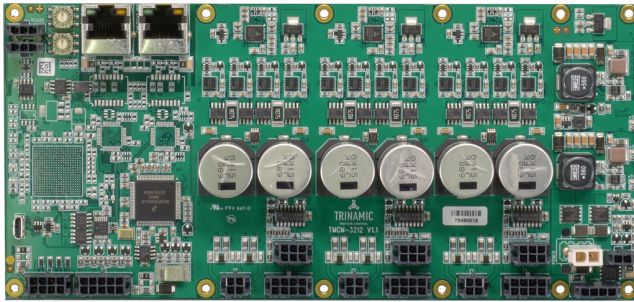


# TMCM-3213 CoE Firmware Manual

Firmware Version V1.07 | Document Revision V1.05 • 2018-JAN-12

The TMCM-3213 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™, dc-Step™, 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.



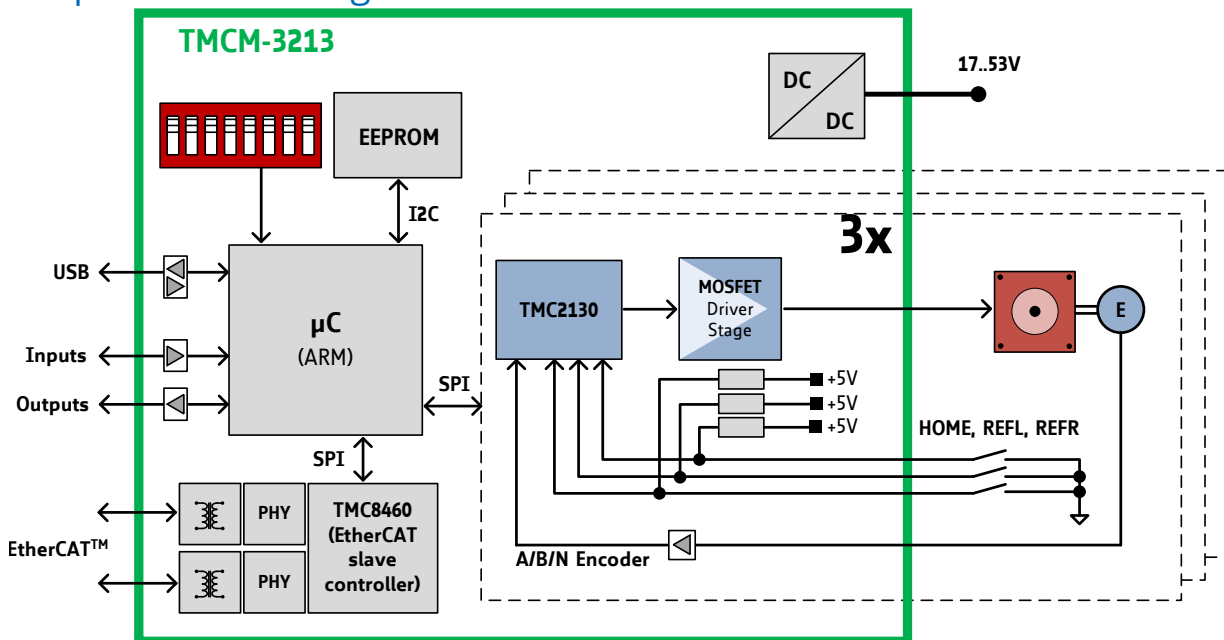
## Features

- 3-Axes Stepper Motor Control
- CoE CiA-402 Drive Profile
- Encoder Support
- coolStep™
- dcStep™
- stallGuard2™
- stealthChop™

## Applications

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

## Simplified Block Diagram



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# 1 Preface

This document specifies objects and modes of operation of the Trinamic TMCM-3213 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-3213 TMCL firmware 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.

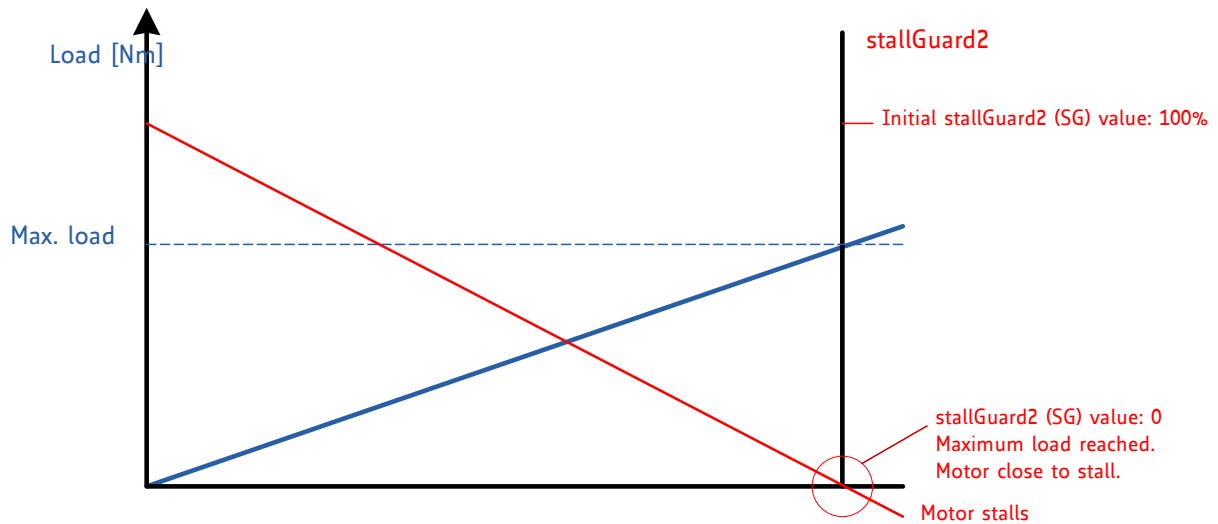


Figure 1: stallGuard2 Load Measurement as a Function of Load

### 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.





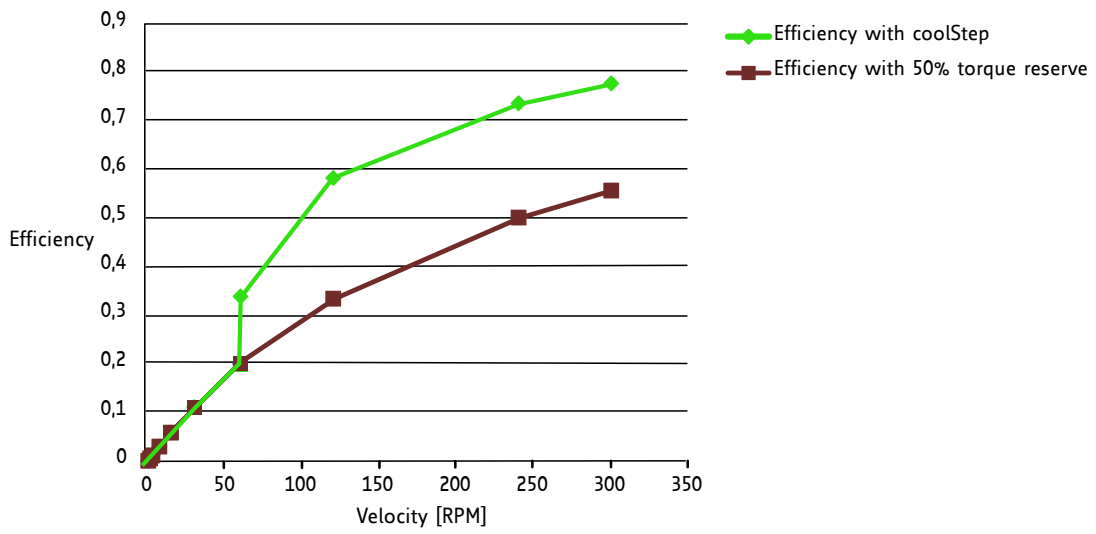


Figure 2: Energy Efficiency Example with coolStep



## 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 2: 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 3: 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 3.

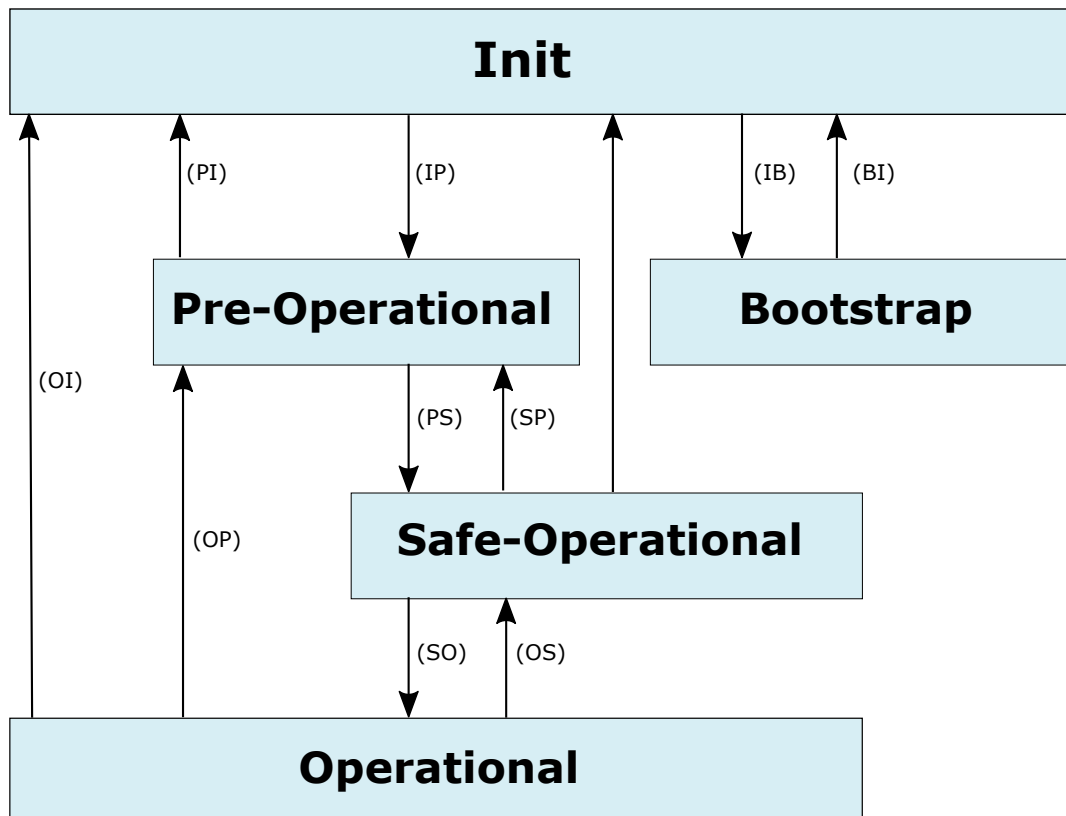


Figure 3: NMT State Machine

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.

