw	M
$60C5_h$	VAR	max_acceleration	Unsigned32	rw	O
$60C6_h$	VAR	max_deceleration	Unsigned32	rw	O

12.2.2 Objects defined in other Chapters

Index	Object	Name	Type	Chapter
6040_h	VAR	controlword	Integer16	dc
6041_h	VAR	statusword	Unsigned16	dc
$605A_h$	VAR	quick_stop_option_code	Integer16	dc
607E	VAR	polarity	Unsigned8	fg
6093_h	ARRAY	position_factor	Unsigned32	fg
6094_h	ARRAY	velocity_encoder_factor	Unsigned32	fg
6095_h	ARRAY	velocity_factor_1	Unsigned32	fg
6097_h	ARRAY	acceleration_factor	Unsigned32	fg

12.3 Object Description

12.3.1 Object 607A$_h$: 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* (see chapter Factor Group). The *target_position* will be interpreted as absolute or relative depending on the *absolute_relative* flag (bit 6) in the *controlword*.

Index	**607A$_h$**
Name	target_position
Object Code	VAR
Data type	Integer32

Value Description

Object Class	M: pp pc ip	O:
Access	rw	
PDO Mapping	Possible	
Units	position units	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

12.3.2 Object 607B$_h$: 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.

Index	**607B$_h$**
Name	position_range_limit
Object Code	ARRAY
Number of Elements	2
Data Type	Integer32

Value description

Sub-Index	01$_h$	
Description	min_position_range_limit	
Object Class	M: -	O: pp pc ip
Access	rw	
PDO Mapping	possibble	
Units	position units	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-2^{31}	
Substitute Value	-	

Sub-Index	02$_h$	
Description	max_position_range_limit	
Object Class	M: -	O: pp pc ip
Access	rw	
PDO Mapping	Possible	
Units	position units	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	$2^{31}-1$	
Substitute Value	-	

12.3.3 Object 607D$_h$: 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. Before being compared with the *target_position* they must be corrected internally by the *home_offset* as follows:

corrected_min_position_limit = *min_position_limit* - *home_offset*
corrected_max_position_limit = *max_position_limit* - *home_offset*

This calculation needs only be performed when *home_offset* or *software_position_limit* is changed.

Index	**607D$_h$**
Name	software_position_limit
Object Code	ARRAY
Number of Elements	2
Data Type	Integer32

Value description

Sub-Index	01$_h$	
Description	min_position_limit	
Object Class	M: -	O: pp pc ip
Access	rw	
PDO Mapping	Possible	
Units	position units	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-2^{31}	
Substitute Value	-	

Sub-Index	02_h	
Description	max_position_limit	
Object Class	M: -	O: pp pc ip
Access	rw	
PDO Mapping	Possible	
Units	position units	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	$2^{31}-1$	
Substitute Value	-	

12.3.4 Object 607F$_h$: max_profile_velocity

The *max_profile_velocity* is the maximum allowed speed in either direction during a profiled move. It is given in the same units as *profile_velocity*.

Index	**607F$_h$**
Name	max_profile_velocity
Object Code	VAR
Data type	Unsigned32

Value Description

Object Class	M: -	O: pp ip pv tq
Access	rw	
PDO Mapping	Possible	
Units	speed units	
Value Range	$0..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

12.3.5 Object 6080$_h$: max_motor_speed

The *max_motor_speed* is the maximum allowable speed for the motor in either direction and is given in rpm. This is used to protect the motor and can be taken from the motor data sheet.

Index	**6080$_h$**
Name	max_motor_speed
Object Code	VAR
Data type	Unsigned16

Value description

Object Class	M: -	O: all
Access	rw	
PDO Mapping	Possible	
Units	rpm	
Value Range	0..65535	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

12.3.6 Object 6081$_h$: 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* (see chapter Factor Group).

Index	**6081$_h$**
Name	profile_velocity
Object Code	VAR
Data type	Unsigned32

Value description

Object Class	M: pp pv	O:
Access	rw	
PDO Mapping	Possible	
Units	speed units	
Value Range	0..(2^{31}-1)	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

12.3.7 Object 6082$_h$: end_velocity

The *end_velocity* defines the velocity which the drive must have on reaching the *target_position*. Normally, the drive stops at the *target_position*, i.e. the *end_velocity* = 0. The *end_velocity* is given in the same units as *profile_velocity*.

Index	**6082$_h$**
Name	end_velocity
Object Code	VAR
Data type	Unsigned32

Value description

Object Class	M: -	O: pp
Access	rw	
PDO Mapping	Possible	
Units	speed units	
Value Range	0..(2^{31}-1)	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

12.3.8 Object 6083$_h$: profile_acceleration

The *profile_acceleration* is given in user defined acceleration units. It is converted to position increments per second ^{2} using the normalizing factors (see chapter Factor Group).

Index	**6083$_h$**
Name	profile_acceleration
Object Code	VAR
Data type	Unsigned32

Value description

Object Class	M: pp pv	O:
Access	rw	
PDO Mapping	Possible	
Units	acceleration units	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

12.3.9 Object 6084_h: 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.

Index	**6084_h**
Name	profile_deceleration
Object Code	VAR
Data type	Unsigned32

Value description

Object Class	M: pp pv	O:
Access	rw	
PDO Mapping	Possible	
Units	acceleration units	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

12.3.10 Object 6085_h: quick_stop_deceleration

The *quick_stop_deceleration* is the deceleration used to stop the motor if the quick stop command (bit 2 of the *controlword*) is given and the *quick_stop_option_code* (605Ah) is set to 2. The *quick_stop_deceleration* is given in the same units as the *profile_acceleration*.

Index	**6085_h**
Name	quick_stop_deceleration
Object Code	VAR
Data type	Unsigned32

Value description

Object Class	M: -	O: pp ip pv vo tq hc
Access	rw	
PDO Mapping	Possible	
Units	acceleration units	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

12.3.11 Object 6086_h: motion_profile_type

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

Index	**6086_h**
Name	motion_profile_type
Object Code	VAR
Data type	Integer16

Value description

Object Class	M: pp pv	O:
Access	rw	
PDO Mapping	Possible	
Units	none	
Value Range	-32768..32767	
Mandatory Range	-	
Default Value	0	
Substitute Value	0	

Profile Code	**Profile Type**
-32768 ... -1	Manufacturer specific
0	Linear ramp (trapezoidal profile)
1	Sin^2 ramp
2	Jerk-free ramp
3	Jerk-limited ramp
4 .. 32767	Reserved for future profile types

12.3.12 Object $60C5_h$: max_acceleration

To prevent the motor and the application from being destroyed, the *max_acceleration* can be used to limit the acceleration to an acceptable value.

The max_acceleration is given in user defined *acceleration_units* ($608D_h$, $608E_h$). It is converted to position increments per second ^{2} using the *acceleration_factor* (6097_h).

Index	**$60C5_h$**
Name	max_acceleration
Object Code	VAR
Data type	Unsigned32

Value description

Object Class	M: -	O: ip pp pc
Access	rw	
PDO Mapping	Possible	
Units	acceleration units	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	-	
Substitute Value	0 (no accelaration limitation)	

12.3.13 Object $60C6_h$: max_deceleration

To prevent the motor and the application from being destroyed, the *max_deceleration* can be used to limit the deceleration to an acceptable value.

The max_deceleration is given in the same units as the *max_acceleration* ($60C5_h$). If this parameter is not supported, then the max_acceleration value is also used for deceleration.

Index	**$60C6_h$**
Name	max_deceleration
Object Code	VAR
Data type	Unsigned32

Value description

Object Class	M: -	O: ip pp pc
Access	rw	
PDO Mapping	Possible	
Units	acceleration units	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	-	
Substitute Value	max_acceleration	

12.4 Functional Description

Two different ways to apply *target_positions* to a drive, are supported by this device profile.

Set of setpoints:
After reaching the target_position the drive unit immediatly 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 setpoint.

Single setpoints:
After reaching the *target_position* the drive unit signals this status to a host computer and then receives a new setpoint. After reaching a *target_position* the velocity normally is reduced to zero before starting a move to the next setpoint.

The two modes are controlled by the timing of the bits *new_setpoint* and *change_set_immediatly* in the *controlword* and *setpoint_acknowledge* in the *statusword*. These bits allow to set up a request-response mechanism in order to prepare a set of setpoints while another set still is processed in the drive unit. This minimizes reaction times within a control program on a host computer.

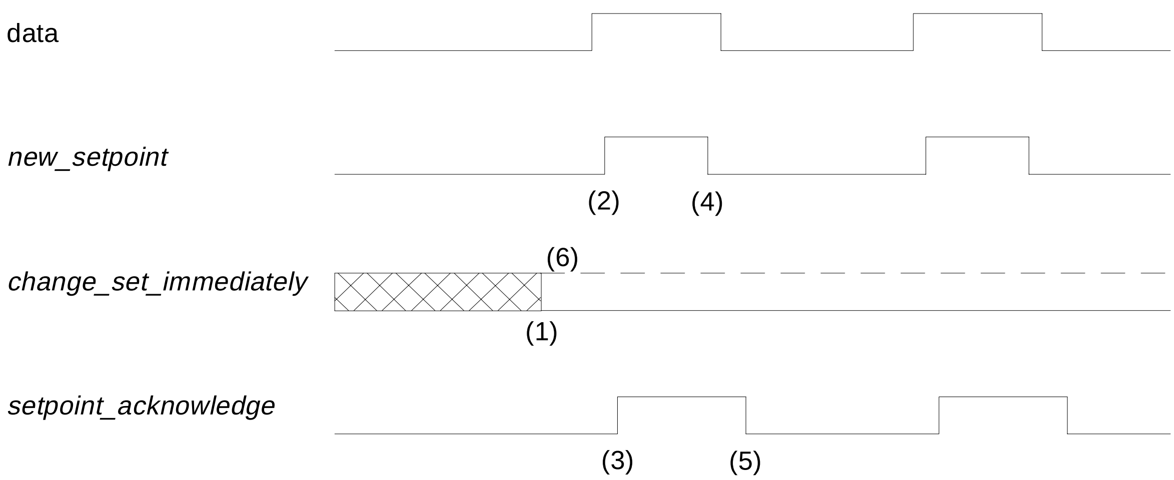


Figure 17: Setpoint transmission from a host computer

Figure 17, Figure 18 and Figure 19 show the difference between the "set of setpoints" mode and the "single setpoint" mode.The initial status of the bit *change_set_immediatly* in the *controlword* determines which mode is used. To keep simple these examples, only trapezoidal moves are used.

If the bit *change_set_immediatly* is "0" (continuously drawn line in Figure 17) a single setpoint is expected by the drive (1). After data is applied to the drive, a host signals that the data is valid by changing the bit *new_setpoint* to "1" in the *controlword* (2). The drive responds with *setpoint_acknowledge* set to "1" in the *statusword* (3) after it recognized and buffered the new valid data. Now the host may release *new_setpoint* (4) and afterwards the drive signals with *setpoint_acknowledge* equal "0" its ability to accept new data again (5). In Figure 18 this mechanism results in a velocity of zero after ramping down in order to reach a *target_position* x_1.at t_1. After signalling to the host, that the setpoint is reached like described above, the next *target_position* x_2 is processed at t_2 and reached at t_3.

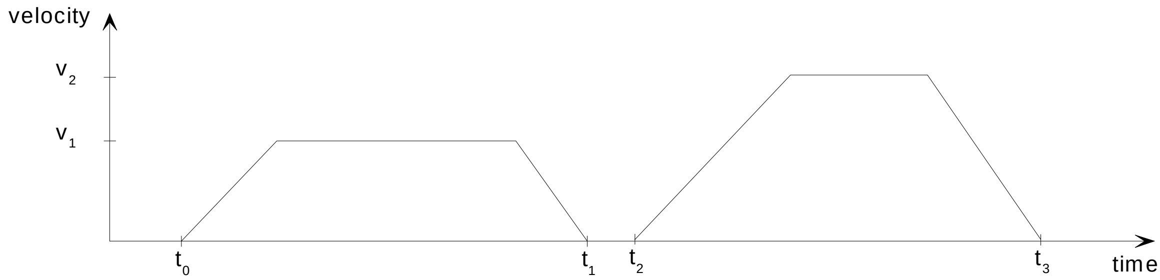


Figure 18: Single setpoint

With *change_set_immediatly* set to "1" (6), symbolized by the dashed line in Figure 17, the host advises the drive to apply a new setpoint immediatly after reaching the last one. The relative timing of the other signals is unchanged. This behaviour causes the drive to already process the next setpoint x_2 and to keep its velocity when it reaches the *target_position* x_1 at t_1. Then drive moves immediatly to the already calculated next *target_position* $x_{2.}$

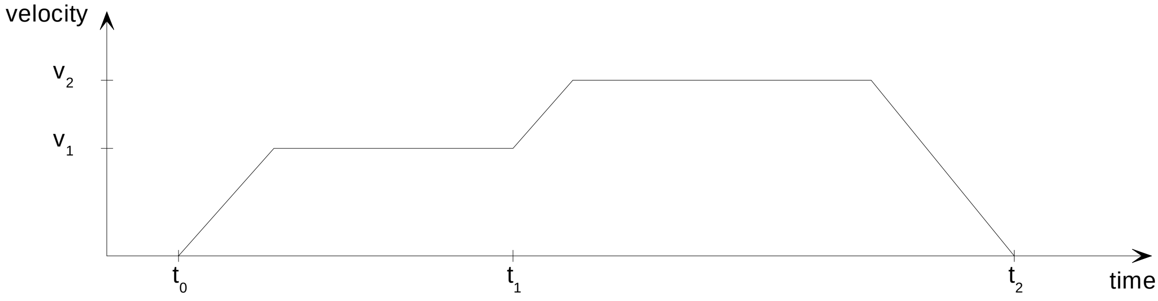


Figure 19: Change set immediatly

13 Homing Mode

13.1 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.

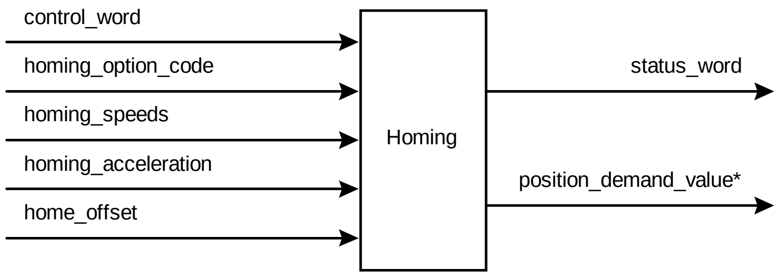


Figure 20: The Homing Function

13.1.1 Input Data Description

The user can specify the speeds, acceleration and the method of homing. There is a further object *home_offset* which allows the user to displace zero in the user's coordinate system from the home position.

There are two *homing_speeds*; in a typical cycle the faster speed is used to find the home switch and the slower speed is used to find the index pulse. The manufacturer is allowed some discretion in the use of these speeds as the response to the signals may be Dependent upon the hardware used.

13.1.2 Output Data Description

There is no output data except for those bits in the *statusword* which return the status or result of the homing process and the demand to the position control loops.

13.1.3 Internal States

There is only one internal state called homing which is reflected in the bits of the *statusword*.

13.2 Object Dictionary Entries

13.2.1 Objects defined in this Chapter

Index	Object	Name	Type	Attr.	M/O
$607C_h$	VAR	home_offset	Integer32	rw	O
6098_h	VAR	homing_method	Integer8	rw	M
6099_h	ARRAY	homing_speeds	Unsigned32	rw	M
$609A_h$	VAR	homing_acceleration	Unsigned32	rw	O

13.2.2 Objects defined in other Chapters

Index	Object	Name	Type	Chapter
6040_h	VAR	controlword	Integer16	dc
6041_h	VAR	statusword	Unsigned16	dc

13.3 Object Description

13.3.1 Object $607C_h$: home_offset

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

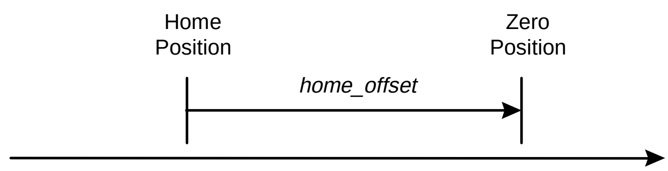


Figure 21: Home Offset

If the *home_offset* is not implemented then it shall be zero.

Index	**$607C_h$**
Name	home_offset
Object Code	VAR
Data type	Integer32

Value Description

Object Class	M: -	O: hm
Access	rw	
PDO Mapping	Possible	
Units	position units	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	0	
Substitute Value	0	

13.3.2 Object 6098_h: homing_method

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

Index	**6098_h**
Name	homing_method
Object Code	VAR
Data Type	Integer8

Value Description

Object Class	M: hm	O:
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-128..127	
Mandatory Range	0	
Default Value	0	
Substitute Value	0	

Data Description

homing_method	**Meaning**
-128 .. -1	Manufacturer specific
0	No homing operation required
1..35	Methods 1 to 35 (see the functional description)
36 .. 127	Reserved

13.3.3 Object 6099_h: homing_speeds

This entry in the object dictionary defines the speeds used during homing.

Index	**6099_h**
Name	homing_speeds
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value Description

Sub-Index	01_h	
Description	speed_during_search_for_switch	
Object Class	M: hm	O: -
Access	rw	
PDO Mapping	Possible	
Units	velocity Units	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	-	
Default Value	0	
Substitute Value	0	

Sub-Index	02_h	
Description	speed_during_search_for_zero	
Object Class	M: hm	O: -
Access	rw	
PDO Mapping	Possible	
Units	velocity units	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	-	
Default Value	0	
Substitute Value	0	

13.3.4 Object 609A$_h$: homing_acceleration

The homing_acceleration establishes the acceleration to be used for all accelerations and decelerations with the standard homing modes.

Index	**609A$_h$**
Name	homing_acceleration
Object Code	VAR
Data Type	Unsigned32

Value Description

Object Class	M: -	O: hm
Access	rw	
PDO Mapping	Possible	
Units	acceleration units	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

13.4 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_offest 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. Further homing methods may be defined by the manufacturer using the negative values of homing_method.

There are four sources of homing signal available, these are the negative and positive limit switches, the home switch and the index pulse from an encoder:

In the diagrams of homing sequences shown below, the encoder count increases as the axle`s 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.

13.4.1 Homing Methods

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

13.4.1.1 Method 1: Homing on the Negative Limit Switch

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.

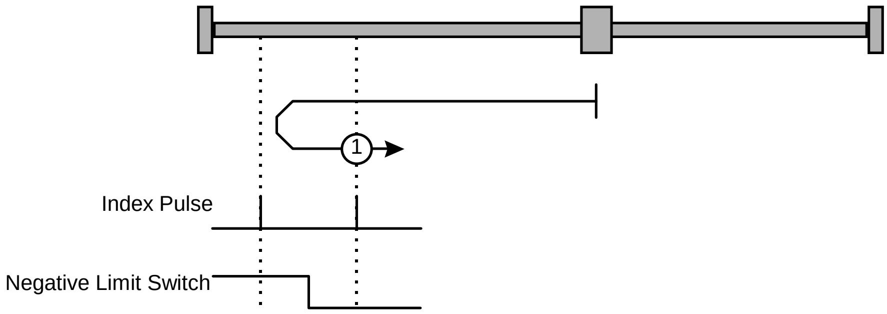


Figure 22: Homing on the Negative Limit Switch

13.4.1.2 Method 2: Homing on the Positive Limit Switch

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.

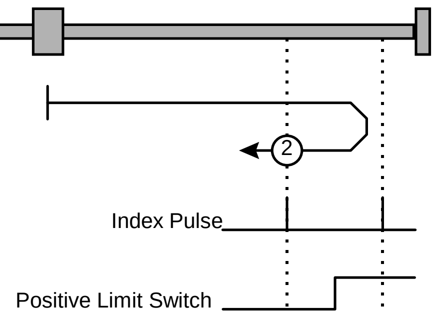


Figure 23: Homing on the Positive Limit Switch

13.4.1.3 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.

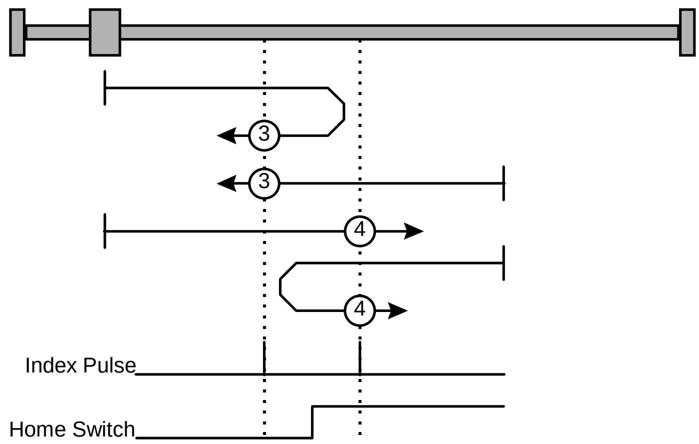


Figure 24: Homing on the Positive Home Switch and Index Pulse

13.4.1.4 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.

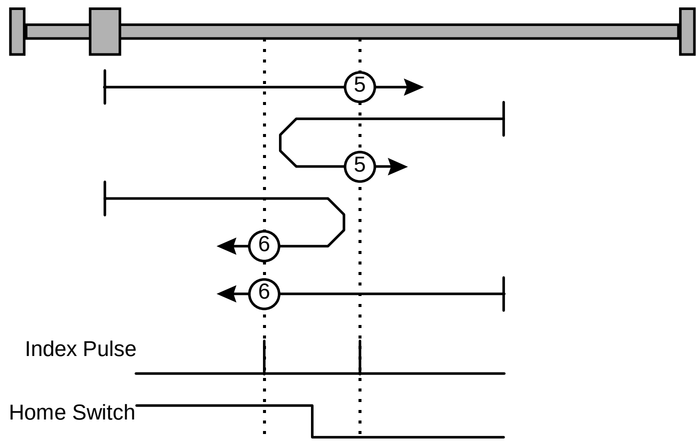


Figure 25: Homing on the Negative Home Switch and Index Pulse

13.4.1.5 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.

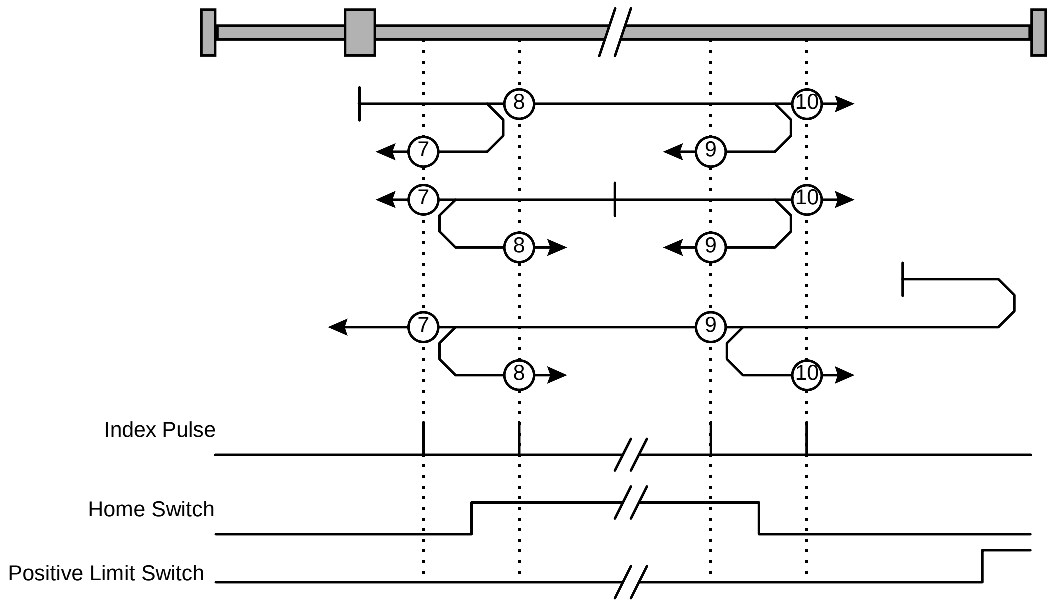


Figure 26: Homing on the Home Switch and Index Pulse - Positive Initial Move

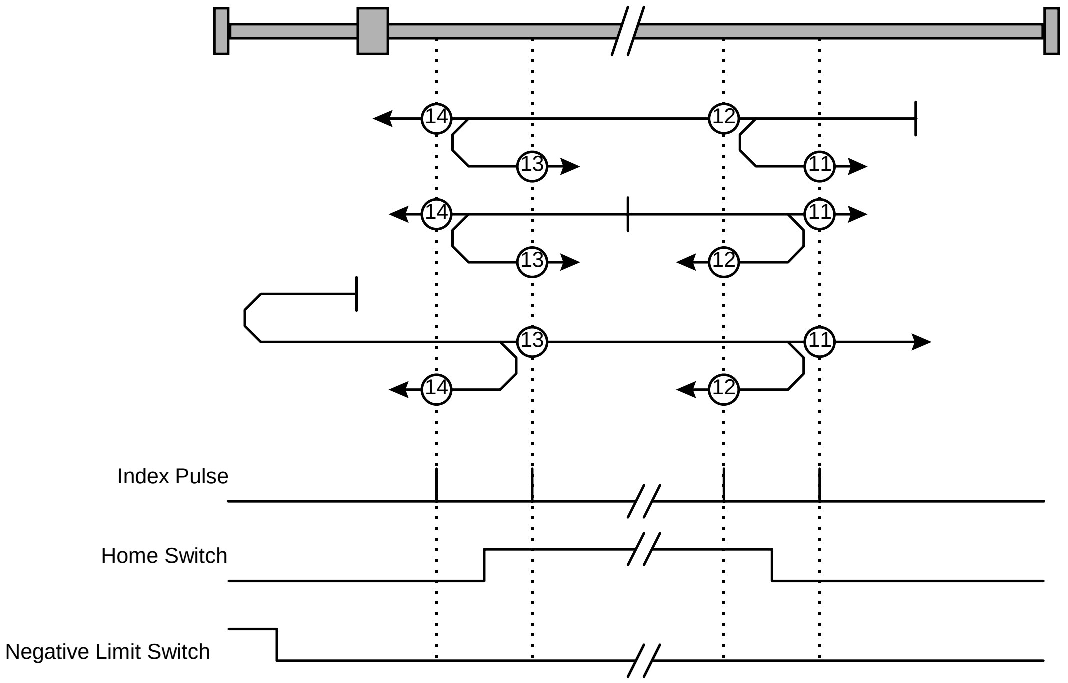


Figure 27: Homing on the Home Switch and Index Pulse - Negative Initial Move

13.4.1.6 Methods 15 and 16: Reserved

These methods are reserved for future expansion of the homing mode.

