TMCM-1633 CANopen Firmware Manual

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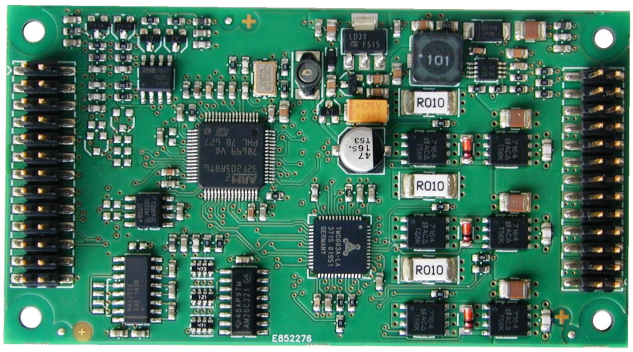
The TMCM-1633 is a single axis controller module for brushless DC (BLDC) and PMSM motors. It offers field oriented control (FOC) with up-to 10A RMS phase currents at +48V DC supply. Besides hall sensor and incremental ABN encoder interfaces for connection to the motor, digital inputs and outputs can be used. A CAN interface allows communication with a CANopen master.



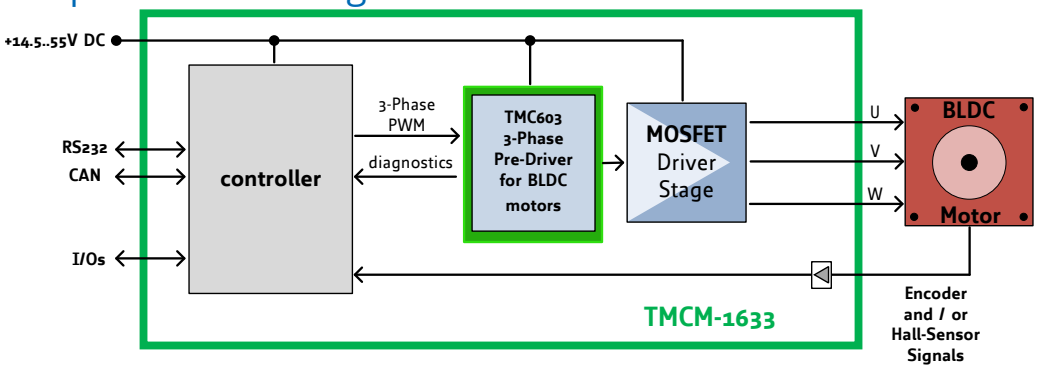
Features

- Single axis field oriented control for BLDC/PMSM motor
- Hall and ABN encoder support
- +14,5..48V DC supply voltage
- Up to 10A RMS peak motor current
- RS232 & CAN interface
- CANopen CiA 402 drive profile
- Torque, Velocity, and Position control

Applications

- Life Sciences
- Test & Measurement
- Robotics / Automation

Simplified Block Diagram



Read entire documentation.

TRINAMIC
MOTION CONTROL

Contents

1 Preface

This document specifies objects and modes of operation of the Trinamic TMCM-1633 BLDC/PMSM motor control module with CANopen firmware. The CANopen firmware is designed to fulfill the CANopen DS402 and DS301 standards. This manual assumes that the reader is already familiar with the basics of the CANopen protocol, defined by the DS301 and DS402 standards of the CAN-CiA.

If necessary, it is always possible to turn the module into a TMCL module by loading the TMCM-1633 TMCL firmware again with the help of the firmware update function of the TMCL-IDE 3.0 and the UART interface.

1.1 General Features of this CANopen Implementation

Main Characteristics

- Communication according to standard CiA-301 V4.1
- CAN bit rate: 20...1000kBit/s
- CAN ID: 11 bit
- Node ID: 1...127 (use vendor specific objects for changing the node ID)
- NMT services: NMT slave

SDO Communication

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

PDO Communication

- Producer
- Consumer
- RPDOs
  - Axis 0: 1, 2, 3, 4
  - Transmission modes: asynchronous.
  - Dynamic mapping with max. 3 mapping entries.
  - Default mappings: according to CiA-402 for first three PDOs of each axis, manufacturer specific for other PDOs of each axis.
- TPDOs
  - Axis 0: 1, 2, 3, 4
  - Transmission modes: asynchronous, asynchronous with event timer, synchronous.
  - Dynamic mapping with max. 3 mapping entries.
  - Default mappings: according to CiA-402 for first three PDOs of each axis, manufacturer specific for other PDOs of each axis.

Further Characteristics

- SYNC: consumer (TPDOs 3 are synchronous PDOs)
- Emergency: producer
- RTR: supported only for node guarding/life guarding
- Heartbeat: consumer and producer

1.2 Abbreviations used in this Manual

Abbreviations	
CAN	Controller area network
CHGND	chassis ground / earth ground
COB	Communication object
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 bootloader and the CANopen firmware itself. Whereas the bootloader is installed during production and testing at TRINAMIC and remains untouched throughout the whole lifetime, the CANopen firmware can easily be updated by the user. The new firmware can be loaded into the module via the firmware update function of the TMCL-IDE, using the UART interface of the module.

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 CAN Network 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 1.

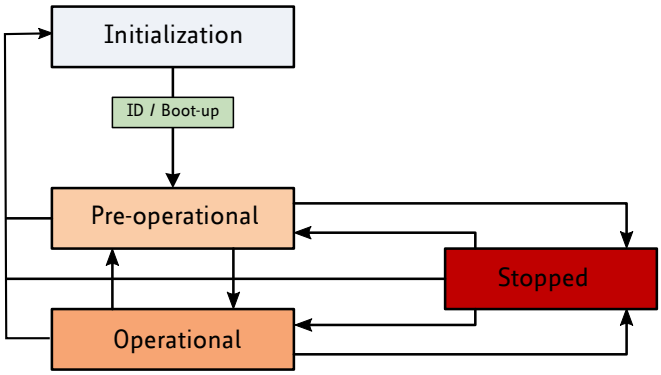


Figure 1: NMT State Machine

After power-on or reset the device enters the Initialization state. After the device initialization is finished, the device automatically transits to the **Pre-operational** state and indicates this state transition by sending the boot-up message. This way the device indicates that it is ready to work. A device that stays in Pre-operational state may start to transmit SYNC-, time stamp- or heartbeat message. In contrast to the PDO communication that is disabled in this state, the device can communicate via SDO.

The PDO communication is only possible within the **Operational** state. During Operational state the device can use all supported communication objects.

A device that was switched to the **Stopped** state only reacts on received NMT commands. In addition the device indicates the current NMT state by supporting the error control protocol during Stopped state.

The transitions between states are made by issuing a network management (NMT) communication object to the device. The NMT protocols are used to generate state machine change commands (e.g. to start and stop the device), detect remote device boot-ups and error conditions.

The Heartbeat message of a CANopen device contains the device status of the NMT state machine and is sent cyclically by the CANopen device.

The NMT state machine (or DS301 state machine) is not to be confused with the DS402 state machine. There is only one NMT state machine for the entire device, but for each motor there is a DS402 state machine which controls the motor. There are no links between these state machines, with one exception: When the NMT state machine is being switched to the stopped state, all DS402 state machines that are in OPERATION_ENABLED state will be switch to FAULT state.

