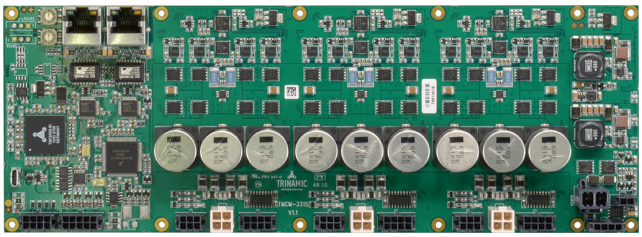
TMCM-3313 CoE Firmware Manual

Firmware Version V1.09 | Document Revision V1.07 • 2019-MAY-09

The TMCM-3313 is a three axes controller/driver module for 2-phase bipolar stepper motors with separate differential encoder and separate home and stop switch inputs for each axis. Dynamic current control, and quiet, smooth and efficient operation are combined with StealthChop™, StallGuard™ and CoolStep™ features. The module offers four analog or digital inputs as well as four digital outputs in combination with a break chopper unit.



EtherCAT®

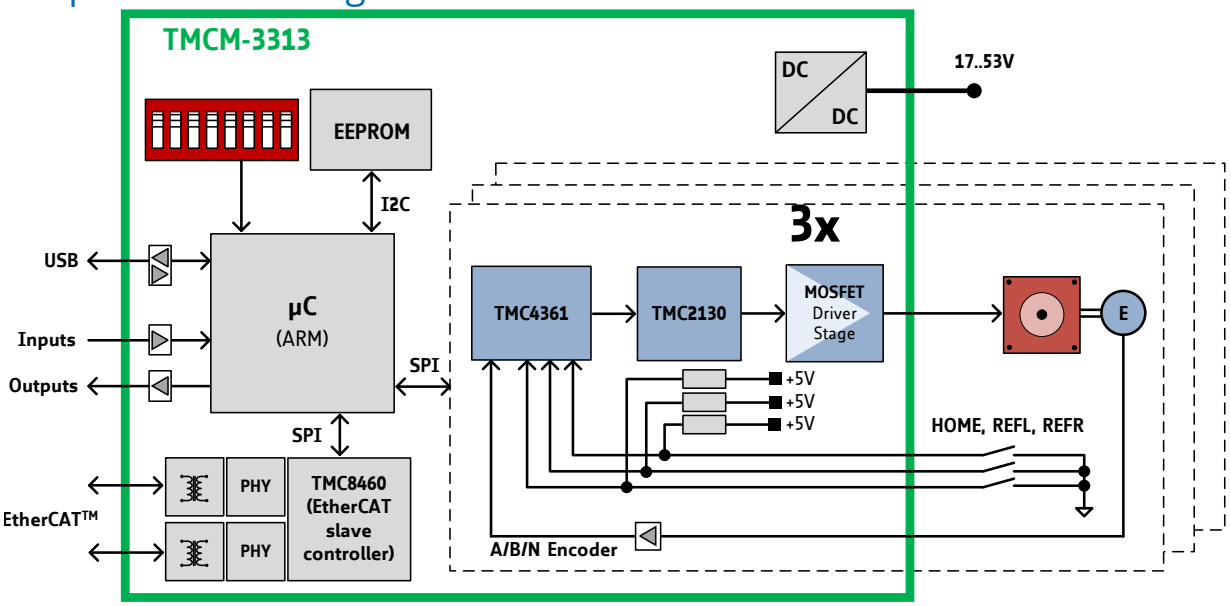
Features

- 3-Axes Stepper Motor Control
- CoE CiA-402 Drive Profile
- Linear ramps, SixPoint™ ramps and s-shaped ramps selectable
- Closed Loop Encoder Support
- CoolStep™
- StallGuard2™
- StealthChop™

Applications

- Laboratory Automation
- Manufacturing
- Semiconductor Handling
- Robotics
- Factory Automation
- Test & Measurement
- Life Science
- Biotechnology
- Liquid Handling

Simplified Block Diagram



TRINAMIC
MOTION CONTROL

Read entire documentation.

Contents

1 Preface

This document specifies objects and modes of operation of the Triamic TMCM-3313 stepper motor control module with CANopen-over-EtherCAT (CoE) firmware. The CoE firmware is designed to fulfill the EtherCAT® version of the CANopen DS402 standards. The EtherCAT® conformance has also been tested. This manual assumes that the reader is already familiar with the basics of EtherCAT® and the CoE protocol (especially DS402).
If necessary it is always possible to turn the module into a TMCL module by loading the TMCM-3313 TMCL fimware again through the USB interface, with the help of the firmware update function of the TMCL-IDE 3.0.

1.1 General Features of this CoE Implementation

Main Characteristics

- Communication according to EtherCAT® standards
- Protocols: CoE, FoE

SDO Communication

- 1 server
- Expedited transfer
- Segmented transfer
- No block transfer

PDO Communication

- Producer
- Consumer
- RPDOs
  - Dynamic mapping with max. 9 mapping entries.
  - Default mappings: manufacturer specific.
- TPDOs
  - Dynamic mapping with max. 9 mapping entries.
  - Default mappings: manufacturer specific.

Sync managers

- Sync manager 0: receive mailbox used for SDO communication
- Sync manager 1: send mailbox used for SDO communication
- Sync manager 2: process data output (used for TPDO)
- Sync manager 3: process data input (used for RPDO)

Further Characteristics

- Emergency: producer

1.2 Abbreviations used in this Manual

Abbreviations	
CAN	Controller area network
CoE	CANopen over EtherCAT
CHGND	chassis ground / earth ground
COB	Communication object
FoE	File transfer over EtherCAT
FSA	Finite state automaton
FSM	Finite state machine
NMT	Network management
ID	Identifier
LSB	Least significant bit
MSB	Most significant bit
PDO	Process data object
PDS	Power drive system
RPDO	Receive process data object
SDO	Service data object
TPDO	Transmit process data object
EMCY	Emergency object
rw	Read and write
ro	Read only
hm	Homing mode
pp	Profile position mode
pv	Profile velocity mode
vm	Velocity mode

Table 1: Abbreviations used in this Manual

1.3 Firmware Update

The software running on the microprocessor consists of two parts, a boot loader and the CoE firmware itself. Whereas the boot loader is installed during production and testing at TRINAMIC and remains untouched throughout the whole lifetime, the CoE firmware can easily be updated by the user. The new firmware can be loaded into the module either via file transfer over EtherCAT (FoE) or via the firmware update function of the TMCL-IDE, using the USB interface of the module.

1.4 Trinamic's unique Features — easy to use with CoE

1.4.1 StallGuard2™

StallGuard2™ is a high-precision sensorless load measurement using the back EMF of the coils. It can be used for stall detection as well as other uses at loads below those which stall the motor. The StallGuard2™ measurement value changes linearly over a wide range of load, velocity, and current settings. At maximum motor load, the value reaches zero or is near zero. This is the most energy-efficient point of operation for the motor.

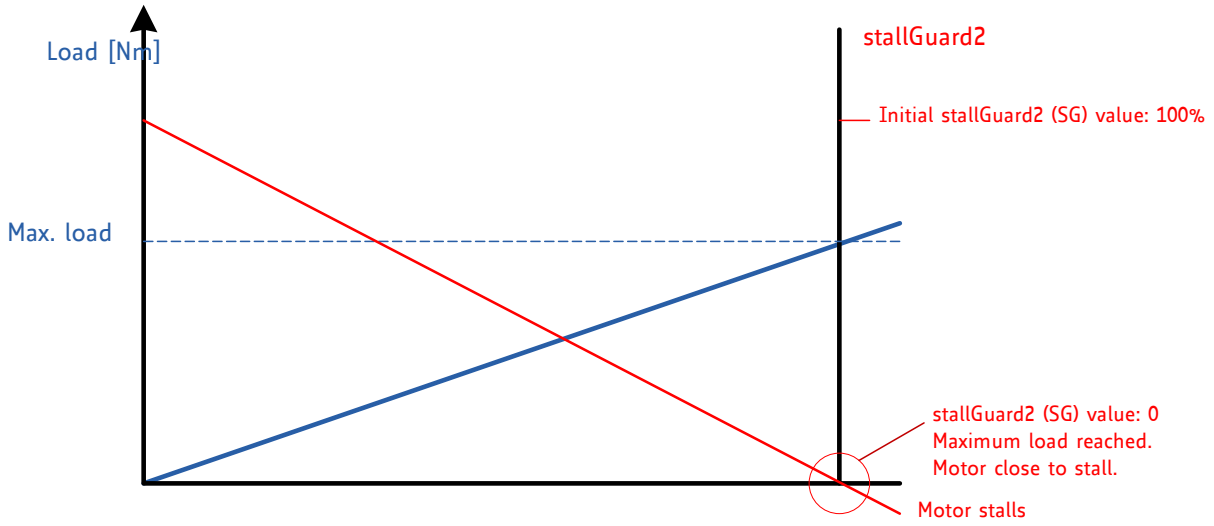


Figure 1: StallGuard2 Load Measurement as a Function of Load

1.4.2 CoolStep™

CoolStep™ is a load-adaptive automatic current scaling based on the load measurement via StallGuard2™ adapting the required current to the load. Energy consumption can be reduced by as much as 75%. CoolStep™ allows substantial energy savings, especially for motors which see varying loads or operate at a high duty cycle. Because a stepper motor application needs to work with a torque reserve of 30% to 50%, even a constant-load application allows significant energy savings because CoolStep™ automatically enables torque reserve when required. Reducing power consumption keeps the system cooler, increases motor life, and allows cost reduction.

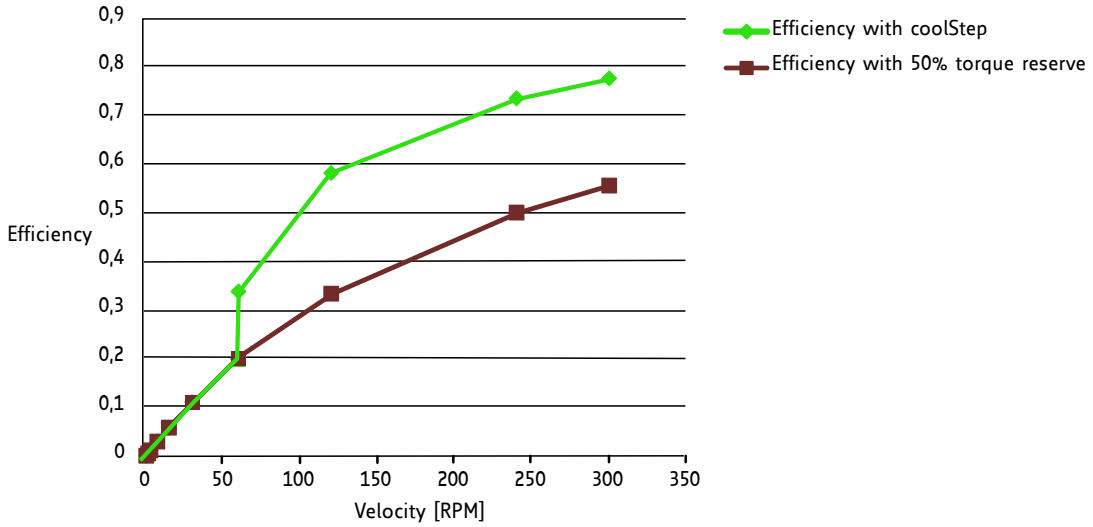


Figure 2: Energy Efficiency Example with CoolStep

1.5 Closed-Loop Operation

Together with an external ABN encoder it is possible to operate each axis of the TMCM-3313 as a closed-loop stepper system. Before enabling this feature, some parameters have to be set. The following table shows which objects should be set to which values in order to make closed-loop work. In this example we assume that a 1.8° motor is used together with a 40000cpr (10000lpr) encoder. Before the encoder can be used, the sensor selection code (object $606A_h$) has to be set to 0 (which means that a position encoder is to be used) and the resolution of the encoder ([cpr]) has to be written to object $608F_h$ sub-index 1.

Closed-Loop Example Settings			
Parameter	Object	Value	Comment
Maximum current	2003_h	85	Set maximum motor current to 1 A.
Standby current	2004_h	10	Set standby current to 0.1 A.
Sensor selection code	$606A_h$	0	Set to 0 in order to make encoder work. (default: -1 = no encoder)
Encoder resolution	$608F_h/1$	10000	Set encoder resolution to 10000cpr.
Field weakening minimim velocity	2034_h	300000	Set gamma Vmin.
Field weakening maximum velocity	2035_h	1600000	Set gamma Vmax.
Field weakening	2036_h	255	(default value)
Closed loop beta	2027_h	255	Beta (default value)
Current scaler minimum	2029_h	50	
Current scaler maximum	$202A_h$	255	
Maximum correction tolerance	2022_h	255	
Upscale delay	2030_h	1000	
Downscale delay	2031_h	10000	
Correction velocity P	$202B_h$	3000	
Correction velocity I	$202C_h$	20	
Correction velocity I clipping	$202D_h$	2000	
Correction velocity DV clock	$202E_h$	0	
Correction velocity DV clipping	$202F_h$	100000	
Correction position P	2021_h	65536	

Table 2: Closed-Loop Example Settings

After these settings have been made, switch the state machine to OPERATIONAL (using the control word). Then, turn on closed-loop operation by setting object 2020_h to 1. Now, read object 2120_h until its value is 1 (closed-loop initialzation finisched).

1.5.1 Closed-Loop Parameters

The closed-loop operation of the TMCM-3313 is based on Trinamic's closed-loop hardware motion controller IC TMC4361.
The 2-phase closed-loop control of the TMCM-3313 follows a different approach than PID control cascades to consider stepper motor driver characteristics. The ramp generator which assigns target and velocity is independent of the position control (commutation angle control) which is also independent of the current control. The closed-loop control scheme is depicted in the following picture.

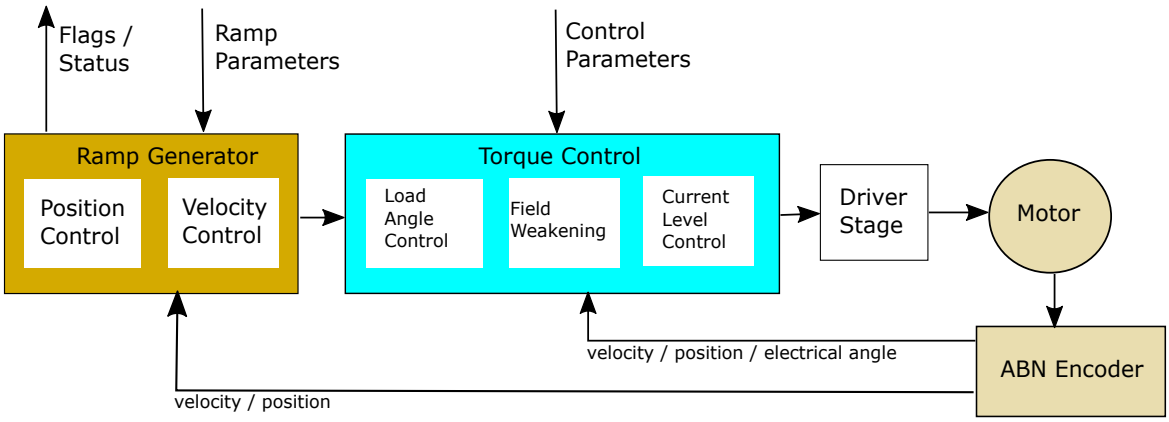


Figure 3: Closed-Loop Control Scheme

Load angle control and current level control will be executed in parallel.

1.5.2 Load Angle Control

As typical for stepper motor drivers, phase currents will be assigned directly to he motor drivers. This results in a current vector which should be followed by the rotor.The rotor position will be directly sampled by encoder feedback. The closed-loop motor control monitors the resulting load angle (deviation between driver stage current vector and encoder angle). Further on, the direction of the current vector will track the rotor position if the load angle should impend to exceed a certain limit. The result is a load angle which will be never exceed the given limit and as a result no step loss will occur. Thus, the current vector will follow an overpowered load until the load is reduced.
Figure 4 shows the parameters which limit the load angle.

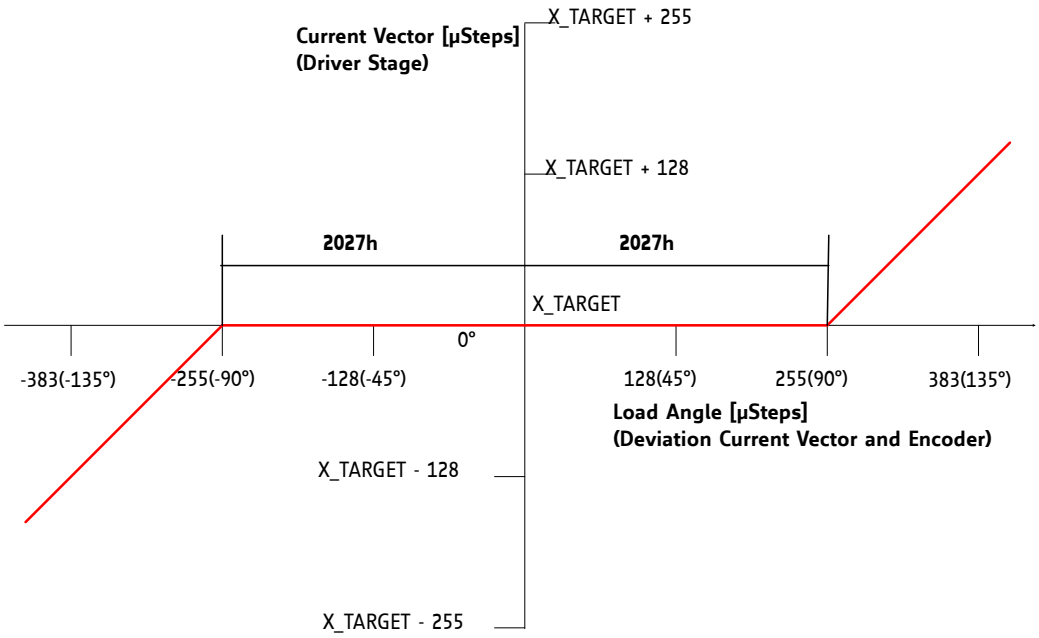


Figure 4: Load Angle Control Parameter

1.5.3 Current Level Control

Parallel to the load angle control the TMCM-3313 controls the motor current level (current vector amplitude) depending on the load angle to save energy during no or light load. Figure 5 gives an overview of the current control parameters.

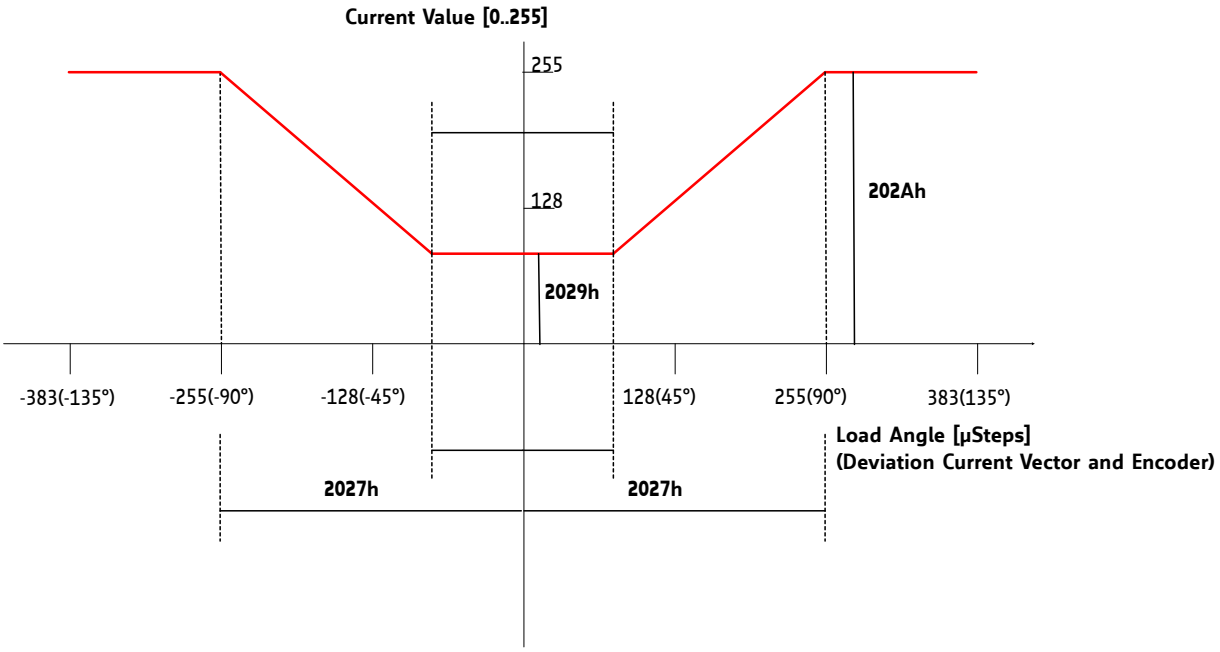


Figure 5: Current Level Control

- Object 2027_h: Closed-loop beta.
- Object 2029_h: Minimum closed-loop current scaler.
- Object $202A_h$: Maximum closed-loop current scaler.