13.4.1.7 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.

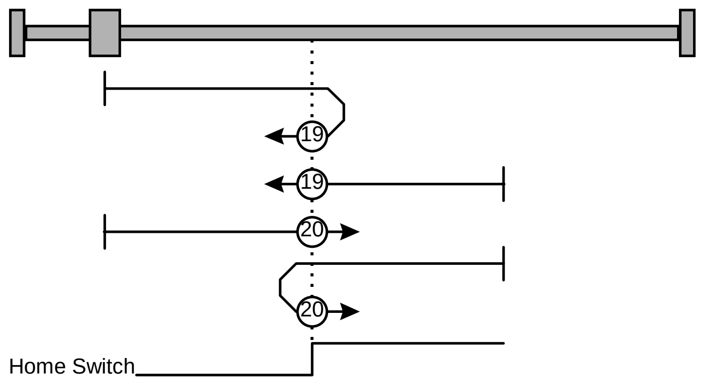


Figure 28: Homing on the Positive Home Switch

13.4.1.8 Methods 31 and 32: Reserved

These methods are reserved for future expansion of the homing mode.

13.4.1.9 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.

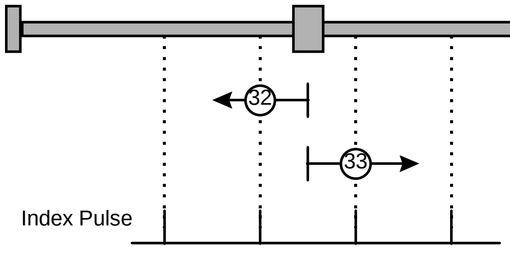


Figure 29: Homing on the Index Pulse

13.4.1.10 Method 35: Homing on the Current Position

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

13.4.2 Homing Mode Sequence

The homing operation is started by setting bit 4 in the device controlword. The successful completion is indicated by a one in bit 12 of the device statusword. A one in bit 13 of the statusword indicates an error was detected during the homing operation. The cause is found by reading the error codes.

Bit 4	**Meaning**
0	homing operation inactive
0→1	Start homing operation
1	homing operation active
1→0	Interrupt homing operation

Table 11: Extended Description of the Bits in the controlword

Bit 13	**Bit 12**	**Meaning**
0	0	homing operation not yet completed
0	1	homing operation carried out successfully
1	0	homing operation not successfully carried out
1	1	prohibited condition

Table 12: Extended Description of the Bits in the statusword

14 Position Control Function

14.1 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*) like a resolver or encoder as input parameters. The behaviour 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.

All values are transformed - if necessary - from user defined units to normalised units like increments with the functions of the chapter Factor Group.

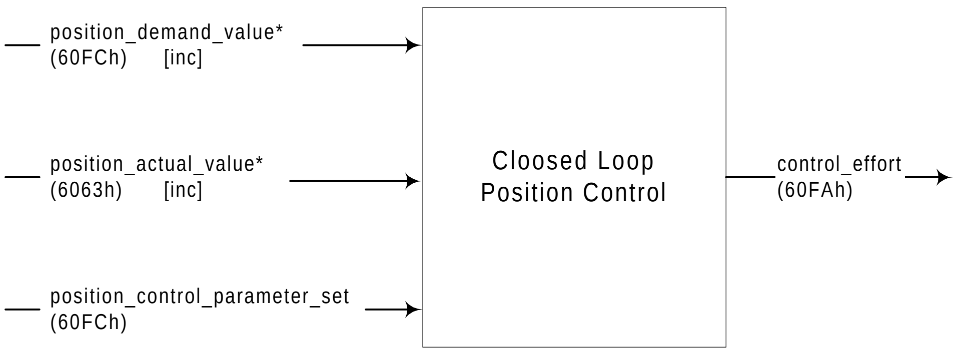


Figure 31: Position Control Function

Within this chapter, the following sub-functions are defined:

1. Following Error

A *position_actual_value* outside the allowed range of the *following_error_window* around a *position_demand_value* for longer than the *following_error_time_out* results in setting bit 13 *following_error* in the *statusword*.

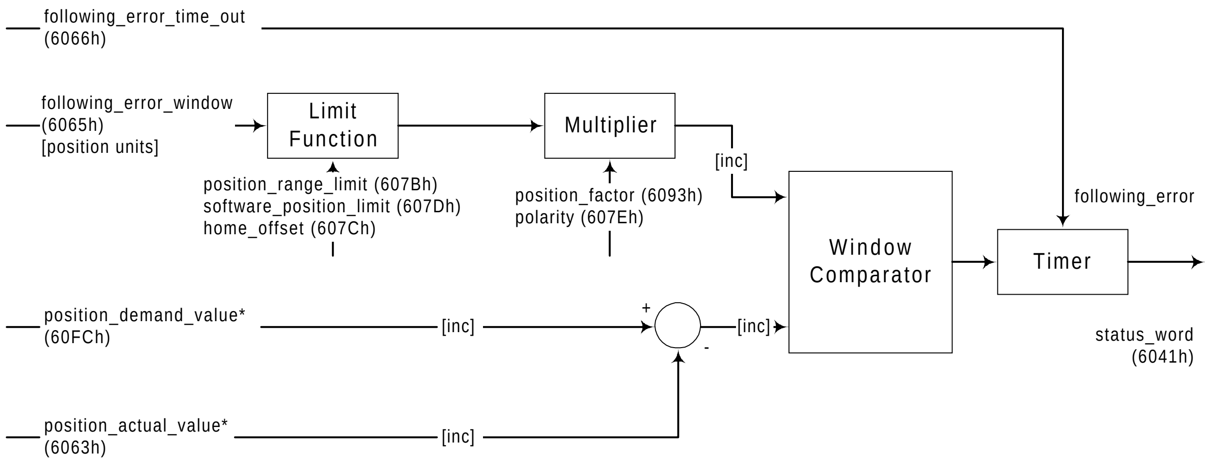


Figure 31: Following Error - Functional Overview

2. Position Reached
   This function offers the possibility to define a position range around a *position_demand_value* to be regarded as valid. If a drive`s position is within this area for a specified time - the *position_window_time* - the related control bit 10 *target_reached* in the *statusword* is set.

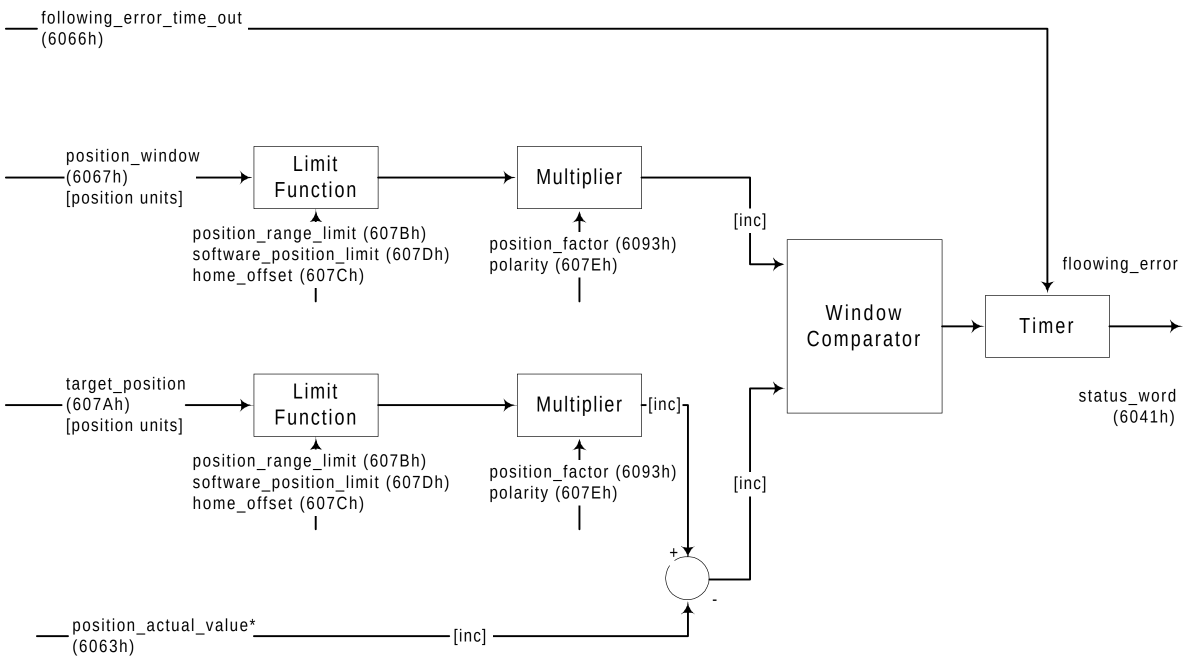


Figure 32: Position Reached - Functional Overview

The control functions following error and position reached have direct access to the *statusword* and give immediate notification to the user if their results change.

14.1.1 Input Data Description

Depending on the supported modes of operation and on the capabilities of different categories of drives, only some of the mentioned input parameters may be necessary.

Operating Mode	Input Parameters used
position mode, homing mode, interpolated position mode	position_demand_value*, position_window_time, position_window, following_error_time_out, following_error_window, position_actual_value, digital_inputs, target_position, position_factor, position_range_limit, polarity

14.1.2 Output Data Description

Operating Mode	Output Parameters used
position mode, homing mode, interpolated position mode	statusword, control_effort, digital_outputs

14.2 Object Dictionary Entries

14.2.1 Objects defined in this Chapter

Index	Object	Name	Type	Attr.	M/O
6062_h	VAR	position_demand_value	Integer32	ro	O
6063_h	VAR	position_actual_value*	Integer32	ro	O
6064_h	VAR	position_actual_value	Integer32	ro	M
6065_h	VAR	following_error_window	Unsigned32	rw	O
6066_h	VAR	following_error_time_out	Unsigned16	rw	O
6067_h	VAR	position_window	Unsigned32	rw	O
6068_h	VAR	position_window_time	Unsigned16	rw	O
$60F4_h$	VAR	following_error_actual_value	Integer32	ro	O
$60FA_h$	VAR	control_effort	Integer32	ro	O
$60FB_h$	RECORD	position_control_parameter_set	-	rw	O
$60FC_h$	VAR	position_demand_value*	Integer32	ro	O

14.2.2 Objects defined in other Chapters

Index	Object	Name	Type	Chapter
$607A_h$	VAR	target_position	Integer32	pp
$607B_h$	VAR	position_range_limit	Integer32	pp
$607C_h$	VAR	home_offset	Integer32	hm
$607D_h$	VAR	software_position_limit	Integer32	pp
$607E_h$	VAR	polarity	Unsigned8	fg
6093_h	VAR	position_factor	Unsigned32	fg
6094_h	ARRAY	velocity_encoder_factor	Unsigned32	fg
6095_h	ARRAY	velocity_factor_1	Unsigned32	fg
6096_h	ARRAY	acceleration_factor	Unsigned32	fg
6041_h	VAR	controlword	Integer16	dc
6041_h	VAR	statusword	Unsigned16	dc

14.3 Object Description

14.3.1 Object 6062_h: position_demand_value

Index	**6062_h**
Name	position_demand_value
Object Code	VAR
Data type	Integer32

Value Description

Object Class	M: -	O: pc
Access	ro	
PDO Mapping	Possible	
Units	position units	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

14.3.2 Object 6063_h: 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. If necessary, the data unit must be transformed with the *position_factor* defined in the Factor Group from user defined units to increments.

Index	**6063_h**
Name	position_actual_value*
Object Code	VAR
Data type	Integer32

Value Description

Object Class	M: -	O: pc, pp, ip, hm, tq
Access	ro	
PDO Mapping	Possible	
Units	increments	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

14.3.3 Object 6064$_h$: position_actual_value

This object represents the actual value of the position measurement device in user defined units.

Index	**6064$_h$**
Name	position_actual_value
Object Code	VAR
Data type	Integer32

Value Description

Object Class	M: pc	O: pc, pp, ip, hm, tq
Access	ro	
PDO Mapping	Possible	
Units	position units	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

14.3.4 Object 6065_h: 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 out of the *following_error_window*, a following error occurs

A following error might occur when:
- a drive is blocked
- unreachable profile velocity
- wrong closed loop coefficients

If the value of the following error window is 2^{32}-1, the following control is switched off.

Index	**6065_h**
Name	following_error_window
Object Code	VAR
Data type	Unsigned32

Value Description

Object Class	M: -	O: pc, pp
Access	rw	
PDO Mapping	Possible	
Units	position units	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

14.3.5 Object 6066_h: following_error_time_out

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

Index	**6066_h**
Name	following_error_time_out
Object Code	VAR
Data type	Unsigned16

Value Description

Object Class	M: -	O: pc, pp
Access	rw	
PDO Mapping	Possible	
Units	milliseconds	
Value Range	0..65535	
Mandatory Range	-	
Default Value	-	
Substitute Value	0	

14.3.6 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 preferes to specify the *position_window* in his application in user defined units, the *position_factor* of the Factor Group 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.

If the value of the position window is 2^{32}-1, the position window control is switched of.

Index	**6067_h**
Name	position_window
Object Code	VAR
Data type	Unsigned32

Value Description

Object Class	M: -	O: pc
Access	rw	
PDO Mapping	Possible	
Units	position units	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	-	
Substitute Value	0	

14.3.7 Object 6068_h : position_window_time

When the actual position is within the *position_window* during the defined *position_window_time*, the corresponding bit 10 *target_reached* in the *statusword* will be set to one.

Index	**6068_h**
Name	position_window_time
Object Code	VAR
Data type	Unsigned16

Value Description

Object Class	M: -	O: pc
Access	rw	
PDO Mapping	Possible	
Units	milliseconds	
Value Range	0..65535	
Mandatory Range	-	
Default Value	-	
Substitute Value	0	

14.3.8 Object $60F4_h$: following_error_actual_value

This object represents the actual value of the following error.

Index	**$60F4_h$**
Name	following_error_actual_value
Object Code	VAR
Data type	Integer32

Value description

Object Class	M: -	O: pc, pp, ip, hm, tq
Access	ro	
PDO Mapping	Possible	
Units	position units	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

14.3.9 Object $60FA_h$: 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.

Index	**$60FA_h$**
Name	control_effort
Object Code	VAR
Data type	Integer32

Value Description

Object Class	M: -	O: pc, pp, ip, hm, tq
Access	ro	
PDO Mapping	Possible	
Units	-	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

14.3.10 Object 60FB$_h$: position_control_parameter_set

In order to control the behaviour of the position control loop, one or more parameters are necessary. This object is a means to define control parameters which are highly manufacturer specific. For this reason, these parameters shall not be described in this document at all.

Index	**60FB$_h$**
Name	position_control_parameter_set
Object Code	RECORD
Number of Elements	0..255

Value Description

Sub-Index	01$_h$..255h$_h$	
Description	Manufacturer specific	
Object Class	M: -	O: pc, pp, ip, hm, tq
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	
Data Type	user defined	

14.3.11 Object $60FC_h$: position_demand_value*

This output of the *trajectory_generator* in *position_mode* is an internal value using increments as unit what is expressed with an *. To save calculation time for some applications, this object is additionally introduced to the *position_demand_value* (6062_h).

Index	**$60FC_h$**
Name	position_demand_value*
Object Code	VAR
Data type	Integer32

Value Description

Object Class	M: -	O: pc, pp, ip, hm; tq
Access	ro	
PDO Mapping	Possible	
Units	increments	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

14.4 Functional Description

Figure 32 shows the meaning of the subfunctions position reached and following error. Symmetrically around the target_position x_i a window is defined for the accepted position range between x_i-x_0 and x_i+x_0. The positions x_{t0} and x_{t1} e.g. are situated within this *position_window*. If a drive is sensed in the accepted range a virtual timer can be imagined to be started. This timer is available as communication object called *position_window_time.* To change the status bit (bit 10) *target_reached* it is necessary that the *position_window_time* expires while the drive position is still in this range between x_i-x_0 and x_i+x_0.

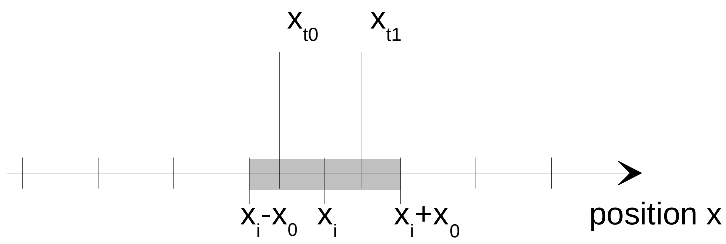


Figure 33: Position reached

Another position area - the *following_error_window* - may be defined to mark a *following_error*. In this case the *following_error_time_out* is used to specify the time the *actual_position* may be outside the *position_window* without a *following_error* to be stated in the *statusword* at bit 13.

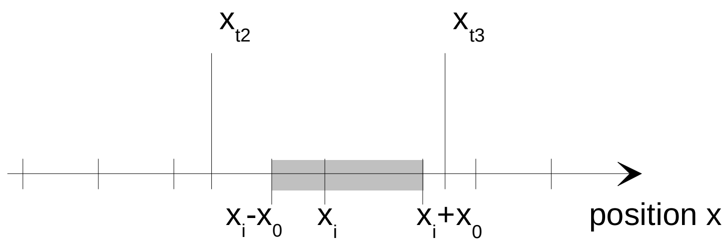


Figure 34: Following error

15 Interpolated Position Mode

15.1 General Information

The Interpolated Position Mode is used to control multiple coordinated axles or a single axle with the need for time-interpolation of setpoint data. The Interpolated Position Mode normally uses time synchronization mechanisms like the sync object defined in /16/ for a time coordination of the related drive units.

The *interpolation_data_record* contains the interpolation data; the data type of the members of this structure is not detailed by the CANopen Device Profile for Drives and Motion Control. Only the record size is fixed in the *size_of_data_record* as sub-index of the *interpolation_data_configuration*

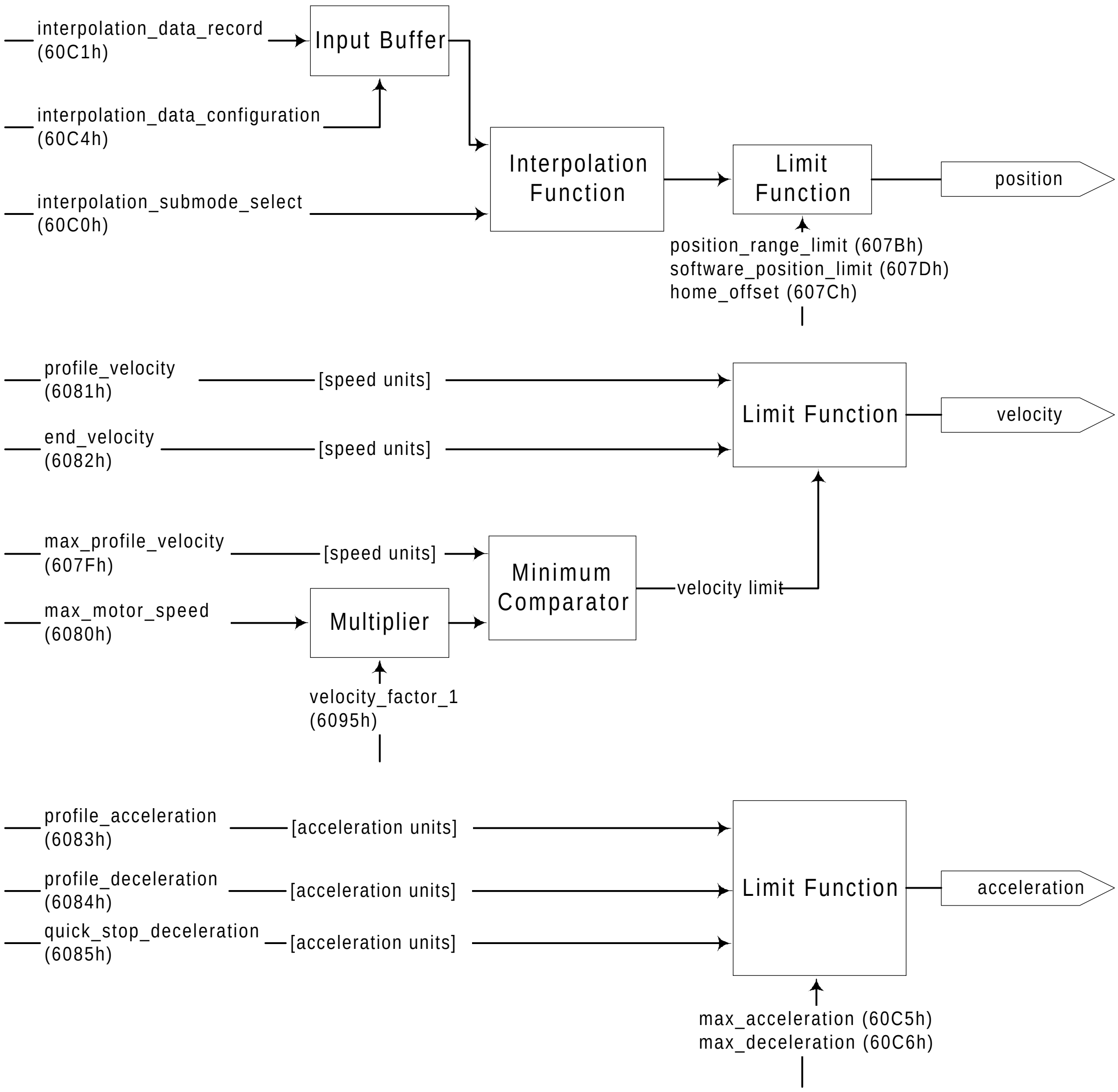
For synchronous operation the interpolation cycle time is defined by the object *interpolation_time_period*. For asynchronous operation, the *interpolation_time_period* for each time slice must be included in the *interpolation_data_record*.

Time synchronization can be done by the CANopen sync message (see /16/), a specific group sync signal (broadcast) or in specified time slices which are activated with the start signal.

The Interpolated Position Mode allows a host controller to transmit a stream of interpolation data with either an implicit or explicit time reference to a drive unit. If the drive supports an input buffer, the interpolation data may be sent in bursts rather than continously in real time. The actually available and the maximum size of the input buffer can be requested by a host using the *interpolation_data_configuration*. The buffer size is the number of *interpolation_data_records* which may be sent to a drive to fill the input buffer and it is not the size in bytes. Devices without input buffer capabilities can only but must accept at least one interpolation data item.

The interpolation algorithm is defined in the *interpolation_submode_select*. Linear interpolation is the default interpolation method. This requires only one interpolation data item to be buffered for the calculation of the next demand value. For each interpolation cycle, the drive will calculate a *position_demand_value* by interpolating positions over a period of time.

Optionally the common limit functions for speed, acceleration and deceleration may be applied to the interpolation data.


interpolation_data_record
(60C1h)
Input Buffer
interpolation_data_configuration
(60C4h)
interpolation_submode_select
(60C0h)
Interpolation
Function
Limit
Function
position
position_range_limit (607Bh)
software_position_limit (607Dh)
home_offset (607Ch)
profile_velocity
(6081h)
[speed units]
end_velocity
(6082h)
[speed units]
Limit Function
velocity
max_profile_velocity
(607Fh)
[speed units]
max_motor_speed
(6080h)
Multiplier
Minimum
Comparator
velocity limit
velocity_factor_1
(6095h)
profile_acceleration
(6083h)
[acceleration units]
profile_deceleration
(6084h)
[acceleration units]
quick_stop_deceleration
(6085h)
[acceleration units]
Limit Function
acceleration
max_acceleration (60C5h)
max_deceleration (60C6h)

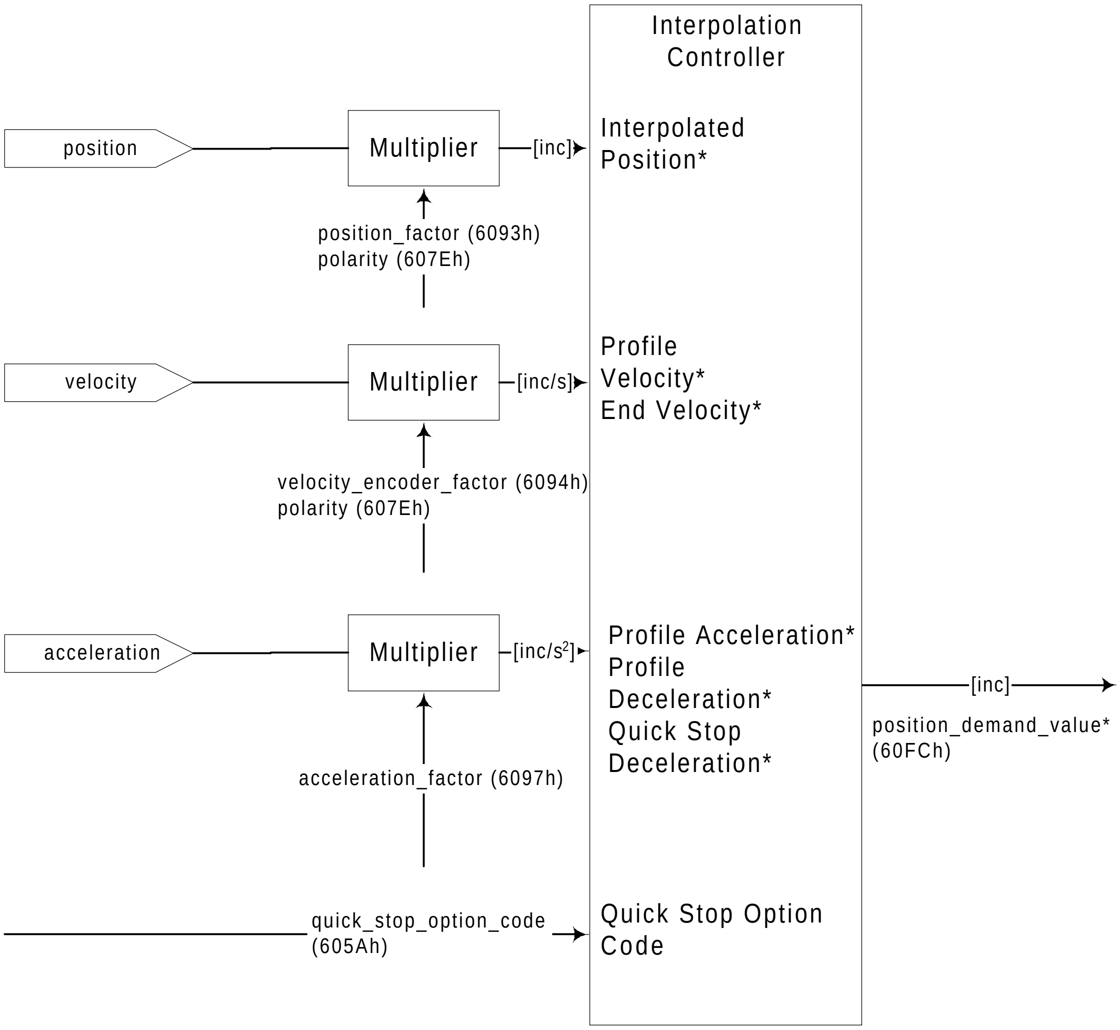


Figure 35: Interpolation Controller

15.1.1 Input Data Description

Operating Mode	Input Parameters Used
Interpolated Position Mode	interpolation_submode_select, max_profile_velocity, profile_acceleration, profile_deceleration, quick_stop_deceleration*, quick_stop_mode

15.1.2 Output Data Description

The output values provided by the Interpolated Position Mode depend on the number and type of interpolation functions implemented by a manufacturer. For the predefined linear time interpolation the output is a *position_demand_value**.