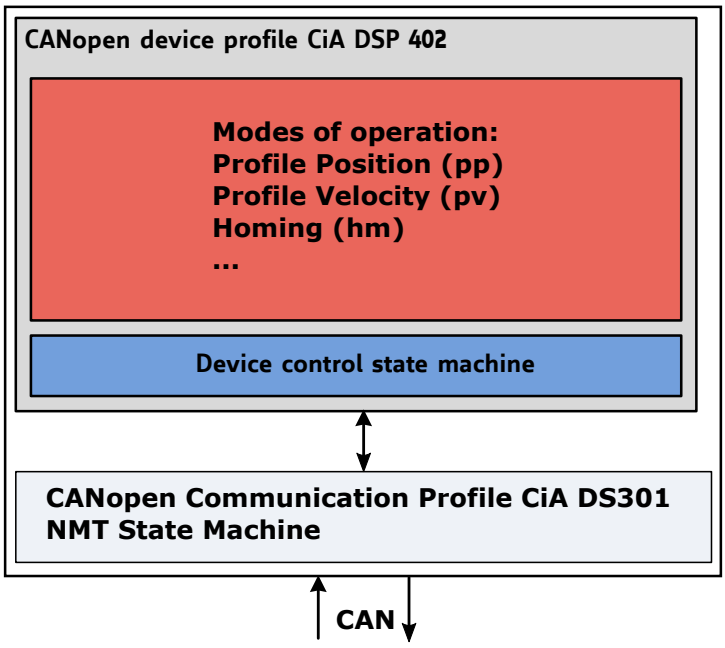


Figure 2: Communication Architecture

2.3 Device Model

A CANopen 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.

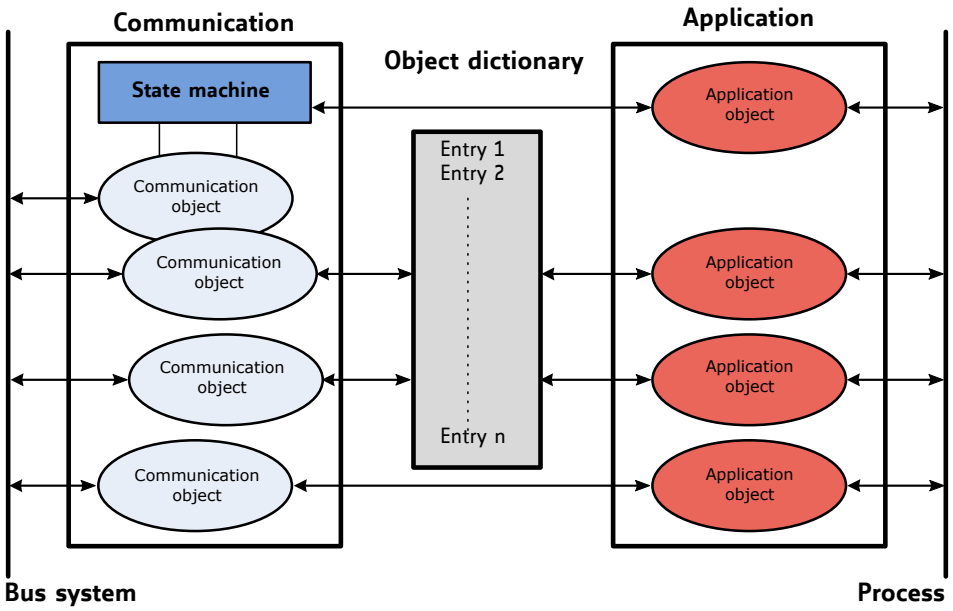


Figure 3: Device Model

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

Table 4: Object Dictionary

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

The manufacturer segment at indices 2000_h through $5FFF_h$ contains manufacturer specific objects. These objects control the special features of the Trinamic TMCM-1633 motion control device.

The standardized device profile area at indices 6000_h through $9FFF_h$ contains all data objects common to a class of devices that can be read or written via the network. They describe the device parameters and the device functionality of the device profile.

3 Communication area

The communication area contains all objects that define the communication parameters of the CANopen device according to the DS301 standard.

3.1 Detailed object specifications

3.1.1 Object 1000_h: Device Type

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

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

Table 5: Object Description (1000_h)

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

Table 6: Entry Description (1000_h)

3.1.2 Object 1001_h: Error Register

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

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

Table 7: Object Description (1001_h)

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

Table 8: Entry Description (1001_h)

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

Table 9: Error Register Bits

3.1.3 Object 1005_h: COB-ID SYNC Message

This object defines the COB-ID of the synchronization object (SYNC). Further, it defines whether the module generates the SYNC.

Value Definition		
Bit	Name	Definition
30	Generate	0: Device does not generate SYNC message 1: Device generates SYNC message
29	Frame	Not supported, always set to 0.
28...11	29 bit ID	Not supported, always set to 0.
10...0	11 bit ID	11 bit COB-ID.

Table 10: Value Definition (1005_h)

Object Description			
Index	Name	Object Type	Data Type
1005_h	COB-ID SYNC message	Variable	UNSIGNED32

Table 11: Object Description (1005_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	UNSIGNED32	80_h

Table 12: Entry Description (1005_h)

3.1.4 Object 1008_h: Manufacturer Device Name

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

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

Table 13: Object Description (1008_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	—	TMCM-1633

Table 14: Entry Description (1008_h)

3.1.5 Object 1009_h: Manufacturer Hardware Version

This object contains the hardware version description.

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

Table 15: Object Description (1009_h)

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

Table 16: Entry Description (1009_h)

3.1.6 Object $100A_h$: Manufacturer Software Version

This object contains the software version description.

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

Table 17: Object Description ($100A_h$)

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

Table 18: Entry Description ($100A_h$)

3.1.7 Object $100C_h$: Guard Time

The objects at index $100C_h$ and $100D_h$ shall indicate the configured guard time respectively the life time factor. The life time factor multiplied with the guard time gives the life time for the life guarding protocol.

Object Description			
Index	Name	Object Type	Data Type
$100C_h$	Guard Time	Variable	UNSIGNED16

Table 19: Object Description ($100C_h$)

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

Table 20: Entry Description ($100C_h$)

3.1.8 Object $100D_h$: Life Time Factor

The life time factor multiplied with the guard time gives the life time for the life guarding protocol.

Object Description			
Index	Name	Object Type	Data Type
$100D_h$	Life Time Factor	Variable	UNSIGNED8

Table 21: Object Description ($100D_h$)

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

Table 22: Entry Description ($100D_h$)

3.1.9 Object 1010_h: Store Parameters

This object supports the saving of parameters in non volatile memory. By read access the device provides information about its saving capabilities.

There are several parameter groups:

- Sub-index 0_h: contains the largest sub-index that is supported.
- Sub-index 1_h: saves all parameters.
- Sub-index 2_h: saves communication parameters $100C_h$, $100D_h$, 1015_h, 1017_h, and 1029_h.
- Sub-index 3_h: saves device profile parameters.
- Sub-index 4_h: saves motor 0 parameters.

Note In order to avoid storage of parameters by mistake, storage is only executed when a specific signature is written to the appropriate sub-Index. This signature is "save" (65766173_h, see also table 23).