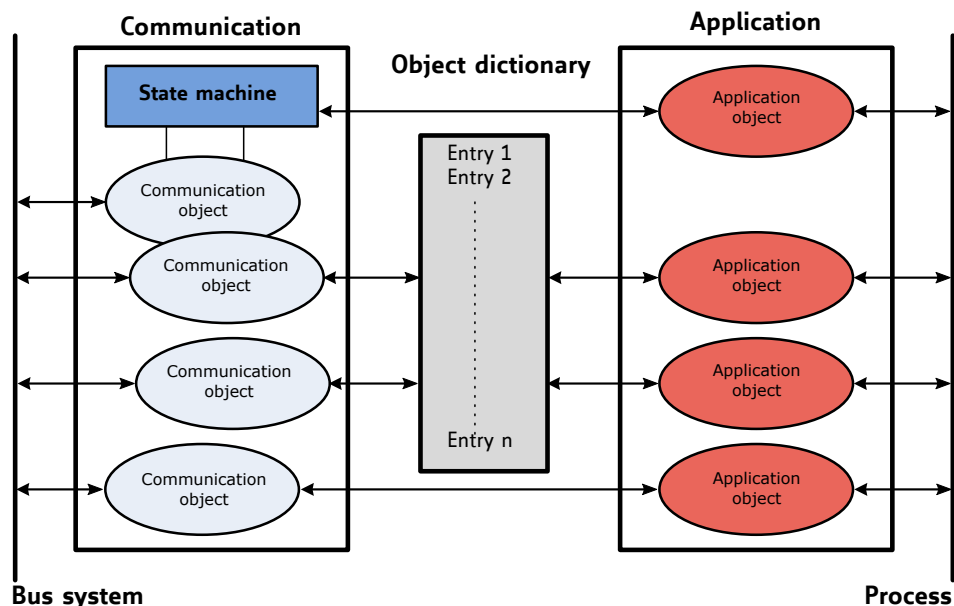


Figure 4: Device Model



## 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 4:

| Object Dictionary                     |   |
|---------------------------------------|---|
| Index                                 | Object                                      |
| 0000 <sub>h</sub>                     | Not used.                                   |
| 0001 <sub>h</sub> – 001F <sub>h</sub> | Static data types.                          |
| 0020 <sub>h</sub> – 003F <sub>h</sub> | Complex data types.                         |
| 0040 <sub>h</sub> – 005F <sub>h</sub> | Manufacturer specific complex data types.   |
| 0060 <sub>h</sub> – 007F <sub>h</sub> | Device profile specific static data types.  |
| 0080 <sub>h</sub> – 009F <sub>h</sub> | Device profile specific complex data types. |
| 00A0 <sub>h</sub> – 0FFF <sub>h</sub> | Reserved for further use.                   |
| 1000 <sub>h</sub> – 1FFF <sub>h</sub> | Communication profile area.                 |
| 2000 <sub>h</sub> – 5FFF <sub>h</sub> | Manufacturer specific profile area.         |
| 6000 <sub>h</sub> – 9FFF <sub>h</sub> | Standardized device profile area.           |
| A000 <sub>h</sub> – BFFF <sub>h</sub> | Standardized interface profile area.        |
| C000 <sub>h</sub> – FFFF <sub>h</sub> | Reserved for further use.                   |

Table 4: Object Dictionary

The communication profile area at indices 1000<sub>h</sub> through 1FFF<sub>h</sub> contains the communication specific parameters for the CAN network. These entries are common to all devices.

The manufacturer segment at indices 2000<sub>h</sub> through 5FFF<sub>h</sub> contains manufacturer specific objects. These objects control the special features of the Trinamic TMCM-3213 motion control device.

The standardized device profile area at indices 6000<sub>h</sub> through 9FFF<sub>h</sub> 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-3213 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 specific 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<sub>h</sub> (instead of 6040<sub>h</sub> for motor #0), and the microstep resolution of motor #1 would be 2200<sub>h</sub> for motor #1 (instead of 2000<sub>h</sub> for motor #0).

| Multi-Axis Object Indices |                                       |                                       |
|---------------------------|---------------------------------------|---------------------------------------|
| Motor                     | Manufacturer area                     | Profile area                          |
| Motor #0                  | 2000 <sub>h</sub> – 21FF <sub>h</sub> | 6000 <sub>h</sub> – 67FF <sub>h</sub> |
| Motor #1                  | 2200 <sub>h</sub> – 23FF <sub>h</sub> | 6800 <sub>h</sub> – 6FFF <sub>h</sub> |
| Motor #2                  | 2400 <sub>h</sub> – 25FF <sub>h</sub> | 7000 <sub>h</sub> – 77FF <sub>h</sub> |

*Table 5: 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<sub>h</sub>: Device Type

This object contains information about the device type. The object 1000<sub>h</sub> 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 <sub>h</sub>  | Device type | Variable    | UNSIGNED32 |

Table 6: Object Description (1000<sub>h</sub>)

| Entry Description |        |             |             |                       |
|-------------------|--------|-------------|-------------|-----------------------|
| Sub-index         | Access | PDO Mapping | Value Range | Default Value         |
| 0                 | ro     | no          | UNSIGNED32  | FFFC0192 <sub>h</sub> |

Table 7: Entry Description (1000<sub>h</sub>)

#### 3.1.2 Object 1001<sub>h</sub>: Error Register

This object contains error information. The CANopen device maps internal errors into object 1001<sub>h</sub>. It is part of an emergency object.

| Object Description |                |             |           |
|--------------------|----------------|-------------|-----------|
| Index              | Name           | Object Type | Data Type |
| 1001 <sub>h</sub>  | Error register | Variable    | UNSIGNED8 |

Table 8: Object Description (1001<sub>h</sub>)

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

Table 9: Entry Description (1001<sub>h</sub>)





| 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 10: Error Register Bits

### 3.1.3 Object 1008<sub>h</sub>: 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 <sub>h</sub>  | Manufacturer Device Name | Variable    | Visible String |

Table 11: Object Description (1008<sub>h</sub>)

| Entry Description |        |             |             |               |
|-------------------|--------|-------------|-------------|---------------|
| Sub-index         | Access | PDO Mapping | Value Range | Default Value |
| 0                 | ro     | no          | —           | TMCM-3213     |

Table 12: Entry Description (1008<sub>h</sub>)

### 3.1.4 Object 1009<sub>h</sub>: Manufacturer Hardware Version

This object contains the hardware version description.

| Object Description |                               |             |                |
|--------------------|-------------------------------|-------------|----------------|
| Index              | Name                          | Object Type | Data Type      |
| 1009 <sub>h</sub>  | Manufacturer Hardware Version | Variable    | Visible String |

Table 13: Object Description (1009<sub>h</sub>)



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

Table 14: Entry Description (1009<sub>h</sub>)

### 3.1.5 Object 100A<sub>h</sub>: Manufacturer Software Version

This object contains the software version description.

| Object Description |                               |             |                |
|--------------------|-------------------------------|-------------|----------------|
| Index              | Name                          | Object Type | Data Type      |
| 100A <sub>h</sub>  | Manufacturer Software Version | Variable    | Visible String |

Table 15: Object Description (100A<sub>h</sub>)

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

Table 16: Entry Description (100A<sub>h</sub>)

### 3.1.6 Object 1018<sub>h</sub>: Identity Object

The object 1018<sub>h</sub> contains general information about the device:

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

| Object Description |                 |             |           |
|--------------------|-----------------|-------------|-----------|
| Index              | Name            | Object Type | Data Type |
| 1018 <sub>h</sub>  | Identity object | Record      | Identity  |

Table 17: Object Description (1018<sub>h</sub>)

| Entry Description |                   |        |             |             |   |
|-------------------|-------------------|--------|-------------|-------------|---|
| Sub-index         | Description       | Access | PDO Mapping | Value Range | Default Value                           |
| 00 <sub>h</sub>   | Number of entries | ro     | no          | 0...3       | 3                                       |
| 01 <sub>h</sub>   | Vendor ID         | ro     | no          | UNSIGNED32  | 0286 <sub>h</sub>                       |
| 02 <sub>h</sub>   | Product code      | ro     | no          | UNSIGNED32  | 3213                                    |
| 03 <sub>h</sub>   | Revision number   | ro     | no          | UNSIGNED32  | e.g. 20003 <sub>h</sub> for version 2.3 |

Table 18: Entry Description (1018<sub>h</sub>)

### 3.1.7 Object 1600<sub>h</sub>: Receive PDO Mapping Parameter

This object contains the mapping parameters for the RPDO the device is able to receive. The sub-index 00<sub>h</sub> 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<sub>h</sub> 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 <sub>h</sub>  | Receive PDO mapping parameter | RECORD      | PDO Mapping |

Table 19: Object Description (1600<sub>h</sub>)

| Entry Description |   |        |             |                       |
|-------------------|---|--------|-------------|-----------------------|
| Sub-index         | Description                                 | Access | Value Range | Default Value         |
| 00 <sub>h</sub>   | Number of mapped application objects in PDO | rw     | 0...9       | 9                     |
| 01 <sub>h</sub>   | Mapping entry 1                             | rw     | UNSIGNED32  | 60400010 <sub>h</sub> |
| 02 <sub>h</sub>   | Mapping entry 2                             | rw     | UNSIGNED32  | 607A0020 <sub>h</sub> |
| 03 <sub>h</sub>   | Mapping entry 3                             | rw     | UNSIGNED32  | 60FF0020 <sub>h</sub> |
| 04 <sub>h</sub>   | Mapping entry 4                             | rw     | UNSIGNED32  | 68400010 <sub>h</sub> |
| 05 <sub>h</sub>   | Mapping entry 5                             | rw     | UNSIGNED32  | 687A0020 <sub>h</sub> |
| 06 <sub>h</sub>   | Mapping entry 6                             | rw     | UNSIGNED32  | 68FF0020 <sub>h</sub> |
| 07 <sub>h</sub>   | Mapping entry 7                             | rw     | UNSIGNED32  | 70400010 <sub>h</sub> |
| 08 <sub>h</sub>   | Mapping entry 8                             | rw     | UNSIGNED32  | 707A0020 <sub>h</sub> |
| 09 <sub>h</sub>   | Mapping entry 9                             | rw     | UNSIGNED32  | 70FF0020 <sub>h</sub> |

Table 20: Entry Description (1600<sub>h</sub>)



### 3.1.8 Objects 1A00<sub>h</sub>: Transmit PDO Mapping Parameter

This object contains the mapping parameters for the TPDO the device is able to transmit. The sub-index 00<sub>h</sub> 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<sub>h</sub> 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 <sub>h</sub>  | Transmit PDO mapping parameter | RECORD      | PDO Mapping |

Table 21: Object Description (1A00<sub>h</sub>)

| Entry Description |   |        |             |                       |
|-------------------|---|--------|-------------|-----------------------|
| Sub-index         | Description                                 | Access | Value Range | Default Value         |
| 00 <sub>h</sub>   | Number of mapped application objects in PDO | rw     | 0...9       | 9                     |
| 01 <sub>h</sub>   | Mapping entry 1                             | rw     | UNSIGNED32  | 60410010 <sub>h</sub> |
| 02 <sub>h</sub>   | Mapping entry 2                             | rw     | UNSIGNED32  | 60640008 <sub>h</sub> |
| 03 <sub>h</sub>   | Mapping entry 3                             | rw     | UNSIGNED32  | 606C0020 <sub>h</sub> |
| 04 <sub>h</sub>   | Mapping entry 4                             | rw     | UNSIGNED32  | 68410010 <sub>h</sub> |
| 05 <sub>h</sub>   | Mapping entry 5                             | rw     | UNSIGNED32  | 68640020 <sub>h</sub> |
| 06 <sub>h</sub>   | Mapping entry 6                             | rw     | UNSIGNED32  | 686C0020 <sub>h</sub> |
| 07 <sub>h</sub>   | Mapping entry 7                             | rw     | UNSIGNED32  | 70410010 <sub>h</sub> |
| 08 <sub>h</sub>   | Mapping entry 8                             | rw     | UNSIGNED32  | 70640020 <sub>h</sub> |
| 09 <sub>h</sub>   | Mapping entry 9                             | rw     | UNSIGNED32  | 706C0020 <sub>h</sub> |

Table 22: Entry Description (1A00<sub>h</sub>)

### 3.1.9 Objects 1C00<sub>h</sub>: Sync Manager Communication Type

This object describes the communication types of the EtherCAT sync managers. The types of the first four sync 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 23: Sync Manager Communication Types

| Object Description |                                 |             |           |
|--------------------|---------------------------------|-------------|-----------|
| Index              | Name                            | Object Type | Data Type |
| 1C00 <sub>h</sub>  | Sync manager communication type | RECORD      | UNSIGNED8 |

Table 24: Object Description (1C00<sub>h</sub>)

| Entry Description |                                   |        |             |               |
|-------------------|-----------------------------------|--------|-------------|---------------|
| Sub-index         | Description                       | Access | Value Range | Default Value |
| 00 <sub>h</sub>   | Number of entries                 | rw     | 0...3       | 4             |
| 01 <sub>h</sub>   | Communication type sync manager 1 | rw     | UNSIGNED8   | 1             |
| 02 <sub>h</sub>   | Communication type sync manager 2 | rw     | UNSIGNED8   | 2             |
| 03 <sub>h</sub>   | Communication type sync manager 3 | rw     | UNSIGNED8   | 3             |
| 04 <sub>h</sub>   | Communication type sync manager 4 | rw     | UNSIGNED8   | 4             |

Table 25: Entry Description (1C00<sub>h</sub>)

### 3.1.10 Objects 1C12<sub>h</sub>: Sync Manager 2 PDO Assignment

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

| Object Description |                               |             |                |
|--------------------|-------------------------------|-------------|----------------|
| Index              | Name                          | Object Type | Data Type      |
| 1C12 <sub>h</sub>  | Sync manager 2 PDO assignment | RECORD      | PDO assignment |

Table 26: Object Description (1C12<sub>h</sub>)



| Entry Description |                                    |        |             |                   |
|-------------------|------------------------------------|--------|-------------|-------------------|
| Sub-index         | Description                        | Access | Value Range | Default Value     |
| 00 <sub>h</sub>   | Number of assigned PDOs            | rw     | 0...1       | 1                 |
| 01 <sub>h</sub>   | PDO mapping index of assigned RPDO | rw     | UNSIGNED16  | 1600 <sub>h</sub> |

Table 27: Entry Description (1C12<sub>h</sub>)

### 3.1.11 Objects 1C13<sub>h</sub>: Sync Manager 3 PDO Assignment

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

| Object Description |                               |             |                |
|--------------------|-------------------------------|-------------|----------------|
| Index              | Name                          | Object Type | Data Type      |
| 1C13 <sub>h</sub>  | Sync manager 3 PDO assignment | RECORD      | PDO assignment |

Table 28: Object Description (1C13<sub>h</sub>)

| Entry Description |                                    |        |             |                   |
|-------------------|------------------------------------|--------|-------------|-------------------|
| Sub-index         | Description                        | Access | Value Range | Default Value     |
| 00 <sub>h</sub>   | Number of assigned PDOs            | rw     | 0...1       | 1                 |
| 01 <sub>h</sub>   | PDO mapping index of assigned TPDO | rw     | UNSIGNED16  | 1A00 <sub>h</sub> |

Table 29: Entry Description (1C13<sub>h</sub>)

## 4 Manufacturer Specific Area

The manufacturer segment contains manufacturer specific objects. These objects control the special features of the Trinamic Motion Control device TMC3213.