Operation Mode	Output Parameter used
Interpolated Position Mode	position_demand_value*

15.1.3 Internal States

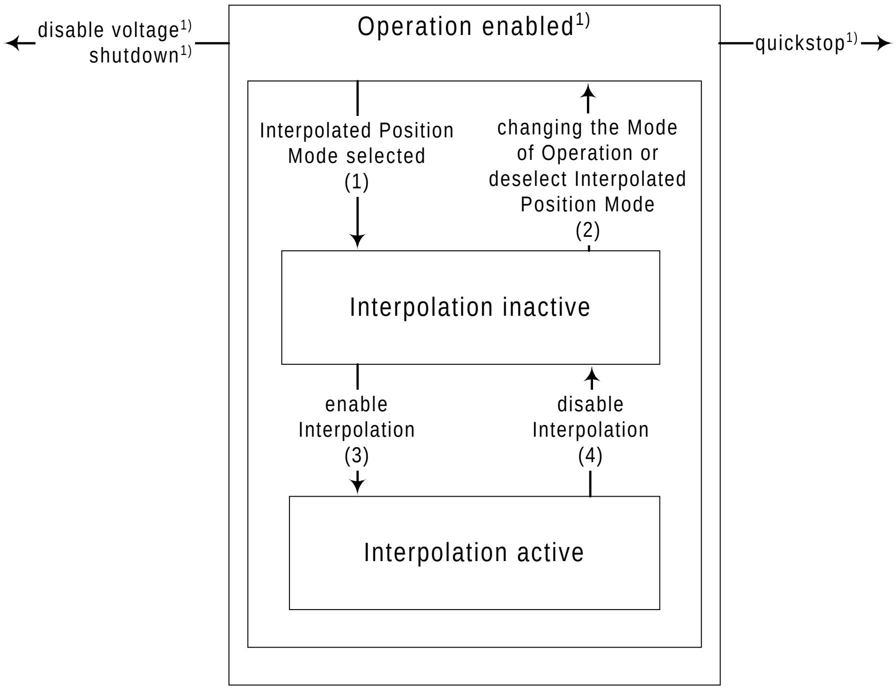


Figure 36: Internal States for the Interpolated Position Mode

1) see statemachine

- ❍ Interpolation inactive
  This state is entered when the device is in state Operation enabled and the Interpolated Position Mode is selected. The drive unit will accept input data and will buffer it for interpolation calculations, but it does not move the axles.

- ❍ Interpolation active
  This state is entered when the device is in state Operation enabled, the Interpolated Position Mode is selected and enabled. The drive unit will accept input data and it moves the axles.

15.1.4 State Transitions of the Internal States

State Transition 1: NO IP-MODE SELECTED => IP-MODE INACTIVE
Event: Select ip-mode with *controlword* while operation enabled

State Transition 2: IP-MODE INACTIVE => NO IP-MODE SELECTED
Event: Select any other mode *controlword* while operation enabled

State Transition 3: IP-MODE INACTIVE => IP-MODE ACTIVE
Event: Set bit enable_ip_mode (bit4) of the *controlword* while in ip-mode and operation enabled

State Transition 4: IP-MODE ACTIVE => IP-MODE INACTIVE
Event: Reset bit enable_ip_mode (bit4) of the *controlword* while in ip-mode and operation enabled

15.2 Object Dictionary Entries

15.2.1 Objects defined in this Chapter

Index	Object	Name	Type	Attr.	M/O
$60C0_h$	VAR	interpolation_submode_select	Integer16	rw	O
$60C1_h$	RECORD	interpolation_data_record	Integer32	rw	O
$60C2_h$	RECORD	interpolation_time_period	Unsigned8	rw	O
$60C3_h$	ARRAY	interpolation_sync_definition	Unsigned8	rw	O
$60C4_h$	RECORD	interpolation_data_configuration	Unsigned16	rw	O

15.2.2 Objects defined in other Chapters

Index	Object	Name	Type	Chapter
6040_h	VAR	controlword	Integer16	dc
6041_h	VAR	statusword	Unsigned16	dc
$605A_h$	VAR	quick_stop_mode	Integer16	tg
6060_h	VAR	modes_of_operation	Unsigned8	dc
6061_h	VAR	modes_of_operation_display	Unsigned8	dc
6062_h	VAR	position_reference_variable	Integer32	pp
6063_h	VAR	position_encoder_actual_value	Integer32	pp
$606A_h$	VAR	sensor_selection_code	Unsigned8	pv
$607F_h$	VAR	max_profile_speed	Unsigned32	pp
6089_h	VAR	position_notation_index	Integer8	fg
$608A_h$	VAR	position_dimension_index	Unsigned8	fg
$608B_h$	VAR	velocity_notation_index	Integer8	fg
$608C_h$	VAR	velocity_dimension_index	Unsigned8	fg
$608D_h$	VAR	acceleration_notation_index	Integer8	fg
$608E_h$	VAR	acceleration_dimension_index	Unsigned8	fg
$608F_h$	ARRAY	position_encoder_solution	Unsigned32	fg
6090_h	ARRAY	velocity_encoder_solution	Unsigned32	fg
6091_h	ARRAY	gear_ratio	Unsigned32	fg
6092_h	ARRAY	feed_constant	Unsigned32	fg
6093_h	ARRAY	position_factor	Unsigned32	fg
6094_h	ARRAY	velocity_encoder_factor	Unsigned32	fg
6095_h	ARRAY	velocity_factor_1	Unsigned32	fg
6098_h	ARRAY	velocity_factor_2	Unsigned32	fg
6097_h	ARRAY	acceleration_factor	Unsigned32	fg
$60C5_h$	VAR	max_acceleration	Integer32	pp
$60C6_h$	VAR	max_deceleration	Integer32	pp

15.3 Object Descriptions

15.3.1 Object 60C0$_h$: interpolation_submode_select

For the Interpolated Position Mode a manufacturer may offer different interpolation algorithms. This object reflects or changes the actually choosen interpolation mode.

Index	**60C0$_h$**
Name	interpolation_submode_select
Object Code	VAR
Data type	Integer16

Value description

Object Class	M: -	O: ip
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-32768..32767	
Mandatory Range	0	
Default Value	0	
Substitute Value	-	

Data Description

Interpolation Submode	**Description**
-32768..-1	manufacturer specific
0	linear interpolation
+1..+32767	reserved

15.3.2 Object 60C1$_h$: interpolation_data_record

The *interpolation_data_record* are the data words which are necessary to perform the interpolation algorithm. The number of data words in the record is defined by *interpolation_data_configuration*. The interpretation of the data words in *interpolation_-data_record* may vary with the different possible interpolation modes as set by the *interpolation_submode_select*.

For the linear interpolation mode each interpolation data record simply can be regarded as a new position setpoint. To describe a cubic spline interpolation e.g., four or more data words are needed for the spline coefficients, and further interpolation parameters.

After the last item of an *interpolation_data_record* is written to the device`s input buffer, the pointer of the buffer is automatically incremented to the next buffer position.

Index	**$60C1_h$**
Name	interpolation_data_record
Object Code	RECORD
Number of Elements	defined by *interpolation_data_configuration* ($60C4_h$)

Value description

Sub-Index	01_h	
Description	x_1 : the first parameter of ip function f_{ip} (x_1, .. x_N)	
Object Class	M: -	O: ip
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	
Data Type	Interpolated Position Mode dependent	

Sub-Index (N > 1)	02_h .. N	
Description	x_i : the i-th parameter of ip function f_{ip} (x_1, .. x_N)	
Object Class	M: -	O: ip
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	
Data Type	Interpolated Position Mode dependent	

15.3.3 Object $60C2_h$: interpolation_time_period

The *interpolation_time_period* is used for time synchronized Interpolated Position Modes.

Index	**$60C2_h$**
Name	interpolation_time_period
Object Code	RECORD
Number of Elements	2

Value description

Sub-Index	01_h	
Description	ip_time_units	
Object Class	M: -	O: ip
Access	rw	
PDO Mapping	Possible	
Units	$10^{ip\_time\_index}$ • seconds	
Value Range	1..255	
Mandatory Range	1	
Default Value	1	
Substitute Value	-	
Data Type	Unsigned8	

Sub-Index	02_h	
Description	ip_time_index	
Object Class	M: -	O: ip
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	63..-128	
Mandatory Range	-3 (= milli second)	
Default Value	-3	
Substitute Value	-	
Data Type	Integer8	

15.3.4 Object 60C3$_h$: interpolation_sync_definition

Devices in the Interpolated Position Mode often interact with other devices. Therefore it is necessary to define a communcation object which is used to synchronize these interactions.

This can be done by the general sync-signal as described in /16/, or a specific group-sync-signal. Each reception of this trigger-signal or a specified number of occurences of the trigger-signal can synchronize the devices; a second opportunity is to use fixed time slices for synchronisation.

Index	**60C3$_h$**
Name	interpolation_sync_definition
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned8

Value description

Sub-Index	01$_h$	
Description	syncronize on group	
Object Class	M: -	O: ip
Access	rw	
PDO Mapping	Possible	
Units	number	
Value Range	0..255	
Mandatory Range	-	
Default Value	0: general sync is used	
Substitute Value	-	

Sub-Index	02$_h$	
Description	ip_sync every n event	
Object Class	M: -	O: ip
Access	rw	
PDO Mapping	Possible	
Units	counts	
Value Range	0..255	
Mandatory Range	-	
Default Value	1 (= each)	
Substitute Value	-	

15.3.5 Object 60C4$_h$: 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 postion the axles should reach. To enable the device to recieve the needed data in advance a data space is used to store the positions and further data sended by the host.

Index	**60C4$_h$**
Name	interpolation_data_configuration
Object Code	RECORD
Number of Elements	6

Value description

Sub-Index	01$_h$	
Description	max_buffer_size	
Object Class	M: -	O: ip
Access	ro	
PDO Mapping	Possible	
Units	number	
Value Range	0..(2^{32}-1)	
Mandatory Range	1	
Default Value	1	
Substitute Value	-	
Data Type	Unsigned32	

Sub-Index	02$_h$	
Description	actual_size	
Object Class	M: -	O: ip
Access	rw	
PDO Mapping	Possible	
Units	number	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	
Data Type	Unsigned32	

Sub-Index	03_h	
Description	buffer_organisation	
Object Class	M: -	O: ip
Access	rw	
PDO Mapping	Possible	
Units	number	
Value Range	0..255	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	
Data Type	Unsigned8	

Data Description

buffer_organisation	description
0	FIFO-buffer
1	ring-buffer
all others	reserved

Sub-Index	04_h	
Description	buffer_position	
Object Class	M: -	O: ip
Access	rw	
PDO Mapping	Possible	
Units	number	
Value Range	0..65535	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	
Data Type	Unsigned16	

Sub-Index	05_h	
Description	size_of_data_record	
Object Class	M: -	O: ip
Access	wo	
PDO Mapping	Possible	
Units	number	
Value Range	1..255	
Mandatory Range	-	
Default Value	1	
Substitute Value	-	
Data Type	Unsigned8	

Sub-Index	06_h	
Description	buffer_clear	
Object Class	M: -	O: ip
Access	wo	
PDO Mapping	Possible	
Units	-	
Value Range	0, 1	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	
Data Type	Unsigned8	

Data Description

buffer_clear	**description**
0	clear input buffer/access disabled clear all ip_data_records
1	enable access to the input buffer for the drive functions
all others	reserved

15.4 Functional Description

15.4.1 Interpolated Position Mode

A drive can be controlled and supervised by the *controlword* and the *statusword* respectively. To choose the operation mode, the *modes_of_operation* is used. The activated operation mode is monitored by *modes_of_operation_display*.

A drive manufacturer has to specify the way the device handles a just received interpolation data record. This can be in a way corresponding to the standard position mode, or might be a more complex algorithm. The standard method is to apply new data immediatly, respectively after the next sync-signal.

An input buffer for interpolation data records is not mandatory, although it eases the data exchange between a host and a drive unit. The real-time requirements to the CAN-bus as well as to the drive unit decrease in this case, because an input buffer decouples the data processing in the drive from the data transmission via the bus line.

15.4.2 Linear Interpolated Position Mode with several Axles

In order to follow a two- or more-dimensional curve through the space with a defined speed, a host (an interpolation controller or a PLC) calculates the different positions P_i for each set of coordinates which have to be reached at specified times t_i.

To use the interpolation mode with several axles the host calculates the next or more positions and timestamps, and transmits them to the different axles. For each setpoint P_i the interpolation controller has to calculate x_i, y_i... and t_i. Each axle gets a set of *interpolation_data_records* which each axle has to process internally independent from the other axles according to the choosen interpolation mode.

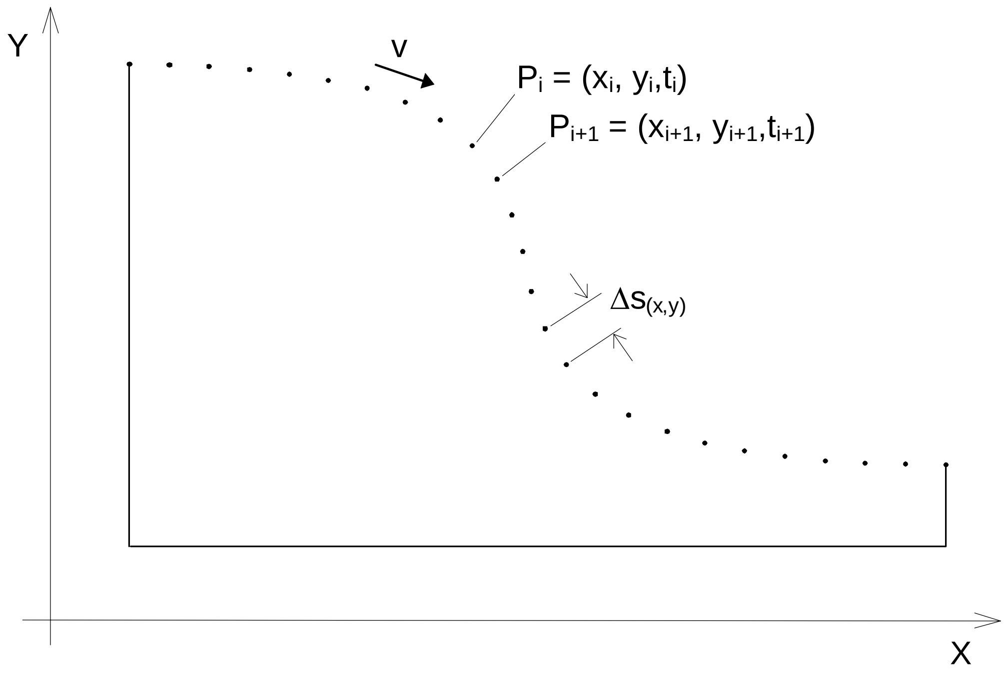


Figure 37: Interpolation for two Axles

In a centralized drive system with a remote motion device doing the interpolation calculation, a central clocking scheme for synchronization of the different axles based on any kind of sync-signal is used. This results in a movement depending on the calculation cycle time of the interpolation controller. The velocity becomes more or less a fixed value for each axle.

calculated	ip_data_records for		
positions	x-axle	y-axle	z-axle
P_i	x_i , t_i	y_i , t_i	z_i , t_i
P_{i+1}	x_{i+1} , t_{i+1}	y_{i+1} , t_{i+1}	z_{i+1} , t_{i+1}
P_{i+2}	x_{i+2} , t_{i+2}	y_{i+2} , t_{i+2}	z_{i+2} , t_{i+2}
P_{i+3}	x_{i+3} , t_{i+3}	y_{i+3} , t_{i+3}	z_{i+3} , t_{i+3}
•	•	•	•
•	•	•	•
•	•	•	•
P_{i+n}	x_{i+n} , t_{i+n}	y_{i+n} , t_{i+n}	z_{i+n} , t_{i+n}

Table 13: Position Calculation in Interpolated Position Mode for several Axles

In decentralized motion systems a host starts all relevant axles by changing the mode-internal state to Interpolation active after preparing and sending one or more *interpolation_data_records* to all axles and synchonizes them by a (group) sync-signal. Each axle calculates internally and inDependently the necessary speed and acceleration needed to move from one position to the next. This can be done done by calculating a linear or any other move between two given position setpoints. Along this track every axle controls the movement between the setpoints indepently from the other axles. The axles may continue their move, as long as there is enough data to continue the calculations. Therefore it is easy to use the input buffer to give data records ahead.

With this information each axle can act like it is shown in Figure 37.

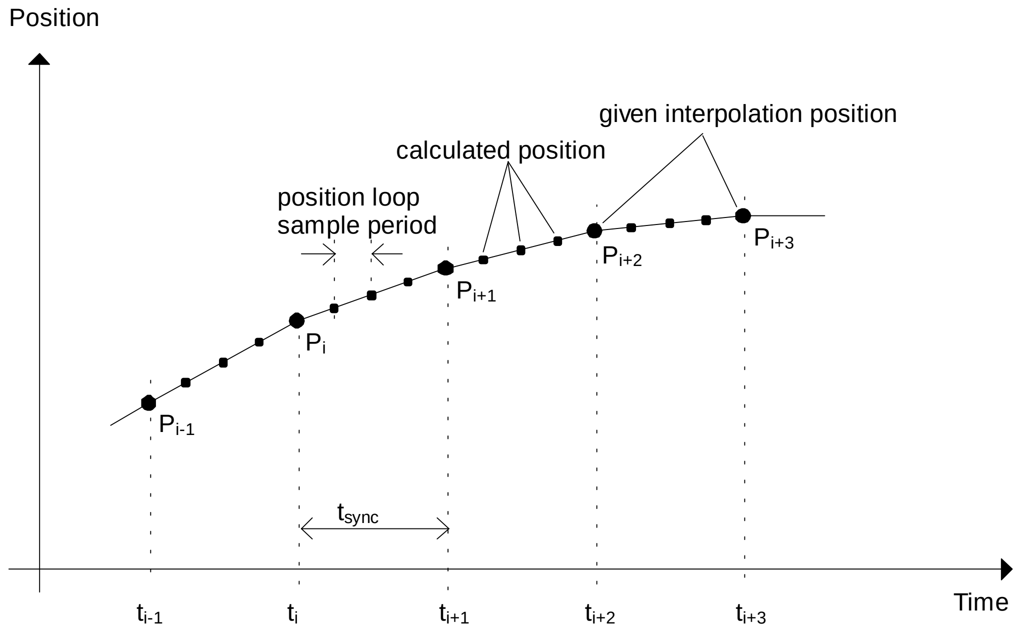


Figure 38: Linear Interpolation for one Axle

15.4.3 Buffer Strategies for the Interpolated Position Mode

If a device provides an input buffer for *interpolation_data_records* its size can be organized by a host using the *interpolation_data_configuration*. The host splits the available buffer capacity into pages which have the size of one *interpolation_data_record* each. This is done by *size_of_data_record*. If one page remains, which can not keep one complete data record, it can not be used. After the reorganisation of the input buffer all previous stored data will be lost. All devices supporting the Interpolated Position Mode need to implement an input buffer, which at least can keep one *interpolation _data_record*.

The contens of the buffer items can only be accessed via the *interpolation_data_record*.

Commonly first-in-first-out (FIFO) structures or ring buffers are used as input buffers.

- FIFO:
  If the buffer is organizied as FIFO, every new received *interpolation_data_record* is placed at the end of the queue, and the device takes the next data record from the top of the queue. When the last item of a data record is stored, the buffer pointer is incremented in order to point to the next buffer position. For this buffer principle the object *buffer_position* does not have any influence.

- Ring Buffer:
  If the buffer is structured as a ring, the host can place an *interpolation_data_record* into

any valid position in the ring by changing the pointer defined in *buffer_position*. Without changing the *buffer_position* all data records will be written at the same location. The drive reads the next entry out of the buffer by an internal ring pointer. It is set to the first data record with *buffer_clear*, and after the reorganisation of the input buffer.

↑ data_ record_ size ↓	parameter 1 parameter 2 • • parameter n	*ip_data_record* 1
↑ data_ record_ size ↓	parameter 1 parameter 2 • • parameter n	*ip_data_record* 2
		more data records
		•
		•
		•
		•
↑ data_ record_ size ↓	parameter 1 parameter 2 • • parameter n	*ip_data_record* i
		not accessable

Figure 39: Input Buffer Organisation

16 Profile Velocity Mode

16.1 General Information

The Profile Velocity Mode includes the following subfunctions:

- demand value input via Trajectory Generator
- velocity capture using position sensor or velocity sensor
- velocity control function with appropriate input and output signals
- limitation of *torque_demand_value*
- monitoring of the *profile_velocity* using a window-function
- monitoring of *velocity_actual_value* using a threshold

The operation of the reference value generator and its input parameters:

- *profile_velocity ;*
- *profile_acceleration ;*
- *profile_deceleration;*
- *emergency_stop* and
- *motion_profile_type*

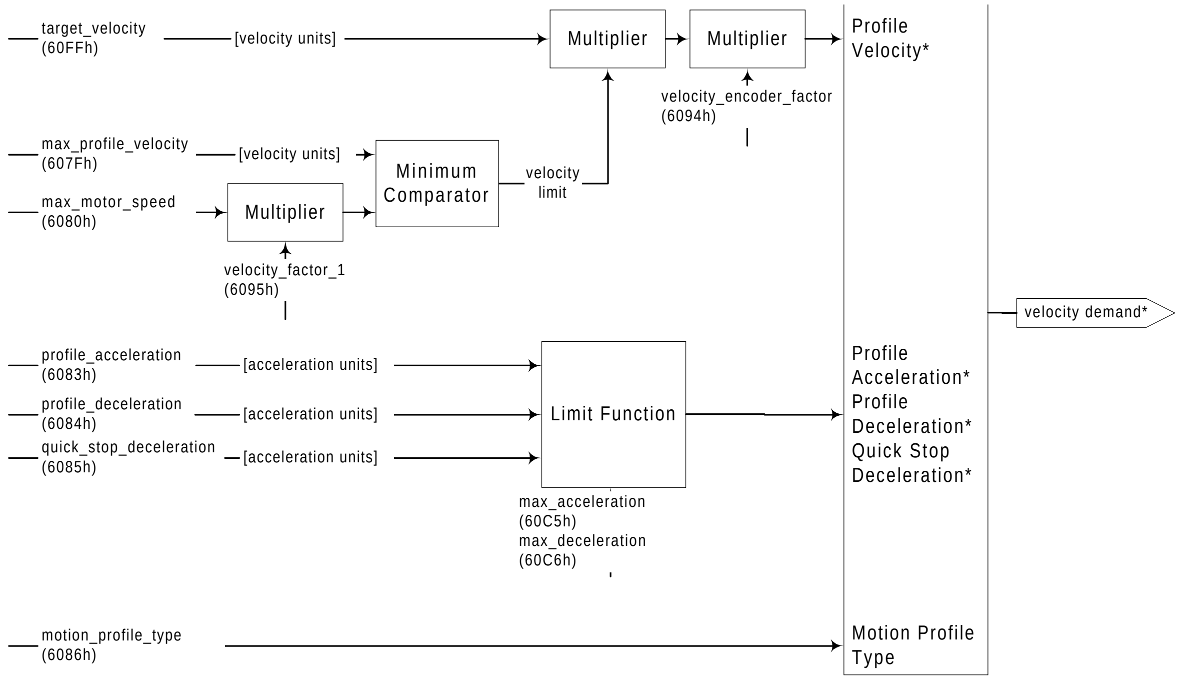
are described in the Profile Position Mode.

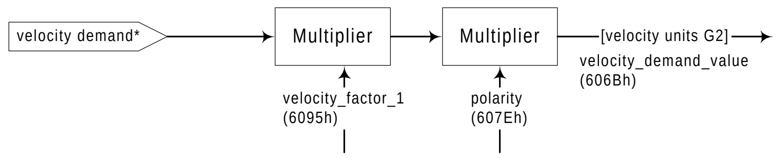
Various sensors can be used for velocity capture. In particular the aim is that costs should be reduced and the system should be simplified by evaluating position and velocity using a common sensor, such as is possible using a resolver or an encoder.

The velocity control function is not specified more precisely at this point as it is highly manufacturer specific, but the format and maximum number of control coefficients are established.

The velocity controller calculates a torque variable. This is added to a torque pre control calculated by the Trajectory Generator and limited to a *torque_max_value*. The limited total is used as input to the torque controller as a *torque_demand_value*.