Save Signature			
e	v	a	s
65_h	76_h	61_h	73_h

Table 23: Save Signature

On reception of the correct signature in the appropriate sub-index the device stores the parameter and then confirms the SDO transmission (initiate download response). If the storing failed, the device responds with an abort SDO transfer (abort code: 06060000_h). If a wrong signature is written, the device refuses to store and responds with abort SDO transfer (abort code: $0800002x_h$).

On read access, each sub-index provides information if it is possible to store the parameter group. It reads 1 if yes and 0 if no.

Object Description			
Index	Name	Object Type	Data Type
1010_h	Store Parameters	Array	UNSIGNED32

Table 24: Object Description (1010_h)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
01h	Save all parameters	rw	no	UNSIGNED32	—
02h	Save communication parameters	rw	no	UNSIGNED32	—
03h	Save device profile parameters	rw	no	UNSIGNED32	—
04h	Save motor axis 0 parameters	rw	no	UNSIGNED32	—

Table 25: Entry Description (1010_h)

3.1.10 Object 1011_h: Restore Parameters

With this object the default values of parameters according to the communication or device profile are restored. By read access the device provides information about its capabilities to restore these values.

There are several parameter groups:

- Sub-index 0_h: contains the largest sub-index that is supported.
- Sub-index 1_h: restores all parameters.
- Sub-index 2_h: restores communication parameters $100C_h$, $100D_h$, 1015_h, 1017_h, and 1029_h.
- Sub-index 3_h: restores device profile parameters.
- Sub-index 4_h: restores motor 0 parameters.

Note In order to avoid restoring the parameters by mistake, restoring is only executed when a specific signature is written to the appropriate sub-Index. This signature is "load" ($64616F6C_h$, see also table 26).

Load Signature			
d	a	o	l
64_h	61_h	$6F_h$	$6C_h$

Table 26: Load Signature

On reception of the correct signature in the appropriate sub-index the device restores the parameter and then confirms the SDO transmission (initiate download response). If the restoring failed, the device responds with an abort SDO transfer (abort code: 06060000_h). If a wrong signature is written, the device refuses to restore and responds with abort SDO transfer (abort code: $0800002x_h$).

On read access, each sub-index provides information if it is possible to restore the parameter group. It reads 1 if yes and 0 if no.

After the default values have been restored they will become active after the next rest or power cycle of the TMCM-1633.

Object Description			
Index	Name	Object Type	Data Type
1011_h	Restore parameters	Array	UNSIGNED32

Table 27: Object Description (1011_h)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
01h	Restore all parameters	rw	no	UNSIGNED32	—
02h	Restore communication parameters	rw	no	UNSIGNED32	—
03h	Restore device profile parameters	rw	no	UNSIGNED32	—
04h	Restore motor axis 0 parameters	rw	no	UNSIGNED32	—

Table 28: Entry Description (1011_h)

3.1.11 Object 1014_h: COB-ID Emergency Object

This object defines the COB-ID of the emergency object (EMCY).

Object Description			
Index	Name	Object Type	Data Type
1014_h	COB-ID emergency object	Variable	UNSIGNED32

Table 29: Object Description (1014_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	UNSIGNED32	80_h + Node ID

Table 30: Entry Description (1014_h)

3.1.12 Object 1015_h: Inhibit Time EMCY

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

Object Description			
Index	Name	Object Type	Data Type
1015_h	COB-ID emergency object	Variable	UNSIGNED16

Table 31: Object Description (1015_h)

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

Table 32: Entry Description (1015_h)

3.1.13 Object 1016_h: Consumer Heartbeat Time

The consumer heartbeat time defines the expected heartbeat cycle time and thus has to be higher than the corresponding producer heartbeat time configured on the module producing this heartbeat. The monitoring starts after the reception of the first heartbeat. If the consumer heartbeat time is 0 the corresponding entry is not used. The time has to be a multiple of 1ms.

Value Definition		
Bits	Name	Definition
31...24	Reserved	—
23...16	Node ID	Heartbeat Producer Node ID
15...0	Heartbeat time	Time in 1ms

Table 33: Value Definition (1016_h)

Object Description			
Index	Name	Object Type	Data Type
1016_h	Consumer heartbeat time	Variable	UNSIGNED16

Table 34: Object Description (1016_h)

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

Table 35: Entry Description (1016_h)

3.1.14 Object 1017_h: Producer Heartbeat Time

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

Object Description			
Index	Name	Object Type	Data Type
1017_h	Producer heartbeat time	Variable	UNSIGNED16

Table 36: Object Description (1017_h)

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

Table 37: Entry Description (1017_h)

3.1.15 Object 1018_h: Identity Object

The object 1018_h contains general information about the device:

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

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

Table 38: Object Description (1018_h)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
00_h	Number of entries	ro	no	0...3	3
01_h	Vendor ID	ro	no	UNSIGNED32	0286_h
02_h	Product code	ro	no	UNSIGNED32	1633
03_h	Revision number	ro	no	UNSIGNED32	e.g. 20003_h for version 2.3

Table 39: Entry Description (1018_h)

3.1.16 Object 1029_h: Error Behaviour

If a device failure is detected in operational state, the device can be configured to enter alternatively the stopped state or remain in the current state in case of a device failure. Device failures include the following errors:

- Communication error
- Application error

Object Description			
Index	Name	Object Type	Data Type
1029_h	Error behaviour	Array	UNSIGNED8

Table 40: Object Description (1029_h)

Entry Description					
Sub-index	Description	Access	PDO Mapping	Value Range	Default Value
00_h	Number of error classes	ro	no	—	2
01_h	Communication error	rw	no	UNSIGNED8	0 (enter stopped state)
02_h	Application error	rw	no	UNSIGNED8	1 (remain in current state)

Table 41: Entry Description (1029_h)

3.1.17 Objects 1400_h – 1403_h: Receive PDO Communication Parameter

This object contains the communication parameters for the RPDOs which the device is able to receive. The sub-index 00_h contains the number of valid entries within the communication record. Its value normally is 2, as this object consists of two other entries.

Sub-index 01_h contains the COB-ID used by this PDO (in bits 10...0). Bit 30 (RTR bit) defines if this PDO uses RTRs. As RTRs are not supported for PDOs by this CANopen implementation, this bit must always be set in order to turn off RTR support for this PDO. Bit 31 defines if this PDO is active or not. If this bit is set, the PDO is inactive, and if this bit is clear, the PDO is active. Before making any changes to a PDO definition, set this bit to inactivate the PDO.

Sub-Index 02_h contains the transmission type of the RPDO. This can be FF_h or FE_h for event-driven, or 00_h for synchronous.