### **i** 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 30: Multi-axis Object Indices (Manufacturer specific Area)

### 4.1 Objects related to coolStep

Figure 5 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.



### coolStep™ adjustment points and thresholds

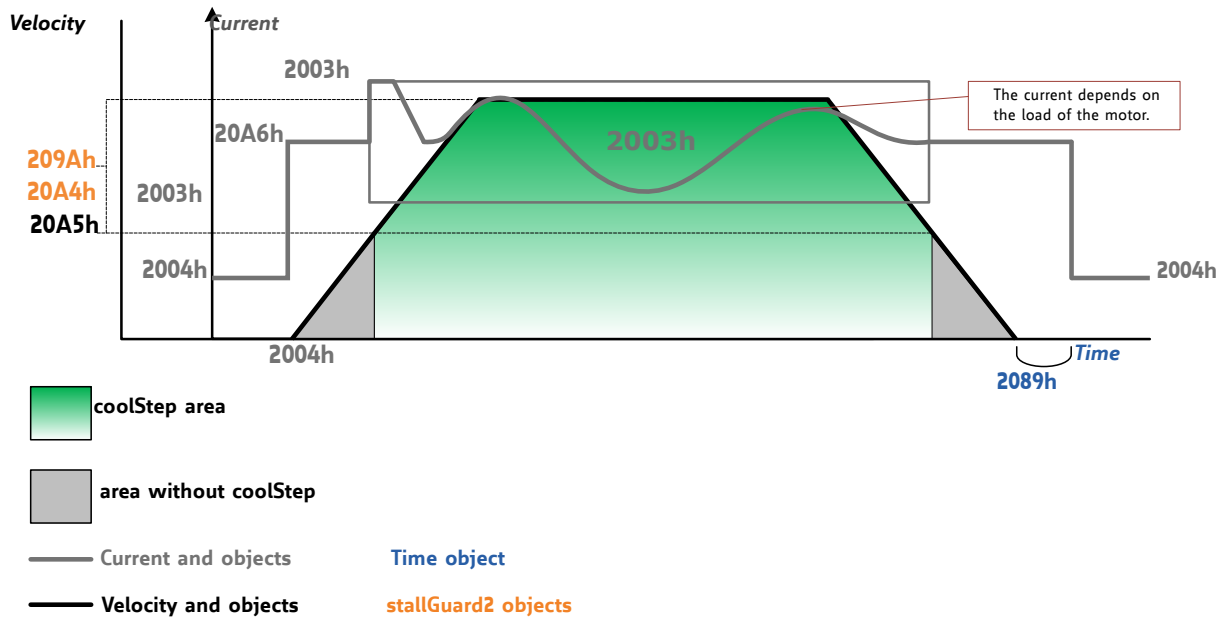


Figure 5: coolStep Adjustment Points and Thresholds





| coolStep Adjustment Objects |                               |  |
|-----------------------------|-------------------------------|--|
| Object                      | Name                          | Description  |
| 2003 <sub>h</sub>           | 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).<br>The most important motor setting, since too high values might cause motor damage! |
| 2004 <sub>h</sub>           | Standby current               | The current limit two seconds after the motor has stopped.   |
| 2098 <sub>h</sub>           | smartEnergy current minimum   | Sets the lower motor current limit for coolStep operation by scaling the run current (object 2003 <sub>h</sub> ) value.<br>This can be:<br>0: for 1/2 of the run current<br>1: for 1/4 of the run current  |
| 2099 <sub>h</sub>           | smartEnergy current down step | Sets the speed of current decrement when the stallGuard reading is above the upper threshold.<br>0: slow decrement<br>3: fast decrement  |
| 209B <sub>h</sub>           | smartEnergy current up step   | Sets the current increment step when the stallGuard below the lower threshold.<br>0: slow increment<br>3: fast increment / fast reaction to rising load  |
| 209A <sub>h</sub>           | 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 <sub>h</sub>           | 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 <sub>h</sub>           | smartEnergy threshold speed.  | Above this speed coolStep becomes enabled.   |
| 2089 <sub>h</sub>           | Standby delay                 | Standstill period before the current is changed down to standby current. The standard value is 200 which is 2 seconds.   |

Table 31: coolStep related Objects



## 4.2 Detailed Object Specifications

### 4.2.1 Object 2000<sub>h</sub>: 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 <sub>h</sub>  | Microstep Resolution | Variable    | UNSIGNED8 |

Table 32: Object Description (2000<sub>h</sub>)

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

Table 33: Entry Description (2000<sub>h</sub>)

### 4.2.2 Object 2001<sub>h</sub>: 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 <sub>h</sub>  | Motor full step resolution | Variable    | UNSIGNED16 |

Table 34: Object Description (2001<sub>h</sub>)

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

Table 35: Entry Description (2001<sub>h</sub>)

### 4.2.3 Object 2002<sub>h</sub>: 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.



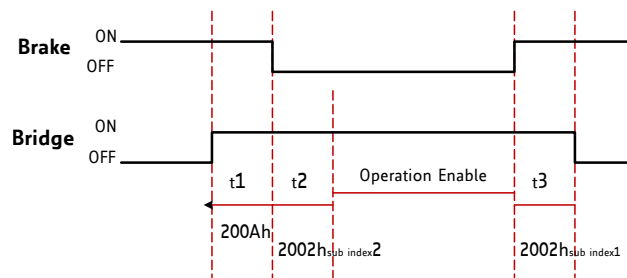


Figure 6: Brake Output Timing

| Object Description |                   |             |            |
|--------------------|-------------------|-------------|------------|
| Index              | Name              | Object Type | Data Type  |
| 2002 <sub>h</sub>  | Brake delay times | Array       | UNSIGNED16 |

Table 36: Object Description (2002<sub>h</sub>)

| 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 37: Entry Description (2002<sub>h</sub>)

#### 4.2.4 Object 2003<sub>h</sub>: 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 <sub>h</sub>  | Maximum current | Variable    | UNSIGNED8 |

Table 38: Object Description (2003<sub>h</sub>)

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

Table 39: Entry Description (2003<sub>h</sub>)



#### 4.2.5 Object 2004<sub>h</sub>: 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 <sub>h</sub>  | Maximum current | Variable    | UNSIGNED8 |

Table 40: Object Description (2004<sub>h</sub>)

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

Table 41: Entry Description (2004<sub>h</sub>)

#### 4.2.6 Object 2005<sub>h</sub>: 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 <sub>h</sub>  | Limit switches | Variable    | UNSIGNED32 |

Table 42: Object Description (2005<sub>h</sub>)

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

Table 43: Entry Description (2005<sub>h</sub>)



| 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 44: Bit Definitions (2005<sub>h</sub>)

#### 4.2.7 Object 200A<sub>h</sub>: 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 <sub>h</sub>  | Enable drive delay time | Variable    | UNSIGNED16 |

Table 45: Object Description (200A<sub>h</sub>)

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

Table 46: Entry Description (200A<sub>h</sub>)

#### 4.2.8 Object 200B<sub>h</sub>: Encoder Parameters

This object defines encoder parameters. These are the polarity of the encoder null channel, the direction of rotation (set it to 1 if the direction is reversed compared to the motor) and if the position is to be initialized with the encoder position. It is only writable in SWITCHED\_ON\_DISABLED state.

| Object Description |                    |             |           |
|--------------------|--------------------|-------------|-----------|
| Index              | Name               | Object Type | Data Type |
| 200B <sub>h</sub>  | Encoder parameters | Array       | UNSIGNED8 |

Table 47: Object Description (200B<sub>h</sub>)

| 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 48: Entry Description (200B<sub>h</sub>)

#### 4.2.9 Object 200C<sub>h</sub>: 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 (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 <sub>h</sub>  | Brake current feed | Array       | UNSIGNED8 |

Table 49: Object Description (200C<sub>h</sub>)

| 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 50: Entry Description (200C<sub>h</sub>)

#### 4.2.10 Object 2010<sub>h</sub>: 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 <sub>h</sub>  | Profile Start Velocity | Variable    | UNSIGNED32 |

Table 51: Object Description (2010<sub>h</sub>)

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

Table 52: Entry Description (2010<sub>h</sub>)

#### 4.2.11 Object 2011<sub>h</sub>: Profile A1

This object contains the acceleration value used for ramping up from the start velocity (object 2011<sub>h</sub>, see section 4.2.10) to the velocity V1 (object (h)2012), see section 4.2.12).

| Object Description |            |             |            |
|--------------------|------------|-------------|------------|
| Index              | Name       | Object Type | Data Type  |
| 2011 <sub>h</sub>  | Profile A1 | Variable    | UNSIGNED32 |

Table 53: Object Description (2011<sub>h</sub>)

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

Table 54: Entry Description (2011<sub>h</sub>)

#### 4.2.12 Object 2012<sub>h</sub>: Profile V1

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

| Object Description |            |             |            |
|--------------------|------------|-------------|------------|
| Index              | Name       | Object Type | Data Type  |
| 2012 <sub>h</sub>  | Profile V1 | Variable    | UNSIGNED32 |

Table 55: Object Description (2012<sub>h</sub>)

| Entry Description |        |             |             |               |
|-------------------|--------|-------------|-------------|---------------|
| Sub-index         | Access | PDO Mapping | Value Range | Default Value |
| 0                 | rw     | no          | 06777215    | 0             |

Table 56: Entry Description (2012<sub>h</sub>)

#### 4.2.13 Object 2013<sub>h</sub>: Profile D1

This object contains the deceleration value used for decelerating from the maximum positioning velocity to the velocity V1 (object 2012<sub>h</sub>, see section 4.2.12).

| Object Description |            |             |            |
|--------------------|------------|-------------|------------|
| Index              | Name       | Object Type | Data Type  |
| 2013 <sub>h</sub>  | Profile D1 | Variable    | UNSIGNED32 |

Table 57: Object Description (2013<sub>h</sub>)

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

Table 58: Entry Description (2013<sub>h</sub>)

#### 4.2.14 Object 2015<sub>h</sub>: Ramp Wait Time

This object defines the waiting time after ramping down to zero velocity before the next movement or direction inversion can start. Time range is 0 to 2 seconds. This setting avoids excess acceleration e.g. from positive stop velocity to negative start velocity.

| Object Description |                |             |            |
|--------------------|----------------|-------------|------------|
| Index              | Name           | Object Type | Data Type  |
| 2015 <sub>h</sub>  | Ramp Wait Time | Variable    | UNSIGNED16 |

Table 59: Object Description (2015<sub>h</sub>)

| Entry Description |        |             |                       |               |
|-------------------|--------|-------------|-----------------------|---------------|
| Sub-index         | Access | PDO Mapping | Value Range           | Default Value |
| 0                 | rw     | no          | 0...65535 [0.000032s] | 0             |

Table 60: Entry Description (2015<sub>h</sub>)

#### 4.2.15 Object 2089<sub>h</sub>: 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 <sub>h</sub>  | Setting Delay | Variable    | UNSIGNED16 |

Table 61: Object Description (2089<sub>h</sub>)

| Entry Description |        |             |             |               |
|-------------------|--------|-------------|-------------|---------------|
| Sub-index         | Access | PDO Mapping | Value Range | Default Value |
| 0                 | rw     | no          | 0...400     | 0             |