Monitoring functions for the *velocity_actual_value* provide status information for super-ordinated systems.


target_velocity
(60FFh)
[velocity units]
Multiplier
Multiplier
Profile
Velocity*
velocity_encoder_factor
(6094h)
max_profile_velocity
(607Fh)
[velocity units]
Minimum
Comparator
velocity
limit
max_motor_speed
(6080h)
Multiplier
velocity_factor_1
(6095h)
velocity demand*
profile_acceleration
(6083h)
[acceleration units]
profile_deceleration
(6084h)
[acceleration units]
quick_stop_deceleration
(6085h)
[acceleration units]
Limit Function
Profile
Acceleration*
Profile
Deceleration*
Quick Stop
Deceleration*
max_acceleration
(60C5h)
max_deceleration
(60C6h)
motion_profile_type
(6086h)
Motion Profile
Type


velocity demand*
Multiplier
Multiplier
[velocity units G2]
velocity_demand_value
(606Bh)
velocity_factor_1
(6095h)
polarity
(607Eh)

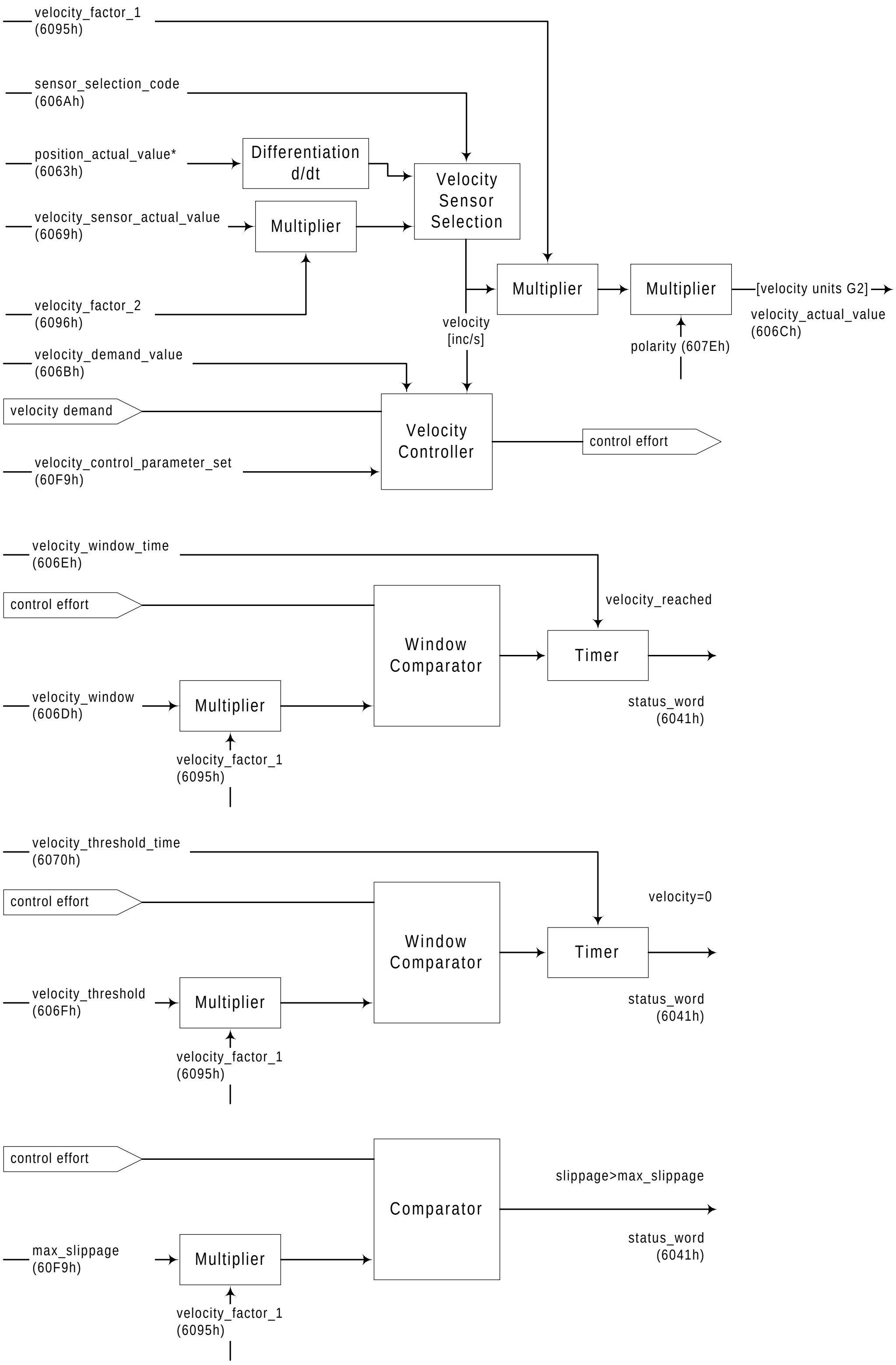


Figure 40: Structure of the Profile Velocity Mode

16.1.1 Input Data Description

Operating Mode	**Input Parameters Used**
Profile Velocity Mode	target_velocity, velocity_factor_1, velocity_factor_2, velocity_window, velocity_window_time, velocity_threshold, velocity_threshold_time, max_slippage, profile_acceleration, profile_deceleration, quick_stop_deceleration, max_acceleration, max_deceleration, polarity, quick_stop_option_code, motion_profile_type, max_profile_velocity, max_motor_speed

16.1.2 Output Data Description

Operation Mode	**Output Parameter used**
Profile Velocity Mode	velocity_actual_value, velocity_demand_value, statusword

16.2 Object Dictionary Entries

16.2.1 Objects defined in this Chapter

Index	**Object**	**Name**	**Type**	**Attr.**	**M/O**
6069_h	VAR	velocity_sensor_actual_value	Integer32	ro	M
$606A_h$	VAR	sensor_selection_code	Integer16	rw	M
$606B_h$	VAR	velocity_demand_value	Integer32	ro	M
$606C_h$	VAR	velocity_actual_value	Integer32	ro	M
$606D_h$	VAR	velocity_window	Unsigned16	rw	O
$606E_h$	VAR	velocity_window_time	Unsigned16	rw	O
$606F_h$	VAR	velocity_threshold	Unsigned16	rw	O
6070_h	VAR	velocity_threshold_time	Unsigned16	rw	O
$60FF_h$	VAR	target_velocity	Integer32	rw	M
$60F8_h$	VAR	max_slippage	Integer32	rw	O
$60F9_h$	RECORD	velocity_control_parameter_set		rw	O

16.2.2 Objects defined in other Chapters

Index	Object	Name	Type	Chapter
6040_h	VAR	controlword	Integer16	dc
6041_h	VAR	statusword	Unsigned16	dc
6063_h	VAR	position_actual_value*	Integer32	pc
6069_h	VAR	velocity_sensor_actual_value	Integer32	pc
6071_h	VAR	torque_demand_extern	Integer16	tq
6072_h	VAR	max_torque_value	Unsigned16	tq
$607E_h$	VAR	polarity	Unsigned8	fg
$607F_h$	VAR	max_profile_velocity	Unsigned32	pp
6080_h	VAR	max_motor_speed	Unsigned32	pp
6083_h	VAR	profile_acceleration	Unsigned32	pp
6084_h	VAR	profile_deceleration	Unsigned32	pp
6085_h	VAR	quick_stop_deceleration	Unsigned32	pp
6086_h	VAR	motion_profile_type	Integer16	pp
6094_h	ARRAY	velocity_encoder_factor	Unsigned32	fg
6095_h	ARRAY	velocity_factor_1	Unsigned32	fg
6096_h	ARRAY	velocity_factor_2	Unsigned32	fg

16.3 Object Description

The factors necessary for scaling

velocity_reference_factor
velocity_factor_1
velocity_factor_2

all have a linear relationship and are therefore described in the Factor Group.

The *polarity* is described in the Factor Group as well.

16.3.1 position_encoder

The actual velocity can be obtained through differentiation from the position encoder and is represented in position encoder increments.

It is described in greater detail in the position function.

16.3.2 Object 6069$_h$: velocity_sensor_actual_value

The *velocity_sensor_actual_value* describes the value read from a velocity encoder (if present) in increments (in the case of encoders) and in increments per second (in the case of tachometers and AD converters. This value is scaled to the format of the position encoder using the scaling factor *velocity_factor_2.*

Index	**6069$_h$**
Name	velocity_sensor_actual_value
Object Code	VAR
Data Type	Integer32

Value Description

Object Class	M: pv	O: -
Access	ro	
PDO Mapping	Possible	
Units	increments/sec	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

16.3.3 Object 606A$_h$: sensor_selection_code

The source of the *velocity_sensor_actual_value* can be determined using the *sensor_-selection_code.* This determines whether a differentiated position signal or the signal from a separate velocity sensor is to be evaluated.

Index	**606A$_h$**
Name	sensor_selection_code
Object Code	VAR
Data Type	Integer16

Value Description

Object Class	M: pv	O: -
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	-32768..32767	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

Data Description

Selection Code	Meaning of the Selection Function
-32768..-1	manufacturer specific
0	velocity actual value from position encoder
1	velocity actual value from velocity encoder
2..32767	reserved for other profiles

16.3.4 Object 606B$_h$: 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.

Index	**606B$_h$**
Name	velocity_demand_value
Object Code	VAR
Data Type	Integer32

Value Description

Object Class	M: pv	O:
Access	ro	
PDO Mapping	Possible	
Units	velocity units G2	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

16.3.5 Object 606C$_h$: 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.

Index	**606C$_h$**
Name	velocity_actual_value
Object Code	VAR
Data Type	Integer32

Value Description

Object Class	M: pv	O: -
Access	ro	
PDO Mapping	Possible	
Units	velocity units G2	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

16.3.6 Object 606D$_h$: velocity_window

The *velocity_window* monitors whether the required process velocity has been achieved after an eventual acceleration or braking phase.

Index	**606D$_h$**
Name	velocity_window
Object Code	VAR
Data Type	Unsigned16

Value Description

Object Class	M: -	O: pv
Access	rw	
PDO Mapping	Possible	
Units	velocity units G2	
Value Range	0..65535	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

16.3.7 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* is within the *velocity_window* longer than the *velocity_window_time*.

Index	**$606E_h$**
Name	velocity_window_time
Object Code	VAR
Data Type	Unsigned16

Value Description

Object Class	M: -	O: pv
Access	rw	
PDO Mapping	Possible	
Units	millisecond	
Value Range	0..65535	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

16.3.8 Object $606F_h$: 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 status word. Below this threshold the bit is set and indicates that the axle is stationary.

Index	**$606F_h$**
Name	velocity_threshold
Object Code	VAR
Data Type	Unsigned16

Value Description

Object Class	M: -	O: pv
Access	rw	
PDO Mapping	Possible	
Units	velocity units G2	
Value Range	0..65535	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

16.3.9 Object 6070_h: velocity_threshold_time

Index	**6070_h**
Name	velocity_threshold_time
Object Code	VAR
Data Type	Unsigned16

Value Description

Object Class	M: -	O: pv
Access	r/w	
PDO Mapping	Possible	
Units	millisecond	
Value Range	0..65535	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

16.3.10 Object $60FF_h$: target_velocity

The *target_velocity* is the input for the Trajectory Generator.

Index	**$60FF_h$**
Name	target_velocity
Object Code	VAR
Data Type	Integer32

Value Description

Object Class	M: pv	O:
Access	rw	
PDO Mapping	Possible	
Units	velocity units G2	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

16.3.11 Object $60F8_h$: max_slippage

The *max_slippage* monitors whether the maximal slippage has actually been reached.

This value is scaled to the format of the position encoder using the scaling factor *velocity_factor_2*.

When the max_slippage has been reached, the corresponding bit 13 *max_slippage_error* in the status message will be set to one. The reaction of the drive when the max_slippage error occurs, is manufacturer specific.

Index	**$60F8_h$**
Name	max_slippage
Object Code	VAR
Data Type	Integer32

Value Description

Object Class	M: pv	O: -
Access	ro	
PDO Mapping	Possible	
Units	velocity units G2	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	

16.3.12 Object 60F9$_h$: velocity_control_parameter_set

In order to control the behaviour of the velocity control loop, one or more parameters are necessary. This object defines a rudimentary set of three parameters for a PID-control which may be enlarged by the manufacturer up to 255 parameters.

Index	**60F9$_h$**
Name	velocity_control_parameter_set
Object Code	RECORD
Number of Elements	3..255

Value Description

Sub-Index	01$_h$	
Description	V: gain	
Object Class	M: -	O: pv
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..65535	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	
Data Type	unsigned16	

Sub-Index	02$_h$	
Description	$T_{i:}$ integration time constant	
Object Class	M: -	O: pv
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..65535	
Mandatory Range	-	
Default Value	-	
Substitute Value	-	
Data Type	unsigned16	

17 Profile Torque Mode

17.1 General Information

This chapter describes the Profile Torque Mode. The Profile Torque Mode allows a host (external) control system (i.e. closed-loop speed controller, open-loop transmission force controller) to transmit the *target_torque* value, which is processed via the Trajectory Generator. The *torque_slope* and *torque_profile_type* parameters are required.

Should the host control system switch the *controlword* bit 8 (hold) from 0 to 1 or from 1 to 0, than the Trajectory Generator ramps its *control_effort* output down to zero, respectively up to the *target_torque*. In both cases the Trajectory Generator takes the *torque_slope* and *torque_profile_type* into consideration.

All definitions within this document refer to rotating motors. Using linear motors instead requires that all "torque" objects refer to a "force" instead. For the sake of simplicity, the objects are not duplicated and their names should not be modified. As an example, the linear motor target force must be transmitted using the *target_torque* object. Refer to the object descriptions for additional information.

The manufacturer-specific torque control and power-stage functions are not described as they fall beyond the scope of this standard. They are only mentioned for showing how some parameters affect them. As an example the closed-loop torque control coefficients (if any) are to be defined and described by the manufacturer.

The *torque_control_parameters*, *power_stage_parameters* and *motor_parameters* are defined as objects in order that they can be handled (i.e. downloaded) in a standard way. Their detailed data content is manufacturer-specific.

The *torque_demand,* *torque_actual_value*, *current_actual_value* and *DC_link_voltage* may be available to the user as parameters, if they are monitored.

Depending on the drive and motor technologies the manufacturer-specific torque control function has to be active when another mode is selected (hc, pv, pc, ip). In such a case, selecting one of these modes implicitly activates the torque control and power-stage function, using the *control_effort* as input.

17.1.1 Structure of the Profile Torque Mode

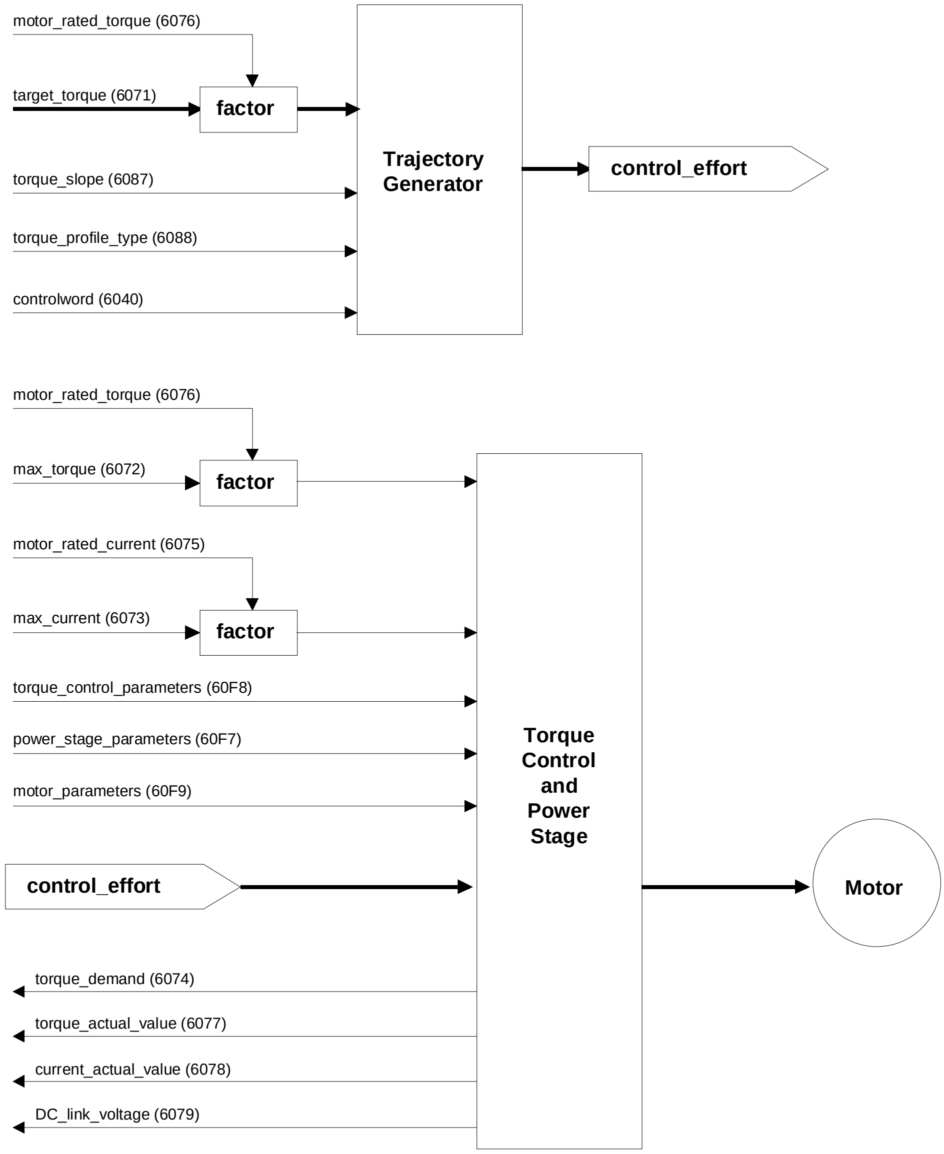


Figure 41: Structure of the Profile Torque Mode

17.2 Object Dictionary Entries

17.2.1 Objects defined in this Chapter

Index	Object	Name	Type	Attr.	M/O
6071_h	VAR	target_torque	Integer16	rw	M
6072_h	VAR	max_torque	Unsigned16	rw	O
6073_h	VAR	max_current	Unsigned16	rw	O
6074_h	VAR	torque_demand_value	Integer16	ro	O
6075_h	VAR	motor_rated_current	Unsigned32	rw	O
6076_h	VAR	motor_rated_torque	Unsigned32	rw	O
6077_h	VAR	torque_actual_value	Integer16	ro	O
6078_h	VAR	current_actual_value	Integer16	ro	O
6079_h	VAR	DC_link_circuit_voltage	Unsigned32	ro	O
6087_h	VAR	torque_slope	Unsigned32	rw	M
6088_h	VAR	torque_profile_type	Integer16	rw	M
$60F7_h$	RECORD	power_stage_parameters		rw	O
$60F6_h$	RECORD	torque_control_parameters		rw	O

17.2.2 Objects defined in other chapters

Index	Object	Name	Type	Chapter
6040_h	VAR	controlword	Integer16	dc
$60F9_h$	RECORD	motor_parameters		go

17.3 Object Description

17.3.1 Object 6071_h: target_torque

This parameter is the input value for the torque controller in Profile Torque Mode.

Index	**6071_h**
Name	target_torque
Object Code	VAR
Data type	Integer16

Value description

Object Class	M: tq	O: -
Access	rw	
PDO Mapping	optional	
Units	per thousand of rated torque	
Value Range	-32768..32767	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

17.3.2 Object 6072_h: max_torque

This value represents the maximum permissible torque in the motor.

Index	**6072_h**
Name	max_torque
Object Code	VAR
Data Type	Unsigned16

Value description

Object Class	M: -	O: tq, hc, pv, pp, ip
Access	rw	
PDO Mapping	optional	
Units	per thousand of rated torque	
Value Range	0..65535	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

17.3.3 Object 6073$_h$: max_current

This value represents the maximum permissible torque creating current in the motor.

Index	**6073$_h$**
Name	max_current
Object Code	VAR
Data Type	Unsigned16

Value description

Object Class	M: -	O: tq, hc, pv, pp, ip
Access	rw	
PDO Mapping	optional	
Units	per thousand of rated current	
Value Range	0..65535	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

17.3.4 Object 6074$_h$: torque_demand_value

This parameter is the output value of the torque limit function (if available wintin the torque control and power-stage function).

Index	**6074$_h$**
Name	torque_demand_value
Object Code	VAR
Data Type	Integer16

Value description

Object Class	M: -	O: tq, hc, pv, pp, ip
Access	ro	
PDO Mapping	optional	
Units	per thousand of rated torque	
Value Range	-32768..32767	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

17.3.5 Object 6075_h: motor_rated_current

This value is taken from the motor name plate and is entered as units of 1 milliamp (or 0.001 amp). Depending on the motor and drive technology this current may be either DC, peak or rms (root-mean-square) current. All relative current data refers to this value.

Index	**6075_h**
Name	motor_rated_current
Object Code	VAR
Data Type	Unsigned32

Value description

Object Class	M: -	O: tq, hc, pv, pp, ip
Access	rw	
PDO Mapping	optional	
Units	1 mA	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

17.3.6 Object 6076_h: motor_rated_torque

This value is taken from the motor name plate and is entered as units of 0.001 Nm. All relative torque data refer to this value.

For linear motors, the object name is not changed, but the motor rated force value must be entered as units of 0.001 N.

Index	**6076_h**
Name	motor_rated_torque
Object Code	VAR
Data Type	Unsigned32

Value description

Object Class	M: -	O: tq, hc, pv, pp, ip
Access	rw	
PDO Mapping	optional	
Units	0.001 Nm	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

17.3.7 Object 6077$_h$: torque_actual_value

The torque actual value corresponds to the instantaneous torque in the drive motor.

Index	**6077$_h$**
Name	torque_actual_value
Object Code	VAR
Data Type	Integer16

Value description

Object Class	M: -	O: tq, hc, pv, pp, ip
Access	ro	
PDO Mapping	optional	
Units	per thousand of rated torque	
Value Range	-32768..32767	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

17.3.8 Object 6078$_h$: current_actual_value

The current actual value refers to the instantaneous current in the drive motor.

Index	**6078$_h$**
Name	current_actual_value
Object Code	VAR
Data Type	Integer16

Value description

Object Class	M: -	O: tq, hc, pv, pp, ip
Access	ro	
PDO Mapping	optional	
Units	per thousand of rated current	
Value Range	-32768..32767	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

17.3.9 Object 6079$_h$: DC_link_circuit_voltage

This parameter describes the instantaneous DC link current voltage at the drive controller.

Index	**6079$_h$**
Name	DC_link_circuit_voltage
Object Code	VAR
Data Type	Unsigned32

Value description

Object Class	M: -	O: tq, hc, pv, pc, ip
Access	ro	
PDO Mapping	optional	
Units	milli volts	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

17.3.10 Object 6087$_h$: torque_slope

This parameter describes the rate of change of torque in units of per thousand of rated torque per second.

Index	**6087$_h$**
Name	torque_slope
Object Code	VAR
Data Type	Unsigned32

Value description

Object Class	M: tq	O:
Access	rw	
PDO Mapping	optional	
Units	per thousand of rated torque per second	
Value Range	0..(2^{32}-1)	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

17.3.11 Object 6088_h: torque_profile_type

The torque_profile_type is used to select the type of torque profile used to perform a torque change.

Index	**6088_h**
Name	torque_profile_type
Object Code	VAR
Data Type	Integer16

Value description

Object Class	M: tq	O:
Access	rw	
PDO Mapping	optional	
Units	none	
Value Range	-32768..32767	
Mandatory Range	-	
Default Value	0	
Substitute Value	-	

Data Description

Profile Code	**Profile Type**
-32768 ... -1	Vendor specific
0	Linear ramp (trapezoidal profile)
1	Sin^2 ramp
2 .. 32767	Reserved for further profile types

17.3.12 Object 60F7$_h$: power_stage_parameters

The *power_stage_parameters* object is used to handle (i.e. download) all manufacturer-specific power-stage parameters as a whole, in a standard way.

Index	**60F7$_h$**
Name	power_stage_parameters
Object Code	RECORD
Number of Elements	1..255

Value description

Sub-Index	01$_h$	
Description		
Object Class	M: -	O: tq, hc, pv, pp, ip
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range		
Mandatory Range	-	
Default Value	-	
Substitute Value	-	
Data Type		

17.3.13 Object 60F6$_h$: torque_control_parameters

The *torque_control_parameters* object is used to handle (i.e. download) all manufacturer-specific torque control parameters as a whole, in a standard way.

Index	**60F6$_h$**
Name	torque_control_parameters
Object Code	RECORD
Number of Elements	1..255

Value description

Sub-Index	01$_h$	
Description		
Object Class	M: -	O: tq, hc, pv, pp, ip
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range		
Mandatory Range	-	
Default Value	-	
Substitute Value	-	
Data Type		

18 Velocity Mode

18.1 General Description

The Velocity Mode is based on /18/ and /19/ and refers to the Speed Function Group 1 of /19/.

The most frequently used devices with this mode are low-cost frequency inverters. But this profile could be used with all types of drives and other devices where it fits. Therefore data objects are almost 16bit wide. The calculation of variables at the drive is possible by usual 8 bit microprocessors.

Most applications use a velocity setpoint and a control word for switching the drive on and off.

Example for a minimal implementation of the Velocity Mode.

See chapter 10 for Device Control.

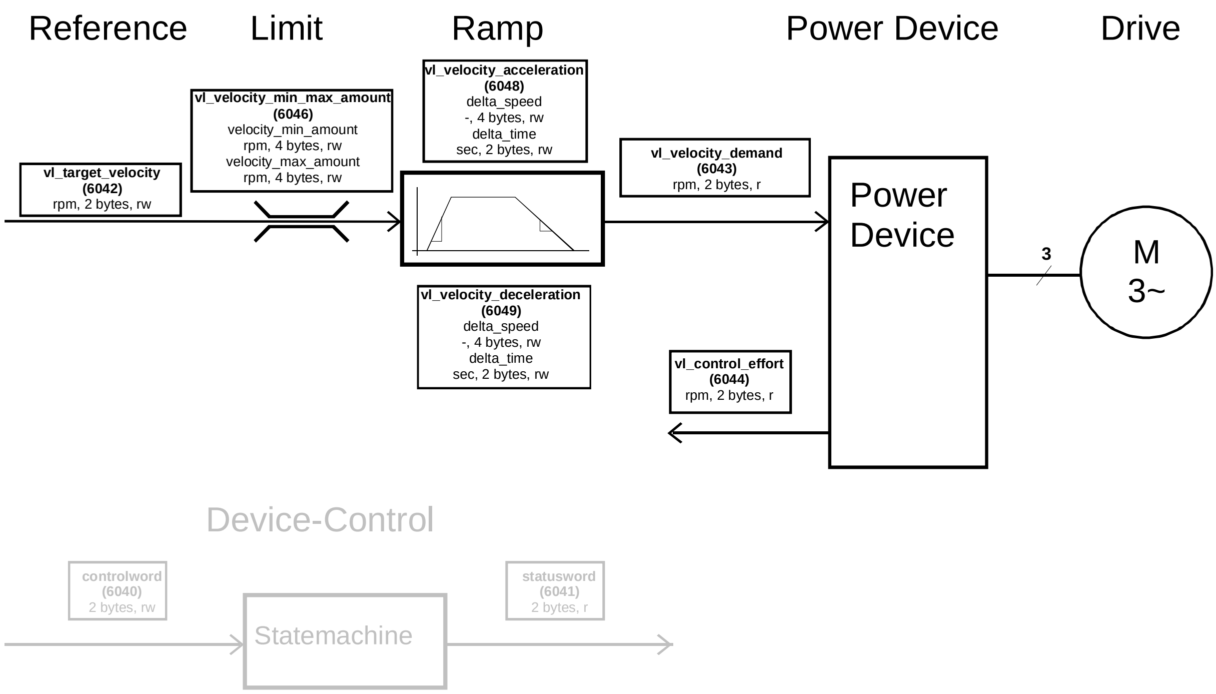


Figure 42: Example of a Velocity Mode application

18.1.1 Input Data Description

The Velocity Mode has the following input parameter:

Operating Mode	Input Parameters Used
Velocity Mode	vl_target_velocity, vl_nominal_percentage, vl_pole_number, vl_dimension_factor; vl_velocity_min_max_amount, vl_velocity_min_max, vl_velocity_motor_min_max_amount - vl_velocity_motor_min_max, vl_frequency_motor_min_max_amount, vl_frequency_motor_min_max, vl_velocity_acceleration, vl_velocity_deceleration, vl_velocity_quick_stop, vl_ramp_function_time, vl_slow_down_time, vl_quick_stop_time, vl_velocity_reference, vl_setpoint_factor

These objects are only used for the Velocity Mode.