Object Description			
Index	Name	Object Type	Data Type
1400_h – 1403_h	Receive PDO parameter	RECORD	RPDO CommPar
1400_h	RPDO 1	RECORD	RPDO CommPar
1401_h	RPDO 2	RECORD	RPDO CommPar
1402_h	RPDO 3	RECORD	RPDO CommPar
1403_h	RPDO 4	RECORD	RPDO CommPar

Table 42: Object Description (1400_h)

Entry Description				
Sub-index	Description	Access	Value Range	Default Value
00_h	Largest sub-index supported	ro	2	2
01_h	COB-ID used by PDO	rw	UNSIGNED32	Index 1400_h: 200_h + Node-ID Index 1401_h: 300_h + Node-ID Index 1402_h: 400_h + Node-ID Index 1403_h: 500_h + Node-ID
02_h	Transmission type	rw	UNSIGNED8	Index 1400_h: FF_h Index 1401_h: FF_h Index 1402_h: FF_h Index 1403_h: FE_h

Table 43: Entry Description (1400_h)

3.1.18 Objects 1600_h – 1603_h: Receive PDO Mapping Parameter

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

Object Description			
Index	Name	Object Type	Data Type
1600_h – 1603_h	Receive PDO mapping parameter	RECORD	PDO Mapping
1600_h	RPDO 1	RECORD	PDO Mapping
1601_h	RPDO 2	RECORD	PDO Mapping
1602_h	RPDO 3	RECORD	PDO Mapping
1603_h	RPDO 4	RECORD	PDO Mapping

Table 44: Object Description (1600_h)

Entry Description				
Sub-index	Description	Access	Value Range	Default Value
00_h	Number of mapped application objects in PDO	rw	0...3	Index 1600_h: 1 Index 1601_h: 2 Index 1602_h: 2 Index 1603_h: 2
01_h	Mapping entry 1	rw	UNSIGNED32	Index 1600_h: 60400010_h Index 1601_h: 60400010_h Index 1602_h: 60400010_h Index 1603_h: 60400010_h
02_h	Mapping entry 2	rw	UNSIGNED32	Index 1600_h: 0 Index 1601_h: 60600008_h Index 1602_h: $607A0020_h$ Index 1603_h: $60FF0020_h$
03_h	Mapping entry 3	rw	UNSIGNED32	Index 1600_h: 0_h Index 1601_h: 0_h Index 1602_h: 0_h Index 1603_h: 0_h

Table 45: Entry Description (1600_h)

Before making changes to PDO definitions, first mark the PDO as inactive by setting bit 31 of its COB-ID (see section 3.1.17). Then, set its number of mapped PDO entries to zero (sub-index 0 of the appropriate PDO mapping object). Now, the mapppings themself can be changed. After that, set the number of map objects to the desired value, and finally activate the PDO by clearing bit 31 of its COB-ID.

3.1.19 Objects 1800_h – 1803_h: Transmit PDO Communication Parameter

This object contains the communication parameters for the TPDOs which the device is able to transmit. The sub-index 00_h contains the number of valid entries within the communication record. Its value normally is 5, as this object consists of five other entries.

Sub-index 01_h contains the COB-ID used by this PDO (in bits 10...0). Bit 30 (RTR bit) defines if this PDO uses RTRs. As RTRs are not supported for PDOs by this CANopen implementation, this bit must always be set in order to turn off RTR support for this PDO. Bit 31 defines if this PDO is active or not. If this bit is set, the PDO is inactive, and if this bit is clear, the PDO is active. Before making any changes to a PDO definition, set this bit to inactivate the PDO.

Sub-index 02_h contains the transmission type of the RPDO. This can be FF_h or FE_h for event-driven, or 00_h or 01_h for synchronous.

Sub-index 03_h contains the inhibit time, given in milliseconds. After a TPDO has been sent, it will not be sent again before the inhibit time has elapsed.

Sub-index 04_h is not used.

Sub-index 05_h contains the event timer value in milliseconds. When this is set to a value greater than 0 the TPDO will be sent repeatedly each time the event timer has elapsed. For example, when this value is set to 250, the TPDO will be sent every 250ms.

Object Description			
Index	Name	Object Type	Data Type
1800_h – 1803_h	Transmit PDO communication parameter	RECORD	TPDO CommPar
1800_h	TPDO 1	RECORD	TPDO CommPar
1801_h	TPDO 2	RECORD	TPDO CommPar
1802_h	TPDO 3	RECORD	TPDO CommPar
1803_h	TPDO 4	RECORD	TPDO CommPar

Table 46: Object Description (1800_h)

Entry Description				
Sub-index	Description	Access	Value Range	Default Value
00_h	Largest sub-index supported	ro	5	5
01_h	COB-ID	rw	UNSIGNED32	Index 1800_h: 180_h + Node-ID Index 1801_h: 280_h + Node-ID Index 1802_h: 380_h + Node-ID Index 1803_h: 480_h + Node-ID
02_h	Transmission type	rw	UNSIGNED8	Index 1800_h: FF_h Index 1801_h: FF_h Index 1802_h: 01_h Index 1803_h: 01_h
03_h	Inhibit time	rw	UNSIGNED16	0
04_h	Compatibility entry	ro	UNSIGNED8	0
05_h	Event timer	rw	UNSIGNED16	0

Table 47: Entry Description (1800_h)

3.1.20 Objects $1A00_h$ – $1A03_h$: Transmit PDO Mapping Parameter

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

Object Description			
Index	Name	Object Type	Data Type
$1A00_h$ – $1A03_h$	Transmit PDO mapping parameter	RECORD	PDO Mapping
$1A00_h$	TPDO 1	RECORD	PDO Mapping
$1A01_h$	TPDO 2	RECORD	PDO Mapping
$1A02_h$	TPDO 3	RECORD	PDO Mapping
$1A03_h$	TPDO 4	RECORD	PDO Mapping

Table 48: Object Description ($1A00_h$)

Entry Description				
Sub-index	Description	Access	Value Range	Default Value
00_h	Number of mapped aapli-cation objects in PDO	rw	0...3	Index $1A00_h$: 1 Index $1A01_h$: 2 Index $1A02_h$: 2 Index $1A03_h$: 2
01_h	Mapping entry 1	rw	UNSIGNED32	Index $1A00_h$: 60410010_h Index $1A01_h$: 60410010_h Index $1A02_h$: 60410010_h Index $1A03_h$: 60410010_h
02_h	Mapping entry 2	rw	UNSIGNED32	Index $1A00_h$: 0 Index $1A01_h$: 60610008_h Index $1A02_h$: 60640020_h Index $1A03_h$: $606C0020_h$
03_h	Mapping entry 3	rw	UNSIGNED32	Index $1A00_h$: 0_h Index $1A01_h$: 0_h Index $1A02_h$: 0_h Index $1A03_h$: 0_h

Table 49: Entry Description ($1A00_h$)

Before making changes to PDO definitions, first mark the PDO as inactive by setting bit 31 of its COB-ID (see section 3.1.19). Then, set its number of mapped PDO entries to zero (sub-index 0 of the appropriate PDO mapping object). Now, the mapppings themself can be changed. After that, set the number of map objects to the desired value, and finally activate the PDO by clearing bit 31 of its COB-ID.

4 Manufacturer specific area

The manufacturer segment contains manufacturer specific objects. These objects control the special features of the Trinamic Motion Control device TMCM-1633.

4.1 Detailed object specifications

4.1.1 Object 2005_h: Limit Switches

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

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

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

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

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

Table 50: Object Description (2005_h)

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

Table 51: Entry Description (2005_h)

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

Table 52: Bit Definitions (2005_h)

4.1.2 Object $200D_h$: Status Flags

This object provides information about the actual module status flags. (0: not active, 1: active).