Table 62: Entry Description (2089<sub>h</sub>)

#### 4.2.16 Object 208C<sub>h</sub>: 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 <sub>h</sub>  | Velocity Dimension Index | Variable    | UNSIGNED8 |

Table 63: Object Description (208C<sub>h</sub>)

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

Table 64: Entry Description (208C<sub>h</sub>)

#### 4.2.17 Object 208E<sub>h</sub>: Acceleration Dimension Index

With this object, the unit for acceleration can be read out. The unit can be set using object 208Ch. Object 208E<sub>h</sub> reads 0 when internal units are selected and 179 when PPS/s is selected.

| Object Description |                              |             |           |
|--------------------|------------------------------|-------------|-----------|
| Index              | Name                         | Object Type | Data Type |
| 208E <sub>h</sub>  | Acceleration Dimension Index | Variable    | UNSIGNED8 |

Table 65: Object Description (208E<sub>h</sub>)

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

Table 66: Entry Description (208E<sub>h</sub>)

#### 4.2.18 Object 2092<sub>h</sub>: 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 <sub>h</sub>  | Chopper Blank Time | Variable    | UNSIGNED8 |

Table 67: Object Description (2092<sub>h</sub>)

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

Table 68: Entry Description (2092<sub>h</sub>)

#### 4.2.19 Object 2093<sub>h</sub>: 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 <sub>h</sub>  | Chopper Mode | Variable    | UNSIGNED8 |

Table 69: Object Description (2093<sub>h</sub>)

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

Table 70: Entry Description (2093<sub>h</sub>)



#### 4.2.20 Object 2094<sub>h</sub>: 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 <sub>h</sub>  | Chopper Hysteresis Decrement | Variable    | UNSIGNED8 |

Table 71: Object Description (2094<sub>h</sub>)

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

Table 72: Entry Description (2094<sub>h</sub>)

#### 4.2.21 Object 2095<sub>h</sub>: 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<sub>h</sub> (section 4.2.20).

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 <sub>h</sub>  | Chopper Hysteresis End | Variable    | SIGNED8   |

Table 73: Object Description (2095<sub>h</sub>)

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

Table 74: Entry Description (2095<sub>h</sub>)



#### 4.2.22 Object 2096<sub>h</sub>: 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 <sub>h</sub>  | Chopper Hysteresis Start | Variable    | UNSIGNED8 |

Table 75: Object Description (2096<sub>h</sub>)

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

Table 76: Entry Description (2096<sub>h</sub>)

#### 4.2.23 Object 2097<sub>h</sub>: 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 <sub>h</sub>  | Chopper Off Time | Variable    | UNSIGNED8 |

Table 77: Object Description (2097<sub>h</sub>)

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

Table 78: Entry Description (2097<sub>h</sub>)

#### 4.2.24 Object 2098<sub>h</sub>: 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 <sub>h</sub>  | Smart Energy Current Minimum | Variable    | UNSIGNED8 |

Table 79: Object Description (2098<sub>h</sub>)

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

Table 80: Entry Description (2098<sub>h</sub>)

#### 4.2.25 Object 2099<sub>h</sub>: 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 <sub>h</sub>  | Smart Energy Current Down Step | Variable    | UNSIGNED8 |

Table 81: Object Description (2099<sub>h</sub>)

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

Table 82: Entry Description (2099<sub>h</sub>)

#### 4.2.26 Object 209A<sub>h</sub>: 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: (smartEnergy hysteresis value + 1) \* 32

Upper stallGuard threshold: (smartEnergy hysteresis start + smartEnergy hysteresis + 1) \* 32



| Object Description |                         |             |           |
|--------------------|-------------------------|-------------|-----------|
| Index              | Name                    | Object Type | Data Type |
| 209A <sub>h</sub>  | Smart Energy Hysteresis | Variable    | UNSIGNED8 |

Table 83: Object Description (209A<sub>h</sub>)

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

Table 84: Entry Description (209A<sub>h</sub>)

#### 4.2.27 Object 209B<sub>h</sub>: 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<sub>h</sub>, section 4.2.28).

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 <sub>h</sub>  | Smart Energy Current Up Step | Variable    | UNSIGNED8 |

Table 85: Object Description (209B<sub>h</sub>)

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

Table 86: Entry Description (209B<sub>h</sub>)

#### 4.2.28 Object 209C<sub>h</sub>: Smart Energy Hysteresis Start

This object serves to set the lower threshold for the stallGuard2 value (see smart Energy current up step (section 4.2.27). Setting this to 0 disables the coolStep function.



| Object Description |                               |             |           |
|--------------------|-------------------------------|-------------|-----------|
| Index              | Name                          | Object Type | Data Type |
| 209C <sub>h</sub>  | Smart Energy Hysteresis Start | Variable    | UNSIGNED8 |

Table 87: Object Description (209C<sub>h</sub>)

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

Table 88: Entry Description (209C<sub>h</sub>)

#### 4.2.29 Object 209D<sub>h</sub>: 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 <sub>h</sub>  | Smart Energy Filter Enable | Variable    | UNSIGNED8 |

Table 89: Object Description (209D<sub>h</sub>)

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

Table 90: Entry Description (209D<sub>h</sub>)

#### 4.2.30 Object 209E<sub>h</sub>: 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 <sub>h</sub>  | stallGuard2 Threshold | Variable    | SIGNED8   |

Table 91: Object Description (209E<sub>h</sub>)

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

Table 92: Entry Description (209E<sub>h</sub>)

#### 4.2.31 Object 20A1<sub>h</sub>: 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 <sub>h</sub>  | Short Protection Disable | Variable    | UNSIGNED8 |

Table 93: Object Description (20A1<sub>h</sub>)

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

Table 94: Entry Description (20A1<sub>h</sub>)

#### 4.2.32 Object 20A3<sub>h</sub>: 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 <sub>h</sub>  | Vsense | Variable    | UNSIGNED8 |

Table 95: Object Description (20A3<sub>h</sub>)

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

Table 96: Entry Description (20A3<sub>h</sub>)

#### 4.2.33 Object 20A4<sub>h</sub>: 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 <sub>h</sub>  | Stop on Stall | Variable    | UNSIGNED32 |

Table 97: Object Description (20A4<sub>h</sub>)

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

Table 98: Entry Description (20A4<sub>h</sub>)

#### 4.2.34 Object 20A5<sub>h</sub>: 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 <sub>h</sub>  | Smart Energy Threshold Speed | Variable    | UNSIGNED32 |

Table 99: Object Description (20A5<sub>h</sub>)

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

Table 100: Entry Description (20A5<sub>h</sub>)

#### 4.2.35 Object 20B0<sub>h</sub>: 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 higher than the value set by this object.

| Object Description |                     |             |            |
|--------------------|---------------------|-------------|------------|
| Index              | Name                | Object Type | Data Type  |
| 20B0 <sub>h</sub>  | PWM Threshold Speed | Variable    | UNSIGNED32 |

Table 101: Object Description (20B0<sub>h</sub>)

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

Table 102: Entry Description (20B0<sub>h</sub>)

#### 4.2.36 Object 20B1<sub>h</sub>: 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 <sub>h</sub>  | PWM Gradient | Variable    | UNSIGNED8 |

Table 103: Object Description (20B1<sub>h</sub>)

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

Table 104: Entry Description (20B1<sub>h</sub>)

#### 4.2.37 Object 20B2<sub>h</sub>: 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 <sub>h</sub>  | PWM Amplitude | Variable    | UNSIGNED8 |

Table 105: Object Description (20B2<sub>h</sub>)

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

Table 106: Entry Description (20B2<sub>h</sub>)

#### 4.2.38 Object 20B3<sub>h</sub>: dcStep Minimum Speed

Minimum speed for switching to dcStep. The motor driver will not switch to dcStep mode when the actual velocity is below this value. Setting this object to zero completely switches off dcStep.

| Object Description |                      |             |            |
|--------------------|----------------------|-------------|------------|
| Index              | Name                 | Object Type | Data Type  |
| 20B3 <sub>h</sub>  | dcStep Minimum Speed | Variable    | UNSIGNED32 |

Table 107: Object Description (20B3<sub>h</sub>)

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

Table 108: Entry Description (20B3<sub>h</sub>)

#### 4.2.39 Object 20B4<sub>h</sub>: dcStep Time

This setting controls the reference pulse width for dcStep load measurement. It must be optimized for robust operation with maximum motor torque. A higher value allows higher torque and higher velocity, a lower value allows operation down to a lower velocity as set by the minimum dcStep speed (object 20B3<sub>h</sub>, see section 4.2.38).



| Object Description |             |             |            |
|--------------------|-------------|-------------|------------|
| Index              | Name        | Object Type | Data Type  |
| 20B4 <sub>h</sub>  | dcStep Time | Variable    | UNSIGNED16 |

Table 109: Object Description (20B4<sub>h</sub>)

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

Table 110: Entry Description (20B4<sub>h</sub>)

#### 4.2.40 Object 20B5<sub>h</sub>: dcStep stallGuard

This setting controls stall detection in dcStep mode. Increase this value for higher sensitivity.

| Object Description |                   |             |           |
|--------------------|-------------------|-------------|-----------|
| Index              | Name              | Object Type | Data Type |
| 20B5 <sub>h</sub>  | dcStep stallGuard | Variable    | UNSIGNED8 |

Table 111: Object Description (20B5<sub>h</sub>)

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

Table 112: Entry Description (20B5<sub>h</sub>)

#### 4.2.41 Object 20B6<sub>h</sub>: Fullstep Threshold Speed

Depending on the settings of objects 20B7<sub>h</sub> and 20B8<sub>h</sub> (see sections 4.2.42 and 4.2.43) the driver switches to fullstep mode and/or to a different chopper mode when the speed set by this object is exceeded.

| Object Description |                          |             |            |
|--------------------|--------------------------|-------------|------------|
| Index              | Name                     | Object Type | Data Type  |
| 20B6 <sub>h</sub>  | Fullstep Threshold Speed | Variable    | UNSIGNED32 |

Table 113: Object Description (20B6<sub>h</sub>)



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

Table 114: Entry Description (20B6<sub>h</sub>)

#### 4.2.42 Object 20B7<sub>h</sub>: High Speed Chopper Mode

The motor driver will switch to a different chopper mode when this object is set to 1 and the measured speed is greater than the threshold speed set by object 20B6<sub>h</sub> (see section 4.2.41).

| Object Description |                         |             |           |
|--------------------|-------------------------|-------------|-----------|
| Index              | Name                    | Object Type | Data Type |
| 20B7 <sub>h</sub>  | High Speed Chopper Mode | Variable    | UNSIGNED8 |

Table 115: Object Description (20B7<sub>h</sub>)

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

Table 116: Entry Description (20B7<sub>h</sub>)

#### 4.2.43 Object 20B8<sub>h</sub>: High Speed Fullstep Mode

The motor driver will switch to fullstep mode when this object is set to 1 and the measured speed is greater than the threshold speed set by object 20B6<sub>h</sub> (see section 4.2.41).

| Object Description |                         |             |           |
|--------------------|-------------------------|-------------|-----------|
| Index              | Name                    | Object Type | Data Type |
| 20B8 <sub>h</sub>  | High Speed Chopper Mode | Variable    | UNSIGNED8 |

Table 117: Object Description (20B8<sub>h</sub>)

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

Table 118: Entry Description (20B8<sub>h</sub>)

#### 4.2.44 Object 20B9<sub>h</sub>: Power Down Ramp

The value set by this object controls the number of clock cycles for motor power down after a motion as soon as the motor has stopped and the setting time (set by object 2089<sub>h</sub>, please see section 4.2.15) has



expired. The smooth transition avoids a motor jerk upon power down.