Objects 2030_h and 2031_h set up the delay which defines how fast the actual current will be increased or decreased and will follow the red marked graph.

1.5.4 Field Weakening

With every stepper motor the TMCM-3313 will reach a velocity where it is not possible to maintain the target motor current due to the motor back EMF. Above this velocity load angle (2027_h, default 90°) and current level control will reach their maximum. To drive the stepper motor faster the back EMF must be compensated by commutating the stepper motor with a commutation angle between 90° and 180°. The parameters for field weakening are described in figure 6.

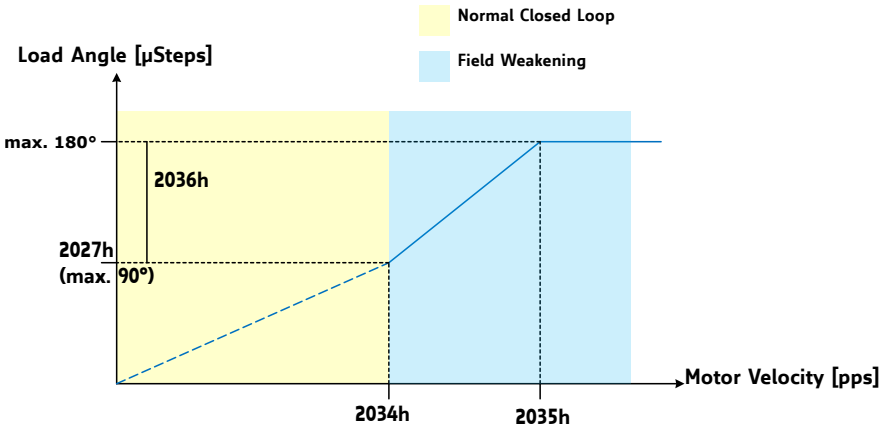


Figure 6: Field Weakening

- Object 2027_h: Closed-loop beta.
- Object 2036_h: Field weakening (closed-loop gamma).
- Object 2034_h: Field weakening minimum velocioty (gamma Vmin).
- Object 2035_h: Field weakening maximum velocioty (gamma Vmax).

1.5.5 Position Catch up

The TMCM-3313 includes a special feature for closed-loop positioning. Positioning parameters like velocity and acceleration will be calculated to reach a position in a dedicated time. If the target trapezoidal ramp cannot be maintained due to high load peaks the TMCM-3313 includes a special position catch-up mode to ensure that the position will still be reached in time if possible.

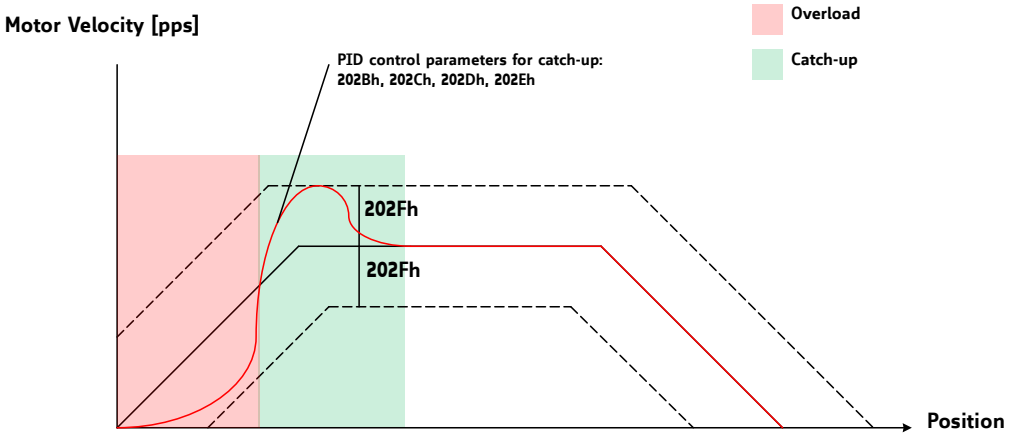


Figure 7: Position Catch up

2 Communication

2.1 Reference Model

The application layer comprises a concept to configure and communicate real-time-data as well as the mechanisms for synchronization between devices. The functionality which the application layer offers to an application is logically divided over different service data objects (SDO) in the application layer. A service object offers a specific functionality and all the related services.

Applications interact by invoking services of a service object in the application layer. To realize these services this object exchanges data via the EtherCAT with peer service object(s) using a protocol.

The application and the application layer interact with service primitives.

Service Primitives	
Primitive	Definition
Request	Issued by the application to the application layer to request a service.
Indication	Issued by the application layer to the application to report an internal event detected by the application layer or indicate that a service is requested.
Response	Issued by the application to the application layer to respond to a previous received indication.
Confirmation	Issued by the application layer to the application to report the result of a previously issued request.

Table 3: Service Primitives

A service type defines the primitives that are exchanged between the application layer and the cooperating applications for a particular service of a service object. Unconfirmed and confirmed services are collectively called remote services.

Service Types	
Type	Definition
Local service	Involves only the local service object. The application issues a request to its local service object that executes the requested service without communicating with peer service object(s).
Unconfirmed service	Involves one or more peer service objects. The application issues a request to its local service object. This request is transferred to the peer service object(s) that each passes it to their application as an indication. The result is not confirmed back.
Confirmed service	Can involve only one peer service object. The application issues a request to its local service object. This request is transferred to the peer service object that passes it to the other application as an indication. The other application issues a response that is transferred to the originating service object that passes it as a confirmation to the requesting application.
Provider initiated service	Involves only the local service object. The service object (being the service provider) detects an event not solicited by a requested service. This event is then indicated to the application.

Table 4: Service Types

2.2 NMT State Machine

The finite state machine (FSM) or simply state machine is a model of behavior composed of a finite number of states, transitions between those states, and actions. It shows which way the logic runs when certain conditions are met.

Starting and resetting the device is controlled via the state machine. The NMT state machine consists of the states shown in figure 8.

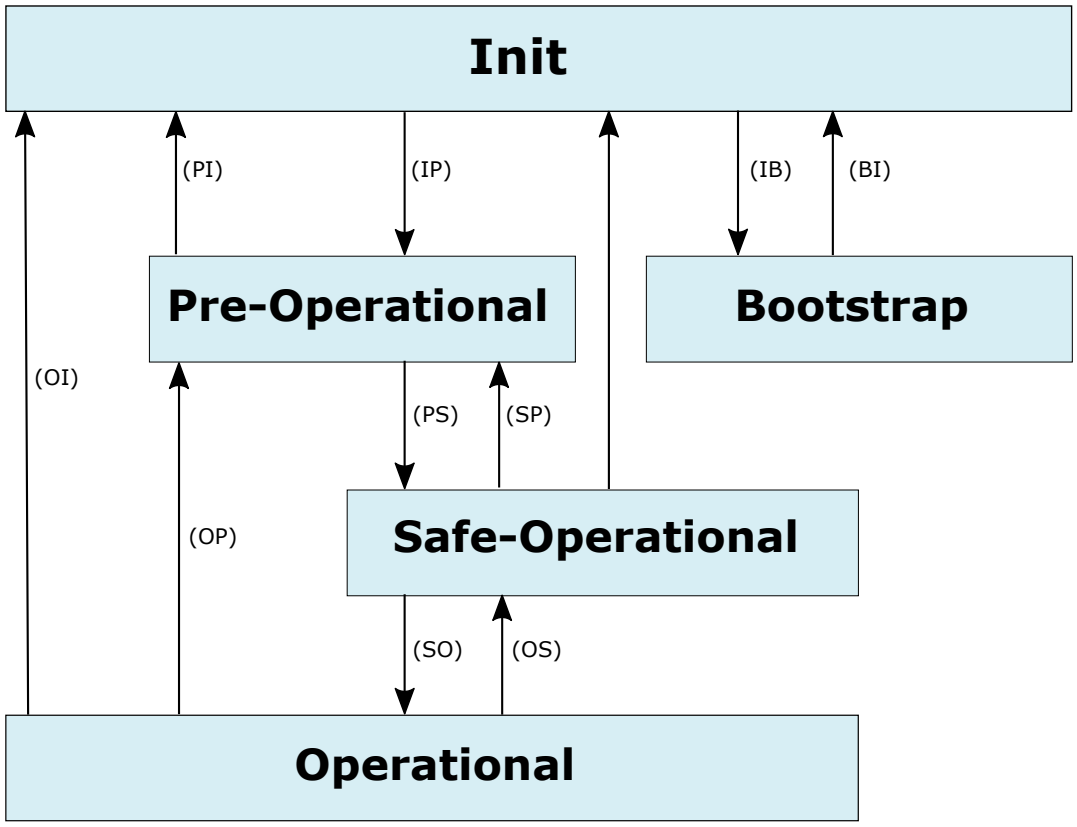


Figure 8: NMT State Machine

After power-on or reset the device enters the Initialization **(INIT)** state.

The master can then switch the device to Pre-Operational **(PRE-OP)** state. In this state, only SDO communication is possible. PDO communication is not possible.

In Safe-Operational **(SAFE-OP)** state, also PDO communication is possible. Inputs can be read, but outputs cannot be switched and the motor cannot be run.

In Operational **(OP)** state, all features of the module can be used. PDO communication is possible, outputs can be switched and the motor can be used. During Operational state the device can use all supported communication objects.

When switching from Operational to Safe-Operational state the motor will be stopped if it has been running. When the EtherCAT connection is lost during Operational state the device will also automatically switch to

Safe-Operational state.

The Bootstrap **(BOOT)** state is used for firmware updates via FoE. Before FoE can be used the device has to be switched to this state.

2.3 Device Model

A CoE device mainly consists of the following parts:

- *Communication:* This function unit provides the communication objects and the appropriate functionality to transport data items via the underlying network structure.
- *Object dictionary:* The object dictionary is a collection of all the data items which have an influence on the behavior of the application objects, the communication objects and the state machine used on this device.
- *Application:* The application comprises the functionality of the device with respect to the interaction with the process environment.

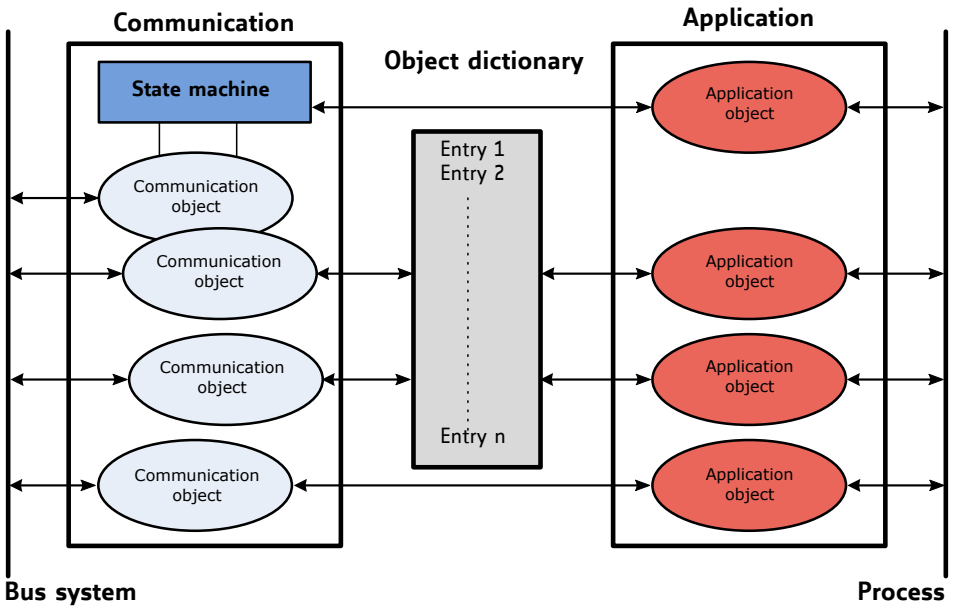


Figure 9: Device Model

2.4 Object Dictionary

The most important part of a device profile is the object dictionary description. The object dictionary is essentially a grouping of objects accessible via the network in an ordered pre-defined fashion. Each object within the dictionary is addressed using a 16-bit index. The overall layout of the standard object dictionary is shown in table 5:

Object Dictionary	
Index	Object
0000_h	Not used.
0001_h – $001F_h$	Static data types.
0020_h – $003F_h$	Complex data types.
0040_h – $005F_h$	Manufacturer specific complex data types.
0060_h – $007F_h$	Device profile specific static data types.
0080_h – $009F_h$	Device profile specific complex data types.
$00A0_h$ – $0FFF_h$	Reserved for further use.
1000_h – $1FFF_h$	Communication profile area.
2000_h – $5FFF_h$	Manufacturer specific profile area.
6000_h – $9FFF_h$	Standardized device profile area.
$A000_h$ – $BFFF_h$	Standardized interface profile area.
$C000_h$ – $FFFF_h$	Reserved for further use.

Table 5: Object Dictionary

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

The manufacturer segment at indices 2000_h through $5FFF_h$ contains manufacturer specific objects. These objects control the special features of the Trinamic TMCM-3313 motion control device.

The standardized 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. They describe the device parameters and the device functionality of the device profile.

2.4.1 Object Indices on Multi-Axis Modules

On a multi-axis module like the TMCM-3313 each object in the manufacturer area and each object in the profile specific area is available for each motor. In this manual, only the object indices for motor #0 are shown. The objects for the other motors can be accessed by adding offsets to the object indices:

- Add an offset of $motor\_number \cdot 200_h$ to the index of a manufacturer specifc object to get its index for other motors.
- Add an offset of $motor\_number \cdot 800_h$ to the index of a profile specific object to get its index for other motors.

For example, the control word for motor #1 would be 6840_h (instead of 6040_h for motor #0), and the microstep resolution of motor #1 would be 2200_h for motor #1 (instead of 2000_h for motor #0).

Multi-Axis Object Indices		
Motor	Manufacturer area	Profile area
Motor #0	2000_h – $21FF_h$	6000_h – $67FF_h$
Motor #1	2200_h – $23FF_h$	6800_h – $6FFF_h$
Motor #2	2400_h – $25FF_h$	7000_h – $77FF_h$

Table 6: Multi-Axis Object Indices

3 Communication Area

The communication area contains all objects that define the communication parameters of the CoE device according to the EtherCAT standard.

3.1 Detailed Object Specifications

3.1.1 Object 1000_h: Device Type

This object contains information about the device type. The object 1000_h describes the type of device and its functionality. It is composed of a 16-bit field which describes the device profile that is used and a second 16-bit field which provides additional information about optional functionality of the device.

Object Description			
Index	Name	Object Type	Data Type
1000_h	Device type	Variable	UNSIGNED32

Table 7: Object Description (1000_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	UNSIGNED32	$FFFC0192_h$

Table 8: Entry Description (1000_h)

3.1.2 Object 1001_h: Error Register

This object contains error information. The CANopen device maps internal errors into object 1001_h. It is part of an emergency object.

Object Description			
Index	Name	Object Type	Data Type
1001_h	Error register	Variable	UNSIGNED8

Table 9: Object Description (1001_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	UNSIGNED8	0

Table 10: Entry Description (1001_h)

Error Register Bits	
Bit	Definition
0	Generic error
1	Current
2	Voltage
3	Temperature
4	Communication error
5	Device profile specific
6	Reserved (always 0)
7	Manufacturer specific

Table 11: Error Register Bits

3.1.3 Object 1008_h: Manufacturer Device Name

This object contains the name of the device as given by the manufacturer.

Object Description			
Index	Name	Object Type	Data Type
1008_h	Manufacturer Device Name	Variable	Visible String

Table 12: Object Description (1008_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	—	TMCM-3313

Table 13: Entry Description (1008_h)

3.1.4 Object 1009_h: Manufacturer Hardware Version

This object contains the hardware version description.

Object Description			
Index	Name	Object Type	Data Type
1009_h	Manufacturer Hardware Version	Variable	Visible String

Table 14: Object Description (1009_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	—	Depends on device, e.g. 1.0.

Table 15: Entry Description (1009_h)

3.1.5 Object $100A_h$: Manufacturer Software Version

This object contains the software version description.

Object Description			
Index	Name	Object Type	Data Type
$100A_h$	Manufacturer Software Version	Variable	Visible String

Table 16: Object Description ($100A_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	—	Depends on device, e.g. 1.0.

Table 17: Entry Description ($100A_h$)

3.1.6 Object 1018_h: Identity Object

The object 1018_h contains general information about the device:

- The vendor ID (sub-index 01_h) contains a unique value allocated to each manufacturer. The vendor ID of Trinamic is 286_h.
- The manufacturer specific product code (sub-index 2_h) identifies a specific device version.
- The manufacturer specific revision number (sub-index 3_h) consists of a major revision number and a minor revision number.

Object Description			
Index	Name	Object Type	Data Type
1018_h	Identity object	Record	Identity

Table 18: Object Description (1018_h)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
00_h	Number of entries	ro	no	0...3	3
01_h	Vendor ID	ro	no	UNSIGNED32	0286_h
02_h	Product code	ro	no	UNSIGNED32	3313
03_h	Revision number	ro	no	UNSIGNED32	e.g. 20003_h for version 2.3

Table 19: Entry Description (1018_h)

3.1.7 Object 1600_h: Receive PDO Mapping Parameter

This object contains the mapping parameters for the RPDO the device is able to receive. The sub-index 00_h contains the number of valid entries within the mapping record. This number of entries is also the number of the application variables which shall be received with the corresponding RPDO. The sub-indices from 01_h to the number of entries contain the information about the mapped application variables. These entries describe the PDO contents by their index, sub-index and length.

Object Description			
Index	Name	Object Type	Data Type
1600_h	Receive PDO mapping parameter	RECORD	PDO Mapping

Table 20: Object Description (1600_h)

Entry Description				
Sub-index	Description	Access	Value Range	Default Value
00_h	Number of mapped application objects in PDO	rw	0...9	9
01_h	Mapping entry 1	rw	UNSIGNED32	60400010_h
02_h	Mapping entry 2	rw	UNSIGNED32	$607A0020_h$
03_h	Mapping entry 3	rw	UNSIGNED32	$60FF0020_h$
04_h	Mapping entry 4	rw	UNSIGNED32	68400010_h
05_h	Mapping entry 5	rw	UNSIGNED32	$687A0020_h$
06_h	Mapping entry 6	rw	UNSIGNED32	$68FF0020_h$
07_h	Mapping entry 7	rw	UNSIGNED32	70400010_h
08_h	Mapping entry 8	rw	UNSIGNED32	$707A0020_h$
09_h	Mapping entry 9	rw	UNSIGNED32	$70FF0020_h$

Table 21: Entry Description (1600_h)

3.1.8 Objects $1A00_h$: Transmit PDO Mapping Parameter

This object contains the mapping parameters for the TPDO the device is able to transmit. The sub-index 00_h contains the number of valid entries within the mapping record. This number of entries is also the number of the application variables which shall be transmitted with the corresponding TPDO. The sub-indices from 01_h to the number of entries contain the information about the mapped application variables. These entries describe the PDO contents by their index, sub-index and length.