This object is organized bit-wise. The bits have the following meaning:

Bit 0: OVERCURRENT
Bit 1: UNDERVOLTAGE

Bit 2: OVERVOLTAGE
Bit 3: OVERTEMPERATURE
Bit 4: MOTORHALTED
Bit 5: HALLERROR
Bit 6: DRIVER_ERROR
Bit 7: INIT_ERROR
Bit 8: STOP_MODE
Bit 9: VELOCITY_MODE
Bit 10: POSITION_MODE
Bit 11: TORQUE_MODE
Bit 12: EMERGENCYSTOP
Bit 13: FREERUNNING
Bit 14: POSITION_END
Bit 15: MODULE_INITIALIZED
Bit 16: unused
Bit 17: IIT_EXCEEDED

Object Description			
Index	Name	Object Type	Data Type
$200D_h$	Status Flags	Variable	UNSIGNED32

Table 53: Object Description ($200D_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Status Flags	no	0	4294967295	0		R

Table 54: Entry Description ($200D_h$)

4.1.3 Object $200E_h$: Supply Voltage

The actual supply voltage.

Object Description			
Index	Name	Object Type	Data Type
$200E_h$	Supply Voltage	Variable	UNSIGNED32

Table 55: Object Description ($200E_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Supply Voltage	no	0	1000	300	[100mV]	R

Table 56: Entry Description ($200E_h$)

4.1.4 Object $200F_h$: Driver Temperatur

The actual temperature of the motor driver.

Object Description			
Index	Name	Object Type	Data Type
$200F_h$	Driver Temperatur	Variable	SIGNED32

Table 57: Object Description ($200F_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Driver Temperature	no	-20	150	0	[degree]	R

Table 58: Entry Description ($200F_h$)

4.1.5 Object 2010_h: Motor Settings

Object Description			
Index	Name	Object Type	Data Type
2010_h	Motor Settings	Variable	Record

Table 59: Object Description (2010_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	MotorPoles	no	2	254	8		RW

Table 60: Entry Description (2010_h)

4.1.6 Object 2020_h: Limits

Object Description			
Index	Name	Object Type	Data Type
2020_h	Limits	Variable	Record

Table 61: Object Description (2020_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	MaxTorque	no	0	15000	4000	[mA] (peak)	RW
2	MaxVelocity	no	0	200000	4000	[rpm]	RW
3	MaxAcceleration	no	0	100000	2000	[rpm/s]	RW

Table 62: Entry Description (2020_h)

4.1.7 Object 2030_h: Torque Mode Settings

Object Description			
Index	Name	Object Type	Data Type
2030_h	Torque Mode Settings	Variable	Record

Table 63: Object Description (2030_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	ActualCurrent	no	-2147483648	2147483647	0	[mA] (peak)	R
2	TargetCurrent	no	-15000	15000	0	[mA] (peak)	R
3	RampTargetCurrent	no	-15000	15000	0	[mA] (peak)	R
4	P_Parameter	no	0	65535	0		RW
5	I_Parameter	no	0	65535	0		RW
6	PI_Torque_Error	no	-2147483648	2147483647	0	[mA]	R
7	PI_Torque_Error_Sum	no	-2147483648	2147483647	0		R
8	PI_Flux_Error	no	-2147483648	2147483647	0	[mA]	R
9	PI_Flux_Error_Sum	no	-2147483648	2147483647	0		R

Table 64: Entry Description (2030_h)

4.1.8 Object 2040_h: Velocity Mode Settings

Object Description			
Index	Name	Object Type	Data Type
2040_h	Velocity Mode Settings	Variable	Record

Table 65: Object Description (2040_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	ActualVelocity	no	-2147483648	2147483647	0	[rpm]	R
2	TargetVelocity	no	-200000	200000	0	[rpm]	R
3	RampTargetVelocity	no	-2147483648	2147483647	0	[rpm]	R
4	MotorHaltedVelocity	no	0	200000	5	[rpm]	RW
5	P_Parameter	no	0	65535	0		RW
6	I_Parameter	no	0	65535	0		RW
7	PI_Velocity_Error	no	-2147483648	2147483647	0	[rpm]	R
8	PI_Velocity_Error_Sum	no	-2147483648	2147483647	0		R

Table 66: Entry Description (2040_h)

4.1.9 Object 2050_h: Position Mode Settings

Object Description			
Index	Name	Object Type	Data Type
2050_h	Position Mode Settings	Variable	Record

Table 67: Object Description (2050_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	ActualPosition	no	-2147483648	2147483647	0		RW
2	TargetPosition	no	-2147483648	2147483647	0		R
3	RampTargetPosition	no	-2147483648	2147483647	0		R
4	P_Parameter	no	0	65535	0		RW
5	PI_Position_Error	no	-2147483648	2147483647	0		R
6	TargetReachedVelocity	no	0	200000	500	[rpm]	RW
7	TargetReachedDistance	no	0	100000	5		RW

Table 68: Entry Description (2050_h)

4.1.10 Object 2055_h: Commutation Mode

Select a commutation mode that fits best to your motor's sensors.

6 : FOC (hall sensor)
7 : FOC (encoder)
8 : FOC (controlled)

Object Description			
Index	Name	Object Type	Data Type
2055_h	Commutation Mode	Variable	Record

Table 69: Object Description (2055_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Commutation Mode	no	6	8	6		RW

Table 70: Entry Description (2055_h)

4.1.11 Object 2056_h: Velocity Ramp Mode

An activated ramp allows a defined acceleration for velocity and position mode.

Object Description			
Index	Name	Object Type	Data Type
2056_h	Velocity Ramp Mode	Variable	UNSIGNED8

Table 71: Object Description (2056_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Velocity Ramp Mode	no	0	1	1		RW

Table 72: Entry Description (2056_h)

4.1.12 Object 2060_h: Open Loop Settings

Object Description			
Index	Name	Object Type	Data Type
2060_h	Open Loop Settings	Variable	Record

Table 73: Object Description (2060_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	ActualAngle	no	-32768	32767	0		R
2	OpenLoopCurrent	no	0	15000	1500	[mA] (peak)	RW

Table 74: Entry Description (2060_h)

4.1.13 Object 2070_h: Hall Sensor Settings

Object Description			
Index	Name	Object Type	Data Type
2070_h	Hall Sensor Settings	Variable	Record

Table 75: Object Description (2070_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	ActualAngle	no	-32768	32767	0		R
2	Inversion	no	0	1	0		RW
3	Interpolation	no	0	1	0		RW

Table 76: Entry Description (2070_h)

4.1.14 Object 2080_h: ABN Encoder Settings

Object Description			
Index	Name	Object Type	Data Type
2080_h	ABN Encoder Settings	Variable	Record

Table 77: Object Description (2080_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	ActualAngle	no	-32768	32767	0		R
2	StepsPerRotation	no	0	65535	4000		RW
3	Offset	no	0	65535	0		RW
4	Direction	no	0	1	0		RW
5	InitMode	no	0	2	1		RW
6	InitDelay	no	0	10000	1000	[ms]	RW
7	InitVelocity	no	-200000	200000	100	[rpm]	RW

Table 78: Entry Description (2080_h)

4.1.15 Object 2100_h: Home Offset Display

This object shows the home offset. The value is given in encoder or hall increments.