- 0=instant power down.
- 15=longest possible power down ramp.

| Object Description |                 |             |           |
|--------------------|-----------------|-------------|-----------|
| Index              | Name            | Object Type | Data Type |
| 20B9 <sub>h</sub>  | Power Down Ramp | Variable    | UNSIGNED8 |

Table 119: Object Description (20B9<sub>h</sub>)

| Entry Description |        |             |             |               |
|-------------------|--------|-------------|-------------|---------------|
| Sub-index         | Access | PDO Mapping | Value Range | Default Value |
| 0                 | rw     | no          | 0...15      | 7             |

Table 120: Entry Description (20B9<sub>h</sub>)

#### 4.2.45 Object 2100<sub>h</sub>: Home Offset Display

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

| Object Description |                     |             |           |
|--------------------|---------------------|-------------|-----------|
| Index              | Name                | Object Type | Data Type |
| 2100 <sub>h</sub>  | Home Offset Display | Variable    | SIGNED32  |

Table 121: Object Description (2100<sub>h</sub>)

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

Table 122: Entry Description (2100<sub>h</sub>)

#### 4.2.46 Object 2101<sub>h</sub>: Actual Load Value

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

| Object Description |                     |             |            |
|--------------------|---------------------|-------------|------------|
| Index              | Name                | Object Type | Data Type  |
| 2101 <sub>h</sub>  | Home Offset Display | Variable    | UNSIGNED16 |

Table 123: Object Description (2101<sub>h</sub>)



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

Table 124: Entry Description (2101<sub>h</sub>)

#### 4.2.47 Object 2102<sub>h</sub>: 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 125: Driver Error Flags (2102<sub>h</sub>)

| Object Description |                     |             |           |
|--------------------|---------------------|-------------|-----------|
| Index              | Name                | Object Type | Data Type |
| 2102 <sub>h</sub>  | Home Offset Display | Variable    | UNSIGNED8 |

Table 126: Object Description (2102<sub>h</sub>)

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

Table 127: Entry Description (2102<sub>h</sub>)

#### 4.2.48 Object 2107<sub>h</sub>: Microstep Resolution Display

This object shows the microstep resolution, set by object 2000<sub>h</sub> (please see section 4.2.1).



| Object Description |                              |             |           |
|--------------------|------------------------------|-------------|-----------|
| Index              | Name                         | Object Type | Data Type |
| 2107 <sub>h</sub>  | Microstep resolution display | Variable    | UNSIGNED8 |

Table 128: Object Description (2107<sub>h</sub>)

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

Table 129: Entry Description (2107<sub>h</sub>)

#### 4.2.49 Object 210B<sub>h</sub>: 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 <sub>h</sub>  | Step Counter | Variable    | RECORD    |

Table 130: Object Description (210B<sub>h</sub>)

| Entry Description |                |        |             |                                    |               |
|-------------------|----------------|--------|-------------|------------------------------------|---------------|
| Sub-index         | Description    | Access | PDO Mapping | Value Range                        | Default Value |
| 1                 | Lower 32 Bits  | ro     | no          | 0... ffffffff <sub>h</sub>         | 0             |
| 2                 | Higher 32 Bits | ro     | no          | 0... ffffffff <sub>h</sub>         | 0             |
| 3                 | 64 Bit Value   | ro     | no          | 0... ffffffffffffffff <sub>h</sub> | 0             |

Table 131: Entry Description (210B<sub>h</sub>)

#### 4.2.50 Object 2121<sub>h</sub>: PWM Scale Value

Actual PWM scale value used when the motor driver is operating in stealthChop mode.

| Object Description |                 |             |           |
|--------------------|-----------------|-------------|-----------|
| Index              | Name            | Object Type | Data Type |
| 2121 <sub>h</sub>  | PWM Scale Value | Variable    | UNSIGNED8 |

Table 132: Object Description (2121<sub>h</sub>)





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

Table 133: Entry Description (2121<sub>h</sub>)

#### 4.2.51 Object 2122<sub>h</sub>: Measured Velocity

This object contains the velocity measured by the motor driver. This value is important only when the motor driver is operating in dcStep mode.

| Object Description |                   |             |           |
|--------------------|-------------------|-------------|-----------|
| Index              | Name              | Object Type | Data Type |
| 2122 <sub>h</sub>  | Measured Velocity | Variable    | SIGNED32  |

Table 134: Object Description (2122<sub>h</sub>)

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

Table 135: Entry Description (2122<sub>h</sub>)

#### 4.2.52 Object 2702<sub>h</sub>: 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 136: Bit Definitions (2702<sub>h</sub>)

| Object Description |                       |             |            |
|--------------------|-----------------------|-------------|------------|
| Index              | Name                  | Object Type | Data Type  |
| 2702 <sub>h</sub>  | Device Digital Inputs | Variable    | UNSIGNED32 |

Table 137: Object Description (2702<sub>h</sub>)

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

Table 138: Entry Description (2702)<sub>h</sub>

#### 4.2.53 Object 2703<sub>h</sub>: 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 139: Bit Definitions (2703<sub>h</sub>)

| Object Description |                        |             |           |
|--------------------|------------------------|-------------|-----------|
| Index              | Name                   | Object Type | Data Type |
| 2703 <sub>h</sub>  | Device Digital Outputs | Variable    | ARRAY     |

Table 140: Object Description (2703<sub>h</sub>)

| 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 141: Entry Description (2703<sub>h</sub>)



#### 4.2.54 Object 270E<sub>h</sub>: Device Analog Inputs

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

| Object Description |                      |             |            |
|--------------------|----------------------|-------------|------------|
| Index              | Name                 | Object Type | Data Type  |
| 270E <sub>h</sub>  | Device Analog Inputs | Array       | UNSIGNED32 |

Table 142: Object Description (270E<sub>h</sub>)

| 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 143: Entry Description (270E<sub>h</sub>)



## 5 Profile Specific Area

The profile segment contains CiA-402 standard motion control objects. These objects control the motion control functions of the TMCM-3213. 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<sub>h</sub>, please see 5.1.6) are implemented on the TMCM-3213:

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

### **i** 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<sub>h</sub> for motor #0) can be accessed as object 6840<sub>h</sub> for motor #1 and as object 7040<sub>h</sub> for motor #2. Please see also section 2.4.1.

| Multi-axis Object Indices |                                       |
|---------------------------|---------------------------------------|
| Motor                     | Object Index Range                    |
| Motor #0                  | 6000 <sub>h</sub> – 67FF <sub>h</sub> |
| Motor #1                  | 6800 <sub>h</sub> – 6FFF <sub>h</sub> |
| Motor #2                  | 7000 <sub>h</sub> – 77FF <sub>h</sub> |

Table 144: Multi-axis Object Indices (Profile specific Area)

## 5.1 Detailed Object Specifications

### 5.1.1 Object 605A<sub>h</sub>: 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 <i>slow down ramp</i> and transit into <i>switch on disabled</i>  |
| 2                | Slow down on <i>quick stop ramp</i> and transit into <i>switch on disabled</i> |
| 5                | Slow down on <i>slow down ramp</i> and stay in <i>quick stop active</i>        |
| 6                | Slow down on <i>quick stop ramp</i> and stay in <i>quick stop active</i>       |

Table 145: Value Description (605A<sub>h</sub>)

| Object Description |                        |             |           |
|--------------------|------------------------|-------------|-----------|
| Index              | Name                   | Object Type | Data Type |
| 605A <sub>h</sub>  | Quick stop option code | Variable    | SIGNED16  |

Table 146: Object Description (605A<sub>h</sub>)

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

Table 147: Entry Description (605A<sub>h</sub>)

### 5.1.2 Object 605B<sub>h</sub>: 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 148: Value Description (605B<sub>h</sub>)

| Object Description |                      |             |            |
|--------------------|----------------------|-------------|------------|
| Index              | Name                 | Object Type | Data Type  |
| 605B <sub>h</sub>  | Shutdown option code | Variable    | UNSIGNED16 |

Table 149: Object Description (605B<sub>h</sub>)



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

Table 150: Entry Description (605B<sub>h</sub>)

### 5.1.3 Object 605C<sub>h</sub>: 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 151: Value Description (605C<sub>h</sub>)

| Object Description |                               |             |            |
|--------------------|-------------------------------|-------------|------------|
| Index              | Name                          | Object Type | Data Type  |
| 605C <sub>h</sub>  | Disable operation option code | Variable    | UNSIGNED16 |

Table 152: Object Description (605C<sub>h</sub>)

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

Table 153: Entry Description (605C<sub>h</sub>)

### 5.1.4 Object 605D<sub>h</sub>: 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 <i>operation enabled</i> |

Table 154: Value Description (605D<sub>h</sub>)

| Object Description |                  |             |            |
|--------------------|------------------|-------------|------------|
| Index              | Name             | Object Type | Data Type  |
| 605D <sub>h</sub>  | Halt option code | Variable    | UNSIGNED16 |

Table 155: Object Description (605D<sub>h</sub>)

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

Table 156: Entry Description (605D<sub>h</sub>)

### 5.1.5 Object 605E<sub>h</sub>: 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 157: Value Description (605E<sub>h</sub>)

| Object Description |                            |             |            |
|--------------------|----------------------------|-------------|------------|
| Index              | Name                       | Object Type | Data Type  |
| 605E <sub>h</sub>  | Fault reaction option code | Variable    | UNSIGNED16 |

Table 158: Object Description (605E<sub>h</sub>)

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

Table 159: Entry Description (605E<sub>h</sub>)

### 5.1.6 Object 6060<sub>h</sub>: 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) |

*Table 160: Value Description (6060<sub>h</sub>)*

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 <sub>h</sub>  | Modes of operation | Variable    | SIGNED8   |

*Table 161: Object Description (6060<sub>h</sub>)*

| Entry Description |        |                  |             |               |
|-------------------|--------|------------------|-------------|---------------|
| Sub-index         | Access | PDO Mapping      | Value Range | Default Value |
| 0                 | rw     | refer to CiA-402 | 0/1/3/6     | 0             |

*Table 162: Entry Description (6060<sub>h</sub>)*

### 5.1.7 Object 6061<sub>h</sub>: 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) |

*Table 163: Value Description (6061<sub>h</sub>)*





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 <sub>h</sub>  | Modes of operation display | Variable    | SIGNED8   |

Table 164: Object Description (6061<sub>h</sub>)

| Entry Description |        |                  |             |               |
|-------------------|--------|------------------|-------------|---------------|
| Sub-index         | Access | PDO Mapping      | Value Range | Default Value |
| 0                 | rw     | refer to CiA-402 | 0/1/3/6     | 0             |

Table 165: Entry Description (6061<sub>h</sub>)

### 5.1.8 Object 606A<sub>h</sub>: 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 166: Value Description (606A<sub>h</sub>)

| Object Description |                       |             |           |
|--------------------|-----------------------|-------------|-----------|
| Index              | Name                  | Object Type | Data Type |
| 606A <sub>h</sub>  | Sensor selection code | Variable    | SIGNED16  |

Table 167: Object Description (606A<sub>h</sub>)

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

Table 168: Entry Description (606A<sub>h</sub>)



### 5.1.9 Object 608F<sub>h</sub>: 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 <sub>h</sub>  | Position Encoder Resolution | Array       | UNSIGNED32 |

Table 169: Object Description (608F<sub>h</sub>)

| 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 170: Entry Description (608F<sub>h</sub>)

### 5.1.10 Object 60FD<sub>h</sub>: 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 <sub>h</sub>  | Digital inputs | Variable    | UNSIGNED32 |

Table 171: Object Description (60FD<sub>h</sub>)

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

Table 172: Entry Description (60FD<sub>h</sub>)

### 5.1.11 Object 6502<sub>h</sub>: 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 173: Value Definition (6502<sub>h</sub>)

| Object Description |                       |             |            |
|--------------------|-----------------------|-------------|------------|
| Index              | Name                  | Object Type | Data Type  |
| 6502 <sub>h</sub>  | Supported drive modes | Variable    | UNSIGNED32 |

Table 174: Object Description (6502<sub>h</sub>)

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

Table 175: Entry Description (6502<sub>h</sub>)



## 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<sub>h</sub> (section 5.1.6) for information about how to choose an operation mode. Object 6061<sub>h</sub> (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.