Object Description			
Index	Name	Object Type	Data Type
$1A00_h$	Transmit PDO mapping parameter	RECORD	PDO Mapping

Table 22: Object Description ($1A00_h$)

Entry Description				
Sub-index	Description	Access	Value Range	Default Value
00_h	Number of mapped aapli-cation objects in PDO	rw	0...9	9
01_h	Mapping entry 1	rw	UNSIGNED32	60410010_h
02_h	Mapping entry 2	rw	UNSIGNED32	60640008_h
03_h	Mapping entry 3	rw	UNSIGNED32	$606C0020_h$
04_h	Mapping entry 4	rw	UNSIGNED32	68410010_h
05_h	Mapping entry 5	rw	UNSIGNED32	68640020_h
06_h	Mapping entry 6	rw	UNSIGNED32	$686C0020_h$
07_h	Mapping entry 7	rw	UNSIGNED32	70410010_h
08_h	Mapping entry 8	rw	UNSIGNED32	70640020_h
09_h	Mapping entry 9	rw	UNSIGNED32	$706C0020_h$

Table 23: Entry Description ($1A00_h$)

3.1.9 Objects $1C00_h$: Sync Manager Communication Type

This object describes the communication types of the EtherCAT sync managers. The types of the first four synch managers are normally fixed and should not be changed. Sync managers can have the following for communication types:

Sync Manager Communication Types	
Type	Description
1	Mailbox receive
2	Mailbox send
3	Process data input
4	Process data output

Table 24: Sync Manager Communication Types

Object Description			
Index	Name	Object Type	Data Type
$1C00_h$	Sync manager communication type	RECORD	UNSIGNED8

Table 25: Object Description ($1C00_h$)

Entry Description				
Sub-index	Description	Access	Value Range	Default Value
00_h	Number of entries	rw	0...3	4
01_h	Communication type sync manager 1	rw	UNSIGNED8	1
02_h	Communication type sync manager 2	rw	UNSIGNED8	2
03_h	Communictaion type sync manager 3	rw	UNSIGNED8	3
04_h	Communictaion type sync manager 4	rw	UNSIGNED8	4

Table 26: Entry Description ($1C00_h$)

3.1.10 Objects $1C12_h$: Sync Manager 2 PDO Assignment

This object contains the index of the PDO definiton object that is assigned to sync manager 2. Normally, the RPDO objects are assigned to sync manager 2. Under most cicumstances there is no need to change this setting.

Object Description			
Index	Name	Object Type	Data Type
$1C12_h$	Sync manager 2 PDO assignment	RECORD	PDO assignment

Table 27: Object Description ($1C12_h$)

Entry Description				
Sub-index	Description	Access	Value Range	Default Value
00_h	Number of assigned PDOs	rw	0...1	1
01_h	PDO mapping index of assigned RPDO	rw	UNSIGNED16	1600_h

Table 28: Entry Description ($1C12_h$)

3.1.11 Objects $1C13_h$: Sync Manager 3 PDO Assignment

This object contains the index of the PDO definiton object that is assigned to sync manager 3. Normally, the TPDO objects are assigned to sync manager 3. Under most cicumstances there is no need to change this setting.

Object Description			
Index	Name	Object Type	Data Type
$1C13_h$	Sync manager 3 PDO assignment	RECORD	PDO assignment

Table 29: Object Description ($1C13_h$)

Entry Description				
Sub-index	Description	Access	Value Range	Default Value
00_h	Number of assigned PDOs	rw	0...1	1
01_h	PDO mapping index of assigned TPDO	rw	UNSIGNED16	$1A00_h$

Table 30: Entry Description ($1C13_h$)

4 Manufacturer Specific Area

The manufacturer segment contains manufacturer specific objects. These objects control the special features of the Trinamic Motion Control device TMCM-3313.

Info

This section of the manual only shows the object indices for motor #0. Of course the same objects are also available for the other motors. For the other motors, add an offset of $motor\_number \cdot 200_h$ to the object index. So for example the microstep resolution (object 2000_h for motor #0) can be accessed as object 2200_h for motor #1 and as object 2400_h for motor #2. Please see also section 2.4.1.

Multi-axis Object Indices	
Motor	Object Index Range
Motor #0	2000_h – $21FF_h$
Motor #1	2200_h – $23FF_h$
Motor #2	2400_h – $25FF_h$

Table 31: Multi-axis Object Indices (Manufacturer specific Area)

4.1 Objects related to CoolStep™

Figure 10 shows an overview of the CoolStep™ related objects for motor #0. Please bear in mind that the figure only shows one example for a drive. There are objects which concern the configuration of the current. Other objects are for velocity regulation and for time adjustment. The CoolStep™ feature is sometimes also called SmartEnergy.

The following adjustments have to be made:

- Thresholds for current and velocity have to be identified and set.
- The StallGuard2™ feature has to be adjusted and enabled.
- The reduction or increasing of the current in the CoolStep™ area (depending on the load) has to be configured.

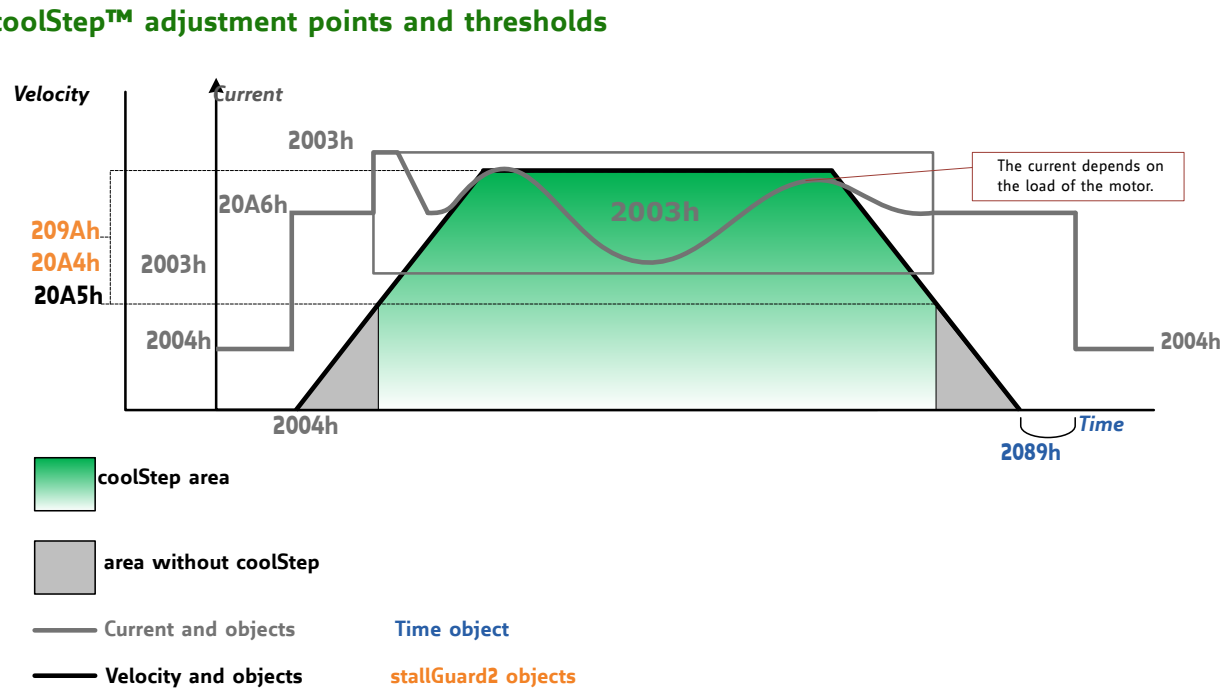


Figure 10: CoolStep Adjustment Points and Thresholds

CoolStep Adjustment Objects		
Object	Name	Description
2003_h	Absolute maximum current	The maximum value is 255. This value means 100% of the maximum current of the module. The current adjustment is within the range 0...255 and can be adjusted in 32 steps (0...255 divided by eight; step 0 = 0...7, step 1 = 8...15 and so on). The most important motor setting, since too high values might cause motor damage!
2004_h	Standby current	The current limit two seconds after the motor has stopped.
2098_h	SmartEnergy current minimum	Sets the lower motor current limit for CoolStep operation by scaling the run current (object 2003_h) value. This can be: 0: for 1/2 of the run current 1: for 1/4 of the run current
2099_h	SmartEnergy current down step	Sets the speed of current decrement when the StallGuard2 reading is above the upper threshold. 0: slow decrement 3: fast decrement
$209B_h$	SmartEnergy current up step	Sets the current increment step when the StallGuard2 below the lower threshold. 0: slow increment 3: fast increment / fast reaction to rising load
$209A_h$	SmartEnergy hysteresis	Sets the distance between the lower and the upper threshold for StallGuard2 reading. Above the upper threshold the motor current becomes decreased.
$20A4_h$	Stop on stall	Below this speed the motor will not be stopped. Above this speed the motor will stop in case StallGuard2 load value reaches zero.
$20A5_h$	SmartEnergy threshold speed.	Above this speed CoolStep becomes enabled.
2089_h	Standby delay	Standstill period before the current is changed down to standby current. The standard value is 200 which is 2 seconds.

Table 32: CoolStep related Objects

4.2 Detailed Object Specifications

4.2.1 Object 2000_h: Microstep Resolution

This object sets the microstep resolution of the drive. A value of 8 selects 256 (2^8) microsteps per full step.

Object Description			
Index	Name	Object Type	Data Type
2000_h	Microstep Resolution	Variable	UNSIGNED8

Table 33: Object Description (2000_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...8	8

Table 34: Entry Description (2000_h)

4.2.2 Object 2001_h: Fullstep Resolution

This object sets the fullstep resolution of the motor connected to the drive. Its default value is 200 because most motors are 1.8° motors.

Object Description			
Index	Name	Object Type	Data Type
2001_h	Motor full step resolution	Variable	UNSIGNED16

Table 35: Object Description (2001_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...65535	200

Table 36: Entry Description (2001_h)

4.2.3 Object 2002_h: Brake Delay Times

With this object the delay times for applying and releasing an (optional) brake can be defined. Please see also object 200Ah for an additional delay between enabling the power stage and releasing the brake. Both times are given in ms.

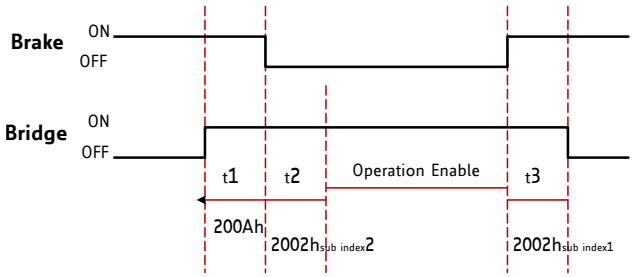


Figure 11: Brake Output Timing

Object Description			
Index	Name	Object Type	Data Type
2002_h	Brake delay times	Array	UNSIGNED16

Table 37: Object Description (2002_h)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Time between applying brake / disabling power stage	rw	no	0...65535	0
2	Time between releasing brake / switching the state machine to operational	rw	no	0..65535	0

Table 38: Entry Description (2002_h)

4.2.4 Object 2003_h: Maximum Current

This object defines the current used when the motor is moving. A value of 255 means 100% of the maximum current of the drive.

Object Description			
Index	Name	Object Type	Data Type
2003_h	Maximum current	Variable	UNSIGNED8

Table 39: Object Description (2003_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...255	128

Table 40: Entry Description (2003_h)

4.2.5 Object 2004_h: Standby Current

This object defines the current used when the motor is standing (two seconds after the last move). A value of 255 means 100% of the maximum current of the drive.

Object Description			
Index	Name	Object Type	Data Type
2004_h	Maximum current	Variable	UNSIGNED8

Table 41: Object Description (2004_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...255	8

Table 42: Entry Description (2004_h)

4.2.6 Object 2005_h: Limit Switches

This object defines which limit switches are to be used. Bit 0 stands for the left and bit 1 stands for the right limit switch. If a bit is set, the corresponding limit switch will not be used. So this object has to be set to the value 3 if limit switches are not connected. The object can only be written when the drive is in the SWITCHED_ON_DISABLED state (but is always readable).

The limit switches can also be inverted using bit 2 and bit 3:

- Bit 2 inverts the left limit switch
- Bit 3 inverts the right limit switch

The polarity of the home switch can be set using bit 5.

Object Description			
Index	Name	Object Type	Data Type
2005_h	Limit switches	Variable	UNSIGNED32

Table 43: Object Description (2005_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...63	0

Table 44: Entry Description (2005_h)

Bit Definitions	
Bit	Definition
0	Left limit switch deactivated if set.
1	Right limit switch deactivated if set.
2	Left limit switch inverted if set.
3	Right limit switch inverted if set.
4	Home switch deactivated if set.
5	Home switch inverted if set.

Table 45: Bit Definitions (2005_h)

4.2.7 Object $200A_h$: Enable Drive Delay Time

This is an additional delay time (in milliseconds) between enabling the power stage and releasing the brake. It can be used to prevent the brake from being released too early (before the hold current in the motor has been reached). Please see also object 4.2.3.

Object Description			
Index	Name	Object Type	Data Type
$200A_h$	Enable drive delay time	Variable	UNSIGNED16

Table 46: Object Description ($200A_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...65535	0

Table 47: Entry Description $(200A)_h$

4.2.8 Object $200B_h$: Encoder Parameters

This object defines encoder parameters. These are the polarity of the encoder null channel, the direction of rotaion (set it to 1 if the direction is reversed compared to the motor) and if the position is to be intialized with the encoder position. It is only writable in SWITCHED_ON_DISABLED state.

Object Description			
Index	Name	Object Type	Data Type
$200B_h$	Encoder parameters	Array	UNSIGNED8

Table 48: Object Description ($200B_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Null channel polarity	rw	no	0/1	0
2	Direction of rotation	rw	no	0/1	0
3	Initialize position	rw	no	0/1	1

Table 49: Entry Description ($200B_h$)

4.2.9 Object $200C_h$: Brake Current Feed

This object configures how much current has to be fed into the brake to apply and to release it. 0 means 0%, 255 means 100% of the maximum current (this depends on the module). In most cases it is needed to feed current into the brake to release it. Setting both values to 0 disables the automatic brake control. This object is only writable in SWITCHED_ON_DISABLED state.

Object Description			
Index	Name	Object Type	Data Type
$200C_h$	Brake current feed	Array	UNSIGNED8

Table 50: Object Description ($200C_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Apply current	rw	no	0...255	0
2	Release current	rw	no	0...255	0

Table 51: Entry Description ($200C_h$)

4.2.10 Object $200F_h$: Encoder N Channel Latch

With this object it is possible to make use of the encoder N channel latch capabilities of the motion controller used on the TMCM-3313 module. Write 1 to sub-index 1 to activate the latch functionality. When the encoder N channel has been passed, the internal position and the encoder position will automatically be stored to sub-index 2 and sub-index 3 of this object, and sub-index 1 will be reset to zero to show that the N channel event has occurred.
The encoder interface must have been configured properly in order to make this function work correctly.

Object Description			
Index	Name	Object Type	Data Type
$200F_h$	Encoder N Channel Latch	Variable	RECORD

Table 52: Object Description ($200F_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Mode	rw	no	0/1	0
2	Latched internal position	ro	no	SIGNED32	0
3	Latched encoder position	ro	no	SIGNED32	0

Table 53: Entry Description ($200F_h$)

4.2.11 Object 2010_h: Profile Start Velocity

This object contains the velocity with which a positioning ramp will be started.

Object Description			
Index	Name	Object Type	Data Type
2010_h	Profile Start Velocity	Variable	UNSIGNED32

Table 54: Object Description (2010_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...268435455	0

Table 55: Entry Description (2010_h)

4.2.12 Object 2011_h: Profile Start Acceleration

This object contains the acceleration value used for ramping up from the start velocity (object 2011_h, see section 4.2.11) to the velocity V1 (object ($_h$2012), see section 4.2.13).

Object Description			
Index	Name	Object Type	Data Type
2011_h	Profile A1	Variable	UNSIGNED32

Table 56: Object Description (2011_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...16777215	0

Table 57: Entry Description (2011_h)

4.2.13 Object 2012_h: Profile Break Velocity

This object contains the velocity used for the first segment of a positioning ramp.

Object Description			
Index	Name	Object Type	Data Type
2012_h	Profile V1	Variable	UNSIGNED32

Table 58: Object Description (2012_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...16777215	0

Table 59: Entry Description (2012_h)

4.2.14 Object 2013_h: Profile Final Deceleration

This object contains the deceleration value used for decelerating from the maximum positioning velocity to the velocity V1 (object 2012_h, see section 4.2.13).

Object Description			
Index	Name	Object Type	Data Type
2013_h	Profile D1	Variable	UNSIGNED32

Table 60: Object Description (2013_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...16777215	0

Table 61: Entry Description (2013_h)

4.2.15 Object 2014_h: Profile Stop Deceleration

This object sets the deceleration used to decelerate from the end velocity to zero velocity.

Object Description			
Index	Name	Object Type	Data Type
2014_h	Profile stop deceleration	Variable	UNSIGNED32

Table 62: Object Description (2014_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	UNSIGNED32	0

Table 63: Entry Description (2014_h)

4.2.16 Object 2015_h: Bow Scaling Factor

The bow or jerk values (object $60A4_h$) will internally be multiplied by this value so that also bow values higher than 2147483647 can be reached. This is only needed in rare cases where very steep S-shaped ramps are required. In most cases this value can be left at its default setting of 1. The bow values multiplied by this factor must not exceed $467.837 \cdot 10^9$.

Object Description			
Index	Name	Object Type	Data Type
2015_h	Ramp Wait Time	Variable	UNSIGNED8

Table 64: Object Description (2015_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	1...255	1

Table 65: Entry Description (2015_h)

4.2.17 Object 2020_h: Closed Loop Mode

Setting this object to 1 selects closed-loop mode, setting it to 0 (default value) selects open-loop mode. Before activating closed-loop mode, all necessary parameters must have been set. After activating closed-loop mode, check object 2120_h until closed loop initialization has finished (please see also section 4.2.64).

Object Description			
Index	Name	Object Type	Data Type
2020_h	Closed-loop mode	Variable	UNSIGNED8

Table 66: Object Description (2020_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	UNSIGNED8	0

Table 67: Entry Description (2020_h)

4.2.18 Object 2021_h: Correction Position P

Proportional controller P parameter for compensating a detected position deviation. Resulting P parameter is this parameter divided by 65536.

Object Description			
Index	Name	Object Type	Data Type
2021_h	Correction position P	Variable	UNSIGNED32

Table 68: Object Description (2021_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...16777215	0

Table 69: Entry Description (2021_h)

4.2.19 Object 2022_h: Maximum Correction Tolerance

This object defines the tolerance range for position deviation.

Object Description			
Index	Name	Object Type	Data Type
2022_h	Maximum correction tolerance	Variable	UNSIGNED8

Table 70: Object Description (2022_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...255	0

Table 71: Entry Description (2022_h)

4.2.20 Object 2027_h: Closed Loop Beta

This object sets the maximum commutation angle that can be used to compensate for an evaluated position deviation.

Object Description			
Index	Name	Object Type	Data Type
2027_h	Maximum correction tolerance	Variable	UNSIGNED16

Table 72: Object Description (2027_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...511	255

Table 73: Entry Description (2027_h)

4.2.21 Object 2028_h: Closed Loop Offset

Offset for closed loop operation. Automatically measured during closed loop initialization. Normally no need to change this value.

Object Description			
Index	Name	Object Type	Data Type
2028_h	Closed-loop Offset	Variable	INTEGER32

Table 74: Object Description (2028_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	-2147483648...2147483647	—

Table 75: Entry Description (2028_h)

4.2.22 Object 2029_h: Current Scaler Minimum

Minimum current setting for current regulation in closed-loop operation.

Object Description			
Index	Name	Object Type	Data Type
2029_h	Current scaler minimum	Variable	UNSIGNED8

Table 76: Object Description (2029_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...255	—

Table 77: Entry Description (2029_h)

4.2.23 Object $202A_h$: Current Scaler Maximum

Maximum current setting for current regulation in closed-loop operation.

Object Description			
Index	Name	Object Type	Data Type
$202A_h$	Current scaler maximum	Variable	UNSIGNED8

Table 78: Object Description ($202A_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...255	—

Table 79: Entry Description ($202A_h$)

4.2.24 Object $202B_h$: Correction Velocity P

This object defines the P parameter of the PI regulator which controls the maximum velocity during closed-loop regulation.

Object Description			
Index	Name	Object Type	Data Type
$202B_h$	Correction velocity P	Variable	UNSIGNED32

Table 80: Object Description ($202B_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...16777215	—

Table 81: Entry Description ($202B_h$)

4.2.25 Object $202C_h$: Correction Velocity I

This object defines the I parameter of the PI regulator which controls the maximum velocity during closed-loop regulation.