18.1.2 Output Data Description

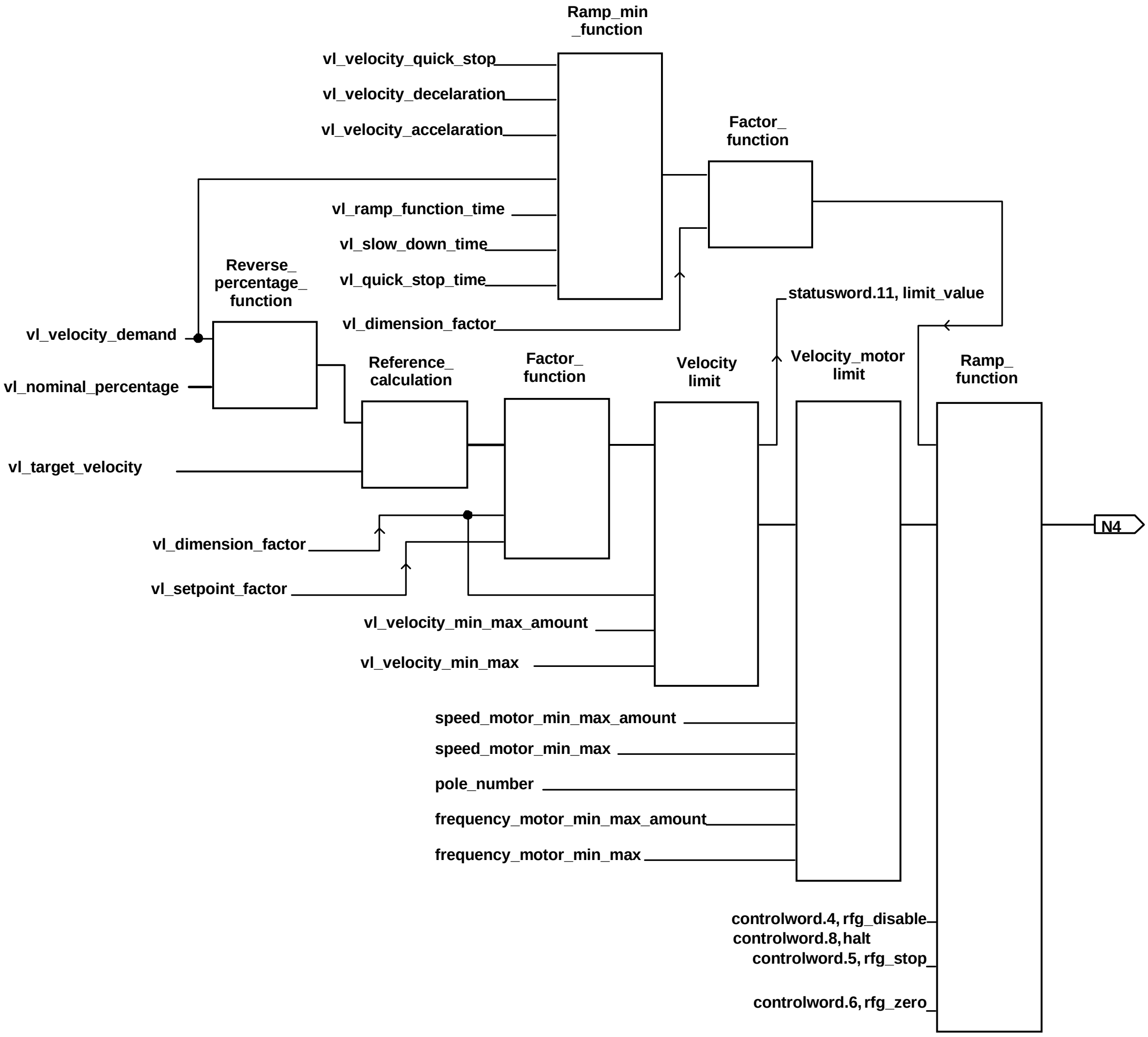
The Velocity Mode provides the following output parameters:

Operation Mode	Output Parameter used
Velocity Mode	vl_control_effort, vl_manipulated_velocity, vl_percentage_demand, vl_actual_percentage, vl_velocity_demand, vl_manipulated_percentage

These objects are only used for the Velocity Mode.

18.1.3 Structure of the Velocity Mode

The diagram below shows the overall structure of the Velocity Mode. All mandatory and optional objects are used. It is not intended with it to specify implementations, but to describe the scope of functions. In these structures, the unit in which the velocity values in the speed functions are calculated is rpm. The descriptions of the drive functions refer to this structure. The Device Control is of course used in the Velocity Mode, but it is described in an extra chapter.


Ramp_min
_function
vl_velocity_quick_stop
vl_velocity_decelaration
vl_velocity_accelaration
Factor_
function
vl_ramp_function_time
vl_slow_down_time
vl_quick_stop_time
Reverse_
percentage_
function
vl_dimension_factor
statusword.11, limit_value
vl_velocity_demand
vl_nominal_percentage
Reference_
calculation
Factor_
function
Velocity
limit
Velocity_motor
limit
Ramp_
function
vl_target_velocity
vl_dimension_factor
vl_setpoint_factor
N4
vl_velocity_min_max_amount
vl_velocity_min_max
speed_motor_min_max_amount
speed_motor_min_max
pole_number
frequency_motor_min_max_amount
frequency_motor_min_max
controlword.4, rfg_disable
controlword.8, halt
controlword.5, rfg_stop
controlword.6, rfg_zero

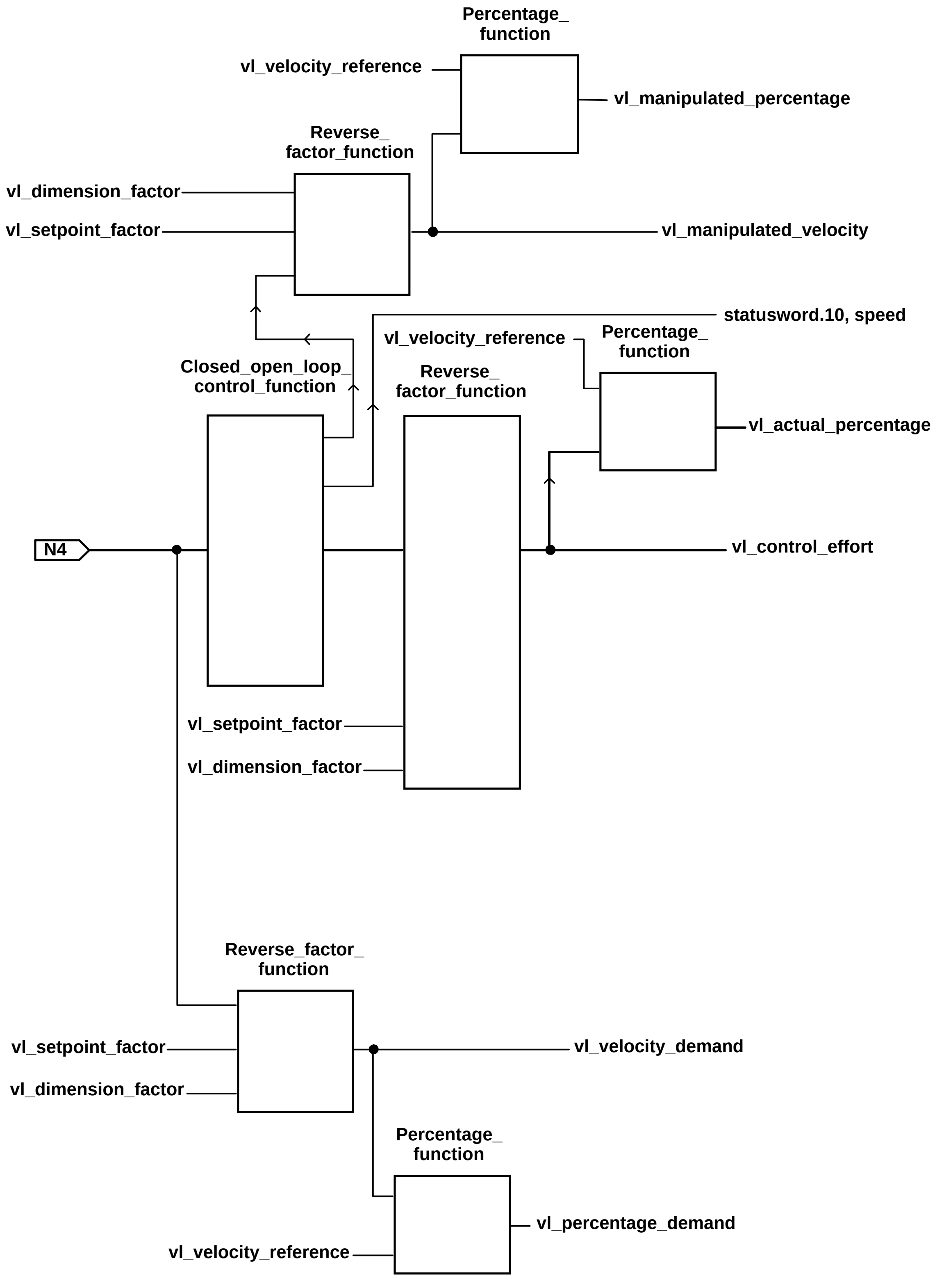


Figure 43: Velocity Mode with all Objects

All device using this profile and supporting the Velocity Mode have to implement the mandatory objects and there functionality. The diagram below shows the structure all devices will have at minimum.

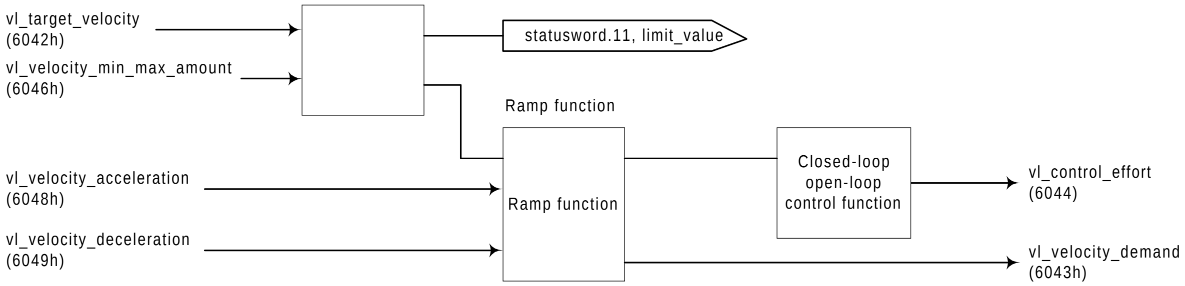


Figure 46: Velocity Mode with mandatory Objects only

18.1.4 Subfunction Description

The Velocity Mode is composed of the following subfunctions:

- Reference Calculation
- Factor Function, Reverse Factor Function
- Percentage Function, Reverse Percentage Function
- Pole Number Function, Reverse Pole Number Function
- Velocity Limit Function
- Velocity Motor Limit Function
- Ramp Function
- Ramp Min Function
- Closed Open Loop Control Function

These subfunctions are only used for the Velocity Mode.

18.2 Object Dictionary Entries

18.2.1 Objects defined in this Chapter

Index	Object	Name	Type	Attr.	M/O
6042_h	VAR	vl_target_velocity	Integer16	rw	M
6043_h	VAR	vl_velocity_demand	Integer16	ro	M
6044_h	VAR	vl_control_effort	Integer16	ro	M
6045_h	VAR	vl_manipulated_velocity	Integer16	ro	O
6046_h	ARRAY	vl_velocity_min_max_amount	Unsigned32	rw	M
6047_h	ARRAY	vl_velocity_min_max	Unsigned32	rw	O
6048_h	RECORD	vl_velocity_acceleration	Ramp	rw	M
6049_h	RECORD	vl_velocity_deceleration	Ramp	rw	M
$604A_h$	RECORD	vl_velocity_quick_stop	Ramp	rw	O
$604B_h$	ARRAY	vl_setpoint_factor	Integer16	rw	O
$604C_h$	ARRAY	vl_dimension_factor	Integer32	rw	O
$604D_h$	VAR	vl_pole_number	Unsigned8	rw	O
$604E_h$	VAR	vl_velocity_reference	Unsigned32	rw	O
$604F_h$	VAR	vl_ramp_function_time	Unsigned32	rw	O
6050_h	VAR	vl_slow_down_time	Unsigned32	rw	O
6051_h	VAR	vl_quick_stop_time	Unsigned32	rw	O
6052_h	VAR	vl_nominal_percentage	Integer16	rw	O
6053_h	VAR	vl_percentage_demand	Integer16	ro	O
6054_h	VAR	vl_actual_percentage	Integer16	ro	O

18.2.2 Objects defined in other Chapters

Index	Object	Name	Type	Chapter
$603F_h$	VAR	error_code	Integer16	ce
6040_h	VAR	controlword	Unsigned16	dc
6041_h	VAR	statusword	Integer16	dc
$605A_h$	VAR	quick_stop_option_code	Integer16	dc
$605B_h$	VAR	shut_down_option_code	Integer16	dc
$605C_h$	VAR	disable_operation_option_code	Integer16	dc
$605D_h$	VAR	stop_option_code	Integer16	dc
6060_h	VAR	modes_of_operation	Integer8	dc
6061_h	VAR	modes_of_operation_display	Integer8	dc

18.3 Object Description

18.3.1 Object 6042_h: vl_target_velocity

The *vl_target_velocity* is the required velocity of the system. It is multiplied by the *vl_dimension_*factor and the *vl_setpoint_factor*, if these are implemented. The *vl_target_velocity* is converted to the unit [rpm] by multiplying the *vl_target_velocity* by the *vl_dimension_factor*. The unit of the *vl_target_velocity* is interpreted as [rpm] if the *vl_dimension_*factor is not implemented or has the value 1.

Index	**6042_h**
Name	vl_target_velocity
Object Code	VAR
Data Type	Integer16

Value description

Object Class	M: vl	O:
Access	rw	
PDO Mapping	Possible	
Units	Speed Units G1a	
Value Range	-32768..32767	
Mandatory Range	-32768..0..+32767	
Default Value	0	
Substitute Value	-	

18.3.2 Object 6043_h: vl_velocity_demand

The *vl_velocity_demand* is the instantaneous velocity provided by the Ramp_function, scaled to the unit of the *vl_target_velocity*. The value ranges from -32768 to 32767 (Integer16). The parameter could only be read, because it is changed only by the drive.

Index	**6043_h**
Name	vl_velocity_demand
Object Code	VAR
Data Type	Integer16

Value description

Object Class	M: vl	O:
Access	ro	
PDO Mapping	Possible	
Units	Speed Units G1a	
Value Range	-32768..32767	
Mandatory Range	-32768..0..+32767	
Default Value	- (drive output variable)	
Substitute Value	-	

18.3.3 Object 6053_h: vl_percentage_demand

The *vl_percentage_demand* is calculated on the basis of the *vl_velocity_demand* by using the Percentage Function. It is the velocity provided by the Ramp_function in percent. Accordingly, the *vl_percentage_demand* is within the same value range as the *vl_nominal_percentage*. The value ranges from -32768 to 32767 (Integer16). The value 16383 corresponds to 100% of the *vl_velocity_reference*. Accordingly, an indication range of +/-200% is possible. The parameter is read-only.

Index	**6053_h**
Name	vl_percentage_demand
Object Code	VAR
Data Type	Integer16

Value description

Object Class	M:	O: vl
Access	ro	
PDO Mapping	Possible	
Units	(100/16383) %	
Value Range	-32768..32767	
Mandatory Range	-32768..0..+32767	
Default Value	- (drive output variable)	
Substitute Value	-	

18.3.4 Object 6054$_h$: vl_actual_percentage

The *vl_actual_percentage* is calculated on the basis of the *vl_control_effort* by using the Percentage Function. In this way, the *vl_actual_percentage* has the same value range as the *vl_nominal_percentage*. The value ranges from -32768 to 32767 (Integer16). The value 16383 corresponds to 100% of the *vl_velocity_reference*. Therefore, an indication range of +/- 200% is possible. The parameter is read-only.

Index	**6054$_h$**
Name	vl_actual_percentage
Object Code	VAR
Data Type	Integer16

Value description

Object Class	M:	O: vl
Access	ro	
PDO Mapping	Possible	
Units	(100/16383) %	
Value Range	-32768..32767	
Mandatory Range	-32768..0..+32767	
Default Value	- (drive output variable)	
Substitute Value	-	

18.3.5 Object 6055_h: vl_manipulated_percentage

The *vl_manipulated_percentage* is calculated on the basis of the *vl_manipulated_velocity*. In this way, the *vl_manipulated_percentage* is shown in the same value range as the *vl_nominal_percentage*. The value ranges from -32768 to 32767 (Integer16). The value 16383 corresponds to 100% of the *vl_velocity_reference*. Therefore, an indication range of +/- 200% is possible. The parameter is read-only.

Index	**6055_h**
Name	vl_manipulated_percentage
Object Code	VAR
Data Type	Integer16

Value description

Object Class	M:	O: vl
Access	ro	
PDO Mapping	Possible	
Units	(100/16383) %	
Value Range	-32768..32767	
Mandatory Range	-32768..0..+32767	
Default Value	- (drive output variable)	
Substitute Value	-	

18.3.6 Object $604E_h$: vl_velocity_reference

This parameter serves to represent *velocity values* (setpoints, actual values and ramps) as relative values. If the *vl_velocity_reference* is modified, the ramps slopes, if objects *vl_ramp_function_time*, *vl_slow_down_time* or *vl_quick_stop_time* are implemented, are changed relative to the change in the *vl_velocity_reference*.

This parameter has the same unit as the *vl_target_velocity* and the following value range: 0....4 294 967 295 (Unsigned32).

Index	**$604E_h$**
Name	vl_velocity_reference
Object Code	VAR
Data Type	Unsigned32

Value description

Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	Speed Units G1a	
Value Range	0..(2^{32}-1)	
Mandatory Range	0 ...+ 4294967295	
Default Value	- (drive output variable)	
Substitute Value	-	

Converting percentages to velocity values

$$\text{Velocity value} = \frac{\text{Percentage} * \mathit{vl\_velocity\_reference}}{3FFF_h}$$

Converting velocity values to percentages

$$\text{Percentage} = \frac{\text{Velocity value} * 3FFF_h}{\mathit{vl\_velocity\_reference}}$$

18.3.7 Object 604C$_h$: vl_dimension_factor

The *vl_dimension_factor* is generated by division using a numerator subparameter and a denominator subparameter. These parameter have a value ranging from -2 147 483 648 to 2 147 483 647 (Integer32), but except the value 0!

The *vl_dimension_factor* serves to include gearing in calculation or serves to scale the frequencies or specific units of the user. It influences the specified setpoint, the velocity limit and the Ramp_function as well as the output variables of the Speed Function .

Index	**604C$_h$**
Name	vl_dimension_factor
Object Code	ARRAY
Number of Elements	2
Data Type	Integer32

Value description

Sub-Index	01_h	
Description	vl_dimension_factor_numerator	
Object Class	M: -	O: vl
Access	rw	
PDO Mapping	Possible	
Units	-(no units)	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	1	
Default Value	manufacturer defined	
Substitute Value	1	

Sub-Index	02_h	
Description	vl_dimension_factor_denominator	
Object Class	M: -	O: vl
Access	rw	
PDO Mapping	Possible	
Units	-(no units)	
Value Range	$(-2^{31})..(2^{31}-1)$	
Mandatory Range	1	
Default Value	manufacturer defined	
Substitute Value	1	

Calculating the vl_dimension_factor

Every user's specific speed consists of a specific unit referred to a specific unit of time (e.g. 1/sec, bottles/min, m/sec,...).

The purpose of the dimension factor is to convert this specific unit to the revolutions/minute unit.

Specific unit * DF = 1 revolution (motor shaft)

$$I \cdot DF = O$$

I = *vl_target_velocity* expressed as the user's specific speed

Input value of the Factor Function

Unit of I: [I] = Specific unit

O = Speed value in [rpm]

Output value of the Factor Function

Unit of O: $[O] = \frac{1}{\text{min}} = \frac{\text{Revolution}}{\text{min}}$

DF = Dimension factor

Unit of DF: $[DF] = \frac{1}{\text{Specific unit}} * \frac{1}{\text{min}}$

Refer to the application note for an examples.

18.3.8 Object $604B_h$: vl_setpoint_factor

The *vl_setpoint_factor* is generated by division, using a numerator subparameter and a denominator subparameter. These subparameter have no unit and have values within a range from -32768 to 32767 (Integer16), but excluding the value 0!

The *vl_setpoint_factor* serves to modify the resolution or directing range of the specified setpoint. It is included in calculation of the specified setpoint and the output variables of the Speed Function only.

Index	**$604B_h$**
Name	vl_setpoint_factor
Object Code	ARRAY
Number of Elements	2
Data Type	Integer16

Value description

Sub-Index	01_h	
Description	vl_setpoint_factor_numerator	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	-(no units)	
Value Range	-32768..32767	
Mandatory Range	1	
Default Value	manufacturer defined	
Substitute Value	1	

Sub-Index	02_h	
Description	vl_setpoint_factor_denominator	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	-(no units)	
Value Range	-32768..32767	
Mandatory Range	1	
Default Value	manufacturer defined	
Substitute Value	1	

18.3.9 Object 604D$_h$: vl_pole_number

The user must describe the *vl_pole_number* parameter with a value corresponding to the number of poles belonging to the connected motor. This parameter has no unit. The value range depends on the manufacturer-specific need and is represented as unsigned 8. If the Object *vl_pole_number* does fit for the desired type of motor, this object could left out or set to value 2.

Index	**604D$_h$**
Name	vl_pole_number
Object Code	VAR
Data Type	Unsigned8

Value description

Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	- (number of poles)	
Value Range	0..255	
Mandatory Range	2	
Default Value	manufacturer defined	
Substitute Value	2	

If the number of pole pairs is known, the number of poles is: $vl\_pole\_number = 2 * \text{pole pairs}$

Converting velocity values to frequency values

$$\text{Frequency} = \frac{\text{Velocity} * vl\_pole\_number}{60 * 2}$$

Converting frequency values to velocity values

$$\text{Velocity} = \frac{\text{Frequency} * 60 * 2}{vl\_pole\_number}$$

18.3.10 Object 6046$_h$: vl_velocity_min_max_amount

The *vl_velocity_min_max_amount* parameter is composed of the *vl_velocity_min_amount* and *vl_velocity_max_amount* subparameter. These subparameters don't have units and have values within a range from 0 to 4 294 967 295 (unsigned 32):

The vl_velocity_max_amount subparameter is mapped internally to the vl_velocity_max_pos and vl_velocity_max_neg values. The vl_velocity_min_amount subparameter is mapped internally to the vl_velocity_min_pos and vl_velocity_min_neg values.

Only the positive values are returned if the *vl_velocity_min_max_amount* parameter is read out.

Index	**6046$_h$**
Name	vl_velocity_min_max_amount
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value description

Sub-Index	01$_h$	
Description	vl_velocity_min_amount	
Object Class	M: vl	O:
Access	rw	
PDO Mapping	Possible	
Units	G1b	
Value Range	0..(2^{32}-1)	
Mandatory Range	0... manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

Sub-Index	02_h	
Description	vl_velocity_max_amount	
Object Class	M: vl	O:
Access	rw	
PDO Mapping	Possible	
Units	G1b	
Value Range	0..(2^{32}-1)	
Mandatory Range	0... manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

This transfer characteristic results from *vl_velocity_min_max_amount*

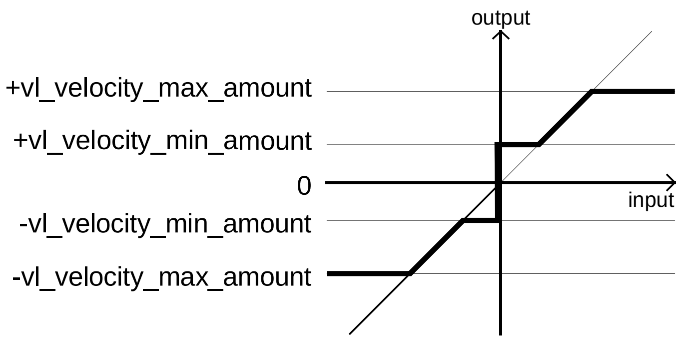


Figure 45: vl_velocity_min_max_amount transfer characteristic

18.3.11 Object 6047_h: vl_velocity_min_max

The *vl_velocity_min_max* parameter is composed of the vl_velocity_min_pos, vl_velocity_max_pos, vl_velocity_min_neg and vl_velocity_max_neg subparameter. These subparameter have no units and have values within a range from 0 to 4 294 967 295 (unsigned 32).

The subparameter are mapped internally to the corresponding values.