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

Table 79: Object Description (2100_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Home Offset Display	no	-2147483648	2147483647	0		R

Table 80: Entry Description (2100_h)

4.1.16 Object 2702_h: Digital Inputs

Bit0: Left limit switch status

Bit1: Right limit switch status

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

Table 81: Object Description (2702_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Digital Inputs	no	0	3	0		R

Table 82: Entry Description (2702_h)

4.1.17 Object 2704_h: CAN Bit Rate

With this object it is possible to change the CAN bit rate.

To do this, first write the new value to this object. Then, store the new setting by writing the save signature to object 2706h. After that, reset the module. The new setting then becomes active.

(Available bit rates: 20, 50, 100, 125, 250, 500, 800, 1000)

Object Description			
Index	Name	Object Type	Data Type
2704_h	CAN Bit Rate	Variable	UNSIGNED16

Table 83: Object Description (2704_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	CAN Bit Rate	no	20	1000	1000		RW

Table 84: Entry Description (2704_h)

4.1.18 Object 2705_h: Node ID

On modules that do not have address switches the node ID can be selected using this object.

On modules with address switches the node ID is normally selected using the address switches.

To change the node ID, first write the new node ID to this object. Then, store the new setting by writing the save signature to object 2706h. After that, reset the module. The new setting then becomes active.

Object Description			
Index	Name	Object Type	Data Type
2705_h	Node ID	Variable	UNSIGNED8

Table 85: Object Description (2705_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Node ID	no	1	127	1		RW

Table 86: Entry Description (2705_h)

4.1.19 Object 2706_h: Store

Writing the save signature to this object permanently saves changes made to objects 2704h and 2705h. The save signature is 65766173h.

Object Description			
Index	Name	Object Type	Data Type
2706_h	Store	Variable	UNSIGNED32

Table 87: Object Description (2706_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Store	no	0	4294967295	0		RW

Table 88: Entry Description (2706_h)

4.1.20 Object 2707_h: CAN Bit Rate Load

This object shows the selected CAN bit rate.

Object Description			
Index	Name	Object Type	Data Type
2707_h	CAN Bit Rate Load	Variable	UNSIGNED8

Table 89: Object Description (2707_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	CAN Bit Rate Load	no	20	1000	1000		R

Table 90: Entry Description (2707_h)

4.1.21 Object 2708_h: Node ID Load

This object shows the selected node ID.

Object Description			
Index	Name	Object Type	Data Type
2708_h	Node ID Load	Variable	UNSIGNED8

Table 91: Object Description (2708_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Node ID Load	no	1	127	1		R

Table 92: Entry Description (2708_h)

4.1.22 Object $270E_h$: Analog Inputs

Object Description			
Index	Name	Object Type	Data Type
$270E_h$	Analog Inputs	Variable	Record

Table 93: Object Description ($270E_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	ADC_IN_0	no	0	4095	0		R
2	ADC_IN_1	no	0	4095	0		R
3	ADC_phase_A	no	0	4095	0		R
4	ADC_phase_B	no	0	4095	0		R
5	ADC_phase_C	no	0	4095	0		R
6	ADC_VSupply	no	0	4095	0		R
7	ADC_Temp	no	0	4095	0		R

Table 94: Entry Description ($270E_h$)

5 Profile specific area

The profile segment contains CiA-402 standard motion control objects. These objects control the motion control functions of the TMCM-1633. Since it is not possible to operate the modes in parallel, the user is able to activate the required function by selecting a mode of operation. The control device writes to the modes of operation object in order to select the operation mode. The drive device provides the modes of operation display object to indicate the actual activated operation mode. Controlword, statusword, and set-points are used mode-specific. This implies the responsibility of the control device to avoid inconsistencies and erroneous behavior.

The following operating modes (selectable via object 6060_h, please see 5.1.6) are implemented on the TMCM-1633:

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

5.1 Detailed object specifications

5.1.1 Object $605A_h$: Quick Stop Option Code

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

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

Object Description			
Index	Name	Object Type	Data Type
$605A_h$	Quick Stop Option Code	Variable	SIGNED16

Table 95: Object Description ($605A_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Quick Stop Option Code	no	1	6	0		RW

Table 96: Entry Description ($605A_h$)

5.1.2 Object $605B_h$: Shutdown Option Code

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

0: Disable drive function (switch off the power stage)

Object Description			
Index	Name	Object Type	Data Type
$605B_h$	Shutdown Option Code	Variable	SIGNED16

Table 97: Object Description ($605B_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Shutdown Option Code	no	0	0	0		RW

Table 98: Entry Description ($605B_h$)

5.1.3 Object $605C_h$: Disable Operation Option Code

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

1: Slow down on slow down ramp

Object Description			
Index	Name	Object Type	Data Type
$605C_h$	Disable Operation Option Code	Variable	SIGNED16

Table 99: Object Description ($605C_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Disable Operation Option Code	no	1	1	1		RW

Table 100: Entry Description ($605C_h$)

5.1.4 Object $605D_h$: Halt Option Code

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

1: Slow down on slow down ramp and stay in operation enabled

Object Description			
Index	Name	Object Type	Data Type
$605D_h$	Halt Option Code	Variable	SIGNED16

Table 101: Object Description ($605D_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Halt Option Code	no	1	1	1		RW

Table 102: Entry Description ($605D_h$)

5.1.5 Object $605E_h$: Fault Reaction Option Code

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

2: Slow down on quick stop ramp

Object Description			
Index	Name	Object Type	Data Type
$605E_h$	Fault Reaction Option Code	Variable	SIGNED16

Table 103: Object Description ($605E_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Fault Reaction Option Code	no	2	2	2		RW

Table 104: Entry Description ($605E_h$)

5.1.6 Object 6060_h: Modes of Operation

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

0: No mode
1: Profile position mode (pp)
3: Profile velocity mode (pv)
6: Homing mode (hm)
10: Cyclic torque mode (cst)

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

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

Table 105: Object Description (6060_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Modes of Operation	no	0	10	0		RW

Table 106: Entry Description (6060_h)

5.1.7 Object 6061_h: Modes of Operation Display

This object shows the operating mode that is currently set.

0: No mode

1: Profile position mode (pp)
3: Profile velocity mode (pv)
6: Homing mode (hm)
10: Cyclic torque mode (cst)

Object Description			
Index	Name	Object Type	Data Type
6061_h	Modes of Operation Display	Variable	SIGNED8

Table 107: Object Description (6061_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Modes of Operation Display	no	0	10	0		R

Table 108: Entry Description (6061_h)

5.1.8 Object $608F_h$: Position Encoder Resolution

This object defines the resolution of the encoder. The position encoder resolution is calculated by the following formula: position encoder resolution = encoder increments / motor revolutions.

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

Table 109: Object Description ($608F_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	Encoder increments	no	0	65535	4000		RW
2	Motor revolutions	no	1	1	1		R

Table 110: Entry Description ($608F_h$)

5.1.9 Object 6099_h: Homing Speeds

This object indicates the configured speeds used during fast and slow homing procedure. 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 609Ah) to search for the exact switch point. When the switch point has been found the motor will be stopped at that point.