Object Description			
Index	Name	Object Type	Data Type
$202C_h$	Correction velocity I	Variable	UNSIGNED32

Table 82: Object Description ($202C_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...16777215	—

Table 83: Entry Description ($202C_h$)

4.2.26 Object $202D_h$: Correction Velocity I Clipping

This object defines the clipping of the error sum of the integral part of the PI regulator which controls the maximum velocity during closed loop regulation.

Object Description			
Index	Name	Object Type	Data Type
$202D_h$	Correction velocity I clipping	Variable	UNSIGNED16

Table 84: Object Description ($202D_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...32767	—

Table 85: Entry Description ($202D_h$)

4.2.27 Object $202E_h$: Correction Velocity DV Clock

This object defines the clock divider for the D part calculation of the regulator that controls the velocity during closed-loop regulation.

Object Description			
Index	Name	Object Type	Data Type
$202E_h$	Correction velocity DV clock	Variable	UNSIGNED16

Table 86: Object Description ($202E_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...32767	—

Table 87: Entry Description ($202E_h$)

4.2.28 Object $202F_h$: Correction Velocity DV Clipping

The maximum velocity used for position correction in closed-loop mode will be limited to the value set by this object.

Object Description			
Index	Name	Object Type	Data Type
$202F_h$	Correction velocity DV clock	Variable	UNSIGNED32

Table 88: Object Description ($202F_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	UNSIGNED32	2147483647

Table 89: Entry Description ($202F_h$)

4.2.29 Object 2030_h: Upscale Delay

Delay used when increasing the motor current during closed-loop operation.

Object Description			
Index	Name	Object Type	Data Type
2030_h	Upscale delay	Variable	UNSIGNED32

Table 90: Object Description (2030_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...16777215	—

Table 91: Entry Description (2030_h)

4.2.30 Object 2031_h: Downscale Delay

Delay used when decreasing the motor current during closed-loop operation.

Object Description			
Index	Name	Object Type	Data Type
2031_h	Downscale delay	Variable	UNSIGNED32

Table 92: Object Description (2031_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...16777215	—

Table 93: Entry Description (2031_h)

4.2.31 Object 2033_h: Actual Scaling Factor

The actual current scaling factor (output of the current scaler) can be read from this object.

Object Description			
Index	Name	Object Type	Data Type
2033_h	Actual scaling factor	Variable	UNSIGNED8

Table 94: Object Description (2033_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	0...255	–

Table 95: Entry Description (2033_h)

4.2.32 Object 2034_h: Field Weakening Minimum Velocity

Minimum speed for field weakening operation. For higher velocities the influence of the back EMF may be compensated. At this velocity the compensation will start.

Object Description			
Index	Name	Object Type	Data Type
2034_h	Filed weakening minimum velocity	Variable	UNSIGNED32

Table 96: Object Description (2034_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...16777215	—

Table 97: Entry Description (2034_h)

4.2.33 Object 2035_h: Field Weakening Maximum Velocity

Maximum speed for field weakening operation. For higher velocities the influence of the back EMF may be compensated. At the field weakening minimum velocity (section 4.2.32) plus this velocity the back EMF compensation will reach its maximum.

Object Description			
Index	Name	Object Type	Data Type
2035_h	Field weakening maximum velocity	Variable	UNSIGNED32

Table 98: Object Description (2035_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...16777215	—

Table 99: Entry Description (2035_h)

4.2.34 Object 2036_h: Field Weakening

For higher velocities the influence of the back EMF may be compensated. This is the compensation factor that will be added scaled by the current velocity and the minimum and maximum field weakening velocity.

Object Description			
Index	Name	Object Type	Data Type
2036_h	Field weakening	Variable	UNSIGNED8

Table 100: Object Description (2036_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...255	—

Table 101: Entry Description (2036_h)

4.2.35 Object $204E_h$: Boost Current

This object defines the motor current that will be used during the acceleration phase and the deceleration phase in open-loop mode. A value of 255 means 100% of the maximum motor current of the drive. When this object is set to zero the run current (section 4.2.4) will also be used for the acceleration abd deceleration phase.

Object Description			
Index	Name	Object Type	Data Type
$204E_h$	Field weakening	Variable	UNSIGNED8

Table 102: Object Description ($204E_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...255	—

Table 103: Entry Description ($204E_h$)

4.2.36 Object 2089_h: Setting Delay

This object has to be used for setting a standstill period before the current is changed down to standby current.

Unit: 10msec

Object Description			
Index	Name	Object Type	Data Type
2089_h	Setting Delay	Variable	UNSIGNED16

Table 104: Object Description (2089_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...65535	200

Table 105: Entry Description (2089_h)

4.2.37 Object $208C_h$: Velocity Dimension Index

With this object different units can be chosen:

- Writing 0 selects internal units.
- Writing 181 sets PPS for velocity and PPS/s for acceleration.

This can only be changed in SWITCHED_ON_DISABLED mode.

Object Description			
Index	Name	Object Type	Data Type
$208C_h$	Velocity Dimension Index	Variable	UNSIGNED8

Table 106: Object Description ($208C_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0/181	181

Table 107: Entry Description ($208C_h$)

4.2.38 Object $208E_h$: Acceleration Dimension Index

With this object, the unit for acceleration can be read out. The unit can be set using object $208C_h$. Object $208E_h$ reads 0 when internal units are selected and 179 when PPS/s is selected.

Object Description			
Index	Name	Object Type	Data Type
$208E_h$	Acceleration Dimension Index	Variable	UNSIGNED8

Table 108: Object Description ($208E_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	0/179	179

Table 109: Entry Description ($208E_h$)

4.2.39 Object 2092_h: Chopper Blank Time

This object serves for selecting the comparator blank time. This time needs to safely cover the switching event and the duration of the ringing on the sense resistor. For low current drivers, a setting of 1 or 2 is good. For higher current applications a setting of 2 or 3 will be required.

Object Description			
Index	Name	Object Type	Data Type
2092_h	Chopper Blank Time	Variable	UNSIGNED8

Table 110: Object Description (2092_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...3	2

Table 111: Entry Description (2092_h)

4.2.40 Object 2093_h: Chopper Mode

Select the chopper mode using this object:

- 0 – spreadCycle chopper
- 1 – classic constant off time chopper

Object Description			
Index	Name	Object Type	Data Type
2093_h	Chopper Mode	Variable	UNSIGNED8

Table 112: Object Description (2093_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0/1	0

Table 113: Entry Description (2093_h)

4.2.41 Object 2094_h: Chopper Hysteresis Decrement

This object serves for the hysteresis decrement setting. This setting determines the slope of the hysteresis during on time and during fast decay time.

- 0 – fast decrement
- 3 – very slow decrement

Object Description			
Index	Name	Object Type	Data Type
2094_h	Chopper Hysteresis Decrement	Variable	UNSIGNED8

Table 114: Object Description (2094_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...3	0

Table 115: Entry Description (2094_h)

4.2.42 Object 2095_h: Chopper Hysteresis End

This object provides the setting of the hysteresis end value after a number of decrements. The decrement interval time is controlled by object 2094_h (section 4.2.41).
Possible values are:

- -3...-1 – negative hysteresis end setting
- 0 – zero hysteresis end setting
- 1...12 – positive hysteresis end setting

Object Description			
Index	Name	Object Type	Data Type
2095_h	Chopper Hysteresis End	Variable	SIGNED8

Table 116: Object Description (2095_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	-3...12	0

Table 117: Entry Description (2095_h)

4.2.43 Object 2096_h: Chopper Hysteresis Start

This object provides the hysteresis start setting. Please notice that this value is an offset to the hysteresis end value.

Object Description			
Index	Name	Object Type	Data Type
2096_h	Chopper Hysteresis Start	Variable	UNSIGNED8

Table 118: Object Description (2096_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...8	3

Table 119: Entry Description (2096_h)

4.2.44 Object 2097_h: Chopper Off Time

The off time setting controls the minimum chopper frequency. Under normal circumstances, an off time within the range of 5µs to 20µs is used. Off time setting for constant t_{OFF} chopper: $N_{CLK} = 12 + 32 * t_{OFF}$.

Minimum is 64 clocks.
Setting this parameter to zero completely disables all driver transistors and so lets the motor free-wheel.

Object Description			
Index	Name	Object Type	Data Type
2097_h	Chopper Off Time	Variable	UNSIGNED8

Table 120: Object Description (2097_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0 / 2...15	5

Table 121: Entry Description (2097_h)

4.2.45 Object 2098_h: Smart Energy Current Minimum

This object provides the setting of the lower motor current limit for CoolStep™ operation by scaling the CS value.
Possible values are:

- 0 – $1/2$ of maximum motor current setting (section 4.2.4)
- 1 – $1/4$ of maximum motor current setting (section 4.2.4)

Object Description			
Index	Name	Object Type	Data Type
2098_h	Smart Energy Current Minimum	Variable	UNSIGNED8

Table 122: Object Description (2098_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0/1	0

Table 123: Entry Description (2098_h)

4.2.46 Object 2099_h: Smart Energy Current Down Step

This object provides the setting of the number of StallGuard2 readings above the upper threshold necessary for each current decrement of the motor current.
Possible values are:

- 0 – 32 measurements – slowest decrement
- 1 – 8 measurements

- 2 – 2 measurements
- 3 – 1 measurements – fastest decrement

Object Description			
Index	Name	Object Type	Data Type
2099_h	Smart Energy Current Down Step	Variable	UNSIGNED8

Table 124: Object Description (2099_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...3	0

Table 125: Entry Description (2099_h)

4.2.47 Object $209A_h$: Smart Energy Hysteresis

This object sets the distance between the lower and the upper threshold for StallGuard2 reading. Above the upper threshold the motor current becomes decreased.

Hysteresis: $(\text{SmartEnergy hysteresis value} + 1) * 32$
Upper StallGuard2 threshold: $(\text{SmartEnergy hysteresis start} + \text{SmartEnergy hysteresis} + 1) * 32$

Object Description			
Index	Name	Object Type	Data Type
$209A_h$	Smart Energy Hysteresis	Variable	UNSIGNED8

Table 126: Object Description ($209A_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...15	0

Table 127: Entry Description ($209A_h$)

4.2.48 Object $209B_h$: Smart Energy Current Up Step

This object sets the current increment step. The current becomes incremented for each measured StallGuard2 value below the lower threshold (see smart energy hysteresis start (object $209C_h$, section 4.2.49).
Possible values are:

- 0 – 1 step – slowest increment

- 1 – 2 steps
- 2 – 4 steps
- 3 – 8 steps – fastest increment

Object Description			
Index	Name	Object Type	Data Type
$209B_h$	Smart Energy Current Up Step	Variable	UNSIGNED8

Table 128: Object Description ($209B_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...3	0

Table 129: Entry Description ($209B_h$)

4.2.49 Object $209C_h$: Smart Energy Hysteresis Start

This object serves to set the lower threshold for the StallGuard2 value (see smart Energy current up step (section 4.2.48). Setting this to 0 disables the CoolStep™ function.

Object Description			
Index	Name	Object Type	Data Type
$209C_h$	Smart Energy Hysteresis Start	Variable	UNSIGNED8

Table 130: Object Description ($209C_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...15	0

Table 131: Entry Description ($209C_h$)

4.2.50 Object $209D_h$: Smart Energy Filter Enable

This object is used to set the StallGuard2 filter for more precision of the measurement. It reduces the measurement frequency to one measurement per four fullsteps if set.
In most cases it is expedient to set the filtered mode when using CoolStep™. Use the standard mode for step loss detection.
Possible values are:

- 0 – standard mode
- 1 – filtered mode

Object Description			
Index	Name	Object Type	Data Type
$209D_h$	Smart Energy Filter Enable	Variable	UNSIGNED8

Table 132: Object Description ($209D_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0/1	0

Table 133: Entry Description ($209D_h$)

4.2.51 Object $209E_h$: StallGuard2 Threshold

This signed value controls the StallGuard2 threshold level for stall output and sets the optimum measurement range for readout. A lower value gives a higher sensitivity. Zero is the starting value. A higher value makes StallGuard2 less sensitive and requires more torque to indicate a stall.

Object Description			
Index	Name	Object Type	Data Type
$209E_h$	StallGuard2 Threshold	Variable	SIGNED8

Table 134: Object Description ($209E_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	-63...63	0

Table 135: Entry Description ($209E_h$)

4.2.52 Object $20A1_h$: Short Protection Disable

This object is used to enable or to disable the short to ground protection. Normally there is no need to change this. Use the default value.
Possible values are:

- 0 – Short to GND protection enabled
- 1 – Short to GND protection disabled

Object Description			
Index	Name	Object Type	Data Type
$20A1_h$	Short Protection Disable	Variable	UNSIGNED8

Table 136: Object Description ($20A1_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0/1	0

Table 137: Entry Description ($20A1_h$)

4.2.53 Object $20A3_h$: Vsense

This object is used for setting the sense resistor voltage based current scaling. *Use the default value and change only when recommended by Trinamic.*
Possible settings are:

- 0 - Full scale sense resistor voltage is 1/18 VDD
- 1 - Full scale sense resistor voltage is 1/36 VDD

Object Description			
Index	Name	Object Type	Data Type
$20A3_h$	Vsense	Variable	UNSIGNED8

Table 138: Object Description ($20A3_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0/1	0

Table 139: Entry Description ($20A3_h$)

4.2.54 Object $20A4_h$: Stop on Stall

Below this speed the motor will not be stopped. Above this speed the motor will be stopped in case the StallGuard2 load value reaches zero.

Object Description			
Index	Name	Object Type	Data Type
$20A4_h$	Stop on Stall	Variable	UNSIGNED32

Table 140: Object Description ($20A4_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...2147483647	0

Table 141: Entry Description ($20A4_h$)

4.2.55 Object $20A5_h$: Smart Energy Threshold Speed

The CoolStep™ functionality will be enabled when the actual speed is above this speed. It will be disabled again when the actual speed drops below this value.

Object Description			
Index	Name	Object Type	Data Type
$20A5_h$	Smart Energy Threshold Speed	Variable	UNSIGNED32

Table 142: Object Description ($20A5_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...2147483647	0

Table 143: Entry Description ($20A5_h$)

4.2.56 Object $20B0_h$: PWM Threshold Speed

The StealthChop feature will be switched on when the value of this object is greater than zero and the actual velocity is lower than the value set by this object.

Object Description			
Index	Name	Object Type	Data Type
$20B0_h$	PWM Threshold Speed	Variable	UNSIGNED32

Table 144: Object Description ($20B0_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...16777215	0

Table 145: Entry Description ($20B0_h$)

4.2.57 Object $20B1_h$: PWM Gradient

Velocity dependent gradient for the PWM amplitude (StealthChop). Setting this value to 0 turns off StealthChop.

Object Description			
Index	Name	Object Type	Data Type
$20B1_h$	PWM Gradient	Variable	UNSIGNED8

Table 146: Object Description ($20B1_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...255	0

Table 147: Entry Description ($20B1_h$)

4.2.58 Object $20B2_h$: PWM Amplitude

Maximum PWM amplitude when switching to StealthChop mode. Do not set too low. Values above 64 are recommended.

Object Description			
Index	Name	Object Type	Data Type
$20B2_h$	PWM Amplitude	Variable	UNSIGNED8

Table 148: Object Description ($20B2_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...255	0

Table 149: Entry Description ($20B2_h$)

4.2.59 Object 2100_h: Home Offset Display

This object shows the home offset. The value is given in microsteps.

Object Description			
Index	Name	Object Type	Data Type
2100_h	Home Offset Display	Variable	SIGNED32

Table 150: Object Description (2100_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	-2147483648...2147483647	0

Table 151: Entry Description (2100_h)

4.2.60 Object 2101_h: Actual Load Value

This object shows the actual load value used for stall detection (StallGuard2™).

Object Description			
Index	Name	Object Type	Data Type
2101_h	Actual Load Value	Variable	UNSIGNED16

Table 152: Object Description (2101_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	0...1023	0

Table 153: Entry Description (2101_h)

4.2.61 Object 2102_h: Driver Error Flags

This object shows the error flags of the motor driver IC.

Error Flags		
Bit	Name	Meaning
7	OT	Overtemperature
6	OTPW	Temperature pre-warning
5	UV	Undervoltage
4	OCHS	Overcurrent high side
3	OLB	Open load on bridge B
2	OLA	Open load on bridge A
1	OCB	Overcurrent on bridge B
0	OCA	Overcurrent on bridge A

Table 154: Driver Error Flags (2102_h)

Object Description			
Index	Name	Object Type	Data Type
2102_h	Driver Error Flags	Variable	UNSIGNED8

Table 155: Object Description (2102_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	0...255	0

Table 156: Entry Description (2102_h)

4.2.62 Object 2107_h: Microstep Resolution Display

This object shows the microstep resolution, set by object 2000_h (please see section 4.2.1).

Object Description			
Index	Name	Object Type	Data Type
2107_h	Microstep resolution display	Variable	UNSIGNED8

Table 157: Object Description (2107_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	0...8	8

Table 158: Entry Description (2107_h)

4.2.63 Object $210B_h$: Step Counter

This object shows the overall number of microsteps done by this motor so far. The value can be read as a 64 bit value (sub-index 3) or split into two 32 bit values (sub-index 1 and sub-index 2).

Object Description			
Index	Name	Object Type	Data Type
$210B_h$	Step Counter	Variable	RECORD

Table 159: Object Description ($210B_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Lower 32 Bits	ro	no	0...ffffffff$_h$	0
2	Higher 32 Bits	ro	no	0...ffffffff$_h$	0
3	64 Bit Value	ro	no	0...ffffffffffffffff$_h$	0

Table 160: Entry Description (210B$_h$)

4.2.64 Object 2120$_h$: Closed Loop Initialization Flag

The closed-loop intialization flag reads 1 when closed-loop is active and the initialzation of closed-loop has finished. Otherwise this object reads 0.

Object Description			
Index	Name	Object Type	Data Type
2120$_h$	Closed Loop Intialization Flag	Variable	UNSIGNED8

Table 161: Object Description (2120$_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	0/1	—

Table 162: Entry Description (2120$_h$)

4.2.65 Object 2702$_h$: Device Digital Inputs

Bits 23...16 of this object reflect the states of the general purpose inputs of the module. The number of available inputs depends on the module type.

Bit Definitions	
Bit	Description
16	IN0
17	IN1
18	IN2
19	IN3

Table 163: Bit Definitions (2702$_h$)

Object Description			
Index	Name	Object Type	Data Type
2702_h	Device Digital Inputs	Variable	UNSIGNED32

Table 164: Object Description (2702_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	yes	–	0

Table 165: Entry Description $(2702)_h$

4.2.66 Object 2703_h: Device Digital Outputs

With this object the digital outputs (general purpose outputs) can be set. Bits 23...16 of sub index 1 switch the outputs of the module. Bits 23...16 of sub index 2 determine which outputs can be switched. The number of available digital outputs depends on the module type.

Bit Definitions	
Bit	Description
16	OUT0
17	OUT1
18	OUT2
19	OUT3

Table 166: Bit Definitions (2703_h)

Object Description			
Index	Name	Object Type	Data Type
2703_h	Device Digital Outputs	Variable	ARRAY

Table 167: Object Description (2703_h)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Physical outputs	rw	yes	UNSIGNED32	0
2	Output mask	rw	yes	UNSIGNED32	0

Table 168: Entry Description (2703_h)

Note Some outputs can also be used for automatically controlling a brake that can be connected to the module via these outputs. In order to be able to control these outputs via this object the autmatic brake control function has to be disabled. Do this by writing 0 to sub-index 1 and sub-index 2 of object $200C_h$.

4.2.67 Object $270E_h$: Device Analog Inputs

This object shows the values of the analog inputs of the device.