Index	**6047_h**
Name	vl_velocity_min_max
Object Code	ARRAY
Number of Elements	4
Data Type	Unsigned32

Value description

Sub-Index	01_h	
Description	vl_velocity_min_pos	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	G1b	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

Sub-Index	02_h	
Description	vl_velocity_max_pos	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	G1b	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

Sub-Index	03_h	
Description	vl_velocity_min_neg	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	G1b	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

Sub-Index	04_h	
Description	vl_velocity_max_neg	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	G1b	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

This transfer characteristic results from *vl_velocity_min_max*

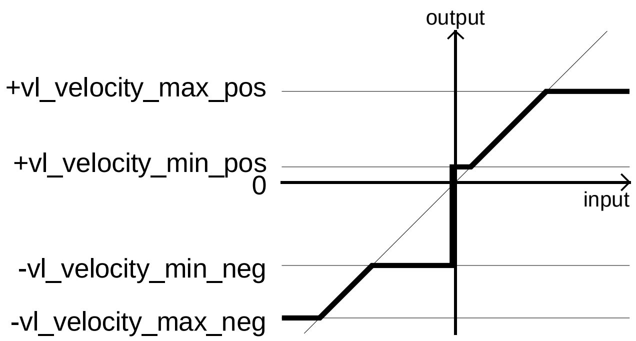


Figure 46: vl_velocity_min_max transfer characteristic

18.3.12 Object 6058_h: vl_frequency_motor_min_max_amount

The frequency parameter of the *vl_frequency_motor_min_max*_amount objects are mapped internally to the parameter of the corresponding speed objects.

Index	**6058_h**
Name	vl_frequency_motor_min_max_amount
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value description

Sub-Index	01_h	
Description	vl_frequency_motor_min_amount	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	0... manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

Sub-Index	02_h	
Description	vl_frequency_motor_max_amount	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	0... manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

This transfer characteristic results from vl_frequency_motor_min_max_amount

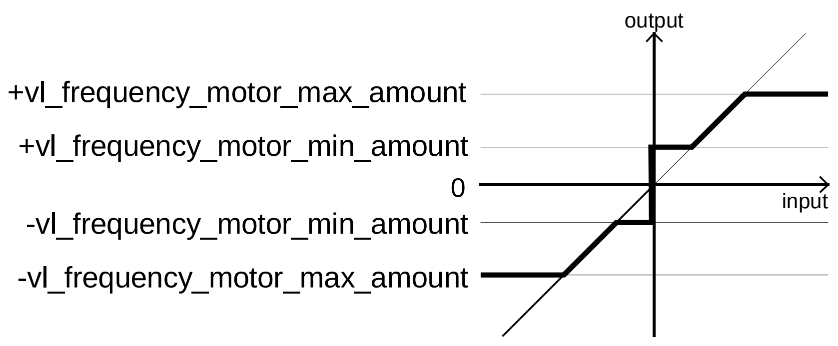


Figure 47: vl_frequency_motor_min_max_amount transfer characteristic

18.3.13 Object 6059_h: vl_frequency_motor_min_max

The frequency parameter of the *vl_frequency_motor_min_max* objects are mapped internally to the parameter of the corresponding speed objects.

Index	**6059_h**
Name	vl_frequency_motor_min_max
Object Code	ARRAY
Number of Elements	4
Data Type	Unsigned32

Value description

Sub-Index	01_h	
Description	vl_frequency_motor_min_pos	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

Sub-Index	02_h	
Description	vl_frequency_motor_max_pos	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

Sub-Index	03_h	
Description	vl_frequency_motor_min_neg	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	- (1/1000 rpm)	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

Sub-Index	04_h	
Description	vl_frequency_motor_max_neg	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	-	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

This transfer characteristic results from vl_velocity_min_max

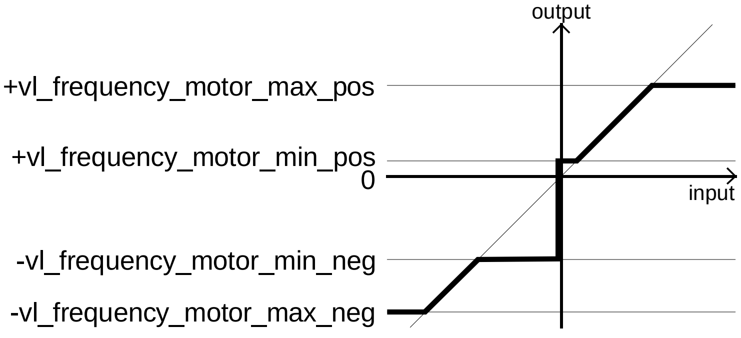


Figure 48: vl_velocity_min_max transfer characteristic

18.3.14 Object 6056_h: vl_velocity_motor_min_max_amount

The *vl_velocity_motor_min_max_amount* parameter is composed of the v*l_velocity_motor_min_amount* and *vl_velocity_motor_max_amount* parameter. These subparameters have the unit [(1/1000) rpm] and values within a range from 0 to 4294967295 [(1/1000) rpm] (Unsigned32). This results in a limiting range from 0..4294967295[rpm].

The *vl_velocity_motor_max_amount* subparameter is mapped internally to the *vl_velocity_motor_max_pos* and *vl_velocity_motor_max_neg* values. The *vl_velocity_motor_min_amount* subparameter is mapped internally to the *vl_velocity_motor_min_pos* and *vl_velocity_motor_min_neg* values.

Only the positive values are returned if the *vl_velocity_motor_min_max_amount* parameter is read.

Index	**6056_h**
Name	vl_velocity_motor_min_max_amount
Object Code	ARRAY
Number of Elements	2
Data Type	Unsigned32

Value description

Sub-Index	01_h	
Description	vl_velocity_motor_min_amount	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	(1/1000 rpm)	
Value Range	0..(2^{32}-1)	
Mandatory Range	0... manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

Sub-Index	02_h	
Description	vl_velocity_motor_max_amount	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	(1/1000 rpm)	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	0... manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

This transfer characteristic results from *vl_velocity_motor_min_max_amount*

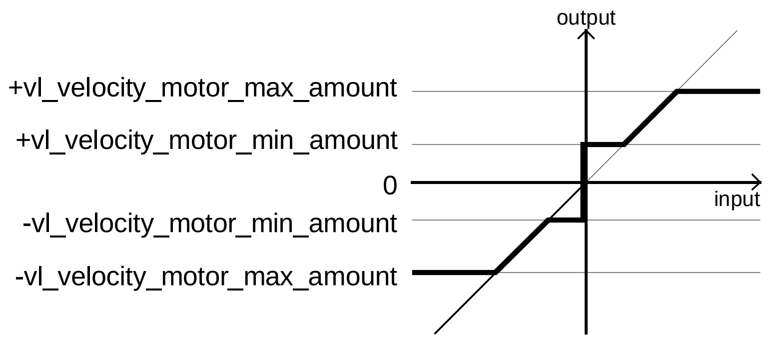


Figure 49: vl_velocity_motor_min_max_amount transfer characteristic

18.3.15 Object 6057_h: vl_velocity_motor_min_max

The *vl_velocity_motor_min_max* parameter is composed of the *vl_velocity_motor_min_pos*, *vl_velocity_motor_max_pos*, *vl_velocity_motor_min_neg* and *vl_velocity_motor_max_neg* subparameter. These subparameters have the unit [1/(1000 min)] and values within a range from 0 ... 4 294 967 295 [1/(1000 min)] (Unsigned32). This results in a limiting range from 0..4 294 967 [rpm].

The subparameter are mapped internally to the corresponding values.

Index	**6057_h**
Name	vl_velocity_motor_min_max
Object Code	ARRAY
Number of Elements	4
Data Type	Unsigned32

Value description

Sub-Index	01_h	
Description	vl_velocity_motor_min_pos	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	- (1/1000 rpm)	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

Sub-Index	02_h	
Description	vl_velocity_motor_max_pos	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	- (1/1000 rpm)	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

Sub-Index	03_h	
Description	vl_velocity_motor_min_neg	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	- (1/1000 rpm)	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

Sub-Index	04_h	
Description	vl_velocity_motor_max_neg	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	- (1/1000 rpm)	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

This transfer characteristic results from vl_velocity_min_max

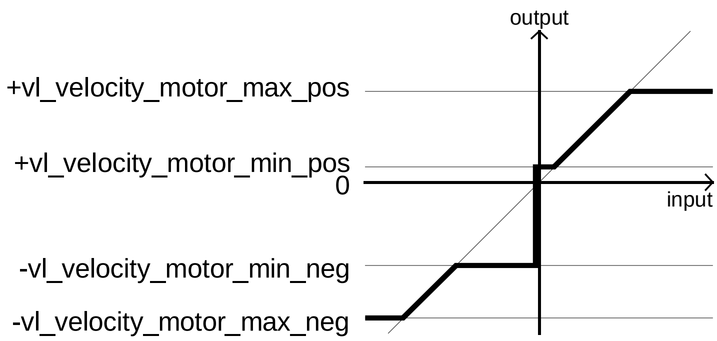


Figure 50: *vl_velocity_min_max* transfer characteristic

Limit-Value

The Limit-Value message is generated if the input value of the *Velocity_motor_limit_function* results in a value outside of the operating range of the *Velocity_motor_limit_function*. The Limit-Value message is mapped as one bit in the status word.

18.3.16 Object 6048$_h$: vl_velocity_acceleration

The *vl_velocity_*acceleration parameter specifies the slope of the acceleration ramp. It is generated as the quotient of the delta_speed and delta_time subparameter.

Index	**6048$_h$**
Name	vl_velocity_acceleration
Object Code	RECORD
Number of Elements	2

Value description

Sub-Index	01_h	
Description	delta_speed	
Object Class	M: vl	O:
Access	rw	
PDO Mapping	Possible	
Units	G1b	
Value Range	0..(2^{32}-1)	
Mandatory Range	0..manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	
Data Type	Unsigned32	

Sub-Index	02_h	
Description	delta_time	
Object Class	M: vl	O:
Access	rw	
PDO Mapping	Possible	
Units	Seconds (s)	
Value Range	0..65535	
Mandatory Range	0..manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	
Data Type	Unsigned16	

delta_speed

The delta_speed has the same unit as the *vl_target_velocity*. This subparameter has the following value range: 0 ... 4294967295 (unsigned 32).

delta_time

This subparameter is specified in sec and has the following value range: 0 ... 65 535 [sec] (unsigned 16).

This function directly follows the setpoint if the parameter 0 is defined for the delta_time value.

$$vl\_velocity\_acceleration = \frac{delta\_speed}{delta\_time} = a_B$$

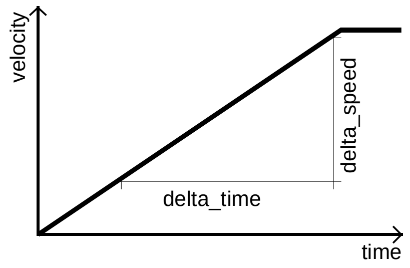


Figure 51: vl_velocity_acceleration transfer characteristic

18.3.17 Object 6049$_h$: vl_velocity_deceleration

The *vl_velocity_deceleration* parameter specifies the slope of the deceleration ramp. It is generated as the quotient of the delta_speed and delta_time subparameter.

index	**6049$_h$**
name	vl_velocity_deceleration
object code	RECORD
number of elements	2

Value description

sub-index	01$_h$	
description	delta_speed	
object class	M: vl	O:
access	rw	
PDO mapping	Possible	
units	G1b	
value range	0...+4294967295	
mandatory range	0... manufacturer defined	
default value	manufacturer defined	
substitute value	-	
Data Type	Unsigned32	

sub-index	02_h	
description	delta_time	
object class	M: vl	O:
access	rw	
PDO mapping	Possible	
units	Seconds (s)	
value range	0 ...+ 65535	
mandatory range	0... manufacturer defined	
default value	manufacturer defined	
substitute value	-	
Data Type	Unsigned16	

delta_speed

The delta_speed has the same unit as the *vl_target_velocity*. This subparameter has the following value range:

0..(2^{32}-1) (Unsigned32).

delta_time

This subparameter is specified in sec and has the following value range:

0..65535 [sec] (Unsigned16).

This function directly follows the setpoint if the value 0 is defined for the delta_time parameter.

$$vl\_velocity\_deceleration = \frac{delta\_speed}{delta\_time} = a_V$$

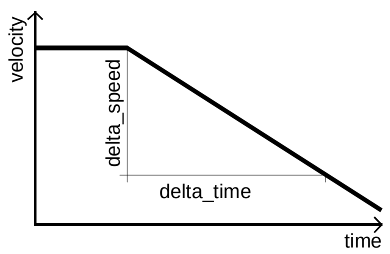


Figure 52: vl_velocity_deceleration transfer characteristic

18.3.18 Object $604A_h$: vl_velocity_quick_stop

The *vl_velocity_quick_stop* parameter specifies the slope of the quick stop ramp. It is generated as the quotient of the delta_speed and delta_time subparameter.

Index	**$604A_h$**
Name	vl_velocity_quick_stop
Object Code	RECORD
Number of Elements	2

Value description

Sub-Index	01_h	
Description	delta_speed	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	G1b	
Value Range	0...+4294967295	
Mandatory Range	0... manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	
Data Type	Unsigned32	

Sub-Index	02_h	
Description	delta_time	
Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	Seconds (s)	
Value Range	0..65535	
Mandatory Range	0..manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	
Data Type	Unsigned16	

delta_speed

The velocity has the same unit as the *vl_target_velocity*. This subparameter has the following value range:

$0..(2^{32}-1)$ (unsigned 32).

delta_time

This subparameter is specified in sec and has the following value range:

0..65535 [sec] (unsigned 16).

This function directly follows the setpoint if the parameter 0 is defined for the delta_time value.

$$velocity\_quick\_stop = \frac{delta\_speed}{delta\_time} = a_S$$

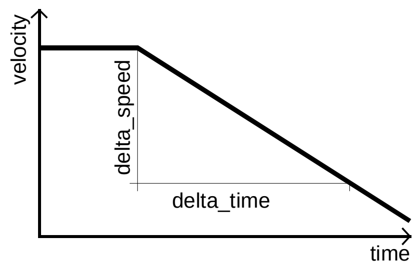


Figure 53: vl_velocity_quick_stop transfer characteristic

18.3.19 Object $604F_h$: vl_ramp_function_time

The *vl_ramp_function_time* specifies the time during which the drive starts up from zero to the *vl_velocity_reference*.

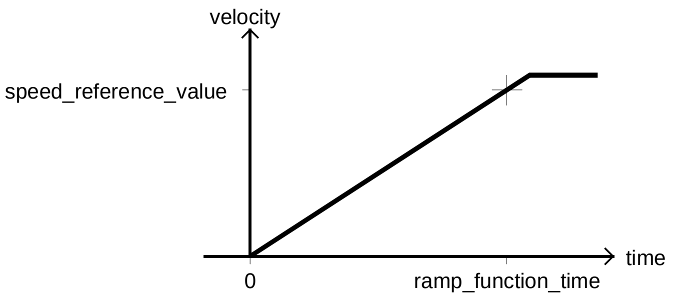


Figure 54: vl_ramp_function_time transfer characteristic

This parameter is specified in ms and has the following value range:

0..(2^{32}-1) [msec] (unsigned 32).

By setting the parameter 0 for the *vl_ramp_function_time*, the ramp becomes infinite and the reference variable directly follows the setpoint.

Index	**604F$_h$**
Name	vl_ramp_function_time
Object Code	VAR
Data Type	Unsigned32

Value description

Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	Milliseconds (ms)	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

18.3.20 Object 6050$_h$: vl_slow_down_time

The *vl_slow_down_time* specifies the time during which the drive slows down from *vl_-velocity_reference* to zero.

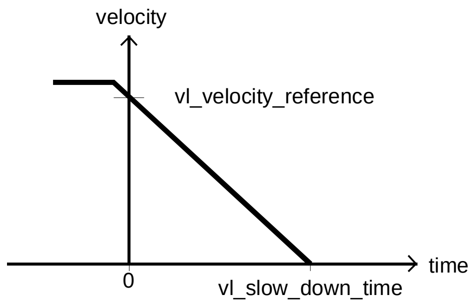


Figure 55: vl_slow_down_time transfer characteristic

This parameter is specified in ms and has the following value range:

0..(2^{32}-1) [msec] (unsigned 32).

By defining the parameter 0 for the *vl_slow_down_time*, the ramp becomes infinite and the reference variable directly follows the setpoint.

Index	**6050$_h$**
Name	vl_slow_down_time
Object Code	VAR
Data Type	Unsigned32

Value description

Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	Milliseconds (ms)	
Value Range	0..(2^{32}-1)	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

18.3.21 Object 6051$_h$: vl_quick_stop_time

The *vl_quick_stop_time* specifies the time during which the drive slows down from *vl-_velocity_reference* to zero in the QUICK STOP ACTIVE state.

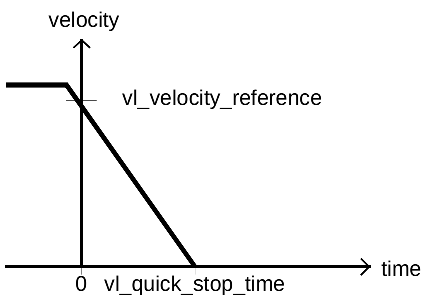


Figure 56: vl_quick_stop_time transfer characteristic

This parameter is specified in ms and has the following value range:

0..(2^{32}-1) [msec] (unsigned 32).

By defining the parameter 0 for the *vl_quick_stop_time*, the ramp becomes infinite and the reference variable directly follows the setpoint.

Index	**6051$_h$**
Name	vl_quick_stop_time
Object Code	VAR
Data Type	Unsigned32

Value description

Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	Milliseconds (ms)	
Value Range	$0..(2^{32}-1)$	
Mandatory Range	manufacturer defined	
Default Value	manufacturer defined	
Substitute Value	-	

18.3.22 Object 6044_h: vl_control_effort

The *vl_control_*effort is the velocity at the motor spindle or load, scaled to the unit of the *vl_target_velocity*. Depending on the system, velocity deviations may occur between the *vl_control_effort* and the physical velocity. For simple drives without closed loop control or observer this value reads the object *vl_velocity_demand*. The value ranges from -32768 to 32767 (Integer16).

Index	**6044_h**
Name	vl_control_effort
Object Code	VAR
Data Type	Integer16

Value description

Object Class	M: vl	O:
Access	ro	
PDO Mapping	Possible	
Units	Speed Units G1a	
Value Range	-32768..32767	
Mandatory Range	-32768..0..+32767	
Default Value	- (drive output variable)	
Substitute Value	-	

18.3.23 Object 6045_h: vl_manipulated_velocity

The *vl_manipulated_velocity* is the velocity of the motor spindle or load with a compensation value, scaled to the unit of the *vl_target_velocity*. The compensation value is generated by the controller/control function. The value ranges from -32768 to 32767 (Integer16). The parameter is read-only.

Index	**6045_h**
Name	vl_manipulated_velocity
Object Code	VAR
Data Type	Integer16

Value description

Object Class	M:	O: vl
Access	ro	
PDO Mapping	Possible	
Units	Speed Units G1a	
Value Range	-32768..32767	
Mandatory Range	-32768..0..+32767	
Default Value	- (drive output variable)	
Substitute Value	-	

18.3.24 Object 6052_h: vl_nominal_percentage

The *vl_nominal_percentage* is converted by the percent function to a velocity value. The *vl_nominal_percentage* has no unit (better (100 / 16383) %). Its value ranges from -32768 to 32767 (Integer16). The value 16383 corresponds to 100% of the *vl_velocity_reference*. Accordingly, a total range of the manipulated variable amounting to +/- 200% is possible. The parameter could be read and written.

Index	**6052_h**
Name	vl_nominal_percentage
Object Code	VAR
Data Type	Integer16

Value description

Object Class	M:	O: vl
Access	rw	
PDO Mapping	Possible	
Units	(100/16383) %	
Value Range	-32768..32767	
Mandatory Range	-32768..0..+32767	
Default Value	0	
Substitute Value	0	

18.4 Functional Description

18.4.1 Percentage Function

The Percentage Function serves to convert percentages to velocity values and vice versa.

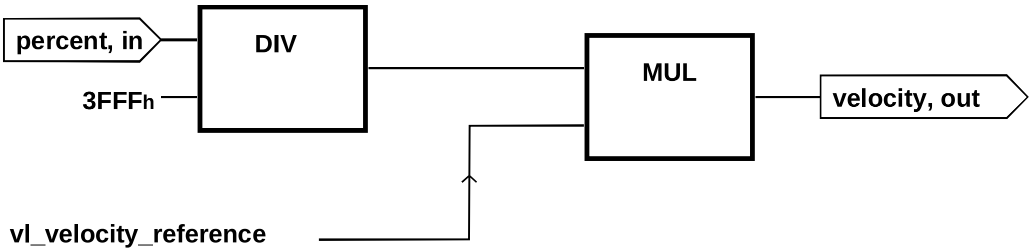


Figure 57: Percentage Function

and vice versa

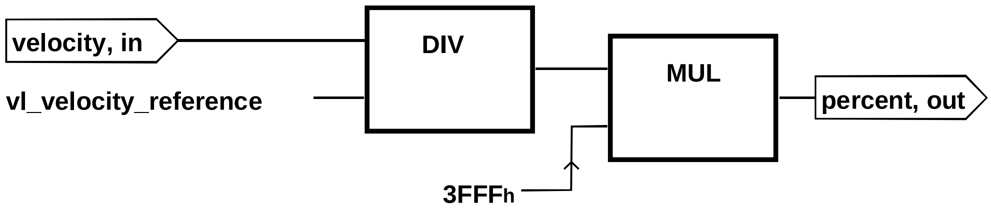


Figure 58: Reverse Percentage Function

18.4.2 Factor Function and Reverse Factor Function

The Factor Function multiplies the input variables by the assigned factors.

- The *vl_target_velocity* is multiplied by the *vl_dimension_factor* and the *vl_setpoint_factor*.

- The values of the velocity limit and the values for the Ramp Function are only multiplied by the *vl_dimension_factor*.

A factor has a value of 1 if it is not implemented.

The Factor Function for two factors is built of two function in series connection.

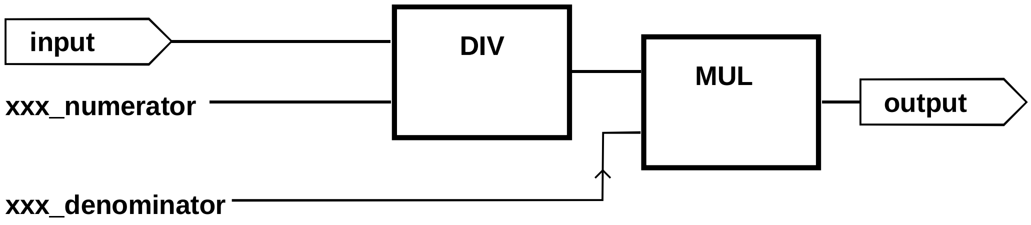


Figure 59: Factor Function

The Reverse Factor Function divides the input variables by the assigned factors.

- The output variables of the Velocity Mode are calculated by division with the *vl_dimension_factor* and the *vl_setpoint_factor* and therefore returned to the scaling of the specified setpoint.

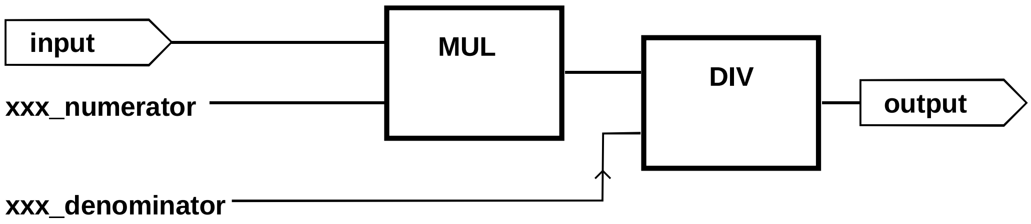


Figure 60: Reverse Factor Function

18.4.3 Pole Number Function

The Pole Number Function serves to convert frequency values to velocity values

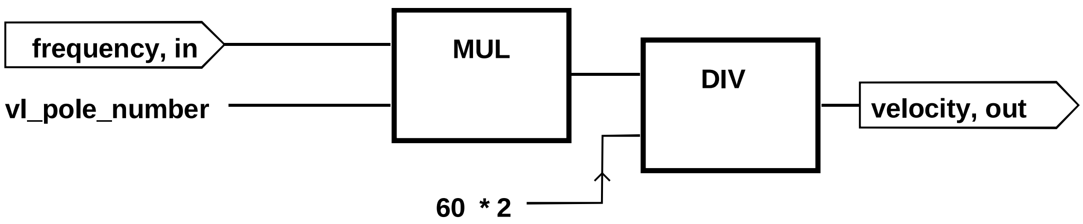


Figure 61: Pole Number Function

and vice versa

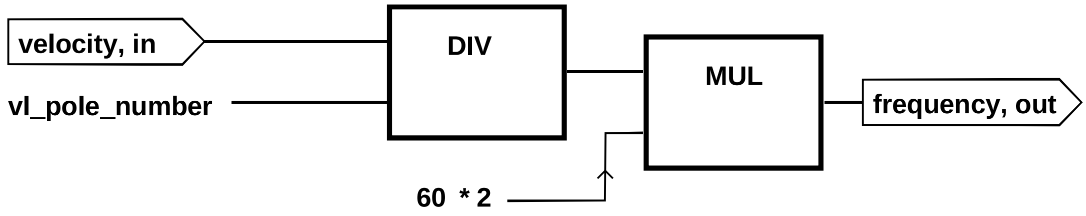


Figure 62: Reverse Pole Number Function

18.4.4 Velocity Limit Function

The velocity limit defines the valid velocity range for the drive. Limits could be specified in the user specific units by including the *vl_dimension_factor* in the speed limit.

Limit-Value

The Limit-Value message is generated if the input value of the speed limit results in a value outside the speed limit's operating range. The Limit-Value message is mapped as one bit in the *statusword*.

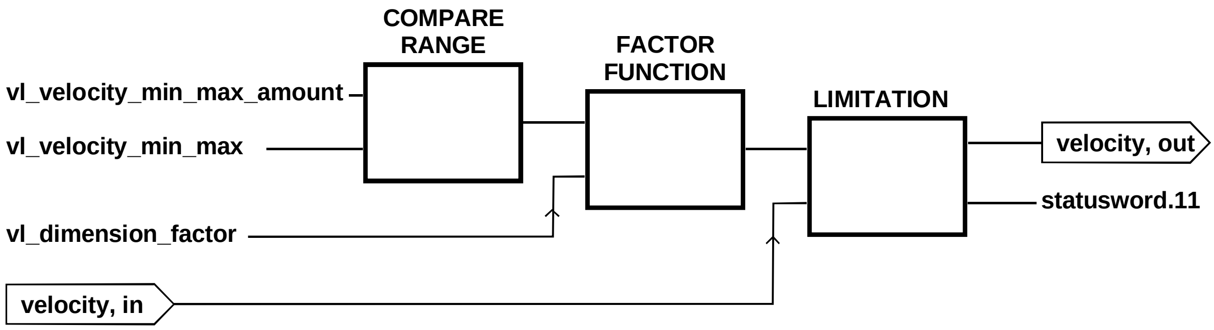


Figure 63: Velocity Limit Function

18.4.5 Velocity Motor Limit Function

The Velocity Motor Limit Function limits the motor velocity range. This parameter has a safety function that ensures that the range of the set value of motor velocity cannot be exceeded inadvertently by a modification of a factor.