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

Table 111: Object Description (6099_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	Fast Homing Speed	no	0	4294967295	0		RW
2	Slow Homing Speed	no	0	4294967295	0		RW

Table 112: Entry Description (6099_h)

5.1.10 Object $60FD_h$: Digital Inputs

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

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

Table 113: Object Description ($60FD_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Limit Switches	no	0	3	0		R

Table 114: Entry Description ($60FD_h$)

5.1.11 Object 6502_h: Supported Drive Modes

This object provides information on the supported drive modes (0: not supported, 1: supported). This object is organized bit-wise. The bits have the following meaning:

Bit 0: profile position mode
Bit 1: velocity mode
Bit 2: profile velocity mode
Bit 3: profile torque mode
Bit 4: reserved
Bit 5: homing mode
Bit 6: interpolated position mode

Bit 7: cyclic synchronous position mode
Bit 8: cyclic synchronous velocity mode
Bit 9: cyclic synchronous torque mode
Bit 10-15: reserved
Bit 16-31: manufacturer-specific

Object Description			
Index	Name	Object Type	Data Type
6502_h	Supported Drive Modes	Variable	UNSIGNED32

Table 115: Object Description (6502_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Supported Drive Modes	no	0	4294967295	0		R

Table 116: Entry Description (6502_h)

6 Profile Position Mode

A target position is applied to the trajectory generator. It is generating a position demand value for the position control loop described in the position control function.

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

6.1 Detailed Object Specifications

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

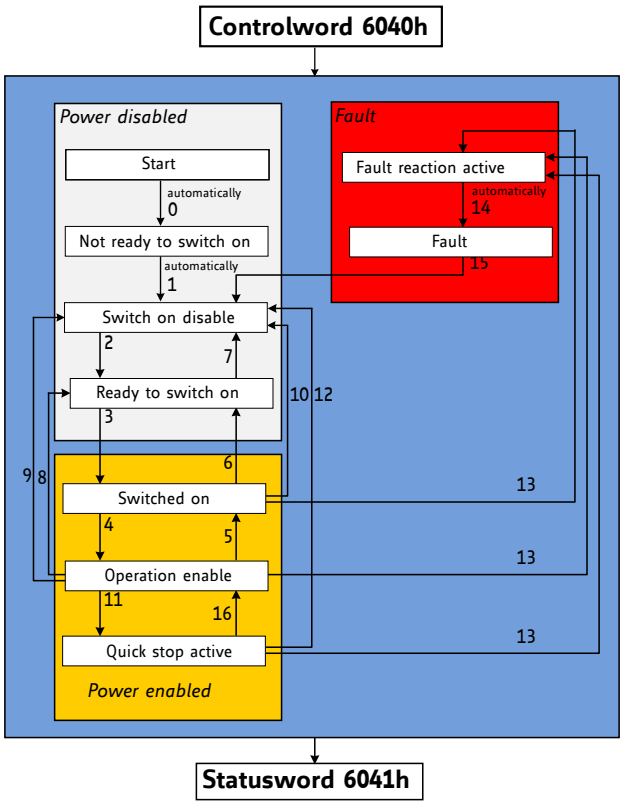


Figure 4: DS402 Finite State Machine

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.

6.2 Detailed Object Specifications

6.2.1 Object 6040_h: Control Word

This object indicates the received command controlling the power drive system finite state automaton (PDS FSA). The CiA-402 state machine can be controlled using this object. Please refer to figure 4 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 117: Structure of the Control Word in pp Mode

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

Table 118: 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 119: Command Coding

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

Table 120: Object Description (6040_h in pp Mode)

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

Table 121: Entry Description (6040_h in pp Mode)

6.2.2 Object 6041_h: Status Word

This object provides the status of the PDS FSA. It reflects the status of the CiA-402 state machine. Please refer to figure 4 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 122: Structure of the Staus Word in pp Mode

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

Table 123: Trinamic Specific Bits

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

Table 124: Operation Mode specific Bits in pp Mode

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

Table 125: State Coding

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

Table 126: Object Description (6041$_h$ in pp Mode)

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

Table 127: Entry Description (6041$_h$ in pp Mode)

6.2.3 Object 6062$_h$: Position Demand Value

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

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

Table 128: Object Description (6062$_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Position Demand Value	no	-2147483648	2147483647	0		R

Table 129: Entry Description (6062_h)

6.2.4 Object 6063_h: Position Actual Internal Value

This object provides the actual position value of the motor.

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

Table 130: Object Description (6063_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Position Actual Internal Value	no	-2147483648	2147483647	0		R

Table 131: Entry Description (6063_h)

6.2.5 Object 6064_h: Position Actual Value

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

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

Table 132: Object Description (6064_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Position Actual Value	no	-2147483648	2147483647	0		R

Table 133: Entry Description (6064_h)

6.2.6 Object 6067_h: Position Window

This object indicates the configured symmetrical range of accepted positions relative to the target position. If the actual value of the position encoder is within the position window, this target position is regarded as having been reached. The value is given in increments. If the value of the position window is FFFFFFFFh, 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 (6062h) has reached the target position (6064h). 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 (6064h) is within (target_position - position_window) and (target_position + position_window).

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

Table 134: Object Description (6067_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Position Window	no	0	4294967295	4294967295		RW

Table 135: Entry Description (6067_h)

6.2.7 Object $606C_h$: Velocity Actual Value

This object shows the actual velocity value derived from the velocity sensor.

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

Table 136: Object Description ($606C_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Velocity Actual Value	no	-2147483648	2147483647	0	[rpm]	R

Table 137: Entry Description ($606C_h$)

6.2.8 Object $607A_h$: Target Position

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

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

Table 138: Object Description ($607A_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Target Position	no	-2147483648	2147483647	0		RW

Table 139: Entry Description ($607A_h$)

6.2.9 Object $607D_h$: Software Position Limit

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

Corrected min position limit = min position limit - home offset
Corrected max position limit = max position limit - home offset

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

Table 140: Object Description ($607D_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	Min Position Limit	no	-2147483648	2147483647	-2147483648		RW
2	Max Position Limit	no	-2147483648	2147483647	2147483647		RW

Table 141: Entry Description ($607D_h$)

6.2.10 Object 6081_h: Max Profile Velocity (pp)

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.

Object Description			
Index	Name	Object Type	Data Type
6081_h	Max Profile Velocity (pp)	Variable	UNSIGNED32

Table 142: Object Description (6081_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Max Profile Velocity	no	0	200000	0	[rpm]	RW

Table 143: Entry Description (6081_h)

6.2.11 Object 6082_h: End Velocity

This object indicates the configured velocity normally attained at the end of the deceleration ramp during a profiled motion and is valid for both directions of motion. The end velocity is the velocity used when reaching the new position.

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

Table 144: Object Description (6082_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	End Velocity	no	-200000	200000	0	[rpm]	RW

Table 145: Entry Description (6082_h)

6.2.12 Object 6083_h: Profile Acceleration

This object indicates the configured acceleration. Object 6083h sets the maximum acceleration to be used in profile positioning mode, and profile velocity mode.

Object Description			
Index	Name	Object Type	Data Type
6083_h	Profile Acceleration	Variable	UNSIGNED32

Table 146: Object Description (6083_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Profile Acceleration	no	0	100000	2000	[rpm/s]	RW

Table 147: Entry Description (6083_h)

6.2.13 Object 6084_h: Profile Deceleration

This object indicates the configured deceleration.