Object Description			
Index	Name	Object Type	Data Type
$270E_h$	Device Analog Inputs	Array	UNSIGNED32

Table 169: Object Description ($270E_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Analog input 0	ro	yes	0...65535	–
2	Analog input 1	ro	yes	0...65535	–
3	Analog input 2	ro	yes	0...65535	–
4	Analog input 3	ro	yes	0...65535	–

Table 170: Entry Description ($270E_h$)

5 Profile Specific Area

The profile segment contains CiA-402 standard motion control objects. These objects control the motion control functions of the TMCM-3313. 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. The control device writes to the modes of operation object in order to select the operation mode. The drive device provides the modes of operation display object to indicate the actual activated operation mode. Controlword, statusword, and set-points are used mode-specific. This implies the responsibility of the control device to avoid inconsistencies and erroneous behavior.
The following operating modes (selectable via object 6060_h, please see 5.1.6) are implemented on the TMCM-3313:

- Profile position mode (pp)
- Profile velocity mode (pv)
- Homing mode (hm)
- Cyclic position mode (csp)

Info

This section of the manual only shows the object indices for motor #0. Of course the same objects are also available for the other motors. For the other motors, add an offset of $motor\_number \cdot 800_h$ to the object index. So for example the control word (object 6040_h for motor #0) can be accessed as object 6840_h for motor #1 and as object 7040_h for motor #2. Please see also section 2.4.1.

Multi-axis Object Indices	
Motor	Object Index Range
Motor #0	6000_h – $67FF_h$
Motor #1	6800_h – $6FFF_h$
Motor #2	7000_h – $77FF_h$

Table 171: Multi-axis Object Indices (Profile specific Area)

5.1 Detailed Object Specifications

5.1.1 Object $605A_h$: Quick Stop Option Code

This object indicates what action is performed when the quick stop function is executed. The slow down ramp is the deceleration value of the used mode of operation. The following quick stop option codes are supported in the current version of the CANopen firmware:

Value Definition	
Value	Definition
1	Slow down on *slow down ramp* and transit into *switch on disabled*
2	Slow down on *quick stop ramp* and transit into *switch on disabled*
5	Slow down on *slow down ramp* and stay in *quick stop active*)
6	Slow down on *quick stop ramp* and stay in *quick stop active*

Table 172: Value Description ($605A_h$)

Object Description			
Index	Name	Object Type	Data Type
$605A_h$	Quick stop option code	Variable	SIGNED16

Table 173: Object Description ($605A_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	1/2/5/6	2

Table 174: Entry Description ($605A_h$)

5.1.2 Object $605B_h$: Shutdown Option Code

This object indicates what action is performed if there is a transition from *operation enabled* state to *ready to switch on state*. The shutdown option code always has the value 0 as only this is supported.

Value Definition	
Value	Definition
0	Disable drive function (switch off the power stage)

Table 175: Value Description ($605B_h$)

Object Description			
Index	Name	Object Type	Data Type
$605B_h$	Shutdown option code	Variable	UNSIGNED16

Table 176: Object Description ($605B_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0	0

Table 177: Entry Description ($605B_h$)

5.1.3 Object $605C_h$: Disable Operation Option Code

This object indicates what action is performed if there is a transition from *operation enabled* state to *switched on* state. The disable operation option code always has the value 1 as only this is supported. The slow down ramp is the deceleration value of the used mode of operation.

Value Definition	
Value	Definition
1	Slow down on slow down ramp

Table 178: Value Description ($605C_h$)

Object Description			
Index	Name	Object Type	Data Type
$605C_h$	Disable operation option code	Variable	UNSIGNED16

Table 179: Object Description ($605C_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	1	1

Table 180: Entry Description ($605C_h$)

5.1.4 Object $605D_h$: Halt Option Code

This object indicates what action is performed when the halt function is executed. The slow down ramp is the deceleration value of the used mode of operation. The halt option code always has the value 1 as only this is supported.

Value Definition	
Value	Definition
1	Slow down on slow down ramp and stay in *operation enabled*

Table 181: Value Description ($605D_h$)

Object Description			
Index	Name	Object Type	Data Type
$605D_h$	Halt option code	Variable	UNSIGNED16

Table 182: Object Description ($605D_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	1	1

Table 183: Entry Description ($605D_h$)

5.1.5 Object $605E_h$: Fault Reaction Option Code

This object indicates what action is performed when fault is detected in the power drive system. The slow down ramp is the deceleration value of the used mode of operation. The fault reaction option code always has the value 2 as only this is supported.

Value Definition	
Value	Definition
2	Slow down on quick stop ramp

Table 184: Value Description ($605E_h$)

Object Description			
Index	Name	Object Type	Data Type
$605E_h$	Fault reaction option code	Variable	UNSIGNED16

Table 185: Object Description ($605E_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	2	2

Table 186: Entry Description ($605E_h$)

5.1.6 Object 6060_h: Modes of Operation

This object indicates the requested operation mode. Supported operating modes are:

Value Definition	
Value	Mode
0	No mode
1	Profile position mode (pp)
3	Profile velocity mode (pv)
6	Homing mode (hm)
8	Cyclic synchronous position mode (csp)
9	Cyclic synchronous velocity mode (csv)
10	Cyclic synchronous torque mode (cst)

Table 187: Value Description (6060_h)

The motor will not run when the operating mode is set to 0. It will be stopped when the motor is running in one of the supported operating modes and the operating mode is then switched to 0.

Object Description			
Index	Name	Object Type	Data Type
6060_h	Modes of operation	Variable	SIGNED8

Table 188: Object Description (6060_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	refer to CiA-402	see table 187	0

Table 189: Entry Description (6060_h)

5.1.7 Object 6061_h: Modes of Operation Display

This object shows the operating mode that is currently set.

Value Definition	
Value	Mode
0	No mode
1	Profile position mode (pp)
3	Profile velocity mode (pv)
6	Homing mode (hm)
8	Cyclic synchronous position mode (csp)
9	Cyclic synchronous velocity mode (csv)
10	Cyclic synchronous torque mode (cst)

Table 190: Value Description (6061_h)

The motor will not run when the operating mode is set to 0. It will be stopped when the motor is running in one of the supported operating modes and the operating mode is then switched to 0.

Object Description			
Index	Name	Object Type	Data Type
6061_h	Modes of operation display	Variable	SIGNED8

Table 191: Object Description (6061_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	refer to CiA-402	see table 190	0

Table 192: Entry Description (6061_h)

5.1.8 Object $606A_h$: Sensor Selection Code

This object provides the source of the position sensor actual value. It selects whether an encoder is to be used or not.

Value Definition	
Value	Mode
0	Encoder used
-1	No encoder

Table 193: Value Description ($606A_h$)

Object Description			
Index	Name	Object Type	Data Type
$606A_h$	Sensor selection code	Variable	SIGNED16

Table 194: Object Description ($606A_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0/-1	-1

Table 195: Entry Description ($606A_h$)

5.1.9 Object $608F_h$: Position Encoder Resolution

This object defines the resolution of the encoder. The position encoder resolution is calculated by the following formula:

$$position\ encoder\ resolution = \frac{encoder\ increments}{motor\ revolutions}$$

All values are dimensionless.

Object Description			
Index	Name	Object Type	Data Type
$608F_h$	Position Encoder Resolution	Array	UNSIGNED32

Table 196: Object Description ($608F_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
0	Highest sub-index supported	ro	no	2	2
1	Encoder increments	rw	no	0...2147483647	1
2	Motor revolutions	ro	no	1	1

Table 197: Entry Description ($608F_h$)

5.1.10 Object $60FD_h$: Digital Inputs

This object contains the states of the digital inputs of the module. Starting from bit 0, every bit reflects the state of one digital input. The number of valid bits depends on the number of digital inputs on the module used.

Object Description			
Index	Name	Object Type	Data Type
$60FD_h$	Digital inputs	Variable	UNSIGNED32

Table 198: Object Description ($60FD_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	mappable	UNSIGNED32	0

Table 199: Entry Description ($60FD_h$)

5.1.11 Object 6502_h: Supported Drive Modes

This object provides information on the supported drive modes. A bit that is set means that the mode is supported, a bit that is not set means that the mode is not supported by the drive.

Value Definition	
Bit	Mode
0	Profile position mode (pp)
1	Velocity mode (vl)
2	Profile velocity mode (pv)
3	Torque mode (tq)
4	Reserved
5	Homing mode (hm)
6	Interpolated position mode (ip)
7	Cyclic synchronous position mode (csp)
8	Cyclic synchronous velocity mode (csv)
9	Cyclic synchronous torque mode (cst)

Table 200: Value Definition (6502_h)

Object Description			
Index	Name	Object Type	Data Type
6502_h	Supported drive modes	Variable	UNSIGNED32

Table 201: Object Description (6502_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	UNSIGNED32	Depends on supported modes.

Table 202: Entry Description (6502_h)

6 Profile Position Mode

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.

Please refer to object 6060_h (section 5.1.6) for information about how to choose an operation mode. Object 6061_h (section 5.1.7) shows the operation mode that is set.

6.1 Detailed Object Specifications

The following text offers detailed object specifications. For a better understanding, it is necessary to see how the state machine works.

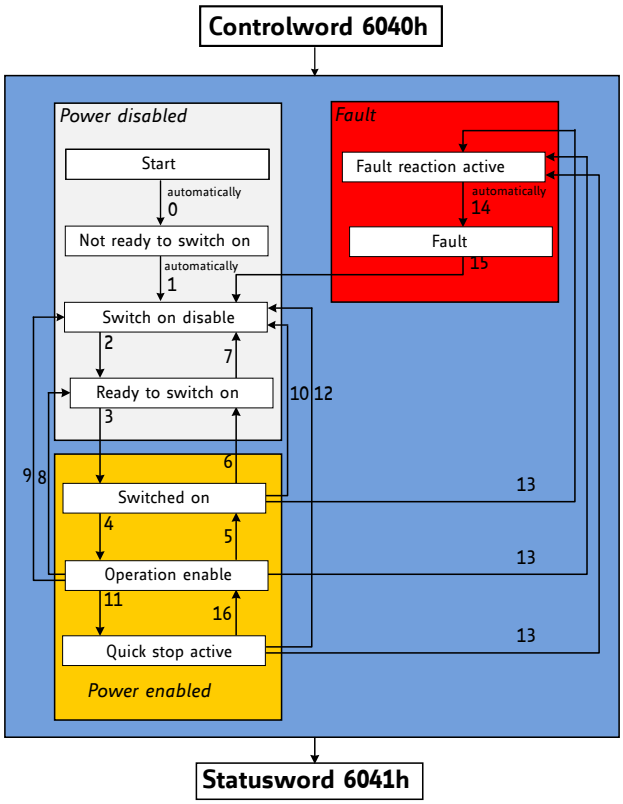


Figure 12: DS402 Finite State Machine

Notes on state transitions:

- Commands directing a change in state are processed completely and the new state achieved before additional state change commands are processed.
- Transitions 0 and 1 occur automatically at drive power-on or reset. Transition 14 occurs automatically, too. All other state changes must be directed by the host.
- Drive function disabled indicates that no current is being supplied to the motor.
- Drive function enabled indicates that current is available for the motor and profile position and profile velocity reference values may be processed.

6.1.1 Object 6040_h: Control Word

This object indicates the received command controlling the power drive system finite state automaton (PDS FSA). The CiA-402 state machine can be controlled using this object. Please refer to figure 12 for detailed information.

Structure of the Control Word											
15	11	10	9	8	7	6	4	3	2	1	0
nu		r	oms	h	fr	oms		eo	qs	ev	so
MSB											LSB

Legend: nu=not used; r=reserved; oms=operation mode specific; h=halt; fr=fault reset; eo=enable operation; qs=quick stop; ev=enable voltage; so=switch on.

Table 203: Structure of the Control Word in pp Mode

Operation Mode specific Bits in pp Mode		
Bit	Name	Definition
4	New set point	0-to-1: the next positioning will be started.
5	Change immediately	Not supported.
6	Absolute / relative	0: New position is absolute. 1: New position is relative.
9	Change set point	Not supported.

Table 204: Operation Mode specific Bits in pp Mode

Command Coding						
Command	Bits of Control Word					Transitions
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	x	1	1	0	2,6,8
Switch on	0	0	1	1	1	3
Switch on & enable operation	0	1	1	1	1	3, 4
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	0-to-1	x	x	x	x	15

Table 205: Command Coding

Object Description			
Index	Name	Object Type	Data Type
6040_h	Controlword	Variable	UNSIGNED16

Table 206: Object Description (6040_h in pp Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	See command coding above.	

Table 207: Entry Description (6040_h in pp Mode)

6.1.2 Object 6041_h: Status Word

This object provides the status of the PDS FSA. It reflects the status of the CiA-402 state machine. Please refer to figure 12 for detailed information. The object is structured as defined below.
For more information about the coding please refer to the CANopen Drives and motion control device profile, part 2.

Structure of the Status Word															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
dir	mot	oms		ila	tr	rm	ms	w	sod	qs	ve	f	oe	so	rtso
MSB															LSB

Legend: nu=not used; r=reserved; oms=operation mode specific; h=halt; fr=fault reset; oe=operation enable; qs=quick stop; ve=voltage enable; so=switch on.

Table 208: Structure of the Staus Word in pp Mode

Trinamic Specific Bits		
Bit	Name	Definition
14	Motor activity	0: Motor stands still. 1: Motor rotates.
15	Direction of rotation	This bit shows the direction of rotation.

Table 209: Trinamic Specific Bits

Operation Mode specific Bits in pp Mode		
Bit	Name	Definition
10	Target reached	Set when the motor is within the position window.
12	Set point acknowledged	0: Set point processed. 1: Set point still in process.
13	Following error	Not supported.

Table 210: Operation Mode specific Bits in pp Mode

State Coding	
Status word	FSA state
xxxx xxxx x0xx 0000_h	Not ready to switch on
xxxx xxxx x1xx 0000_h	Switch on disabled
xxxx xxxx x01x 0001_h	Ready to switch on
xxxx xxxx x01x 0011_h	Switched on
xxxx xxxx x01x 0111_h	Operation enabled
xxxx xxxx x00x 0111_h	Quick stop active
xxxx xxxx x0xx 1111_h	Fault reaction active
xxxx xxxx x0xx 1000_h	Fault

Table 211: State Coding

Object Description			
Index	Name	Object Type	Data Type
6041_h	Controlword	Variable	UNSIGNED16

Table 212: Object Description (6041_h in pp Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	See state coding above.	

Table 213: Entry Description (6041_h in pp Mode)

6.1.3 Object 6062_h: Position Demand Value

This object provides the demanded position value. The value is given in microsteps. Object 6062_h indicates the actual position that the motor should have. It is not to be confused with objects 6063_h and 6064_h.

Object Description			
Index	Name	Object Type	Data Type
6062_h	Position Demand Value	Variable	SIGNED32

Table 214: Object Description (6062_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 215: Entry Description (6062_h)

6.1.4 Object 6063_h: Position Actual Internal Value

This object provides the actual value of the encoder or the motor. Please use the sensor selection object $606A_h$ (see section 5.1.8) for selecting the motor or the encoder first. Object 6063_h indicates the actual position of the encoder or the motor, re-scaled to the microstep resolution. The value is given in microsteps.

Object Description			
Index	Name	Object Type	Data Type
6063_h	Position Actual Internal Value	Variable	SIGNED32

Table 216: Object Description (6063_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 217: Entry Description (6063_h)

6.1.5 Object 6064_h: Position Actual Value

This object provides the actual value of the position measurement device. It always contains the same value as object 6063_h.

Object Description			
Index	Name	Object Type	Data Type
6064_h	Position Actual Value	Variable	SIGNED32

Table 218: Object Description (6064_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 219: Entry Description (6064_h)

6.1.6 Object 6065_h: Following Error Window

This object indicates the configured range of tolerated position values symmetrically to the position demand value. If the position actual value is out of the following error window, a following error occurs. A following error may occur when a drive is blocked, unreachable profile velocity occurs, or at wrong closed-loop coefficients. The value shall be given in microsteps.

When the difference between motor position (object 6062_h) and encoder position (object 6063_h or 6064_h) is greater than the value set here, the motor will be stopped and an emergency message will be sent. Setting this object to zero will turn off this feature completely.

Note Setting this object to a too low value will lead to false alarms.

Object Description			
Index	Name	Object Type	Data Type
6065_h	Following Error Window	Variable	UNSIGNED32

Table 220: Object Description (6065_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...2147483647	0

Table 221: Entry Description (6065_h)

6.1.7 Object 6067_h: Position Window

This object indicates the configured symmetrical range of accepted positions relative to the target position. If the actual value of the position encoder is within the position window, this target position is regarded as having been reached. The value is given in increments. If the value of the position window is $FFFFFFFF_h$, the position window control is switched off. If this object is set to zero, the target reached event will be signaled when the demand position (6062_h) has reached the target position (6064_h). When the position window is set to a value greater than zero, the target reached event will be signaled when the actual encoder position value (6064_h) is within $(target\_position - position\_window)$ and $(target\_position + position\_window)$.

Object Description			
Index	Name	Object Type	Data Type
6067_h	Position Window	Variable	UNSIGNED32

Table 222: Object Description (6067_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	UNSIGNED32	$FFFFFFFF_h$

Table 223: Entry Description (6067_h)

6.1.8 Object 6068_h: Position Window Time

This object indicates the configured time, during which the actual position within the position window is measured. The value is given in ms. If this object is set to a value greater than zero and also the position window (6067_h) is set to a value greater than zero the target reached event will not be signaled until the actual position (6064_h) is at least as many milliseconds within the position window as defined by this object.

Object Description			
Index	Name	Object Type	Data Type
6068_h	Position Window Time	Variable	UNSIGNED16

Table 224: Object Description (6068_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	UNSIGNED16	0

Table 225: Entry Description (6068_h)

6.1.9 Object $606C_h$: Velocity Actual Value

This object shows the actual velocity value of the motor. The value is given in internal or user-defined velocity units (depending on object $208C_h$, described in section 4.2.37).

Object Description			
Index	Name	Object Type	Data Type
$606C_h$	Velocity Actual Value	Variable	SIGNED32

Table 226: Object Description ($606C_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 227: Entry Description ($606C_h$)

6.1.10 Object $607A_h$: Target Position

The target position is the position that the drive should move to in profile position mode using the current settings of motion control parameters (such as velocity, acceleration, deceleration, motion profile type etc.). The value of this object is interpreted as absolute or relative depending on the abs/rel flag in the controlword. It is given in microsteps.

Object Description			
Index	Name	Object Type	Data Type
$607A_h$	Target Position	Variable	SIGNED32

Table 228: Object Description ($607A_h$ in pp Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	Refer to CiA402-3	SIGNED32	0

Table 229: Entry Description ($607A_h$ in pp Mode)

6.1.11 Object $607D_h$: Software Position Limit

This object indicates the configured maximal and minimal software position limits. These parameters define the absolute position limits for the position demand value and the position actual value. Every new target position is checked against these limits. The limit positions are always relative to the machine home position. Before being compared with the target position, they are corrected internally by the home offset as follows:

$$Corrected\_min\_position\_limit = min\_position\_limit - home\_offset$$
$$Corrected\_max\_position\_limit = max\_position\_limit - home\_offset$$

Object Description			
Index	Name	Object Type	Data Type
$607D_h$	Software Position Limit	Array	SIGNED32

Table 230: Object Description ($607D_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Mininmum Position Limit	rw	no	SIGNED32	-2147483648
2	Maximum Position Limit	rw	no	SIGNED32	2147483647

Table 231: Entry Description ($607D_h$)

6.1.12 Object 6081_h: Profile Velocity

This object indicates the configured velocity normally attained at the end of the acceleration ramp during a profiled motion and is valid for both directions of motion. The profile velocity is the maximum velocity used when driving to a new position. It is given in internal or user specific units (depending on object $208C_h$, section 4.2.37).

Object Description			
Index	Name	Object Type	Data Type
6081_h	Profile Velocity	Variable	SIGNED32

Table 232: Object Description (6081_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	SIGNED32	0

Table 233: Entry Description (6081_h)

6.1.13 Object 6082_h: End Velocity

This object indicates the configured velocity normally attained at the end of the deceleration ramp during a profiled motion and is valid for both directions of motion. The end velocity is the velocity used when reaching the new position. It is given in internal or user specific units (depending on object $208C_h$, section 4.2.37).

Object Description			
Index	Name	Object Type	Data Type
6082_h	End Velocity	Variable	SIGNED32

Table 234: Object Description (6082_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	SIGNED32	0

Table 235: Entry Description (6082_h)

6.1.14 Object 6083_h: Profile Acceleration

This object indicates the configured acceleration. Object 6083_h sets the maximum acceleration to be used in profile positioning and in profile velocity mode.
The units for object 6083_h can be choosen with object $208E_h$, described in section 4.2.38.