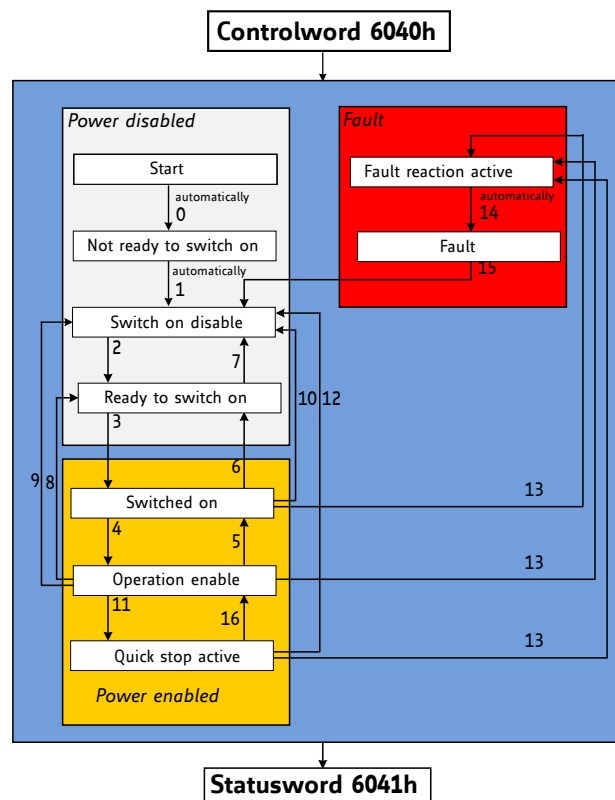


Figure 7: DS402 Finite State Machine

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<sub>n</sub>: 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 7 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 176: 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.<br>1: New position is relative. |
| 9                                       | Change set point    | Not supported.   |

Table 177: 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 178: Command Coding



| Object Description |             |             |            |
|--------------------|-------------|-------------|------------|
| Index              | Name        | Object Type | Data Type  |
| 6040 <sub>h</sub>  | Controlword | Variable    | UNSIGNED16 |

Table 179: Object Description (6040<sub>h</sub> in pp Mode)

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

Table 180: Entry Description (6040<sub>h</sub> in pp Mode)

### 6.1.2 Object 6041<sub>h</sub>: 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 7 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 181: Structure of the Status Word in pp Mode

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

Table 182: 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.<br>1: Set point still in process. |
| 13                                      | Following error        | Not supported.  |

Table 183: Operation Mode specific Bits in pp Mode

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

Table 184: State Coding

| Object Description |             |             |            |
|--------------------|-------------|-------------|------------|
| Index              | Name        | Object Type | Data Type  |
| 6041 <sub>h</sub>  | Controlword | Variable    | UNSIGNED16 |

Table 185: Object Description (6041<sub>h</sub> in pp Mode)

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

Table 186: Entry Description (6041<sub>h</sub> in pp Mode)

### 6.1.3 Object 6062<sub>h</sub>: Position Demand Value

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



| Object Description |                       |             |           |
|--------------------|-----------------------|-------------|-----------|
| Index              | Name                  | Object Type | Data Type |
| 6062 <sub>h</sub>  | Position Demand Value | Variable    | SIGNED32  |

Table 187: Object Description (6062<sub>h</sub>)

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

Table 188: Entry Description (6062<sub>h</sub>)

#### 6.1.4 Object 6063<sub>h</sub>: Position Actual Internal Value

This object provides the actual value of the encoder or the motor. Please use the sensor selection object 606A<sub>h</sub> (see section 5.1.8) for selecting the motor or the encoder first. Object 6063<sub>h</sub> 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 <sub>h</sub>  | Position Actual Internal Value | Variable    | SIGNED32  |

Table 189: Object Description (6063<sub>h</sub>)

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

Table 190: Entry Description (6063<sub>h</sub>)

#### 6.1.5 Object 6064<sub>h</sub>: Position Actual Value

This object provides the actual value of the position measurement device. It always contains the same value as object 6063<sub>h</sub>.

| Object Description |                       |             |           |
|--------------------|-----------------------|-------------|-----------|
| Index              | Name                  | Object Type | Data Type |
| 6064 <sub>h</sub>  | Position Actual Value | Variable    | SIGNED32  |

Table 191: Object Description (6064<sub>h</sub>)



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

Table 192: Entry Description (6064<sub>h</sub>)

### 6.1.6 Object 6065<sub>h</sub>: 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<sub>h</sub>) and encoder position (object 6063<sub>h</sub> or 6064<sub>h</sub>) 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 <sub>h</sub>  | Following Error Window | Variable    | UNSIGNED32 |

Table 193: Object Description (6065<sub>h</sub>)

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

Table 194: Entry Description (6065<sub>h</sub>)

### 6.1.7 Object 6067<sub>h</sub>: 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<sub>h</sub>, 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<sub>h</sub>) has reached the target position (6064<sub>h</sub>). 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<sub>h</sub>) is within  $(target\_position - position\_window)$  and  $(target\_position + position\_window)$ .



| Object Description |                 |             |            |
|--------------------|-----------------|-------------|------------|
| Index              | Name            | Object Type | Data Type  |
| 6067 <sub>h</sub>  | Position Window | Variable    | UNSIGNED32 |

Table 195: Object Description (6067<sub>h</sub>)

| Entry Description |        |             |             |                      |
|-------------------|--------|-------------|-------------|----------------------|
| Sub-index         | Access | PDO Mapping | Value Range | Default Value        |
| 0                 | rw     | no          | UNSIGNED32  | FFFFFFF <sub>h</sub> |

Table 196: Entry Description (6067<sub>h</sub>)

### 6.1.8 Object 6068<sub>h</sub>: 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<sub>h</sub>) is set to a value greater than zero the target reached event will not be signaled until the actual position (6064<sub>h</sub>) is at least as many milliseconds within the position window as defined by this object.

| Object Description |                      |             |            |
|--------------------|----------------------|-------------|------------|
| Index              | Name                 | Object Type | Data Type  |
| 6068 <sub>h</sub>  | Position Window Time | Variable    | UNSIGNED16 |

Table 197: Object Description (6068<sub>h</sub>)

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

Table 198: Entry Description (6068<sub>h</sub>)

### 6.1.9 Object 606C<sub>h</sub>: 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<sub>h</sub>, described in section 4.2.16).

| Object Description |                       |             |           |
|--------------------|-----------------------|-------------|-----------|
| Index              | Name                  | Object Type | Data Type |
| 606C <sub>h</sub>  | Velocity Actual Value | Variable    | SIGNED32  |

Table 199: Object Description (606C<sub>h</sub>)

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

Table 200: Entry Description (606C<sub>h</sub>)

### 6.1.10 Object 607A<sub>h</sub>: 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 <sub>h</sub>  | Target Position | Variable    | SIGNED32  |

Table 201: Object Description (607A<sub>h</sub> in pp Mode)

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

Table 202: Entry Description (607A<sub>h</sub> in pp Mode)

### 6.1.11 Object 607D<sub>h</sub>: 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:

$$\text{Corrected\_min\_position\_limit} = \text{min\_position\_limit} - \text{home\_offset}$$

$$\text{Corrected\_max\_position\_limit} = \text{max\_position\_limit} - \text{home\_offset}$$

| Object Description |                         |             |           |
|--------------------|-------------------------|-------------|-----------|
| Index              | Name                    | Object Type | Data Type |
| 607D <sub>h</sub>  | Software Position Limit | Array       | SIGNED32  |

Table 203: Object Description (607D<sub>h</sub>)

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

Table 204: Entry Description (607D<sub>h</sub>)

### 6.1.12 Object 6081<sub>h</sub>: 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<sub>h</sub>, section 4.2.16).

| Object Description |                  |             |           |
|--------------------|------------------|-------------|-----------|
| Index              | Name             | Object Type | Data Type |
| 6081 <sub>h</sub>  | Profile Velocity | Variable    | SIGNED32  |

Table 205: Object Description (6081<sub>h</sub>)

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

Table 206: Entry Description (6081<sub>h</sub>)

### 6.1.13 Object 6082<sub>h</sub>: 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<sub>h</sub>, section 4.2.16).

| Object Description |              |             |           |
|--------------------|--------------|-------------|-----------|
| Index              | Name         | Object Type | Data Type |
| 6082 <sub>h</sub>  | End Velocity | Variable    | SIGNED32  |

Table 207: Object Description (6082<sub>h</sub>)

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

Table 208: Entry Description (6082<sub>h</sub>)

### 6.1.14 Object 6083<sub>h</sub>: Profile Acceleration

This object indicates the configured acceleration. Object 6083<sub>h</sub> sets the maximum acceleration to be used in profile position and profile velocity mode.

The units for object 6083<sub>h</sub> can be chosen with object 208E<sub>h</sub>, described in section 4.2.17.

In profile velocity mode, this object also sets the deceleration to be used (the deceleration ramp is always the same as the acceleration ramp in pv mode).

| Object Description |                      |             |           |
|--------------------|----------------------|-------------|-----------|
| Index              | Name                 | Object Type | Data Type |
| 6083 <sub>h</sub>  | Profile Acceleration | Variable    | SIGNED32  |

Table 209: Object Description (6083<sub>h</sub>)

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

Table 210: Entry Description (6083<sub>h</sub>)

### 6.1.15 Object 6084<sub>h</sub>: Profile Deceleration

This object indicates the configured deceleration. Object 6084<sub>h</sub> sets the maximum deceleration to be used in profile positioning mode.

The units for object 6084<sub>h</sub> can be chosen with object 208E<sub>h</sub>, described in section 4.2.17.

| Object Description |                      |             |           |
|--------------------|----------------------|-------------|-----------|
| Index              | Name                 | Object Type | Data Type |
| 6084 <sub>h</sub>  | Profile Deceleration | Variable    | SIGNED32  |

Table 211: Object Description (6084<sub>h</sub>)

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

Table 212: Entry Description (6084<sub>h</sub>)

### 6.1.16 Object 6085<sub>h</sub>: 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<sub>h</sub> is set to 2 (or 6). The value is given in the same unit as profile acceleration object 6083<sub>h</sub>.



| Object Description |                         |             |            |
|--------------------|-------------------------|-------------|------------|
| Index              | Name                    | Object Type | Data Type  |
| 6085 <sub>h</sub>  | Quick stop deceleration | Variable    | UNSIGNED32 |

Table 213: Object Description (6085<sub>h</sub>)

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

Table 214: Entry Description (6085<sub>h</sub>)

### 6.1.17 Object 60F2<sub>h</sub>: 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 <sub>h</sub> ). |
| 1               | 0     | Positioning moves shall be performed relative to the position actual value (object 6064 <sub>h</sub> ).        |
| 1               | 1     | reserved   |

Table 215: Bit Definitions of Object 60F2<sub>h</sub>

| Object Description |                         |             |            |
|--------------------|-------------------------|-------------|------------|
| Index              | Name                    | Object Type | Data Type  |
| 60F2 <sub>h</sub>  | Positioning option code | Variable    | UNSIGNED16 |

Table 216: Object Description (60F2<sub>h</sub>)

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

Table 217: Entry Description (60F2<sub>h</sub>)



## 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<sub>h</sub>.
- Select pp mode by writing 1 to object 6060<sub>h</sub>.
- Write 6 to object 6040<sub>h</sub> to switch to READY\_TO\_SWITCH\_ON state.
- Write 7 to object 6040<sub>h</sub> to switch to SWITCHED\_ON state.
- Write 15 to object 6040<sub>h</sub> to switch to OPERATION\_ENABLED state.
- Write the desired target position (e.g. 500000) to object 607A<sub>h</sub>.
- Mark the new target position as active by writing 31 to object 6040<sub>h</sub>. The motor starts moving now.
- Reset the activation by writing 15 to object 6040<sub>h</sub> (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<sub>n</sub>: 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 7 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 218: 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 219: Command Coding

| Object Description |             |             |            |
|--------------------|-------------|-------------|------------|
| Index              | Name        | Object Type | Data Type  |
| 6040 <sub>h</sub>  | Controlword | Variable    | UNSIGNED16 |

Table 220: Object Description (6040<sub>h</sub> in pv Mode)

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

Table 221: Entry Description (6040<sub>h</sub> in pv Mode)

### 7.1.2 Object 6041<sub>h</sub>: 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 7 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 222: Structure of the Status Word in pv Mode



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

Table 223: 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 224: Operation Mode specific Bits in pv Mode

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

Table 225: State Coding

| Object Description |             |             |            |
|--------------------|-------------|-------------|------------|
| Index              | Name        | Object Type | Data Type  |
| 6041 <sub>h</sub>  | Controlword | Variable    | UNSIGNED16 |

Table 226: Object Description (6041<sub>h</sub> in pv Mode)

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

Table 227: Entry Description (6041<sub>h</sub> in pv Mode)

### 7.1.3 Object 6062<sub>h</sub>: Position Demand Value

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

| Object Description |                       |             |           |
|--------------------|-----------------------|-------------|-----------|
| Index              | Name                  | Object Type | Data Type |
| 6062 <sub>h</sub>  | Position Demand Value | Variable    | SIGNED32  |

Table 228: Object Description (6062<sub>h</sub>)

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

Table 229: Entry Description (6062<sub>h</sub>)

### 7.1.4 Object 6063<sub>h</sub>: Position Actual Internal Value

This object provides the actual value of the encoder or the motor. Please use the sensor selection object 606A<sub>h</sub> (see section 5.1.8) for selecting the motor or the encoder first. Object 6063<sub>h</sub> 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 <sub>h</sub>  | Position Actual Internal Value | Variable    | SIGNED32  |