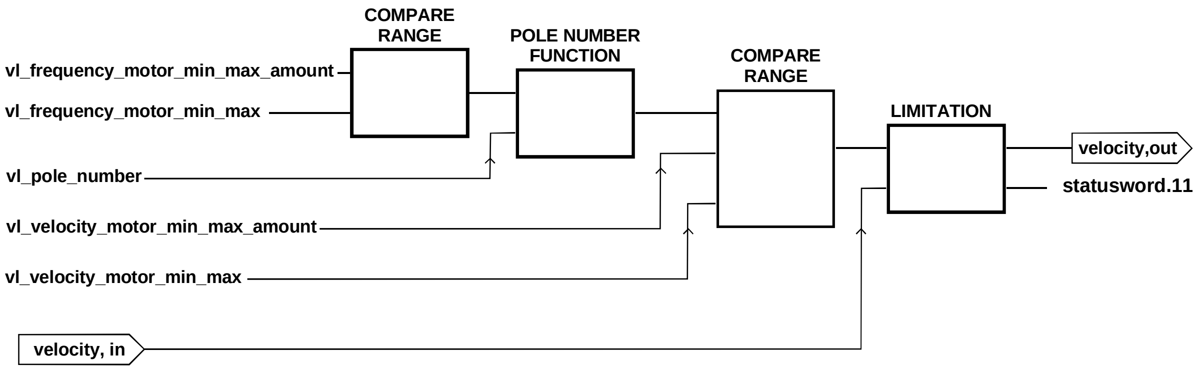


Figure 64: Velocity Motor Limit Function

18.4.6 Ramp Function

The Ramp Function is used to limit the increase and decrease of velocity. The velocity output is equal to the input as long as the changes are below $a_{B_{min}}$, $a_{V_{min}}$ or $a_{S_{min}}$.

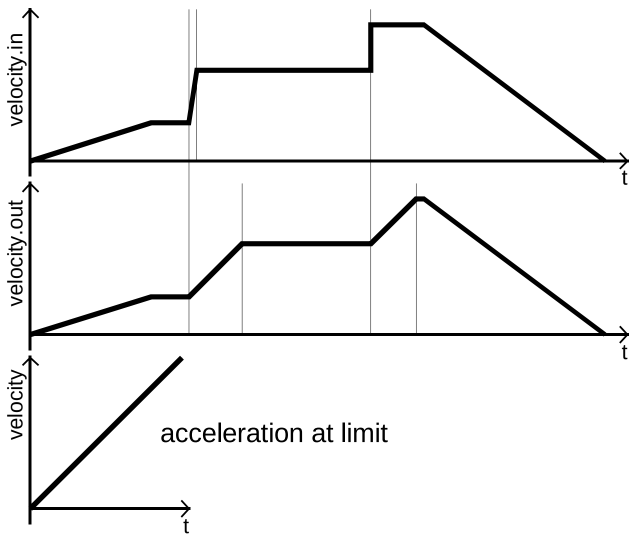


Figure 65: Velocity Profile

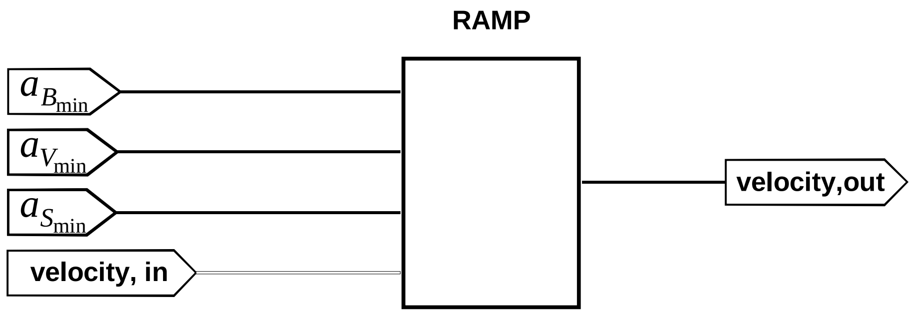


Figure 66: Ramp Function

The internal ramp values $a_{B_{min}}$ and $a_{V_{min}}$ directly consist of the *vl_velocity_acceleration* and *vl_velocity_deceleration* parameter.

The internal ramp values $a_{B_{min}}$, $a_{V_{min}}$ and $a_{S_{min}}$ are the output values of the *Ramp_min_-function*, weighted with the *vl_dimension_factor*.

18.4.7 Ramp Min Function

The Ramp Min Function selects the minimal change of velocity.

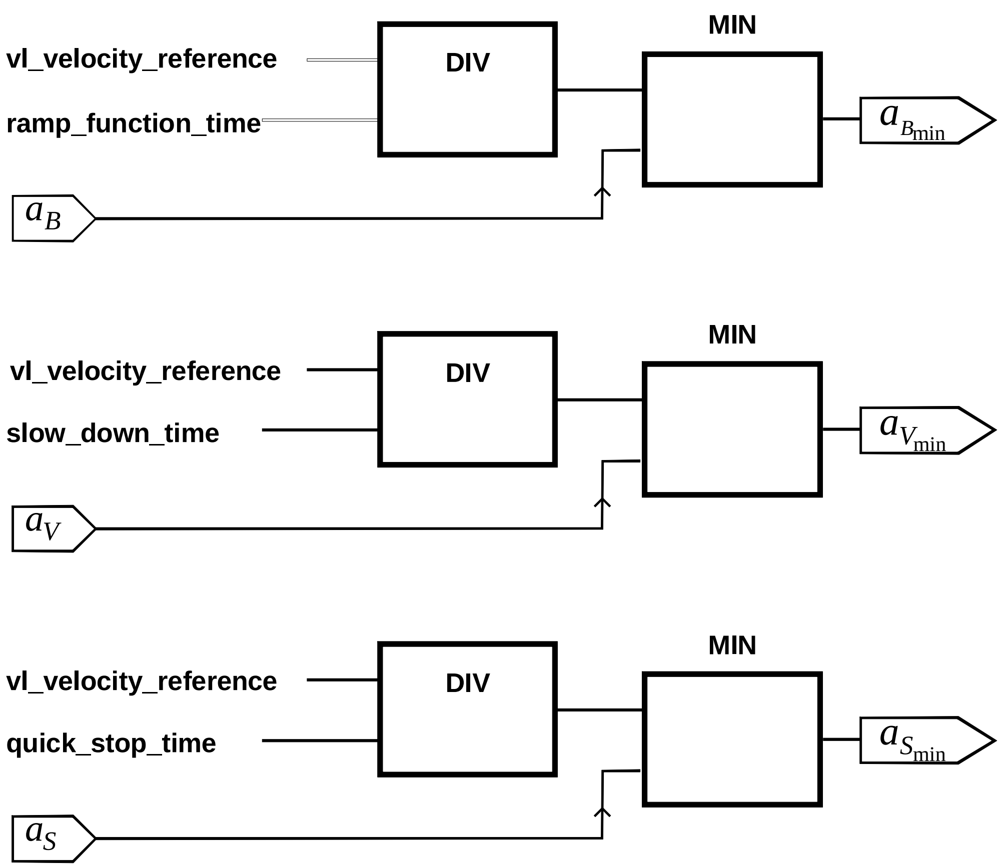


Figure 67: Ramp Min Function

The internal ramp values ($a_{B\min}$, $a_{V\min}$, $a_{S\min}$) are recalculated as follows if one of the input parameter for the Ramp Function is modified.

$$a_{B_{\min}} = \mathrm{MIN}\left(a_B , \frac{vl\_velocity\_reference}{vl\_ramp\_function\_time} \right)$$

$$a_{V_{\min}} = \mathrm{MIN}\left(a_V , \frac{vl\_velocity\_reference}{vl\_slow\_down\_time} \right)$$

$$a_{S_{\min}} = \mathrm{MIN}\left(a_S , \frac{vl\_velocity\_reference}{vl\_quick\_stop\_time} \right)$$

The Ramp Min Function selects the lower respective value of the slopes.

18.4.8 Reference Calculation

This subfunction decides on the setpoint processing. The setpoint value may be given as an percentage and (or) as an absolute value. Therefore two objects are defined in this profile. The first object is the *vl_target_velocity* containing the absolute setpoint value. This is an mandatory object for every drive. Some drives may have implemented the object *vl_nominal_percentage* which consist of an percentage setpoint value. So these manufactures have to specify how this two values are handled within the drive. Most profile implementations will add the percentage and the absolute setpoint value to calculate the internal setpoint. It is also possible to use only one value. Then the last written object is used internally.

18.4.9 Closed Open Loop Control Function

On the basis of the *vl_control_effort*, the controller/control function returns the *vl_control-_effort* and the *vl_manipulated_velocity*.

Depending on realisation of the function, the *vl_control_effort* is the *vl_control_effort* or a calculated or measured *vl_control_effort*.

Depending on realisation of the function, the *vl_manipulated_velocity* is the *vl_control_effort* or a calculated speed_output.

19 Appendix

A Object Dictionary by Chapter

A.1 Common Entries in the Object Dictionary

Object Dictionary for Chapter Common Entries in the Object Dictionary

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
6007_h	abort_connection_option_code	VAR	Integer16		rw	Possible	-	o							
6007_h	abort_connection_option_code	VAR	Integer16		rw	Possible	-	o							
$603F_h$	error_code	VAR	Unsigned16		ro	Possible	-	o							
6402_h	motor_type	VAR	Unsigned16		rw	Possible	-								
6403_h	motor_catalogue_number	VAR	Visible String		rw	Possible	-								
6404_h	motor_manufacturer	VAR	Visible String		rw	Possible	-								
6405_h	http_motor_catalog_address	VAR	Visible String		rw	Possible	-								
6406_h	motor_calibration_date	VAR	Date		rw	Possible	-								
6407_h	motor_service_period	VAR	Unsigned32		rw	Possible	-								
6410_h	motor_data	RECORD													
6502_h	supported_drive_modes	VAR	Unsigned32		ro	Possible	-								
6503_h	drive_catalogue_number	VAR	Visible String		rw	Possible	-								
6504_h	drive_manufacturer	VAR	Visible String		rw	Possible	-								
6505_h	http_drive_catalog_address	VAR	Visible String		rw	Possible	-								
6510_h	drive_data	RECORD													
$60FD_h$	digital_inputs	VAR	Unsigned32		ro	Possible	-	o							
$60FE_h$	digital_outputs	RECORD													
	physical_outputs	RECORD		01	rw	Possible	-	o							
	bitmask	RECORD		02	rw	Possible	-	o							

A.2 Device Control

Object Dictionary for Chapter Device Control

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
6040_h	controlword	VAR	Unsigned16		rw	Possible	-	m							
6041_h	statusword	VAR	Unsigned16		ro	Possible	-	m							
$605B_h$	shutdown_option_code	VAR	Integer16		rw	No	-	o							
$605C_h$	disable_operation_option_code	VAR	Integer16		rw	No	-	o							
$605A_h$	quick_stop_option_code	VAR	Integer16		rw	No	-	o							
$605D_h$	stop_option_code	VAR	Integer16		rw	No	-	o							
$605E_h$	fault_reaction_option_code	VAR	Integer16		rw	No	-	o							
6060_h	modes_of_operation	VAR	Integer8		wo	Possible	-	m							
6061_h	modes_of_operation_display	VAR	Integer8		ro	Possible	-	m							

A.3 Factor Group

Object Dictionary for Chapter Factor Group

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
6089$_h$	position_notation_index	VAR	Integer8		rw	Possible	-		o	o	o	o	o		
608A$_h$	position_dimension_index	VAR	Unsigned8		rw	Possible	-		o	o	o	o	o		
608B$_h$	velocity_notation_index	VAR	Integer8		rw	Possible	-		o	o	o	o	o		
608C$_h$	velocity_dimension_index	VAR	Unsigned8		rw	Possible	-		o	o	o	o	o		
608D$_h$	acceleration_notation_index	VAR	Integer8		rw	Possible	-		o	o	o	o	o		
608E$_h$	acceleration_dimension_index	VAR	Unsigned8		rw	Possible	-		o	o	o	o	o		
608F$_h$	position_encoder_resolution	ARRAY	Unsigned32												
	encoder_increments	ARRAY		01	rw	Possible	inc			o	o	o	o		
	motor_revolutions	ARRAY		02	rw	Possible	inc			o	o	o	o		
6090$_h$	velocity_encoder_resolution	ARRAY	Unsigned32												
	encoder_increments_per_second	ARRAY		01	rw	Possible	inc/sec			o	o	o	o		
	motor_revolutions_per_second	ARRAY		02	rw	Possible	inc/sec			o	o	o	o		
6091$_h$	gear_ratio	ARRAY	Unsigned32												
	motor_revolutions	ARRAY		01	rw	Possible	-			o	o	o	o		
	shaft_revolutions	ARRAY		02	rw	Possible	-			o	o	o	o		
6092$_h$	feed_constant	ARRAY	Unsigned32												
	feed	ARRAY		01	rw	Possible	-			o	o	o	o		
	shaft_revolutions	ARRAY		02	rw	Possible	-			o	o	o	o		
6093$_h$	position_factor	ARRAY	Unsigned32												
	numerator	ARRAY		01	rw	Possible	-			o	o				
	feed_constant	ARRAY		02	rw	Possible	-			o	o				
6094$_h$	velocity_encoder_factor	ARRAY	Unsigned32												
	numerator	ARRAY		01	rw	Possible	-					o			
	divisor	ARRAY		02	rw	Possible	-					o			
6095$_h$	velocity_factor_1	ARRAY	Unsigned32												
	numerator	ARRAY		01	rw	Possible	-			o	o	o	o		
	divisor	ARRAY		02	rw	Possible	-			o	o	o	o		
6096$_h$	velocity_factor_2	ARRAY	Unsigned32												
	numerator	ARRAY		01	rw	Possible	-			o	o	o	o		
	divisor	ARRAY		02	rw	Possible	-			o	o	o	o		
6097$_h$	acceleration_factor	ARRAY	Unsigned32												
	numerator	ARRAY		01	rw	Possible	-			o	o	o	o		
	divisor	ARRAY		02	rw	Possible	-			o	o	o	o		

Object Dictionary for Chapter Factor Group																
object no	**object name**	**object code**	**type**	**sub-index**	**attr.**	**PDO**	**units**	**mandatory for**							**description**
								all	**hm**	**pp**	**ip**	**pv**	**tq**	**vl**	
$607E_h$	polarity	VAR	Unsigned8		rw	Possible	-			o	o	o	o		

A.4 Profile Position Mode

Object Dictionary for Chapter Profile Position Mode

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
$607A_h$	target_position	VAR	Integer32		rw	Possible	position units			m	m				
$607B_h$	position_range_limit	ARRAY	Integer32												
	min_position_range_limit	ARRAY		01	rw	possibble	position units			o	o				
	max_position_range_limit	ARRAY		02	rw	Possible	position units			o	o				
$607D_h$	software_position_limit	ARRAY	Integer32												
	min_position_limit	ARRAY		01	rw	Possible	position units			o	o				
	max_position_limit	ARRAY		02	rw	Possible	position units			o	o				
$607F_h$	max_profile_velocity	VAR	Unsigned32		rw	Possible	speed units			o	o	o	o		
6080_h	max_motor_speed	VAR	Unsigned16		rw	Possible	rpm	o							
6081_h	profile_velocity	VAR	Unsigned32		rw	Possible	speed units			m		m			
6082_h	end_velocity	VAR	Unsigned32		rw	Possible	speed units			o					
6083_h	profile_acceleration	VAR	Unsigned32		rw	Possible	acceleration units			m		m			
6084_h	profile_deceleration	VAR	Unsigned32		rw	Possible	acceleration units			m		m			
6085_h	quick_stop_deceleration	VAR	Unsigned32		rw	Possible	acceleration units			o	o	o	o		
6086_h	motion_profile_type	VAR	Integer16		rw	Possible	none			m		m			
$60C5_h$	max_acceleration	VAR	Unsigned32		rw	Possible	acceleration units			o	o				
$60C6_h$	max_deceleration	VAR	Unsigned32		rw	Possible	acceleration units			o	o				

A.5 Homing Mode

Object Dictionary for Chapter Homing Mode																
object no	**object name**	**object code**	**type**	**sub-index**	**attr.**	**PDO**	**units**	**mandatory for**							**description**
								all	**hm**	**pp**	**ip**	**pv**	**tq**	**vl**	
$607C_h$	home_offset	VAR	Integer32		rw	Possible	position units		o						
6098_h	homing_method	VAR	Integer8		rw	Possible	-		m						
6099_h	homing_speeds	ARRAY	Unsigned32												
	speed_during_search_for_switch	ARRAY		01	rw	Possible	velocity Units		m						
	speed_during_search_for_zero	ARRAY		02	rw	Possible	velocity units		m						
$609A_h$	homing_acceleration	VAR	Unsigned32		rw	Possible	acceleration units		o						

A.6 Position Control Function

Object Dictionary for Chapter Position Control Function															
object no	**object name**	**object code**	**type**	**sub-index**	**attr.**	**PDO**	**units**	**mandatory for**							**description**
								all	**hm**	**pp**	**ip**	**pv**	**tq**	**vl**	
6062_h	position_demand_value	VAR	Integer32		ro	Possible	position units								
6063_h	position_actual_value*	VAR	Integer32		ro	Possible	increments		o						
6064_h	position_actual_value	VAR	Integer32		ro	Possible	position units		o						
6065_h	following_error_window	VAR	Unsigned32		rw	Possible	position units								
6066_h	following_error_time_out	VAR	Unsigned16		rw	Possible	milliseconds								
6067_h	position_window	VAR	Unsigned32		rw	Possible	position units								
6068_h	position_window_time	VAR	Unsigned16		rw	Possible	milliseconds								
$60F4_h$	following_error_actual_value	VAR	Integer32		ro	Possible	position units		o						
$60FA_h$	control_effort	VAR	Integer32		ro	Possible	-		o						
$60FB_h$	position_control_parameter_set	RECORD													
$60FC_h$	position_demand_value*	VAR	Integer32		ro	Possible	increments		o						

A.7 Interpolated Position Mode

Object Dictionary for Chapter Interpolated Position Mode															
object no	**object name**	**object code**	**type**	**sub-index**	**attr.**	**PDO**	**units**	**mandatory for**							**description**
								all	**hm**	**pp**	**ip**	**pv**	**tq**	**vl**	
$60C0_h$	interpolation_submode_select	VAR	Integer16		rw	Possible	-				o				
$60C1_h$	interpolation_data_record	RECORD													
$60C2_h$	interpolation_time_period	RECORD													
	ip_time_units	RECORD		01	rw	Possible	10ip_time_index (seconds				o				
	ip_time_index	RECORD		02	rw	Possible	-				o				
$60C3_h$	interpolation_sync_definition	ARRAY	Unsigned8												
	syncronize on group	ARRAY		01	rw	Possible	number				o				
	ip_sync every n event	ARRAY		02	rw	Possible	counts				o				
$60C4_h$	interpolation_data_configuration	RECORD													
	max_buffer_size	RECORD		01	ro	Possible	number				o				
	actual_size	RECORD		02	rw	Possible	number				o				
	buffer_organisation	RECORD		03	rw	Possible	number				o				
	buffer_position	RECORD		04	rw	Possible	number				o				
	size_of_data_record	RECORD		05	wo	Possible	number				o				
	buffer_clear	RECORD		06	wo	Possible	-				o				

A.8 Profile Velocity Mode

Object Dictionary for Chapter Profile Velocity Mode															
object no	**object name**	**object code**	**type**	**sub-index**	**attr.**	**PDO**	**units**	**mandatory for**							**description**
								all	**hm**	**pp**	**ip**	**pv**	**tq**	**vl**	
6069_h	velocity_sensor_actual_value	VAR	Integer32		ro	Possible	increments/sec					m			
6069_h	velocity_sensor_actual_value	VAR	Integer32		ro	Possible	increments/sec					m			
$606A_h$	sensor_selection_code	VAR	Integer16		rw	Possible	-					m			
$606B_h$	velocity_demand_value	VAR	Integer32		ro	Possible	velocity units G2					m			
$606C_h$	velocity_actual_value	VAR	Integer32		ro	Possible	velocity units G2					m			
$606D_h$	velocity_window	VAR	Unsigned16		rw	Possible	velocity units G2					o			
$606E_h$	velocity_window_time	VAR	Unsigned16		rw	Possible	millisecond					o			
$606F_h$	velocity_threshold	VAR	Unsigned16		rw	Possible	velocity units G2					o			
6070_h	velocity_threshold_time	VAR	Unsigned16		r/w	Possible	millisecond					o			
$60FF_h$	target_velocity	VAR	Integer32		rw	Possible	velocity units G2					m			
$60F8_h$	max_slippage	VAR	Integer32		ro	Possible	velocity units G2					m			
$60F9_h$	velocity_control_parameter_set	RECORD													
	V: gain	RECORD		01	rw	Possible	-					o			
	Ti: integration time constant	RECORD		02	rw	Possible	-					o			
	vl_velocity_min_neg	RECORD		03	rw	Possible	G1b							o	

A.9 Profile Torque Mode

Object Dictionary for Chapter Profile Torque Mode

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
6071_h	target_torque	VAR	Integer16		rw	optional	per thousand of rated torque						m		
6072_h	max_torque	VAR	Unsigned16		rw	optional	per thousand of rated torque			o			o		
6073_h	max_current	VAR	Unsigned16		rw	optional	per thousand of rated current			o			o		
6074_h	torque_demand_value	VAR	Integer16		ro	optional	per thousand of rated torque			o			o		
6075_h	motor_rated_current	VAR	Unsigned32		rw	optional	1 mA			o			o		
6076_h	motor_rated_torque	VAR	Unsigned32		rw	optional	0.001 Nm			o			o		
6077_h	torque_actual_value	VAR	Integer16		ro	optional	per thousand of rated torque			o			o		
6078_h	current_actual_value	VAR	Integer16		ro	optional	per thousand of rated current			o			o		
6079_h	DC_link_circuit_voltage	VAR	Unsigned32		ro	optional	milli volts						o		
6087_h	torque_slope	VAR	Unsigned32		rw	optional	per thousand of rated torque per second						m		
6088_h	torque_profile_type	VAR	Integer16		rw	optional	none						m		
$60F7_h$	power_stage_parameters	RECORD													
		RECORD		01	rw	Possible	-			o			o		
$60F6_h$	torque_control_parameters	RECORD													
		RECORD		01	rw	Possible	-			o			o		

A.10 Velocity Mode

Object Dictionary for Chapter Velocity Mode

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
6042_h	vl_target_velocity	VAR	Integer16		rw	Possible	Speed Units G1a							m	
6043_h	vl_velocity_demand	VAR	Integer16		ro	Possible	Speed Units G1a							m	
6053_h	vl_percentage_demand	VAR	Integer16		ro	Possible	(100/16383) %							o	
6054_h	vl_actual_percentage	VAR	Integer16		ro	Possible	(100/16383) %							o	
6055_h	vl_manipulated_percentage	VAR	Integer16		ro	Possible	(100/16383) %							o	
$604E_h$	vl_velocity_reference	VAR	Unsigned32		rw	Possible	Speed Units G1a							o	
$604C_h$	vl_dimension_factor	ARRAY	Integer32												
	vl_dimension_factor_numerator	ARRAY		01	rw	Possible	-(no units)							o	
	vl_dimension_factor_denominator	ARRAY		02	rw	Possible	-(no units)							o	
$604B_h$	vl_setpoint_factor	ARRAY	Integer16												
	vl_setpoint_factor_numerator	ARRAY		01	rw	Possible	-(no units)							o	
	vl_setpoint_factor_denominator	ARRAY		02	rw	Possible	-(no units)							o	
$604D_h$	vl_pole_number	VAR	Unsigned8		rw	Possible	- (number of poles)							o	
6046_h	vl_velocity_min_max_amount	ARRAY	Unsigned32												
	vl_velocity_min_amount	ARRAY		01	rw	Possible	G1b							m	
	vl_velocity_max_amount	ARRAY		02	rw	Possible	G1b							m	
6047_h	vl_velocity_min_max	ARRAY	Unsigned32												
	vl_velocity_min_pos	ARRAY		01	rw	Possible	G1b							o	
	vl_velocity_max_pos	ARRAY		02	rw	Possible	G1b							o	
	vl_velocity_min_neg	ARRAY		03	rw	Possible	G1b							o	
	vl_velocity_max_neg	ARRAY		04	rw	Possible	G1b							o	
6058_h	vl_frequency_motor_min_max_amount	ARRAY	Unsigned32												
	vl_frequency_motor_min_amount	ARRAY		01	rw	Possible	-							o	
	vl_frequency_motor_max_amount	ARRAY		02	rw	Possible	-							o	
6059_h	vl_frequency_motor_min_max	ARRAY	Unsigned32												
	vl_frequency_motor_min_pos	ARRAY		01	rw	Possible	-							o	
	vl_frequency_motor_max_pos	ARRAY		02	rw	Possible	-							o	
	vl_frequency_motor_min_neg	ARRAY		03	rw	Possible	- (1/1000 rpm)							o	
	vl_frequency_motor_max_neg	ARRAY		04	rw	Possible	-							o	