Object Description			
Index	Name	Object Type	Data Type
6083_h	Profile Acceleration	Variable	SIGNED32

Table 236: Object Description (6083_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	SIGNED32	0

Table 237: Entry Description (6083_h)

6.1.15 Object 6084_h: Profile Deceleration

This object indicates the configured deceleration. Object 6084_h sets the maximum deceleration to be used in profile positioning mode and in profile velocizy mode.
The units for object 6084_h can be choosen with object $208E_h$, described in section 4.2.38.

Object Description			
Index	Name	Object Type	Data Type
6084_h	Profile Deceleration	Variable	SIGNED32

Table 238: Object Description (6084_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	SIGNED32	0

Table 239: Entry Description (6084_h)

6.1.16 Object 6085_h: Quick Stop Deceleration

This object indicates the configured deceleration used to stop the motor when the quick stop function is activated and the quick stop code object $605A_h$ is set to 2 (or 6). The value is given in the same unit as profile acceleration object 6083_h.

Object Description			
Index	Name	Object Type	Data Type
6085_h	Quick stop deceleration	Variable	UNSIGNED32

Table 240: Object Description (6085_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	UNSIGNED32	51200

Table 241: Entry Description (6085_h)

6.1.17 Object 6086_h: Motion Profile Type

This object indicates the configured type of motion profile used to perform a profiled motion. Set this object to 0 to select trapezoid ramps or to 1 for S-shaped ramps.

Value Definition	
Value	Definition
0	Linear (six-point) ramp, trapezoidal profile
1	S-shaped ramp, defined by object $60A4_h$ (section 6.1.18)

Table 242: Value Definitions of Object 6086_h

Object Description			
Index	Name	Object Type	Data Type
6086_h	Motion profile type	Variable	UNSIGNED16

Table 243: Object Description (6086_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0/1	0

Table 244: Entry Description (6086_h)

6.1.18 Object $60A4_h$: Profile Jerk

This object indicates the configured set of jerk parameters that shall be used during the profile movement. The bow of S-shaped ramps is set here. Object $60A4_h$ can only be used when S-shaped ramps are selected by setting object 6086_h (section 6.1.17) to 1.

Note The TMC4361 motion controller used on the TMCM-3313 module also offers bow values higher than the 32 bit range. Under most circumstances, the normal 32 bit value range is sufficient. Use object 2015_h if higher values are required.

Object Description			
Index	Name	Object Type	Data Type
$60A4_h$	Profile Jerk	Array	UNSIGNED32

Table 245: Object Description ($60A4_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
0	Highest sub-index supported	ro	no	4	4
1	Profile jerk 1	rw	no	0...2147483647	0
2	Profile jerk 2	rw	no	0...2147483647	0
3	Profile jerk 3	rw	no	0...2147483647	0
4	Profile jerk 4	rw	no	0...2147483647	0

Table 246: Entry Description ($60A4_h$)

6.1.19 Object $60F2_h$: Positioning Option Code

This object indicates the positioning behaviour in profile position mode. Only bits 0 and 1 (relative option) are supported.

Bit Definitions		
Bit 1	Bit 0	Definition
0	0	Positioning moves shall be performed relative to the preceding (internal absolute) target position.
0	1	Positioning moves shall be performed relative to the actual position demand value (object 6063_h).
1	0	Positioning moves shall be performed relative to the position actual value (object 6064_h).
1	1	reserved

Table 247: Bit Definitions of Object $60F2_h$

Object Description			
Index	Name	Object Type	Data Type
$60F2_h$	Positioning option code	Variable	UNSIGNED16

Table 248: Object Description ($60F2_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	UNSIGNED16	0

Table 249: Entry Description ($60F2_h$)

6.2 How to move a Motor in pp Mode

Here is a little example that shows how to get a motor running in pp mode. In this little example we assume that the module has been reset (and then switched to pre-operational or operational) by NMT commands before. Please note that the values are decimal.

- If you do not have any limit switches connected, first disable the limit switch inputs by writing 3 to object 2005_h.
- Select pp mode by writing 1 to object 6060_h.
- Write 6 to object 6040_h to switch to READY_TO_SWITCH_ON state.
- Write 7 to object 6040_h to switch to SWITCHED_ON state.
- Write 15 to object 6040_h to switch to OPERATION_ENABLED state.
- Write the desired target position (e.g. 500000) to object $607A_h$.
- Mark the new target position as active by writing 31 to object 6040_h. The motor starts moving now.
- Reset the activation by writing 15 to object 6040_h (this can be done while the motor is still moving).

7 Profile Velocity Mode

The profile velocity mode is used to control the velocity of the drive without a special regard of the position. It contains limit functions and trajectory generation.

The profile velocity mode covers the following sub-functions:

- Demand value input via trajectory generator.
- 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 include:

- Profile velocity
- Profile acceleration
- Profile deceleration
- Emergency stop
- Motion profile type

7.1 Detailed Object Specifications

7.1.1 Object 6040_h: Control Word

This object indicates the received command controlling the power drive system finite state automaton (PDS FSA). The CiA-402 state machine can be controlled using this object. Please refer to figure 12 for detailed information.

In pv mode the control word does not contain any operation mode specific bits.

Structure of the Control Word											
15	11	10	9	8	7	6	4	3	2	1	0
nu		r	r	h	fr	r		eo	qs	ev	so
MSB											LSB

Legend: nu=not used; r=reserved; h=halt; fr=fault reset; eo=enable operation; qs=quick stop; ev=enable voltage; so=switch on.

Table 250: Structure of the Control Word in pv Mode

Command Coding						
Command	Bits of Control Word					Transitions
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	x	1	1	0	2,6,8
Switch on	0	0	1	1	1	3
Switch on & enable operation	0	1	1	1	1	3, 4
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	0-to-1	x	x	x	x	15

Table 251: Command Coding

Object Description			
Index	Name	Object Type	Data Type
6040_h	Controlword	Variable	UNSIGNED16

Table 252: Object Description (6040_h in pv Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	See command coding above.	

Table 253: Entry Description (6040_h in pv Mode)

7.1.2 Object 6041_h: Status Word

This object provides the status of the PDS FSA. It reflects the status of the CiA-402 state machine. Please refer to figure 12 for detailed information. The object is structured as defined below.
For more information about the coding please refer to the CANopen Drives and motion control device profile, part 2.

Structure of the Status Word															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
dir	mot	oms		ila	tr	rm	ms	w	sod	qs	ve	f	oe	so	rtso
MSB															LSB

Legend: nu=not used; r=reserved; oms=operation mode specific; h=halt; fr=fault reset; oe=operation enable; qs=quick stop; ve=voltage enable; so=switch on.

Table 254: Structure of the Status Word in pv Mode

Trinamic Specific Bits		
Bit	Name	Definition
14	Motor activity	0: Motor stands still. 1: Motor rotates.
15	Direction of rotation	This bit shows the direction of rotation.

Table 255: Trinamic Specific Bits

Operation Mode specific Bits in pv Mode		
Bit	Name	Definition
10	Target reached	Indicates that the target speed has been reached.
12	Speed	Not supported.
13	Max. slippage error	Not supported.

Table 256: Operation Mode specific Bits in pv Mode

State Coding	
Status word	FSA state
xxxx xxxx x0xx 0000_h	Not ready to switch on
xxxx xxxx x1xx 0000_h	Switch on disabled
xxxx xxxx x01x 0001_h	Ready to switch on
xxxx xxxx x01x 0011_h	Switched on
xxxx xxxx x01x 0111_h	Operation enabled
xxxx xxxx x00x 0111_h	Quick stop active
xxxx xxxx x0xx 1111_h	Fault reaction active
xxxx xxxx x0xx 1000_h	Fault

Table 257: State Coding

Object Description			
Index	Name	Object Type	Data Type
6041_h	Controlword	Variable	UNSIGNED16

Table 258: Object Description (6041_h in pv Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	See state coding above	

Table 259: Entry Description (6041_h in pv Mode)

7.1.3 Object 6062_h: Position Demand Value

This object provides the demanded position value. The value is given in microsteps. Object 6062_h indicates the actual position that the motor should have. It is not to be confused with objects 6063_h and 6064_h.

Object Description			
Index	Name	Object Type	Data Type
6062_h	Position Demand Value	Variable	SIGNED32

Table 260: Object Description (6062_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 261: Entry Description (6062_h)

7.1.4 Object 6063_h: Position Actual Internal Value

This object provides the actual value of the encoder or the motor. Please use the sensor selection object $606A_h$ (see section 5.1.8) for selecting the motor or the encoder first. Object 6063_h indicates the actual position of the encoder or the motor, re-scaled to the microstep resolution. The value is given in microsteps.

Object Description			
Index	Name	Object Type	Data Type
6063_h	Position Actual Internal Value	Variable	SIGNED32

Table 262: Object Description (6063_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 263: Entry Description (6063_h)

7.1.5 Object 6064_h: Position Actual Value

This object provides the actual value of the position measurement device. It always contains the same value as object 6063_h.

Object Description			
Index	Name	Object Type	Data Type
6064_h	Position Actual Value	Variable	SIGNED32

Table 264: Object Description (6064_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 265: Entry Description (6064_h)

7.1.6 Object 6065_h: Following Error Window

This object indicates the configured range of tolerated position values symmetrically to the position demand value. If the position actual value is out of the following error window, a following error occurs. A following error may occur when a drive is blocked, unreachable profile velocity occurs, or at wrong closed-loop coefficients. The value shall be given in microsteps.

When the difference between motor position (object 6062_h) and encoder position (object 6063_h or 6064_h) is greater than the value set here, the motor will be stopped and an emergency message will be sent. Setting this object to zero will turn off this feature completely.

Note Setting this object to a too low value will lead to false alarms.

Object Description			
Index	Name	Object Type	Data Type
6065_h	Following Error Window	Variable	UNSIGNED32

Table 266: Object Description (6065_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0...2147483647	0

Table 267: Entry Description (6065_h)

7.1.7 Object 606C$_h$: Velocity Actual Value

This object shows the actual velocity value of the motor. The value is given in internal or user-defined velocity units (depending on object 208C$_h$, described in section 4.2.37).

Object Description			
Index	Name	Object Type	Data Type
606C$_h$	Velocity Actual Value	Variable	SIGNED32

Table 268: Object Description (606C$_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 269: Entry Description (606C$_h$)

7.1.8 Object 607D$_h$: Software Position Limit

This object indicates the configured maximal and minimal software position limits. These parameters define the absolute position limits for the position demand value and the position actual value. Every new target position is checked against these limits. The limit positions are always relative to the machine home position. Before being compared with the target position, they are corrected internally by the home offset as follows:

$$Corrected\_min\_position\_limit = min\_position\_limit - home\_offset$$
$$Corrected\_max\_position\_limit = max\_position\_limit - home\_offset$$

Object Description			
Index	Name	Object Type	Data Type
607D$_h$	Software Position Limit	Array	SIGNED32

Table 270: Object Description (607D$_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Mininmum Position Limit	rw	no	SIGNED32	-2147483648
2	Maximum Position Limit	rw	no	SIGNED32	2147483647

Table 271: Entry Description (607D$_h$)

7.1.9 Object 6083_h: Profile Acceleration

This object indicates the configured acceleration. Object 6083_h sets the maximum acceleration to be used in profile positioning and in profile velocity mode.
The units for object 6083_h can be choosen with object $208E_h$, described in section 4.2.38.

Object Description			
Index	Name	Object Type	Data Type
6083_h	Profile Acceleration	Variable	SIGNED32

Table 272: Object Description (6083_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	SIGNED32	0

Table 273: Entry Description (6083_h)

7.1.10 Object 6084_h: Profile Deceleration

This object indicates the configured deceleration. Object 6084_h sets the maximum deceleration to be used in profile positioning mode and in profile velocizy mode.
The units for object 6084_h can be choosen with object $208E_h$, described in section 4.2.38.

Object Description			
Index	Name	Object Type	Data Type
6084_h	Profile Deceleration	Variable	SIGNED32

Table 274: Object Description (6084_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	SIGNED32	0

Table 275: Entry Description (6084_h)

7.1.11 Object 6085_h: Quick Stop Deceleration

This object indicates the configured deceleration used to stop the motor when the quick stop function is activated and the quick stop code object $605A_h$ is set to 2 (or 6). The value is given in the same unit as profile acceleration object 6083_h.

Object Description			
Index	Name	Object Type	Data Type
6085_h	Quick stop deceleration	Variable	UNSIGNED32

Table 276: Object Description (6085_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	UNSIGNED32	51200

Table 277: Entry Description (6085_h)

7.1.12 Object 6086_h: Motion Profile Type

This object indicates the configured type of motion profile used to perform a profiled motion. Set this object to 0 to select trapezoid ramps or to 1 for S-shaped ramps.

Value Definition	
Value	Definition
0	Linear (six-point) ramp, trapezoidal profile
1	S-shaped ramp, defined by object $60A4_h$ (section 7.1.13)

Table 278: Value Definitions of Object 6086_h

Object Description			
Index	Name	Object Type	Data Type
6086_h	Motion profile type	Variable	UNSIGNED16

Table 279: Object Description (6086_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0/1	0

Table 280: Entry Description (6086_h)

7.1.13 Object $60A4_h$: Profile Jerk

This object indicates the configured set of jerk parameters that shall be used during the profile movement. The bow of S-shaped ramps is set here. Object $60A4_h$ can only be used when S-shaped ramps are selected by setting object 6086_h (section 7.1.12) to 1.

Note The TMC4361 motion controller used on the TMCM-3313 module also offers bow values higher than the 32 bit range. Under most circumstances, the normal 32 bit value range is sufficient. Use object 2015_h if higher values are required.

Object Description			
Index	Name	Object Type	Data Type
$60A4_h$	Profile Jerk	Array	UNSIGNED32

Table 281: Object Description ($60A4_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
0	Highest sub-index supported	ro	no	4	4
1	Profile jerk 1	rw	no	0...2147483647	0
2	Profile jerk 2	rw	no	0...2147483647	0
3	Profile jerk 3	rw	no	0...2147483647	0
4	Profile jerk 4	rw	no	0...2147483647	0

Table 282: Entry Description ($60A4_h$)

7.1.14 Object $60FF_h$: Target Velocity

This object indicates the configured target velocity and is used as input for the trajectory generator. Object $60FF_h$ sets the target velocity when using profile velocity mode. The drive then accelerates or decelerates to that velocity using the acceleration and deceleration set by objects 6083_h and 6084_h. The values are given in units which can be selected with object $208C_h$, described in section 4.2.37.

Object Description			
Index	Name	Object Type	Data Type
$60FF_h$	Target Velocity	Variable	SIGNED32

Table 283: Object Description ($60FF_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	SIGNED32	0

Table 284: Entry Description ($60FF_h$)

7.2 How to move a Motor in pv Mode

Here is a little example that shows how to get a motor running in pv mode. In this little example we assume that the module has been reset (and then switched to pre-operational or operational) by NMT commands before.

- If you do not have any limit switches connected, first disable the limit switch inputs by writing 3 to object 2005_h.
- Select pv mode by writing 3 to object 6060_h.
- Write 6 to object 6040_h to switch to READY_TO_SWITCH_ON state.
- Write 7 to object 6040_h to switch to SWITCHED_ON state.
- Write 15 to object 6040_h to switch to OPERATION_ENABLED state.
- Write the desired target speed (e.g. 100000) to object $60FF_h$. The motor now accelerates to that speed.
- Stop the motor by writing 0 to object $60FF_h$.

8 Homing Mode

This chapter describes the method by which a drive seeks the home position (reference point). There are various methods of achieving this using limit switches at the ends of travel or a home switch in mid-travel. Some methods also use the index (zero) pulse train from an incremental encoder. The user may specify the speeds, acceleration and the method of homing.

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.

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

Figure 13 shows the defined input objects as well as the output objects. The user can specify the speeds, acceleration and method of homing. The home offset object $607C_h$ allows displacing the zero in point the coordinate system for the home position.

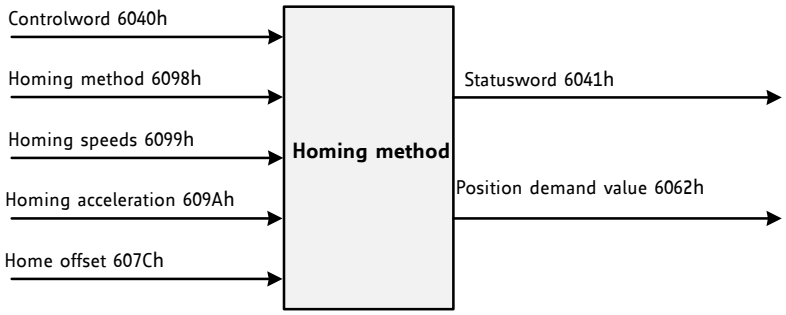


Figure 13: Homing Mode Function

Choosing a homing mode determines the following things:

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

The home position and the zero position are offset by the home offset (see object $607C_h$, section 8.2.4).

Depending on the module there are different sources of homing methods available:

- Negative and positive limit switches.
- Home switch.
- Index pulse of an encoder.

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.

8.1 Homing Methods

The TMCM-3313 supports a subset of different standard CANopen homing methods. The homing method that is to be used can be choosen via object 6098_h (section 8.2.5).

Supported Homing Methods	
Method	Description
0	No homing (default value for object 6098_h).
1	Search the left end switch, then search the next encoder index pulse.
2	Search the right end switch, then search the next encoder index pulse.
3	Search the positive edge of the home switch, then search the next encoder index pulse.
5	Search the negative edge of the home switch, then search the next encoder index pulse.
17	Search the left end switch.
18	Search the right end switch.
19	Search the positive edge of the home switch.
21	Search the negative edge of the home switch.
33	Search next index pulse in negative direction.
34	Search next index pulse in positive direction.
35	The actual position is used as home position. All position values (objects 6062h, 6063h, and 6064h) are set to zero, but the motor will not move.

Table 285: Supported CANopen Homing Methods

When using homing methods that need end switch inputs or home switch inputs please take care of their configuration (object 2005_h, section 4.2.6).

8.1.1 Homing Method 1: Homing on negative Limit Switch and Index Pulse

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

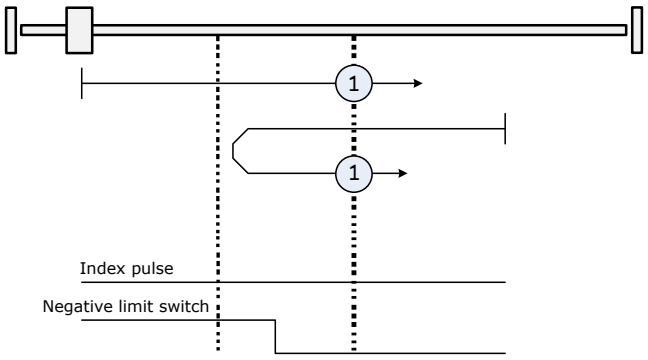


Figure 14: Homing Method 1

8.1.2 Homing Method 2: Homing on positive Limit Switch and Index Pulse

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

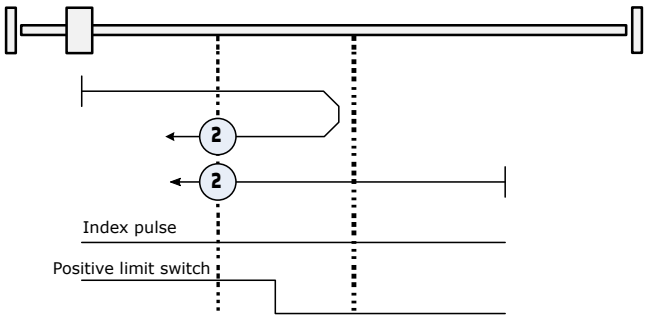


Figure 15: Homing Method 2

8.1.3 Homing Method 3: Homing on positive Home Switch and Index Pulse

Using this method, the initial direction of movement shall be dependent on the state of the home switch. The home position shall be 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 situated so that the direction of movement shall reverse during homing, the point at which the reversal takes place is anywhere after a change of state of the home switch.