Table 230: Object Description (6063<sub>h</sub>)

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

Table 231: Entry Description (6063<sub>h</sub>)



### 7.1.5 Object 6064<sub>h</sub>: Position Actual Value

This object provides the actual value of the position measurement device. It always contains the same value as object 6063<sub>h</sub>.

| Object Description |                       |             |           |
|--------------------|-----------------------|-------------|-----------|
| Index              | Name                  | Object Type | Data Type |
| 6064 <sub>h</sub>  | Position Actual Value | Variable    | SIGNED32  |

Table 232: Object Description (6064<sub>h</sub>)

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

Table 233: Entry Description (6064<sub>h</sub>)

### 7.1.6 Object 6065<sub>h</sub>: 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<sub>h</sub>) and encoder position (object 6063<sub>h</sub> or 6064<sub>h</sub>) 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 <sub>h</sub>  | Following Error Window | Variable    | UNSIGNED32 |

Table 234: Object Description (6065<sub>h</sub>)

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

Table 235: Entry Description (6065<sub>h</sub>)



### 7.1.7 Object 606C<sub>h</sub>: 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<sub>h</sub>, described in section 4.2.16).

| Object Description |                       |             |           |
|--------------------|-----------------------|-------------|-----------|
| Index              | Name                  | Object Type | Data Type |
| 606C <sub>h</sub>  | Velocity Actual Value | Variable    | SIGNED32  |

Table 236: Object Description (606C<sub>h</sub>)

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

Table 237: Entry Description (606C<sub>h</sub>)

### 7.1.8 Object 607D<sub>h</sub>: 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:

$$\text{Corrected\_min\_position\_limit} = \text{min\_position\_limit} - \text{home\_offset}$$

$$\text{Corrected\_max\_position\_limit} = \text{max\_position\_limit} - \text{home\_offset}$$

| Object Description |                         |             |           |
|--------------------|-------------------------|-------------|-----------|
| Index              | Name                    | Object Type | Data Type |
| 607D <sub>h</sub>  | Software Position Limit | Array       | SIGNED32  |

Table 238: Object Description (607D<sub>h</sub>)

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

Table 239: Entry Description (607D<sub>h</sub>)



### 7.1.9 Object 6083<sub>h</sub>: Profile Acceleration

This object indicates the configured acceleration. Object 6083<sub>h</sub> sets the maximum acceleration to be used in profile position and profile velocity mode.

The units for object 6083<sub>h</sub> can be chosen with object 208E<sub>h</sub>, described in section 4.2.17.

In profile velocity mode, this object also sets the deceleration to be used (the deceleration ramp is always the same as the acceleration ramp in pv mode).

| Object Description |                      |             |           |
|--------------------|----------------------|-------------|-----------|
| Index              | Name                 | Object Type | Data Type |
| 6083 <sub>h</sub>  | Profile Acceleration | Variable    | SIGNED32  |

Table 240: Object Description (6083<sub>h</sub>)

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

Table 241: Entry Description (6083<sub>h</sub>)

### 7.1.10 Object 6085<sub>h</sub>: 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<sub>h</sub> is set to 2 (or 6). The value is given in the same unit as profile acceleration object 6083<sub>h</sub>.

| Object Description |                         |             |            |
|--------------------|-------------------------|-------------|------------|
| Index              | Name                    | Object Type | Data Type  |
| 6085 <sub>h</sub>  | Quick stop deceleration | Variable    | UNSIGNED32 |

Table 242: Object Description (6085<sub>h</sub>)

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

Table 243: Entry Description (6085<sub>h</sub>)

### 7.1.11 Object 60FF<sub>h</sub>: Target Velocity

This object indicates the configured target velocity and is used as input for the trajectory generator. Object 60FF<sub>h</sub> 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<sub>h</sub> and 6084<sub>h</sub>. The values are given in units which can be selected with object 208C<sub>h</sub>, described in section 4.2.16.



| Object Description |                 |             |           |
|--------------------|-----------------|-------------|-----------|
| Index              | Name            | Object Type | Data Type |
| 60FF <sub>h</sub>  | Target Velocity | Variable    | SIGNED32  |

Table 244: Object Description (60FF<sub>h</sub>)

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

Table 245: Entry Description (60FF<sub>h</sub>)

## 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<sub>h</sub>.
- Select pv mode by writing 3 to object 6060<sub>h</sub>.
- Write 6 to object 6040<sub>h</sub> to switch to READY\_TO\_SWITCH\_ON state.
- Write 7 to object 6040<sub>h</sub> to switch to SWITCHED\_ON state.
- Write 15 to object 6040<sub>h</sub> to switch to OPERATION\_ENABLED state.
- Write the desired target speed (e.g. 100000) to object 60FF<sub>h</sub>. The motor now accelerates to that speed.
- Stop the motor by writing 0 to object 60FF<sub>h</sub>.



## 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 8 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<sub>h</sub> allows displacing the zero in point the coordinate system for the home position.

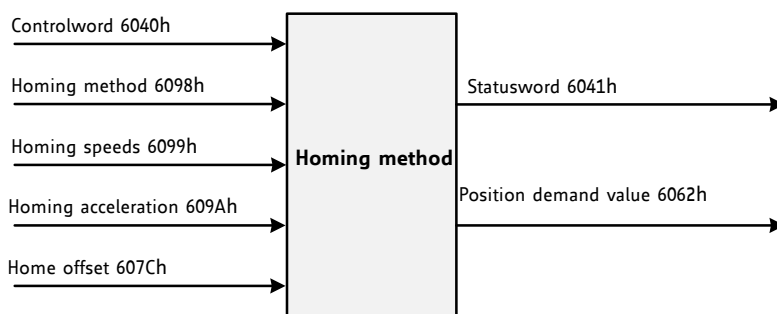


Figure 8: Homing Mode Function

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<sub>h</sub>, section 8.2.4).

There are four sources of homing signals 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-3213 supports a subset of different standard CANopen homing methods. The homing method that is to be used can be chosen via object 6098<sub>h</sub> (section 8.2.5).

| Supported Homing Methods |   |
|--------------------------|---|
| Method                   | Description   |
| 0                        | No homing (default value for object 6098 <sub>h</sub> ).  |
| 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 246: 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<sub>h</sub>, 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.

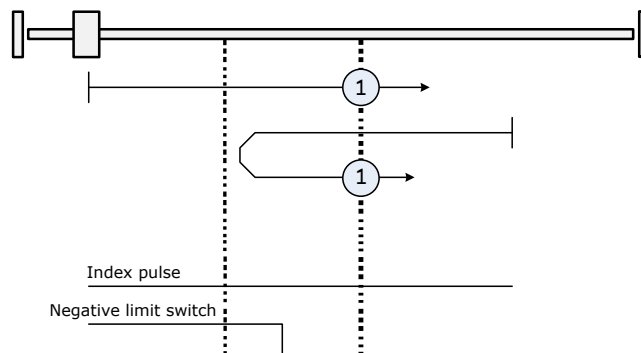


Figure 9: Homing Method 1



### 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.

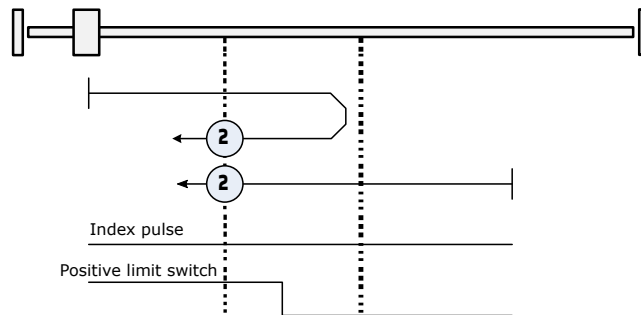


Figure 10: Homing Method 2

### 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.

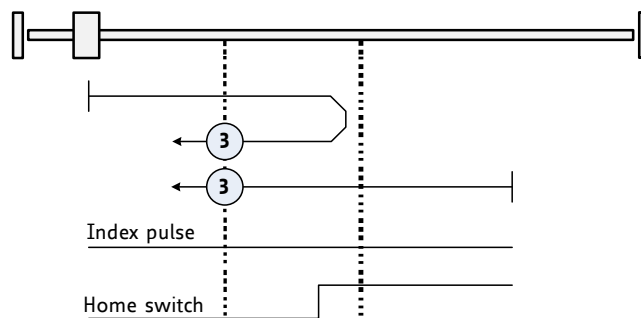


Figure 11: Homing Method 3

### 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.



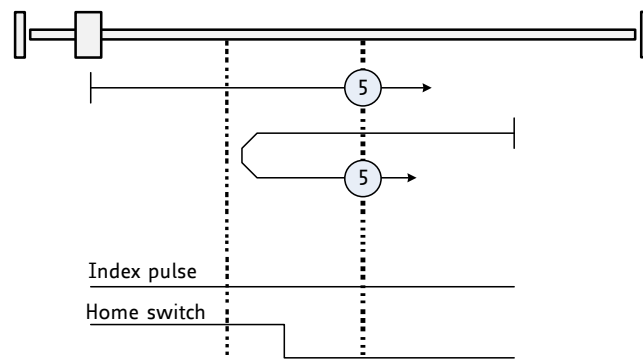


Figure 12: Homing Method 5

### 8.1.5 Homing Method 17, 18, 19, and 21: Homing without Index Pulse

These methods are similar to methods 1 to 5 except that the home position is not dependent on the index pulse but only dependent on the relevant home or limit switch transitions. As an example, homing method 19 (which is similar to homing method 3) is shown in figure 13.

| Homing Methods 17... 21 |   |
|-------------------------|---|
| Method                  | Description   |
| 17                      | Search the left end switch. (Similar to method 1)                   |
| 18                      | Search the right end switch. (Similar to method 2)                  |
| 19                      | Search the positive edge of the home switch. (Similar to method 3)  |
| 21                      | Search the negative edge of the home switch. (Similar to method 5.) |

Table 247: Homing Methods 17 - 21

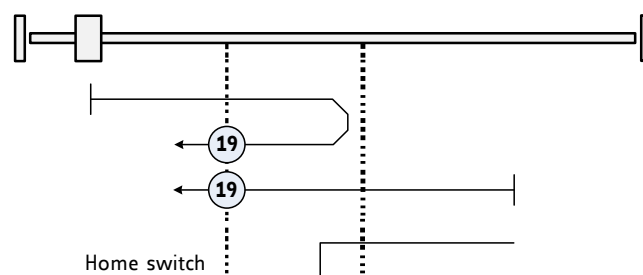


Figure 13: Homing Method 19

### 8.1.6 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 as shown in Figure 4.10.



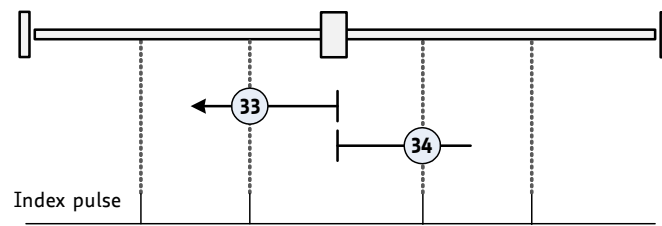


Figure 14: Homing Methods 33 and 34

### 8.1.7 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<sub>h</sub>: 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 7 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 248: 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 249: 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 250: Command Coding



| Object Description |             |             |            |
|--------------------|-------------|-------------|------------|
| Index              | Name        | Object Type | Data Type  |
| 6040 <sub>h</sub>  | Controlword | Variable    | UNSIGNED16 |

Table 251: Object Description (6040<sub>h</sub> in hm Mode)

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

Table 252: Entry Description (6040<sub>h</sub> in hm Mode)

### 8.2.2 Object 6041<sub>h</sub>: 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 7 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 253: Structure of the Status Word in hm Mode

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

Table 254: 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 255: Operation Mode specific Bits in hm Mode

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

Table 256: State Coding

| Object Description |             |             |            |
|--------------------|-------------|-------------|------------|
| Index              | Name        | Object Type | Data Type  |
| 6041 <sub>h</sub>  | Controlword | Variable    | UNSIGNED16 |

Table 257: Object Description (6041<sub>h</sub> in hm Mode)

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

Table 258: Entry Description (6041<sub>h</sub> in hm Mode)

### 8.2.3 Object 606C<sub>h</sub>: 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<sub>h</sub>, described in section 4.2.16).