Object Dictionary for Chapter Velocity Mode

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
6056_h	vl_velocity_motor_min_max_amount	ARRAY	Unsigned32												
	vl_velocity_motor_min_amount	ARRAY		01	rw	Possible	(1/1000 rpm)							o	
	vl_velocity_motor_max_amount	ARRAY		02	rw	Possible	(1/1000 rpm)							o	
6057_h	vl_velocity_motor_min_max	ARRAY	Unsigned32												
	vl_velocity_motor_min_pos	ARRAY		01	rw	Possible	- (1/1000 rpm)							o	
	vl_velocity_motor_max_pos	ARRAY		02	rw	Possible	- (1/1000 rpm)							o	
	vl_velocity_motor_min_neg	ARRAY		03	rw	Possible	- (1/1000 rpm)							o	
	vl_velocity_motor_max_neg	ARRAY		04	rw	Possible	- (1/1000 rpm)							o	
6048_h	vl_velocity_acceleration	RECORD													
	delta_speed	RECORD		01	rw	Possible	G1b							m	
	delta_time	RECORD		02	rw	Possible	Seconds (s)							m	
6049_h	vl_velocity_deceleration	RECORD													
	delta_speed	RECORD		01	rw	Possible	G1b							m	
	delta_time	RECORD		02	rw	Possible	Seconds (s)							m	
$604A_h$	vl_velocity_quick_stop	RECORD													
	delta_speed	RECORD		01	rw	Possible	G1b							o	
	delta_time	RECORD		02	rw	Possible	Seconds (s)							o	
$604F_h$	vl_ramp_function_time	VAR	Unsigned32		rw	Possible	Milliseconds (ms)							o	
6050_h	vl_slow_down_time	VAR	Unsigned32		rw	Possible	Milliseconds (ms)							o	
6051_h	vl_quick_stop_time	VAR	Unsigned32		rw	Possible	Milliseconds (ms)							o	
6044_h	vl_control_effort	VAR	Integer16		ro	Possible	Speed Units G1a							m	
6045_h	vl_manipulated_velocity	VAR	Integer16		ro	Possible	Speed Units G1a							o	
6052_h	vl_nominal_percentage	VAR	Integer16		rw	Possible	(100/16383) %							o	

B Object Dictionary by Index

Object Dictionary sorted by Index

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
6007$_h$	abort_connection_option_code	VAR	Integer16		rw	Possible	-	o							
603F$_h$	error_code	VAR	Unsigned16		ro	Possible	-	o							
6040$_h$	controlword	VAR	Unsigned16		rw	Possible	-	m							
6041$_h$	statusword	VAR	Unsigned16		ro	Possible	-	m							
6042h	vl_target_velocity	VAR	Integer16		rw	Possible	Speed Units G1a							m	
6043h	vl_velocity_demand	VAR	Integer16		ro	Possible	Speed Units G1a							m	
6044h	vl_control_effort	VAR	Integer16		ro	Possible	Speed Units G1a							m	
6045h	vl_manipulated_velocity	VAR	Integer16		ro	Possible	Speed Units G1a							o	
6046h	vl_velocity_min_max_amount	ARRAY	Unsigned32												
6047h	vl_velocity_min_max	ARRAY	Unsigned32												
6048h	vl_velocity_acceleration	RECORD													
6049h	vl_velocity_deceleration	RECORD													
604Ah	vl_velocity_quick_stop	RECORD													
604Bh	vl_setpoint_factor	ARRAY	Integer16												
604Ch	vl_dimension_factor	ARRAY	Integer32												
604Dh	vl_pole_number	VAR	Unsigned8		rw	Possible	- (number of poles)							o	
604Eh	vl_velocity_reference	VAR	Unsigned32		rw	Possible	Speed Units G1a							o	
604Fh	vl_ramp_function_time	VAR	Unsigned32		rw	Possible	Milliseconds (ms)							o	
6050h	vl_slow_down_time	VAR	Unsigned32		rw	Possible	Milliseconds (ms)							o	
6051h	vl_quick_stop_time	VAR	Unsigned32		rw	Possible	Milliseconds (ms)							o	
6052h	vl_nominal_percentage	VAR	Integer16		rw	Possible	(100/16383) %							o	
6053h	vl_percentage_demand	VAR	Integer16		ro	Possible	(100/16383) %							o	
6054h	vl_actual_percentage	VAR	Integer16		ro	Possible	(100/16383) %							o	
6055h	vl_manipulated_percentage	VAR	Integer16		ro	Possible	(100/16383) %							o	
6056h	vl_velocity_motor_min_max_amount	ARRAY	Unsigned32												
6057h	vl_velocity_motor_min_max	ARRAY	Unsigned32												
6058h	vl_frequency_motor_min_max_amount	ARRAY	Unsigned32												
6059h	vl_frequency_motor_min_max	ARRAY	Unsigned32												

Object Dictionary sorted by Index

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
605A$_h$	quick_stop_option_code	VAR	Integer16		rw	No	-	o							
605B$_h$	shutdown_option_code	VAR	Integer16		rw	No	-	o							
605C$_h$	disable_operation_option_code	VAR	Integer16		rw	No	-	o							
605D$_h$	stop_option_code	VAR	Integer16		rw	No	-	o							
605E$_h$	fault_reaction_option_code	VAR	Integer16		rw	No	-	o							
6060$_h$	modes_of_operation	VAR	Integer8		wo	Possible	-	m							
6061$_h$	modes_of_operation_display	VAR	Integer8		ro	Possible	-	m							
6062$_h$	position_demand_value	VAR	Integer32		ro	Possible	position units								
6063$_h$	position_actual_value*	VAR	Integer32		ro	Possible	increments		o						
6064$_h$	position_actual_value	VAR	Integer32		ro	Possible	position units		o						
6065$_h$	following_error_window	VAR	Unsigned32		rw	Possible	position units								
6066$_h$	following_error_time_out	VAR	Unsigned16		rw	Possible	milliseconds								
6067$_h$	position_window	VAR	Unsigned32		rw	Possible	position units								
6068$_h$	position_window_time	VAR	Unsigned16		rw	Possible	milliseconds								
6069h	velocity_sensor_actual_value	VAR	Integer32		ro	Possible	increments/sec					m			
6069h	velocity_sensor_actual_value	VAR	Integer32		ro	Possible	increments/sec					m			
606Ah	sensor_selection_code	VAR	Integer16		rw	Possible	-					m			
606Bh	velocity_demand_value	VAR	Integer32		ro	Possible	velocity units G2					m			
606Ch	velocity_actual_value	VAR	Integer32		ro	Possible	velocity units G2					m			
606Dh	velocity_window	VAR	Unsigned16		rw	Possible	velocity units G2					o			
606Eh	velocity_window_time	VAR	Unsigned16		rw	Possible	millisecond					o			
606Fh	velocity_threshold	VAR	Unsigned16		rw	Possible	velocity units G2					o			
6070h	velocity_threshold_time	VAR	Unsigned16		r/w	Possible	millisecond					o			
6071h	target_torque	VAR	Integer16		rw	optional	per thousand of rated torque						m		
6072h	max_torque	VAR	Unsigned16		rw	optional	per thousand of rated torque			o			o		
6073h	max_current	VAR	Unsigned16		rw	optional	per thousand of rated current			o			o		
6074h	torque_demand_value	VAR	Integer16		ro	optional	per thousand of rated torque			o			o		
6075h	motor_rated_current	VAR	Unsigned32		rw	optional	1 mA			o			o		

Object Dictionary sorted by Index

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
6076h	motor_rated_torque	VAR	Unsigned32		rw	optional	0.001 Nm			o			o		
6077h	torque_actual_value	VAR	Integer16		ro	optional	per thousand of rated torque			o			o		
6078h	current_actual_value	VAR	Integer16		ro	optional	per thousand of rated current			o			o		
6079h	DC_link_circuit_voltage	VAR	Unsigned32		ro	optional	milli volts						o		
607A$_h$	target_position	VAR	Integer32		rw	Possible	position units			m	m				
607B$_h$	position_range_limit	ARRAY	Integer32												
607C$_h$	home_offset	VAR	Integer32		rw	Possible	position units		o						
607D$_h$	software_position_limit	ARRAY	Integer32												
607E$_h$	polarity	VAR	Unsigned8		rw	Possible	-			o	o	o	o		
607F$_h$	max_profile_velocity	VAR	Unsigned32		rw	Possible	speed units			o	o	o	o		
6080$_h$	max_motor_speed	VAR	Unsigned16		rw	Possible	rpm	o							
6081$_h$	profile_velocity	VAR	Unsigned32		rw	Possible	speed units			m		m			
6082$_h$	end_velocity	VAR	Unsigned32		rw	Possible	speed units			o					
6083$_h$	profile_acceleration	VAR	Unsigned32		rw	Possible	acceleration units			m		m			
6084$_h$	profile_deceleration	VAR	Unsigned32		rw	Possible	acceleration units			m		m			
6085$_h$	quick_stop_deceleration	VAR	Unsigned32		rw	Possible	acceleration units			o	o	o	o		
6086$_h$	motion_profile_type	VAR	Integer16		rw	Possible	none			m		m			
6087h	torque_slope	VAR	Unsigned32		rw	optional	per thousand of rated torque per second						m		
6088h	torque_profile_type	VAR	Integer16		rw	optional	none						m		
6089$_h$	position_notation_index	VAR	Integer8		rw	Possible	-		o	o	o	o	o		
608A$_h$	position_dimension_index	VAR	Unsigned8		rw	Possible	-		o	o	o	o	o		
608B$_h$	velocity_notation_index	VAR	Integer8		rw	Possible	-		o	o	o	o	o		
608C$_h$	velocity_dimension_index	VAR	Unsigned8		rw	Possible	-		o	o	o	o	o		
608D$_h$	acceleration_notation_index	VAR	Integer8		rw	Possible	-		o	o	o	o	o		
608E$_h$	acceleration_dimension_index	VAR	Unsigned8		rw	Possible	-		o	o	o	o	o		
608F$_h$	position_encoder_resolution	ARRAY	Unsigned32												
6090$_h$	velocity_encoder_resolution	ARRAY	Unsigned32												

Object Dictionary sorted by Index

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
6091h	gear_ratio	ARRAY	Unsigned32												
6092h	feed_constant	ARRAY	Unsigned32												
6093h	position_factor	ARRAY	Unsigned32												
6094h	velocity_encoder_factor	ARRAY	Unsigned32												
6095h	velocity_factor_1	ARRAY	Unsigned32												
6096h	velocity_factor_2	ARRAY	Unsigned32												
6097h	acceleration_factor	ARRAY	Unsigned32												
6098h	homing_method	VAR	Integer8		rw	Possible	-		m						
6099h	homing_speeds	ARRAY	Unsigned32												
609Ah	homing_acceleration	VAR	Unsigned32		rw	Possible	acceleration units		o						
60C0h	interpolation_submode_select	VAR	Integer16		rw	Possible	-				o				
60C1h	interpolation_data_record	RECORD													
60C2h	interpolation_time_period	RECORD													
60C3h	interpolation_sync_definition	ARRAY	Unsigned8												
60C4h	interpolation_data_configuration	RECORD													
60C5h	max_acceleration	VAR	Unsigned32		rw	Possible	acceleration units			o	o				
60C6h	max_deceleration	VAR	Unsigned32		rw	Possible	acceleration units			o	o				
60F4h	following_error_actual_value	VAR	Integer32		ro	Possible	position units		o						
60F6h	torque_control_parameters	RECORD													
60F7h	power_stage_parameters	RECORD													
60F8h	max_slippage	VAR	Integer32		ro	Possible	velocity units G2					m			
60F9h	velocity_control_parameter_set	RECORD													
60FAh	control_effort	VAR	Integer32		ro	Possible	-		o						
60FBh	position_control_parameter_set	RECORD													
60FCh	position_demand_value*	VAR	Integer32		ro	Possible	increments		o						
60FDh	digital_inputs	VAR	Unsigned32		ro	Possible	-	o							
60FEh	digital_outputs	RECORD													
60FFh	target_velocity	VAR	Integer32		rw	Possible	velocity units G2					m			
6402h	motor_type	VAR	Unsigned16		rw	Possible	-								
6403h	motor_catalogue_number	VAR	Visible String		rw	Possible	-								
6404h	motor_manufacturer	VAR	Visible String		rw	Possible	-								

Object Dictionary sorted by Index																
object no	**object name**	**object code**	**type**	**sub-index**	**attr.**	**PDO**	**units**	**mandatory for**								**description**
								all	**hm**	**pp**	**ip**	**pv**	**tq**	**vl**		
6405_h	http_motor_catalog_address	VAR	Visible String		rw	Possible	-									
6406_h	motor_calibration_date	VAR	Date		rw	Possible	-									
6407_h	motor_service_period	VAR	Unsigned32		rw	Possible	-									
6410_h	motor_data	RECORD														
6502_h	supported_drive_modes	VAR	Unsigned32		ro	Possible	-									
6503_h	drive_catalogue_number	VAR	Visible String		rw	Possible	-									
6504_h	drive_manufacturer	VAR	Visible String		rw	Possible	-									
6505_h	http_drive_catalog_address	VAR	Visible String		rw	Possible	-									
6510_h	drive_data	RECORD														

C Object Dictionary by Name

Object Dictionary sorted by Name															
object no	**object name**	**object code**	**type**	**sub-index**	**attr.**	**PDO**	**units**	**mandatory for**							**description**
								all	**hm**	**pp**	**ip**	**pv**	**tq**	**vl**	
6007_h	abort_connection_option_code	VAR	Integer16		rw	Possible	-	o							
$608E_h$	acceleration_dimension_index	VAR	Unsigned8		rw	Possible	-		o	o	o	o	o		
6097_h	acceleration_factor	ARRAY	Unsigned32												
$608D_h$	acceleration_notation_index	VAR	Integer8		rw	Possible	-		o	o	o	o	o		
$60FA_h$	control_effort	VAR	Integer32		ro	Possible	-		o						
6040_h	controlword	VAR	Unsigned16		rw	Possible	-	m							
6078h	current_actual_value	VAR	Integer16		ro	optional	per thousand of rated current			o			o		
6079h	DC_link_circuit_voltage	VAR	Unsigned32		ro	optional	milli volts						o		
$60FD_h$	digital_inputs	VAR	Unsigned32		ro	Possible	-	o							
$60FE_h$	digital_outputs	RECORD													
$605C_h$	disable_operation_option_code	VAR	Integer16		rw	No	-	o							
6503_h	drive_catalogue_number	VAR	Visible String		rw	Possible	-								
6510_h	drive_data	RECORD													
6504_h	drive_manufacturer	VAR	Visible String		rw	Possible	-								
6082_h	end_velocity	VAR	Unsigned32		rw	Possible	speed units			o					
$603F_h$	error_code	VAR	Unsigned16		ro	Possible	-	o							
$605E_h$	fault_reaction_option_code	VAR	Integer16		rw	No	-	o							
6092_h	feed_constant	ARRAY	Unsigned32												
$60F4_h$	following_error_actual_value	VAR	Integer32		ro	Possible	position units		o						
6066_h	following_error_time_out	VAR	Unsigned16		rw	Possible	milliseconds								
6065_h	following_error_window	VAR	Unsigned32		rw	Possible	position units								
6091_h	gear_ratio	ARRAY	Unsigned32												
$607C_h$	home_offset	VAR	Integer32		rw	Possible	position units		o						
$609A_h$	homing_acceleration	VAR	Unsigned32		rw	Possible	acceleration units		o						
6098_h	homing_method	VAR	Integer8		rw	Possible	-		m						
6099_h	homing_speeds	ARRAY	Unsigned32												
6505_h	http_drive_catalog_address	VAR	Visible String		rw	Possible	-								

Object Dictionary sorted by Name

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
6405$_h$	http_motor_catalog_address	VAR	Visible String		rw	Possible	-								
60C4$_h$	interpolation_data_configuration	RECORD													
60C1$_h$	interpolation_data_record	RECORD													
60C0$_h$	interpolation_submode_select	VAR	Integer16		rw	Possible	-				o				
60C3$_h$	interpolation_sync_definition	ARRAY	Unsigned8												
60C2$_h$	interpolation_time_period	RECORD													
60C5$_h$	max_acceleration	VAR	Unsigned32		rw	Possible	acceleration units			o	o				
6073h	max_current	VAR	Unsigned16		rw	optional	per thousand of rated current			o			o		
60C6$_h$	max_deceleration	VAR	Unsigned32		rw	Possible	acceleration units			o	o				
6080$_h$	max_motor_speed	VAR	Unsigned16		rw	Possible	rpm	o							
607F$_h$	max_profile_velocity	VAR	Unsigned32		rw	Possible	speed units			o	o	o	o		
60F8h	max_slippage	VAR	Integer32		ro	Possible	velocity units G2					m			
6072h	max_torque	VAR	Unsigned16		rw	optional	per thousand of rated torque			o			o		
6060$_h$	modes_of_operation	VAR	Integer8		wo	Possible	-	m							
6061$_h$	modes_of_operation_display	VAR	Integer8		ro	Possible	-	m							
6086$_h$	motion_profile_type	VAR	Integer16		rw	Possible	none			m		m			
6406$_h$	motor_calibration_date	VAR	Date		rw	Possible	-								
6403$_h$	motor_catalogue_number	VAR	Visible String		rw	Possible	-								
6410$_h$	motor_data	RECORD													
6404$_h$	motor_manufacturer	VAR	Visible String		rw	Possible	-								
6075h	motor_rated_current	VAR	Unsigned32		rw	optional	1 mA			o			o		
6076h	motor_rated_torque	VAR	Unsigned32		rw	optional	0.001 Nm			o			o		
6407$_h$	motor_service_period	VAR	Unsigned32		rw	Possible	-								
6402$_h$	motor_type	VAR	Unsigned16		rw	Possible	-								
607E$_h$	polarity	VAR	Unsigned8		rw	Possible	-			o	o	o	o		
6064$_h$	position_actual_value	VAR	Integer32		ro	Possible	position units		o						
6063$_h$	position_actual_value*	VAR	Integer32		ro	Possible	increments		o						
60FB$_h$	position_control_parameter_set	RECORD													
6062$_h$	position_demand_value	VAR	Integer32		ro	Possible	position units								

Object Dictionary sorted by Name

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
$60FC_h$	position_demand_value*	VAR	Integer32		ro	Possible	increments		o						
$608A_h$	position_dimension_index	VAR	Unsigned8		rw	Possible	-		o	o	o	o	o		
$608F_h$	position_encoder_resolution	ARRAY	Unsigned32												
6093_h	position_factor	ARRAY	Unsigned32												
6089_h	position_notation_index	VAR	Integer8		rw	Possible	-		o	o	o	o	o		
$607B_h$	position_range_limit	ARRAY	Integer32												
6067_h	position_window	VAR	Unsigned32		rw	Possible	position units								
6068_h	position_window_time	VAR	Unsigned16		rw	Possible	milliseconds								
60F7h	power_stage_parameters	RECORD													
6083_h	profile_acceleration	VAR	Unsigned32		rw	Possible	acceleration units			m		m			
6084_h	profile_deceleration	VAR	Unsigned32		rw	Possible	acceleration units			m		m			
6081_h	profile_velocity	VAR	Unsigned32		rw	Possible	speed units			m		m			
6085_h	quick_stop_deceleration	VAR	Unsigned32		rw	Possible	acceleration units			o	o	o	o		
$605A_h$	quick_stop_option_code	VAR	Integer16		rw	No	-	o							
606Ah	sensor_selection_code	VAR	Integer16		rw	Possible	-					m			
$605B_h$	shutdown_option_code	VAR	Integer16		rw	No	-	o							
$607D_h$	software_position_limit	ARRAY	Integer32												
6041_h	statusword	VAR	Unsigned16		ro	Possible	-	m							
$605D_h$	stop_option_code	VAR	Integer16		rw	No	-	o							
6502_h	supported_drive_modes	VAR	Unsigned32		ro	Possible	-								
$607A_h$	target_position	VAR	Integer32		rw	Possible	position units			m	m				
6071h	target_torque	VAR	Integer16		rw	optional	per thousand of rated torque						m		
60FFh	target_velocity	VAR	Integer32		rw	Possible	velocity units G2					m			
6077h	torque_actual_value	VAR	Integer16		ro	optional	per thousand of rated torque			o			o		
60F6h	torque_control_parameters	RECORD													
6074h	torque_demand_value	VAR	Integer16		ro	optional	per thousand of rated torque			o			o		
6088h	torque_profile_type	VAR	Integer16		rw	optional	none						m		

Object Dictionary sorted by Name

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
6087h	torque_slope	VAR	Unsigned32		rw	optional	per thousand of rated torque per second						m		
606Ch	velocity_actual_value	VAR	Integer32		ro	Possible	velocity units G2					m			
60F9h	velocity_control_parameter_set	RECORD													
606Bh	velocity_demand_value	VAR	Integer32		ro	Possible	velocity units G2					m			
608Ch	velocity_dimension_index	VAR	Unsigned8		rw	Possible	-		o	o	o	o	o		
6094h	velocity_encoder_factor	ARRAY	Unsigned32												
6090h	velocity_encoder_resolution	ARRAY	Unsigned32												
6095h	velocity_factor_1	ARRAY	Unsigned32												
6096h	velocity_factor_2	ARRAY	Unsigned32												
608Bh	velocity_notation_index	VAR	Integer8		rw	Possible	-		o	o	o	o	o		
6069h	velocity_sensor_actual_value	VAR	Integer32		ro	Possible	increments/sec					m			
6069h	velocity_sensor_actual_value	VAR	Integer32		ro	Possible	increments/sec					m			
606Fh	velocity_threshold	VAR	Unsigned16		rw	Possible	velocity units G2					o			
6070h	velocity_threshold_time	VAR	Unsigned16		r/w	Possible	millisecond					o			
606Dh	velocity_window	VAR	Unsigned16		rw	Possible	velocity units G2					o			
606Eh	velocity_window_time	VAR	Unsigned16		rw	Possible	millisecond					o			
6054h	vl_actual_percentage	VAR	Integer16		ro	Possible	(100/16383) %							o	
6044h	vl_control_effort	VAR	Integer16		ro	Possible	Speed Units G1a							m	
604Ch	vl_dimension_factor	ARRAY	Integer32												
6059h	vl_frequency_motor_min_max	ARRAY	Unsigned32												
6058h	vl_frequency_motor_min_max_amount	ARRAY	Unsigned32												
6055h	vl_manipulated_percentage	VAR	Integer16		ro	Possible	(100/16383) %							o	
6045h	vl_manipulated_velocity	VAR	Integer16		ro	Possible	Speed Units G1a							o	
6052h	vl_nominal_percentage	VAR	Integer16		rw	Possible	(100/16383) %							o	
6053h	vl_percentage_demand	VAR	Integer16		ro	Possible	(100/16383) %							o	
604Dh	vl_pole_number	VAR	Unsigned8		rw	Possible	- (number of poles)							o	
6051h	vl_quick_stop_time	VAR	Unsigned32		rw	Possible	Milliseconds (ms)							o	
604Fh	vl_ramp_function_time	VAR	Unsigned32		rw	Possible	Milliseconds (ms)							o	
604Bh	vl_setpoint_factor	ARRAY	Integer16												

Object Dictionary sorted by Name

object no	object name	object code	type	sub-index	attr.	PDO	units	mandatory for							description
								all	hm	pp	ip	pv	tq	vl	
6050h	vl_slow_down_time	VAR	Unsigned32		rw	Possible	Milliseconds (ms)							o	
6042h	vl_target_velocity	VAR	Integer16		rw	Possible	Speed Units G1a							m	
6048h	vl_velocity_acceleration	RECORD													
6049h	vl_velocity_deceleration	RECORD													
6043h	vl_velocity_demand	VAR	Integer16		ro	Possible	Speed Units G1a							m	
6047h	vl_velocity_min_max	ARRAY	Unsigned32												
6046h	vl_velocity_min_max_amount	ARRAY	Unsigned32												
6057h	vl_velocity_motor_min_max	ARRAY	Unsigned32												
6056h	vl_velocity_motor_min_max_amount	ARRAY	Unsigned32												
604Ah	vl_velocity_quick_stop	RECORD													
604Eh	vl_velocity_reference	VAR	Unsigned32		rw	Possible	Speed Units G1a							o	

D Definition of Dimension Indices

D.1 Dimension/Notation Index Table

physical dimension	dimension index	units exponent	unit typ	notation index
non	0	units		0
length	1		metre	0
		milli	metre	-3
		kilo	metre	3
		micro	metre	-6
area	2	square	metre	0
		square milli	metre	-6
		square kilo	metre	6
volume	3	cubic	metre	0
time	4		second	0
			minute	70
			hour	74
			day	77
		milli	second	-3
		micro	second	-6
actual power	9		watt	0
		kilo	watt	3
		mega	watt	6
		milli	watt	-3
apparent power	10		voltampere	0
		kilo	voltampere	3
		mega	voltampere	6
no. of revolutions	11		per second	0
			per minute	73
			per hour	74
angle	12		radian	0
			second	75
			minute	76
			degree	77
			newdegree	78

physical dimension	dimension index	units exponent	unit typ	notation index
velocity	13		metre p. second	0
		milli	metre p. second	-3
		milli	metre p. minute	79
			metre p. minute	80
		kilo	metre p. minute	81
		milli	metre p. hour	82
			metre p. hour	83
		kilo	metre p. hour	84
torque	16		newton metre	0
		kilo	newton metre	3
		mega	newton metre	6
temperature	17		kelvin	0
			centigrade	94
			Fahrenheit	95
voltage	21		Volt	0
		kilo	Volt	3
		milli	Volt	-3
		micro	Volt	-6
current	22		Ampere	0
		kilo	Ampere	3
		milli	Ampere	-3
		micro	Ampere	-6
ratio	24		percent	0
frequency	28		Hertz	0
		kilo	Hertz	3
		mega	Hertz	6
		giga	Hertz	9
steps	32		steps	0
encoder resolution	33	revolution	steps per	0

Table 14: Dimension/Notation Index Table

D.2 Examples for Notation Indices

Examples for notation indices < 64:

For notation index <64 the value is used as an exponent. The unit is defined by the physical dimension and calculated by unit type and exponent, all declared in the dimension/notation index table above.

position unit
dimension index = 1: length
notation index = -6: micro meter

position_units = $10^{notation\_index}$ x f(dimension_index)
= 10^{-6} m

dimension index = 12: angle
notation index = 0: radian

position_units = $10^{notation\_index}$ x f(dimension_index)
= radian

velocity unit
dimension index = 13: velocity
notation index = -3: milli metre per second

velocity_units = $10^{notation\_index}$ x f(dimension_index)
= 10^{-3} m/s

frequency units
dimension index = 28: frequency
notation index = 3: kilo hertz

frequency_units = $10^{notation\_index}$ x f(dimension_index)
= 10^{3} Hz

Examples for notation indices > 64:

The unit is defined by the physical dimension and unit type, both declared in the dimension/notation index table**.**

time units
dimension index = 4: time
notation index = 77: day

time_units = f(dimension_index,notation_index)
= day

position unit
dimension index = 12: angle
notation index = 76: minute

position_units = f(dimension_index,notation_index)
= minute

E Index