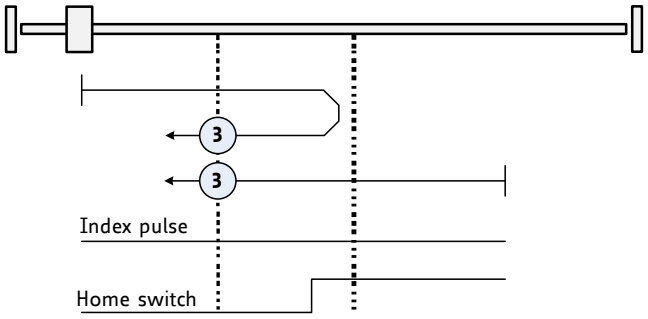


Figure 16: Homing Method 3

8.1.4 Homing Method 5: Homing on negative Home Switch and Index Pulse

Using this method, the initial direction of movement shall be dependent on the state of the home switch. The home position shall be 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 situated so that the direction of movement shall reverse during homing, the point at which the reversal takes place is anywhere after a change of state of the home switch.

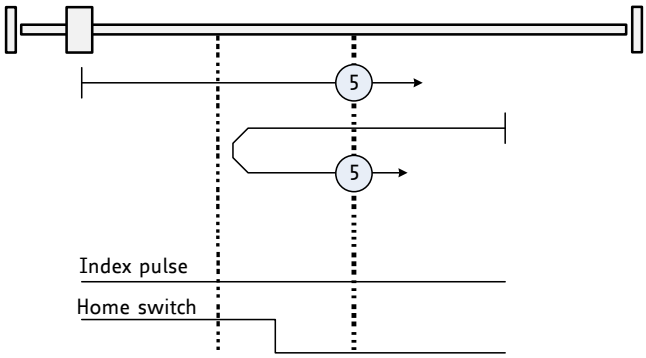


Figure 17: Homing Method 5

8.1.5 Homing Method 17: Homing on negative Limit Switch

Using this method, the initial direction of movement shall be leftward if the negative limit switch is inactive (here: low). The home position shall at the point where the negative limit switch becomes inactive.

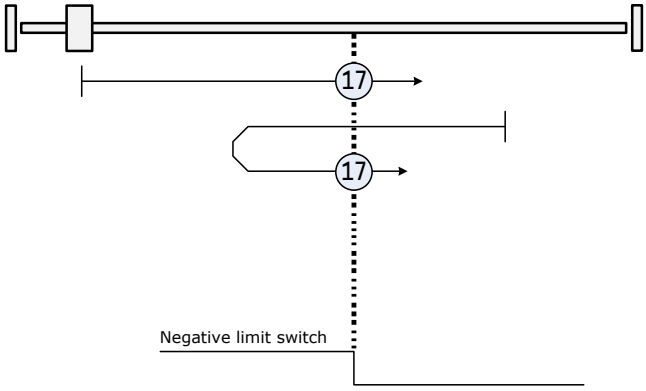


Figure 18: Homing Method 17

8.1.6 Homing Method 18: Homing on positive Limit Switch

Using this method, the initial direction of movement shall be rightward if the positive limit switch is inactive (here: low). The home position shall be at point the where the positive limit switch becomes inactive.

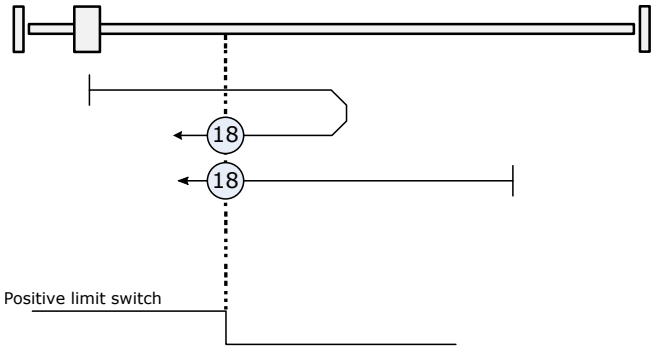


Figure 19: Homing Method 18

8.1.7 Homing Method 19: Homing on positive Home Switch

Using this method, the initial direction of movement shall be dependent on the state of the home switch. The home position shall be at the point where the home switch changes state. If the initial direction of movement leads away from the home switch, the drive shall reverse on encountering the relevant limit switch.

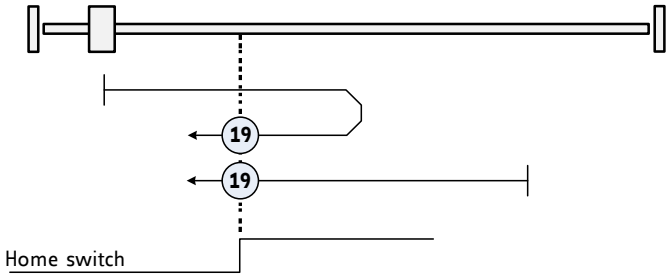


Figure 20: Homing Method 19

8.1.8 Homing Method 21: Homing on negative Home Switch

Using this method, the initial direction of movement shall be dependent on the state of the home switch. The home position shall be at the point where the home switch changes state. If the initial direction of movement leads away from the home switch, the drive shall reverse on encountering the relevant limit switch.

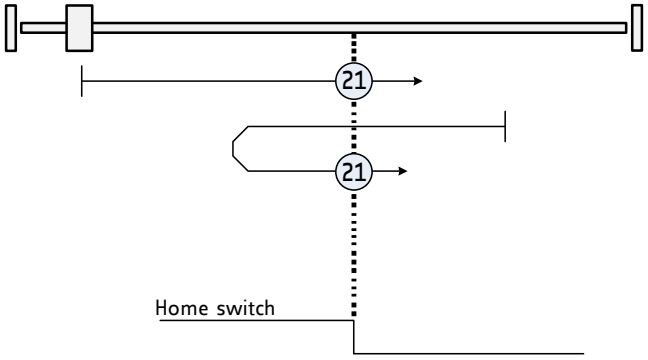


Figure 21: Homing Method 21

8.1.9 Homing Method 33 and 34: Homing on next Index Pulse

Using these methods, the direction of homing is negative or positive respectively. The home position shall be at the index pulse found in the selected direction.

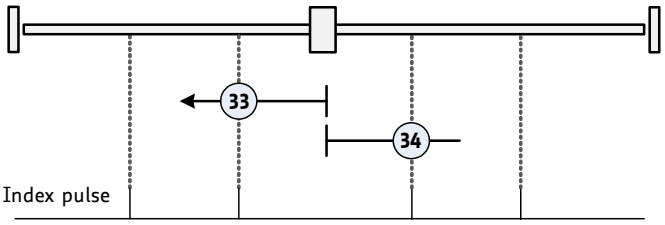


Figure 22: Homing Methods 33 and 34

8.1.10 Homing Method 35: Current Position as Home Position

In this method, the current position shall be taken to be the home position. This method does not require the drive device to be in operation enabled state.

8.2 Detailed Object Specifications

8.2.1 Object 6040_h: Control Word

This object indicates the received command controlling the power drive system finite state automaton (PDS FSA). The CiA-402 state machine can be controlled using this object. Please refer to figure 12 for detailed information.

Structure of the Control Word										
15 11	10	9	8	7	6 4	3	2	1	0	
nu	r	oms	h	fr	oms	eo	qs	ev	so	
MSB										LSB

Legend: nu=not used; r=reserved; oms=operation mode specific; h=halt; fr=fault reset; eo=enable operation; qs=quick stop; ev=enable voltage; so=switch on.

Table 286: Structure of the Control Word in hm Mode

Operation Mode specific Bits in hm Mode		
Bit	Name	Definition
4	Homing operation start	1: start homing; 0: stop homing
8	Halt	Not supported.

Table 287: Operation Mode specific Bits in hm Mode

Command Coding						
Command	Bits of Control Word					Transitions
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	x	1	1	0	2,6,8
Switch on	0	0	1	1	1	3
Switch on & enable operation	0	1	1	1	1	3, 4
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	0-to-1	x	x	x	x	15

Table 288: Command Coding

Object Description			
Index	Name	Object Type	Data Type
6040_h	Controlword	Variable	UNSIGNED16

Table 289: Object Description (6040_h in hm Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	See command coding above.	

Table 290: Entry Description (6040_h in hm Mode)

8.2.2 Object 6041_h: Status Word

This object provides the status of the PDS FSA. It reflects the status of the CiA-402 state machine. Please refer to figure 12 for detailed information. The object is structured as defined below.
For more information about the coding please refer to the CANopen Drives and motion control device profile, part 2.

Structure of the Status Word															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
dir	mot	oms		ila	tr	rm	ms	w	sod	qs	ve	f	oe	so	rtso
MSB															LSB

Legend: nu=not used; r=reserved; oms=operation mode specific; h=halt; fr=fault reset; oe=operation enable; qs=quick stop; ve=voltage enable; so=switch on.

Table 291: Structure of the Status Word in hm Mode

Trinamic Specific Bits		
Bit	Name	Definition
14	Motor activity	0: Motor stands still. 1: Motor rotates.
15	Direction of rotation	This bit shows the direction of rotation.

Table 292: Trinamic Specific Bits

Operation Mode specific Bits in hm Mode		
Bit	Name	Definition
10	Target reached	Set when the zero position has been found or homing has been stopped by setting controlword bit 4 to zero.
12	Home attained	Set when zero position has been found.
13	Homing error	Not supported.

Table 293: Operation Mode specific Bits in hm Mode

State Coding	
Status word	FSA state
xxxx xxxx x0xx 0000_h	Not ready to switch on
xxxx xxxx x1xx 0000_h	Switch on disabled
xxxx xxxx x01x 0001_h	Ready to switch on
xxxx xxxx x01x 0011_h	Switched on
xxxx xxxx x01x 0111_h	Operation enabled
xxxx xxxx x00x 0111_h	Quick stop active
xxxx xxxx x0xx 1111_h	Fault reaction active
xxxx xxxx x0xx 1000_h	Fault

Table 294: State Coding

Object Description			
Index	Name	Object Type	Data Type
6041_h	Controlword	Variable	UNSIGNED16

Table 295: Object Description (6041_h in hm Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	See state coding above.	

Table 296: Entry Description (6041_h in hm Mode)

8.2.3 Object $606C_h$: Velocity Actual Value

This object shows the actual velocity value of the motor. The value is given in internal or user-defined velocity units (depending on object $208C_h$, described in section 4.2.37).

Object Description			
Index	Name	Object Type	Data Type
$606C_h$	Velocity Actual Value	Variable	SIGNED32

Table 297: Object Description ($606C_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 298: Entry Description ($606C_h$)

8.2.4 Object $607C_h$: Home Offset

This object indicates the configured difference between the zero position for the application and the machine home position/home switch (found during homing). While homing, the machine home position is found and once the homing is completed, the zero position is offset from the home position by adding the home offset to the home position. The effect of setting the home position to a non-zero value depends on the selected homing method. The value of this object is given in microsteps. Negative values indicate the opposite direction.

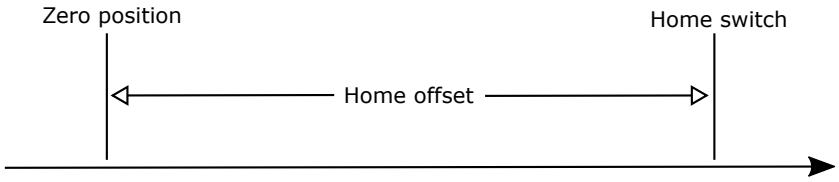


Figure 23: Home Offset

Object Description			
Index	Name	Object Type	Data Type
$607C_h$	Home offset	Variable	SIGNED32

Table 299: Object Description ($607C_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	SIGNED32	0

Table 300: Entry Description ($607C_h$)

8.2.5 Object 6098_h: Homing Method

The homing method to be used can be selected by writing to this object. Please see table 285 for a list of homing methods supported by the current version of the TMCM-3313 CANopen firmware.

Object Description			
Index	Name	Object Type	Data Type
6098_h	Homing method	Variable	SIGNED8

Table 301: Object Description (6098_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	SIGNED8	0

Table 302: Entry Description (6098_h)

8.2.6 Object 6099_h: Homing Speeds

This object indicates the configured speeds used during homing procedure. The values are given in pps units or internal units selectable with object $208C_h$ (section 4.2.37). Using object 6099_h a fast and a slow homing speed can be set. In most homing modes, the home switch is searched with the fast speed first. When the home switch has been found, the motor will be decelerated to the slow speed (using the homing acceleration, object $609A_h$) to search for the exact switch point. When the switch point has been found the motor will be stopped at that point.

Object Description			
Index	Name	Object Type	Data Type
6099_h	Homing speeds	Array	UNSIGNED32

Table 303: Object Description (6099_h)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Fast homing speed	rw	no	UNSIGNED32	0
2	Slow homing speed	rw	no	UNSIGNED32	0

Table 304: Entry Description (6099_h)

8.2.7 Object $609A_h$: Homing Acceleration

This object indicates the configured acceleration and deceleration to be used during homing operation. The value is given in units selected by object $208E_h$ (section 4.2.38).

Object Description			
Index	Name	Object Type	Data Type
$609A_h$	Homing acceleration	Variable	UNSIGNED32

Table 305: Object Description ($609A_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	UNSIGNED32	0

Table 306: Entry Description ($609A_h$)

8.3 How to start a Homing in hm Mode

Here is a little example that shows how to home the motor in hm mode. In this little example we assume that the module has been reset (and then switched to pre-operational or operational) by NMT commands before. The home switch must be connected to the home switch input. It can be operated manually.

- Select hm mode by writing 6 to object 6060_h.
- Write 6 to object 6040_h to switch to READY_TO_SWITCH_ON state.
- Write 7 to object 6040_h to switch to SWITCHED_ON state.
- Write 15 to object 6040_h to switch to OPERATION_ENABLED state.
- Select homing method 19 by writing 19 to object 6098_h.
- Set the homing speeds by writing e.g. 50000 to object 6099_h sub index 1 and e.g. 10000 to object 6099_h sub index 2.
- Write 31 to object 6040_h to start the homing process.
- Press and release the home switch.
- When homing has finished, write 15 to object 6040_h again.

9 Cyclic synchonous Position Mode

The cyclic synchronous position mode is used to directly control the position of the motor. It contains limit functions, but not a trajectory generator. The trajectory generator is located in the control device (the master), not in the drive device. In cyclic synchronous manner, the control device provides a target position to the drive device, which performs position control, velocity control and torque control.

The main control parameters are the target position (object $607A_h$, see section 9.1.7) and the interpolation time period (object $60C2_h$, see section 9.1.10). The drive automatically sets the velocity in such a manner that the next target position is reached within the interpolation time period. Acceleration and deceleration ramps are not used in this mode.

The cyclic synchronous position mode covers the following sub-functions:

- Position demand value input directly via an object.
- Monitoring of the position.
- Limiting the position using the software limits or the hardware limit switches.

9.1 Detailed Object Specifications

9.1.1 Object 6040_h: Control Word

This object indicates the received command controlling the power drive system finite state automaton (PDS FSA). The CiA-402 state machine can be controlled using this object. Please refer to figure 12 for detailed information. The cyclic synchronous position mode does not use any mode specific bits of the control word.

Structure of the Control Word									
15	9	8	7	6	4	3	2	1	0
nu		h	fr	nu		eo	qs	ev	so
MSB									LSB

Legend: nu=not used; h=halt; fr=fault reset; eo=enable operation; qs=quick stop; ev=enable voltage; so=switch on.

Table 307: Structure of the Control Word in csp Mode

Command Coding						
Command	Bits of Control Word					Transitions
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	x	1	1	0	2,6,8
Switch on	0	0	1	1	1	3
Switch on & enable operation	0	1	1	1	1	3, 4
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	0-to-1	x	x	x	x	15

Table 308: Command Coding

Object Description			
Index	Name	Object Type	Data Type
6040_h	Controlword	Variable	UNSIGNED16

Table 309: Object Description (6040_h in csp Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	See command coding above.	

Table 310: Entry Description (6040_h in csp Mode)

9.1.2 Object 6041_h: Status Word

This object provides the status of the PDS FSA. It reflects the status of the CiA-402 state machine. Please refer to figure 12 for detailed information. The object is structured as defined below.
For more information about the coding please refer to the CANopen Drives and motion control device profile, part 2.

Structure of the Status Word															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
dir	mot	oms		ila	r	rm	ms	w	sod	qs	ve	f	oe	so	rtso
MSB															LSB

Legend: nu=not used; r=reserved; oms=operation mode specific; h=halt; fr=fault reset; oe=operation enable; qs=quick stop; ve=voltage enable; so=switch on.

Table 311: Structure of the Status Word in csp Mode

Trinamic Specific Bits		
Bit	Name	Definition
14	Motor activity	0: Motor stands still. 1: Motor rotates.
15	Direction of rotation	This bit shows the direction of rotation.

Table 312: Trinamic Specific Bits

Operation Mode specific Bits in csp Mode		
Bit	Name	Definition
10	Reserved	Not used.
12	Target position ignored	0: Target position ignored. 1: Target position used as input to position controller.
13	Following error	0: No following error. 1: Following error.

Table 313: Operation Mode specific Bits in csp Mode

State Coding	
Status word	FSA state
xxxx xxxx x0xx 0000_h	Not ready to switch on
xxxx xxxx x1xx 0000_h	Switch on disabled
xxxx xxxx x01x 0001_h	Ready to switch on
xxxx xxxx x01x 0011_h	Switched on
xxxx xxxx x01x 0111_h	Operation enabled
xxxx xxxx x00x 0111_h	Quick stop active
xxxx xxxx x0xx 1111_h	Fault reaction active
xxxx xxxx x0xx 1000_h	Fault

Table 314: State Coding

Object Description			
Index	Name	Object Type	Data Type
6041_h	Controlword	Variable	UNSIGNED16

Table 315: Object Description (6041_h in csp Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	See state coding above	

Table 316: Entry Description (6041_h in csp Mode)

9.1.3 Object 6062_h: Position Demand Value

This object provides the demanded position value. The value is given in microsteps. Object 6062_h indicates the actual position that the motor should have. It is not to be confused with objects 6063_h and 6064_h.

Object Description			
Index	Name	Object Type	Data Type
6062_h	Position Demand Value	Variable	SIGNED32

Table 317: Object Description (6062_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 318: Entry Description (6062_h)

9.1.4 Object 6063_h: Position Actual Internal Value

This object provides the actual value of the encoder or the motor. Please use the sensor selection object $606A_h$ (see section 5.1.8) for selecting the motor or the encoder first. Object 6063_h indicates the actual position of the encoder or the motor, re-scaled to the microstep resolution. The value is given in microsteps.

Object Description			
Index	Name	Object Type	Data Type
6063_h	Position Actual Internal Value	Variable	SIGNED32

Table 319: Object Description (6063_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 320: Entry Description (6063_h)

9.1.5 Object 6064_h: Position Actual Value

This object provides the actual value of the position measurement device. It always contains the same value as object 6063_h.

Object Description			
Index	Name	Object Type	Data Type
6064_h	Position Actual Value	Variable	SIGNED32

Table 321: Object Description (6064_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 322: Entry Description (6064_h)

9.1.6 Object $606C_h$: Velocity Actual Value

This object shows the actual velocity value of the motor. The value is given in internal or user-defined velocity units (depending on object $208C_h$, described in section 4.2.37).

Object Description			
Index	Name	Object Type	Data Type
$606C_h$	Velocity Actual Value	Variable	SIGNED32

Table 323: Object Description ($606C_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 324: Entry Description ($606C_h$)

9.1.7 Object $607A_h$: Target Position

The target position is the position that the drive should move to in cyclic synchronous position mode using the current interpolation time period. In csp mode this value is always interpreted as an absolute value.

Object Description			
Index	Name	Object Type	Data Type
$607A_h$	Target Position	Variable	SIGNED32

Table 325: Object Description ($607A_h$ in csp Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	Refer to CiA402-3	SIGNED32	0

Table 326: Entry Description ($607A_h$ in csp Mode)

9.1.8 Object $607D_h$: Software Position Limit

This object indicates the configured maximal and minimal software position limits. These parameters define the absolute position limits for the position demand value and the position actual value. Every new target position is checked against these limits. The limit positions are always relative to the machine home position. Before being compared with the target position, they are corrected internally by the home offset as follows:

$$Corrected\_min\_position\_limit = min\_position\_limit - home\_offset$$
$$Corrected\_max\_position\_limit = max\_position\_limit - home\_offset$$

Object Description			
Index	Name	Object Type	Data Type
$607D_h$	Software Position Limit	Array	SIGNED32

Table 327: Object Description ($607D_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Mininmum Position Limit	rw	no	SIGNED32	-2147483648
2	Maximum Position Limit	rw	no	SIGNED32	2147483647

Table 328: Entry Description ($607D_h$)

9.1.9 Object $60B0_h$: Position Offset

This object provides an offset to the target position (object $607A_h$, see section 9.1.7)). The value is given in microsteps and will be added to the target position.