| Object Description |                       |             |           |
|--------------------|-----------------------|-------------|-----------|
| Index              | Name                  | Object Type | Data Type |
| 606C <sub>h</sub>  | Velocity Actual Value | Variable    | SIGNED32  |

Table 259: Object Description (606C<sub>h</sub>)

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

Table 260: Entry Description (606C<sub>h</sub>)

### 8.2.4 Object 607C<sub>h</sub>: 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.

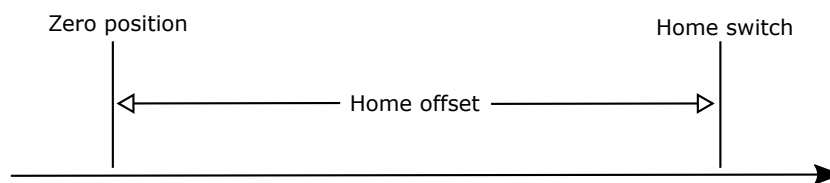


Figure 15: Home Offset

| Object Description |             |             |           |
|--------------------|-------------|-------------|-----------|
| Index              | Name        | Object Type | Data Type |
| 607C <sub>h</sub>  | Home offset | Variable    | SIGNED32  |

Table 261: Object Description (607C<sub>h</sub>)

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

Table 262: Entry Description (607C<sub>h</sub>)





### 8.2.5 Object 6098<sub>h</sub>: Homing Method

The homing method to be used can be selected by writing to this object. Please see table 246 for a list of homing methods supported by the current version of the TMCM-3213 CANopen firmware.

| Object Description |               |             |           |
|--------------------|---------------|-------------|-----------|
| Index              | Name          | Object Type | Data Type |
| 6098 <sub>h</sub>  | Homing method | Variable    | SIGNED8   |

Table 263: Object Description (6098<sub>h</sub>)

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

Table 264: Entry Description (6098<sub>h</sub>)

### 8.2.6 Object 6099<sub>h</sub>: Homing Speeds

This object indicates the configured speeds used during homing procedure. The values are given in pps units or inernal units selectable with object 208C<sub>h</sub> (section 4.2.16). Using object 6099<sub>h</sub> 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<sub>h</sub>) 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 <sub>h</sub>  | Homing speeds | Array       | UNSIGNED32 |

Table 265: Object Description (6099<sub>h</sub>)

| 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 266: Entry Description (6099<sub>h</sub>)

### 8.2.7 Object 609A<sub>h</sub>: 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<sub>h</sub> (section 4.2.17).



| Object Description |                     |             |            |
|--------------------|---------------------|-------------|------------|
| Index              | Name                | Object Type | Data Type  |
| 609A <sub>h</sub>  | Homing acceleration | Variable    | UNSIGNED32 |

Table 267: Object Description (609A<sub>h</sub>)

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

Table 268: Entry Description (609A<sub>h</sub>)

### 8.2.8 Object 2100<sub>h</sub>: Home Offset Display

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

| Object Description |                     |             |           |
|--------------------|---------------------|-------------|-----------|
| Index              | Name                | Object Type | Data Type |
| 2100 <sub>h</sub>  | Home Offset Display | Variable    | SIGNED32  |

Table 269: Object Description (2100<sub>h</sub>)

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

Table 270: Entry Description (2100<sub>h</sub>)

## 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<sub>h</sub>.
- Write 6 to object 6040<sub>h</sub> to switch to READY\_TO\_SWITCH\_ON state.
- Write 7 to object 6040<sub>h</sub> to switch to SWITCHED\_ON state.
- Write 15 to object 6040<sub>h</sub> to switch to OPERATION\_ENABLED state.
- Select homing method 19 by writing 19 to object 6098<sub>h</sub>.
- Set the homing speeds by writing e.g. 50000 to object 6099<sub>h</sub> sub index 1 and e.g. 10000 to object 6099<sub>h</sub> sub index 2.



- Write 31 to object 6040<sub>h</sub> to start the homing process.
- Press and release the home switch.
- When homing has finished, write 15 to object 6040<sub>h</sub> again.



## 9 Cyclic synchronous 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<sub>h</sub>, see section 9.1.7) and the interpolation time period (object 60C2<sub>h</sub>, 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<sub>h</sub>: 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 7 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 271: 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 272: Command Coding

| Object Description |             |             |            |
|--------------------|-------------|-------------|------------|
| Index              | Name        | Object Type | Data Type  |
| 6040 <sub>h</sub>  | Controlword | Variable    | UNSIGNED16 |

Table 273: Object Description (6040<sub>h</sub> in csp Mode)

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

Table 274: Entry Description (6040<sub>h</sub> in csp Mode)

### 9.1.2 Object 6041<sub>h</sub>: 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 7 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 275: Structure of the Status Word in csp Mode



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

Table 276: 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.<br>1: Target position used as input to position controller. |
| 13                                       | Following error         | 0: No following error.<br>1: Following error.   |

Table 277: Operation Mode specific Bits in csp Mode

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

Table 278: State Coding

| Object Description |             |             |            |
|--------------------|-------------|-------------|------------|
| Index              | Name        | Object Type | Data Type  |
| 6041 <sub>h</sub>  | Controlword | Variable    | UNSIGNED16 |

Table 279: Object Description (6041<sub>h</sub> in csp Mode)



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

Table 280: Entry Description (6041<sub>h</sub> in csp Mode)

### 9.1.3 Object 6062<sub>h</sub>: Position Demand Value

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

| Object Description |                       |             |           |
|--------------------|-----------------------|-------------|-----------|
| Index              | Name                  | Object Type | Data Type |
| 6062 <sub>h</sub>  | Position Demand Value | Variable    | SIGNED32  |

Table 281: Object Description (6062<sub>h</sub>)

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

Table 282: Entry Description (6062<sub>h</sub>)

### 9.1.4 Object 6063<sub>h</sub>: Position Actual Internal Value

This object provides the actual value of the encoder or the motor. Please use the sensor selection object 606A<sub>h</sub> (see section 5.1.8) for selecting the motor or the encoder first. Object 6063<sub>h</sub> 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 <sub>h</sub>  | Position Actual Internal Value | Variable    | SIGNED32  |

Table 283: Object Description (6063<sub>h</sub>)

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

Table 284: Entry Description (6063<sub>h</sub>)

### 9.1.5 Object 6064<sub>h</sub>: Position Actual Value

This object provides the actual value of the position measurement device. It always contains the same value as object 6063<sub>h</sub>.

| Object Description |                       |             |           |
|--------------------|-----------------------|-------------|-----------|
| Index              | Name                  | Object Type | Data Type |
| 6064 <sub>h</sub>  | Position Actual Value | Variable    | SIGNED32  |

Table 285: Object Description (6064<sub>h</sub>)

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

Table 286: Entry Description (6064<sub>h</sub>)

### 9.1.6 Object 606C<sub>h</sub>: 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<sub>h</sub>, described in section 4.2.16).

| Object Description |                       |             |           |
|--------------------|-----------------------|-------------|-----------|
| Index              | Name                  | Object Type | Data Type |
| 606C <sub>h</sub>  | Velocity Actual Value | Variable    | SIGNED32  |

Table 287: Object Description (606C<sub>h</sub>)

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

Table 288: Entry Description (606C<sub>h</sub>)

### 9.1.7 Object 607A<sub>h</sub>: 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 <sub>h</sub>  | Target Position | Variable    | SIGNED32  |

Table 289: Object Description (607A<sub>h</sub> in csp Mode)





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

Table 290: Entry Description (607A<sub>h</sub> in csp Mode)

### 9.1.8 Object 607D<sub>h</sub>: 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:

$$\text{Corrected\_min\_position\_limit} = \text{min\_position\_limit} - \text{home\_offset}$$

$$\text{Corrected\_max\_position\_limit} = \text{max\_position\_limit} - \text{home\_offset}$$

| Object Description |                         |             |           |
|--------------------|-------------------------|-------------|-----------|
| Index              | Name                    | Object Type | Data Type |
| 607D <sub>h</sub>  | Software Position Limit | Array       | SIGNED32  |

Table 291: Object Description (607D<sub>h</sub>)

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

Table 292: Entry Description (607D<sub>h</sub>)

### 9.1.9 Object 60B0<sub>h</sub>: Position Offset

This object provides an offset to the target position (object 607A<sub>h</sub>, 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 <sub>h</sub>  | Offset Torque | Variable    | INTEGER32 |

Table 293: Object Description (60B0<sub>h</sub>)

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

Table 294: Entry Description (60B0<sub>h</sub>)

### 9.1.10 Object 60C2<sub>h</sub>: Interpolation Time Period

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

| Object Description |               |             |   |
|--------------------|---------------|-------------|---|
| Index              | Name          | Object Type | Data Type   |
| 60C2 <sub>h</sub>  | Offset Torque | Vecord      | Interpolation time period record (0080 <sub>h</sub> ) |

Table 295: Object Description (60C2<sub>h</sub>)

| 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 296: Entry Description (60C2<sub>h</sub>)

## 10 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<sub>h</sub> (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-3213 |                 |       |   |   |   |  |
|--|-----------------|-------|---|---|---|--|
| Error code                                 | Additional byte |       |   |   |   | Description  |
|  | 1               | 2     | 3 | 4 | 5 |  |
| 0000 <sub>h</sub>                          | 0               | 0...2 | 0 | 0 | 0 | <b>Fault reset</b><br>The fault reset command has been executed.   |
| 1000 <sub>h</sub>                          | 1               | 0...2 | 0 | 0 | 0 | <b>Generic error: open load bridge A</b><br>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 <sub>h</sub>                          | 2               | 0...2 | 0 | 0 | 0 | <b>Generic error: open load bridge B</b><br>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 <sub>h</sub>                          | 0               | 0...2 | 0 | 0 | 0 | <b>Overcurrent high side</b><br>The motor driver indicates an overcurrent on the high side. This can be caused by a short circuit in the driver stage.   |
| 2311 <sub>h</sub>                          | 0               | 0...2 | 0 | 0 | 0 | <b>Overcurrent bridge B</b><br>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 <sub>h</sub>                          | 0               | 0...2 | 0 | 0 | 0 | <b>Overcurrent bridge A</b><br>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 <sub>h</sub>                          | 0               | 0...2 | 0 | 0 | 0 | <b>stallGuard2 error</b><br>The actual load value exceeds the stallGuard2 limit.   |
| 4310 <sub>h</sub>                          | 1               | 0...2 | 0 | 0 | 0 | <b>Overtemperature pre-warning</b><br>The temperature in the motor driver exceeds the pre-warning limit.   |
| 4310 <sub>h</sub>                          | 2               | 0...2 | 0 | 0 | 0 | <b>Overtemperature error</b><br>The motor driver has been switched off because the temperature limit has been exceeded.  |
| 5441 <sub>h</sub>                          | 0               | 255   | 0 | 0 | 0 | <b>Shutdown switch active</b><br>The enable signal is missing (due to the shutdown switch) and the motor driver has been switched off.   |
| 6320 <sub>h</sub>                          | 0               | 255   | 0 | 0 | 0 | <b>Parameter error</b><br>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 <sub>h</sub> | 0               | 0...2 | 0 | 0 | 0 | <b>Following error</b><br>The deviation between motor position counter and encoder position counter has exceeded the following error window. |
| ff00 <sub>h</sub> | 0               | 0...2 | 0 | 0 | 0 | <b>Undervoltage</b><br>The supply voltage is too low to drive a motor.   |
| ff01 <sub>h</sub> | 1               | 0...2 | 0 | 0 | 0 | <b>Positive software limit</b><br>The actual position is outside the range defined by object 607d <sub>h</sub> .                             |
| ff01 <sub>h</sub> | 2               | 0...2 | 0 | 0 | 0 | <b>Negative software limit</b><br>The actual position is outside the range defined by object 607d <sub>h</sub> .                             |
| ff01 <sub>h</sub> | 3               | 0...2 | 0 | 0 | 0 | <b>Positive limit switch</b><br>The positive limit switch has been touched outside of the homing function.                                   |
| ff01 <sub>h</sub> | 4               | 0...2 | 0 | 0 | 0 | <b>Negative limit switch</b><br>The negative limit switch has been touched outside of the homing function.                                   |

Table 297: Emergency Messages (EMCY)



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## 13 Supplemental Directives

### 13.1 Producer Information

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## 14 Revision History

### 14.1 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 included. |

*Table 298: Firmware Revision*

### 14.2 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 <sub>h</sub> and 1A00 <sub>h</sub> ) fixed. |
| V1.05   | 2018-JAN-12 | OK     | Firmware V1.07 included.   |

*Table 299: Document Revision*