Object Description			
Index	Name	Object Type	Data Type
$60B0_h$	Offset Torque	Variable	INTEGER32

Table 329: Object Description ($60B0_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	yes	-2147483648...2147483647	0

Table 330: Entry Description ($60B0_h$)

9.1.10 Object $60C2_h$: Interpolation Time Period

This object indicates the interpolation cycle time. The interpolation time period (sub-index 01_h) is given in $10^{interpolation\_time\_index}$ s. The interpolation time index (sub-index 02_h) is dimensionless.

Object Description			
Index	Name	Object Type	Data Type
$60C2_h$	Offset Torque	Vecord	Interpolation time period record (0080_h)

Table 331: Object Description ($60C2_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
0	Highest sub-index supported	ro	no	UNSIGNED8	2
1	Interpolation time period value	rw	no	UNSIGNED8	1
2	Interpolation time index	rw	no	-3...3	-3

Table 332: Entry Description ($60C2_h$)

10 Cyclic synchonous Velocity Mode

The cyclic synchronous velocity mode is used to directly control the velocity of the motor. It contains limit functions, but not a trajectory generator. The trajectory generator is located in the control device (the master), not in the drive device. In cyclic synchronous manner, the control device provides a target velocity to the drive device, which performs position control, velocity control and torque control.

The main control parameters are the target velocity (object $60FF_h$, see section 10.1.4) and the interpolation time period (object $60C2_h$, see section 10.1.7). The drive automatically sets the acceleration in such a manner that the next target velocity is reached within the interpolation time period. Acceleration and deceleration ramps are not used in this mode.

The cyclic synchronous velocity mode covers the following sub-functions:

- Velocity demand value input directly via an object.
- Monitoring of the position.
- Limiting the position using the software limits or the hardware limit switches.

10.1 Detailed Object Specifications

10.1.1 Object 6040_h: Control Word

This object indicates the received command controlling the power drive system finite state automaton (PDS FSA). The CiA-402 state machine can be controlled using this object. Please refer to figure 12 for detailed information. The cyclic synchronous velocity mode does not use any mode specific bits of the control word.

Structure of the Control Word									
15	9	8	7	6	4	3	2	1	0
nu		h	fr	nu		eo	qs	ev	so
MSB									LSB

Legend: nu=not used; h=halt; fr=fault reset; eo=enable operation; qs=quick stop; ev=enable voltage; so=switch on.

Table 333: Structure of the Control Word in csv Mode

Command Coding						
Command	Bits of Control Word					Transitions
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	x	1	1	0	2,6,8
Switch on	0	0	1	1	1	3
Switch on & enable operation	0	1	1	1	1	3, 4
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	0-to-1	x	x	x	x	15

Table 334: Command Coding

Object Description			
Index	Name	Object Type	Data Type
6040_h	Controlword	Variable	UNSIGNED16

Table 335: Object Description (6040_h in csv Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	See command coding above.	

Table 336: Entry Description (6040_h in csv Mode)

10.1.2 Object 6041_h: Status Word

This object provides the status of the PDS FSA. It reflects the status of the CiA-402 state machine. Please refer to figure 12 for detailed information. The object is structured as defined below.
For more information about the coding please refer to the CANopen Drives and motion control device profile, part 2.

Structure of the Status Word															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
dir	mot	oms		ila	r	rm	ms	w	sod	qs	ve	f	oe	so	rtso
MSB															LSB

Legend: nu=not used; r=reserved; oms=operation mode specific; h=halt; fr=fault reset; oe=operation enable; qs=quick stop; ve=voltage enable; so=switch on.

Table 337: Structure of the Status Word in csv Mode

Trinamic Specific Bits		
Bit	Name	Definition
14	Motor activity	0: Motor stands still. 1: Motor rotates.
15	Direction of rotation	This bit shows the direction of rotation.

Table 338: Trinamic Specific Bits

Operation Mode specific Bits in csv Mode		
Bit	Name	Definition
10	Reserved	Not used.
12	Target position ignored	0: Target velocity ignored. 1: Target velocity used as input to velocity controller.
13	Reserved	Not used.

Table 339: Operation Mode specific Bits in csv Mode

State Coding	
Status word	FSA state
xxxx xxxx x0xx 0000_h	Not ready to switch on
xxxx xxxx x1xx 0000_h	Switch on disabled
xxxx xxxx x01x 0001_h	Ready to switch on
xxxx xxxx x01x 0011_h	Switched on
xxxx xxxx x01x 0111_h	Operation enabled
xxxx xxxx x00x 0111_h	Quick stop active
xxxx xxxx x0xx 1111_h	Fault reaction active
xxxx xxxx x0xx 1000_h	Fault

Table 340: State Coding

Object Description			
Index	Name	Object Type	Data Type
6041_h	Controlword	Variable	UNSIGNED16

Table 341: Object Description (6041_h in csv Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	See state coding above	

Table 342: Entry Description (6041_h in csv Mode)

10.1.3 Object $606C_h$: Velocity Actual Value

This object shows the actual velocity value of the motor. The value is given in internal or user-defined velocity units (depending on object $208C_h$, described in section 4.2.37).

Object Description			
Index	Name	Object Type	Data Type
$606C_h$	Velocity Actual Value	Variable	SIGNED32

Table 343: Object Description ($606C_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 344: Entry Description ($606C_h$)

10.1.4 Object $60FF_h$: Target Velocity

In csv mode the target velocity specifies the velocity that is to be reached within the interpolation time period. The values are given in units which can be selected with object $208C_h$, described in section 4.2.37.

Object Description			
Index	Name	Object Type	Data Type
$60FF_h$	Target Velocity	Variable	SIGNED32

Table 345: Object Description ($60FF_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	SIGNED32	0

Table 346: Entry Description ($60FF_h$)

10.1.5 Object $607D_h$: Software Position Limit

This object indicates the configured maximal and minimal software position limits. These parameters define the absolute position limits for the position demand value and the position actual value. Every new

target position is checked against these limits. The limit positions are always relative to the machine home position. Before being compared with the target position, they are corrected internally by the home offset as follows:

$$Corrected\_min\_position\_limit = min\_position\_limit - home\_offset$$
$$Corrected\_max\_position\_limit = max\_position\_limit - home\_offset$$

Object Description			
Index	Name	Object Type	Data Type
$607D_h$	Software Position Limit	Array	SIGNED32

Table 347: Object Description ($607D_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Mininmum Position Limit	rw	no	SIGNED32	-2147483648
2	Maximum Position Limit	rw	no	SIGNED32	2147483647

Table 348: Entry Description ($607D_h$)

10.1.6 Object $60B1_h$: Velocity Offset

This object provides an offset to the target velocity (object $60FF_h$, see section 10.1.4)). The value will be added to the target velocity.

Object Description			
Index	Name	Object Type	Data Type
$60B1_h$	Velocity Offset	Variable	INTEGER32

Table 349: Object Description ($60B1_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	yes	-2147483648...2147483647	0

Table 350: Entry Description ($60B1_h$)

10.1.7 Object $60C2_h$: Interpolation Time Period

This object indicates the interpolation cycle time. The interpolation time period (sub-index 01_h) is given in $10^{interpolation\_time\_index}$ s. The interpolation time index (sub-index 02_h) is dimensionless.

Object Description			
Index	Name	Object Type	Data Type
$60C2_h$	Offset Torque	Vecord	Interpolation time period record (0080_h)

Table 351: Object Description ($60C2_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
0	Highest sub-index supported	ro	no	UNSIGNED8	2
1	Interpolation time period value	rw	no	UNSIGNED8	1
2	Interpolation time index	rw	no	-3...3	-3

Table 352: Entry Description ($60C2_h$)

11 Cyclic synchonous Torque Mode

The cyclic synchronous torque mode is used to directly control the torque of the motor, without the need for position or velocity control. It contains limit functions, but not a trajectory generator.
The cyclic synchronous torque mode covers the following sub-functions:

- Demand value input directly via an object.
- Monitoring of the torque.
- Limiting the position using the software limits or the hardware limit switches.

11.1 Detailed Object Specifications

11.1.1 Object 6040_h: Control Word

This object indicates the received command controlling the power drive system finite state automaton (PDS FSA). The CiA-402 state machine can be controlled using this object. Please refer to figure 12 for detailed information. The cyclic synchronous torque mode does not use any mode specific bits of the control word.

Structure of the Control Word									
15	9	8	7	6	4	3	2	1	0
nu		h	fr	nu		eo	qs	ev	so
MSB									LSB

Legend: nu=not used; h=halt; fr=fault reset; eo=enable operation; qs=quick stop; ev=enable voltage; so=switch on.

Table 353: Structure of the Control Word in cst Mode

Command Coding						
Command	Bits of Control Word					Transitions
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	x	1	1	0	2,6,8
Switch on	0	0	1	1	1	3
Switch on & enable operation	0	1	1	1	1	3, 4
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	0-to-1	x	x	x	x	15

Table 354: Command Coding

Object Description			
Index	Name	Object Type	Data Type
6040_h	Controlword	Variable	UNSIGNED16

Table 355: Object Description (6040_h in cst Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	See command coding above.	

Table 356: Entry Description (6040_h in cst Mode)

11.1.2 Object 6041_h: Status Word

This object provides the status of the PDS FSA. It reflects the status of the CiA-402 state machine. Please refer to figure 12 for detailed information. The object is structured as defined below.
For more information about the coding please refer to the CANopen Drives and motion control device profile, part 2.

Structure of the Status Word															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
dir	mot	oms		ila	r	rm	ms	w	sod	qs	ve	f	oe	so	rtso
MSB															LSB

Legend: nu=not used; r=reserved; oms=operation mode specific; h=halt; fr=fault reset; oe=operation enable; qs=quick stop; ve=voltage enable; so=switch on.

Table 357: Structure of the Status Word in cst Mode

Trinamic Specific Bits		
Bit	Name	Definition
14	Motor activity	0: Motor stands still. 1: Motor rotates.
15	Direction of rotation	This bit shows the direction of rotation.

Table 358: Trinamic Specific Bits

Operation Mode specific Bits in cst Mode		
Bit	Name	Definition
10	Reserved	Not used.
12	Target torque ignored	0: Target torque ignored. 1: Target torque used as input to control loop.
13	Reserved	Not used.

Table 359: Operation Mode specific Bits in cst Mode

State Coding	
Status word	FSA state
xxxx xxxx x0xx 0000_h	Not ready to switch on
xxxx xxxx x1xx 0000_h	Switch on disabled
xxxx xxxx x01x 0001_h	Ready to switch on
xxxx xxxx x01x 0011_h	Switched on
xxxx xxxx x01x 0111_h	Operation enabled
xxxx xxxx x00x 0111_h	Quick stop active
xxxx xxxx x0xx 1111_h	Fault reaction active
xxxx xxxx x0xx 1000_h	Fault

Table 360: State Coding

Object Description			
Index	Name	Object Type	Data Type
6041_h	Controlword	Variable	UNSIGNED16

Table 361: Object Description (6041_h in cst Mode)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	see CiA402-3	See state coding above	

Table 362: Entry Description (6041_h in cst Mode)

11.1.3 Object 6062_h: Position Demand Value

This object provides the demanded position value. The value is given in microsteps. Object 6062_h indicates the actual position that the motor should have. It is not to be confused with objects 6063_h and 6064_h.

Object Description			
Index	Name	Object Type	Data Type
6062_h	Position Demand Value	Variable	SIGNED32

Table 363: Object Description (6062_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 364: Entry Description (6062_h)

11.1.4 Object 6063_h: Position Actual Internal Value

This object provides the actual value of the encoder or the motor. Please use the sensor selection object $606A_h$ (see section 5.1.8) for selecting the motor or the encoder first. Object 6063_h indicates the actual position of the encoder or the motor, re-scaled to the microstep resolution. The value is given in microsteps.

Object Description			
Index	Name	Object Type	Data Type
6063_h	Position Actual Internal Value	Variable	SIGNED32

Table 365: Object Description (6063_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 366: Entry Description (6063_h)

11.1.5 Object 6064_h: Position Actual Value

This object provides the actual value of the position measurement device. It always contains the same value as object 6063_h.

Object Description			
Index	Name	Object Type	Data Type
6064_h	Position Actual Value	Variable	SIGNED32

Table 367: Object Description (6064_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 368: Entry Description (6064_h)

11.1.6 Object 6071_h: Target Torque

This object sets the desired torque value. The value is given in mA.

Object Description			
Index	Name	Object Type	Data Type
6071_h	Target torque	Variable	INTEGER16

Table 369: Object Description (6071_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	yes	-32768...32767	0

Table 370: Entry Description (6071_h)

11.1.7 Object 6077_h: Torque actual Value

This object provides the actual torque value. The value is given in mA.

Object Description			
Index	Name	Object Type	Data Type
6077_h	Torque actual Value	Variable	INTEGER16

Table 371: Object Description (6077_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	yes	-32768...32767	0

Table 372: Entry Description (6077_h)

11.1.8 Object $607D_h$: Software Position Limit

This object indicates the configured maximal and minimal software position limits. These parameters define the absolute position limits for the position demand value and the position actual value. Every new

target position is checked against these limits. The limit positions are always relative to the machine home position. Before being compared with the target position, they are corrected internally by the home offset as follows:

$$Corrected\_min\_position\_limit = min\_position\_limit - home\_offset$$
$$Corrected\_max\_position\_limit = max\_position\_limit - home\_offset$$

Object Description			
Index	Name	Object Type	Data Type
$607D_h$	Software Position Limit	Array	SIGNED32

Table 373: Object Description ($607D_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
1	Mininmum Position Limit	rw	no	SIGNED32	-2147483648
2	Maximum Position Limit	rw	no	SIGNED32	2147483647

Table 374: Entry Description ($607D_h$)

11.1.9 Object $60B2_h$: Torque Offset

This object provides an offset to the torque value. It will be added to the target torque (object 6071_h, see section 11.1.6).

Object Description			
Index	Name	Object Type	Data Type
$60B2_h$	Offset Torque	Variable	INTEGER16

Table 375: Object Description ($60B2_h$)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	yes	-32768...32767	0

Table 376: Entry Description ($60B2_h$)

11.1.10 Object $60C2_h$: Interpolation Time Period

This object indicates the interpolation cycle time. The interpolation time period (sub-index 01_h) is given in $10^{interpolation\_time\_index}$ s. The interpolation time index (sub-index 02_h) is dimensionless.

Object Description			
Index	Name	Object Type	Data Type
$60C2_h$	Offset Torque	Vecord	Interpolation time period record (0080_h)

Table 377: Object Description ($60C2_h$)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
0	Highest sub-index supported	ro	no	UNSIGNED8	2
1	Interpolation time period value	rw	no	UNSIGNED8	1
2	Interpolation time index	rw	no	-3...3	-3

Table 378: Entry Description ($60C2_h$)

12 Emergency Messages (EMCY)

The module sends an emergency message if an error occurs. The message contains information about the error type. The module can map internal errors and object 1001_h (error register) is part of every emergency object.
Please note that the additional byte #2 shows which motor is affected.

Emergency Messages (EMCY) of the TMCM-3313						
Error code	Additional byte					Description
	1	2	3	4	5	
0000_h	0	0...2	0	0	0	**Fault reset** The fault reset command has been executed.
1000_h	1	0...2	0	0	0	**Generic error: open load bridge A** The motor driver indicates open load on bridge A. It is possible that the motor cable is broken or that there is an error in the power amplifier itself.
1000_h	2	0...2	0	0	0	**Generic error: open load bridge B** The motor driver indicates open load on bridge B. It is possible that the motor cable is broken or that there is an error in the power amplifier itself.
2310_h	0	0...2	0	0	0	**Overcurrent high side** The motor driver indicates an overcurrent on the high side. This can be caused by a short circuit in the driver stage.
2311_h	0	0...2	0	0	0	**Overcurrent bridge B** The motor driver indicates that there is overcurrent on bridge B. This can be caused by a short circuit in the motor itself or in the motor driver stage.
2312_h	0	0...2	0	0	0	**Overcurrent bridge A** The motor driver indicates that there is overcurrent on bridge A. This can be caused by a short circuit in the motor itself or in the motor driver stage.
3230_h	0	0...2	0	0	0	**stallGuard2 error** The actual load value exceeds the stallGuard2 limit.
4310_h	1	0...2	0	0	0	**Overtemperature pre-warning** The temperature in the motor driver exceeds the pre-warning limit.
4310_h	2	0...2	0	0	0	**Overtemperature error** The motor driver has been switched off because the temperature limit has been exceeded.
5441_h	0	255	0	0	0	**Shutdown switch active** The enable signal is missing (due to the shutdown switch) and the motor driver has been switched off.
6320_h	0	255	0	0	0	**Parameter error** The data in the received PDO is either wrong or cannot be accepted due to the internal state of the drive.

Error code	Additional byte					Description
	1	2	3	4	5	
8611_h	0	0...2	0	0	0	**Following error** The deviation between motor position counter and encoder position counter has exceeded the following error window.
$ff00_h$	0	0...2	0	0	0	**Undervoltage** The supply voltage is too low to drive a motor.
$ff01_h$	1	0...2	0	0	0	**Positive software limit** The actual position is outside the range defined by object $607d_h$.
$ff01_h$	2	0...2	0	0	0	**Negative software limit** The actual position is outside the range defined by object $607d_h$.
$ff01_h$	3	0...2	0	0	0	**Positive limit switch** The positive limit switch has been touched outside of the homing function.
$ff01_h$	4	0...2	0	0	0	**Negative limit switch** The negative limit switch has been touched outside of the homing function.

Table 379: Emergency Messages (EMCY)

13 Figures Index

14 Tables Index

15 Supplemental Directives

15.1 Producer Information

15.2 Copyright

15.3 Trademark Designations and Symbols

Trademark designations and symbols used in this documentation indicate that a product or feature is owned and registered as trademark and/or patent either by TRINAMIC or by other manufacturers, whose products are used or referred to in combination with TRINAMIC's products and TRINAMIC's product documentation.

This CoE Firmware Manual is a non-commercial publication that seeks to provide concise scientific and technical user information to the target user. Thus, trademark designations and symbols are only entered in the Short Spec of this document that introduces the product at a quick glance. The trademark designation /symbol is also entered when the product or feature name occurs for the first time in the document. All trademarks and brand names used are property of their respective owners.

15.4 Target User

The documentation provided here, is for programmers and engineers only, who are equipped with the necessary skills and have been trained to work with this type of product.

The Target User knows how to responsibly make use of this product without causing harm to himself or others, and without causing damage to systems or devices, in which the user incorporates the product.

15.5 Disclaimer: Life Support Systems

TRINAMIC Motion Control GmbH & Co. KG does not authorize or warrant any of its products for use in life support systems, without the specific written consent of TRINAMIC Motion Control GmbH & Co. KG.

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15.6 Disclaimer: Intended Use

The data specified in this user manual is intended solely for the purpose of product description. No representations or warranties, either express or implied, of merchantability, fitness for a particular purpose

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15.7 Collateral Documents & Tools

This product documentation is related and/or associated with additional tool kits, firmware and other items, as provided on the product page at: www.trinamic.com.

16 Revision History

16.1 Firmware Revision

Version	Date	Author	Description
1.01	2016-JUL-20	OK	First release.
1.02...1.06		OK	Not deployed.
1.07	2018-JAN-12	OK	CSP mode and CST mode included.
1.08	2019-JAN-11	OK	Object $200F_h$ added. CSV mode included. Distributed clocks fixed.
1.09	2019-MAY-09	OK	Fully compliant with latest conformance test.

Table 380: Firmware Revision

16.2 Document Revision

Version	Date	Author	Description
V1.01	2016-JUL-20	OK	First release.
V1.02	2016-NOV-29	OK	Block diagrams included.
V1.03	2017-JAN-18	OK	CSP mode included.
V1.04	2017-FEB-27	OK	Mapping tables (objects 1600_h and $1A00_h$) fixed.
V1.05	2018-JAN-12	OK	Firmware V1.07 included.
V1.06	2019-JAN-11	OK	Firmware V1.08 included.
V1.07	2019-MAY-09	OK	Firmware V1.09 included.

Table 381: Document Revision