Object Description			
Index	Name	Object Type	Data Type
6084_h	Profile Deceleration	Variable	UNSIGNED32

Table 148: Object Description (6084_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Profile Deceleration	no	0	100000	2000	[rpm/s]	RW

Table 149: Entry Description (6084_h)

6.2.14 Object 6085_h: Quick Stop Deceleration

This object indicates the configured deceleration used to stop the motor when the quick stop function is activated and the quick stop code object 605Ah is set to 2 (or 6).

Object Description			
Index	Name	Object Type	Data Type
6085_h	Quick Stop Deceleration	Variable	UNSIGNED32

Table 150: Object Description (6085_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Quick Stop Deceleration	no	0	100000	2000	[rpm/s]	RW

Table 151: Entry Description (6085_h)

6.3 How to move a Motor in pp Mode

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

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

7 Profile Velocity Mode

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

The profile velocity mode covers the following sub-functions:

- Demand value input via trajectory generator.
- Monitoring of the profile velocity using a window-function.
- Monitoring of velocity actual value using a threshold.

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

- Profile velocity
- Profile acceleration
- Motion profile type

7.1 Detailed Object Specifications

7.1.1 Object 6040_h: Control Word

This object indicates the received command controlling the power drive system finite state automaton (PDS FSA). The CiA-402 (www.can-cia.org/can-knowledge/canopen/cia402) state machine can be controlled using this object. Please refer to figure 4 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 152: 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 153: Command Coding

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

Table 154: Object Description (6040_h in pv Mode)

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

Table 155: Entry Description (6040_h in pv Mode)

7.1.2 Object 6041_h: Status Word

This object provides the status of the PDS FSA. It reflects the status of the CiA-402 state machine. Please refer to figure 4 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 156: Structure of the Status Word in pv Mode

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

Table 157: 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 158: Operation Mode specific Bits in pv Mode

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

Table 159: State Coding

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

Table 160: Object Description (6041_h in pv Mode)

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

Table 161: Entry Description (6041_h in pv Mode)

7.1.3 Object 6062_h: Position Demand Value

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

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

Table 162: Object Description (6062_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Position Demand Value	no	-2147483648	2147483647	0		R

Table 163: Entry Description (6062_h)

7.1.4 Object 6063_h: Position Actual Internal Value

This object provides the actual position value of the motor.

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

Table 164: Object Description (6063_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Position Actual Internal Value	no	-2147483648	2147483647	0		R

Table 165: Entry Description (6063_h)

7.1.5 Object 6064_h: Position Actual Value

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

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

Table 166: Object Description (6064_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Position Actual Value	no	-2147483648	2147483647	0		R

Table 167: Entry Description (6064_h)

7.1.6 Object $606C_h$: Velocity Actual Value

This object shows the actual velocity value derived from the velocity sensor.

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

Table 168: Object Description ($606C_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Velocity Actual Value	no	-2147483648	2147483647	0	[rpm]	R

Table 169: Entry Description ($606C_h$)

7.1.7 Object $607D_h$: Software Position Limit

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

Corrected min position limit = min position limit - home offset
Corrected max position limit = max position limit - home offset

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

Table 170: Object Description ($607D_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	Min Position Limit	no	-2147483648	2147483647	-2147483648		RW
2	Max Position Limit	no	-2147483648	2147483647	2147483647		RW

Table 171: Entry Description ($607D_h$)

7.1.8 Object 6083_h: Profile Acceleration

This object indicates the configured acceleration. Object 6083h sets the maximum acceleration to be used in profile positioning mode, and profile velocity mode.

Object Description			
Index	Name	Object Type	Data Type
6083_h	Profile Acceleration	Variable	UNSIGNED32

Table 172: Object Description (6083_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Profile Acceleration	no	0	100000	2000	[rpm/s]	RW

Table 173: Entry Description (6083_h)

7.1.9 Object 6085_h: Quick Stop Deceleration

This object indicates the configured deceleration used to stop the motor when the quick stop function is activated and the quick stop code object 605Ah is set to 2 (or 6).

Object Description			
Index	Name	Object Type	Data Type
6085_h	Quick Stop Deceleration	Variable	UNSIGNED32

Table 174: Object Description (6085_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Quick Stop Deceleration	no	0	100000	2000	[rpm/s]	RW

Table 175: Entry Description (6085_h)

7.1.10 Object $60FF_h$: Target Velocity

This object indicates the configured target velocity and is used as input for the trajectory generator. Object 60FFh 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 6083h and 6084h.

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

Table 176: Object Description ($60FF_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Target Velocity	no	-200000	200000	0	[rpm]	RW

Table 177: Entry Description ($60FF_h$)

7.2 How to move a Motor in pv Mode

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

- Select pv mode by writing 3 to object 6060_h (Modes_of_Operation).
- Write 6 to object 6040_h (Controlword) to switch to READY_TO_SWITCH_ON state.
- Write 7 to object 6040_h to switch to SWITCHED_ON state.
- Write the desired target velocity (e.g. 2000) to object $60FF_h$ (Target_Velocity).
- Write 15 to object 6040_h to switch to OPERATION_ENABLED state. The motor now accelerates to the target velocity.
- Stop the motor by writing 0 to object $60FF_h$.

8 Homing mode

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

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

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

Figure 5 shows the defined input objects as well as the output objects. The user can specify the speeds, acceleration and method of homing. The home offset object $607C_h$ allows displacing the zero in point the coordinate system for the home position.

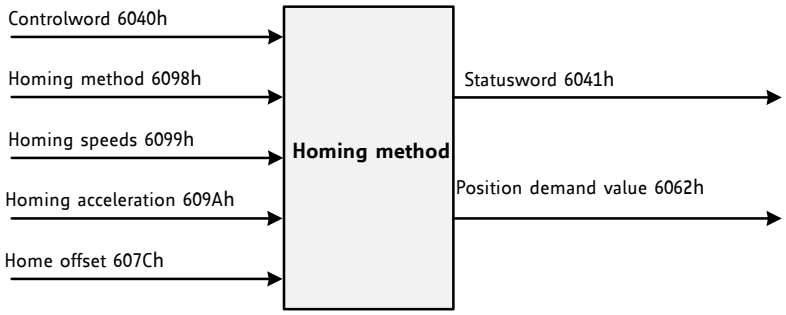


Figure 5: Homing Mode Function

Choosing a homing mode determines the following things:

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

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

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-1633 supports a subset of different standard CANopen homing methods. The homing method that is to be used can be choosen via object 6098_h (section 8.2.5).

Supported Homing Methods	
Method	Description
0	No homing (default value for object 6098_h).
17	Search the left end switch.
18	Search the right end switch.
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 178: Supported CANopen Homing Methods

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

8.1.1 Homing Method 17 and 18: Homing without Index Pulse

For these methods the home position only depends on the relevant home or limit switch transitions.

Homing Methods 17…21	
Method	Description
17	Search the left end switch.
18	Search the right end switch.

Table 179: Homing Methods 17 – 21

8.1.2 Homing Method 35: Current Position as Home Position

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

8.2 Detailed Object Specifications

8.2.1 Object 6040_h: Control Word

This object indicates the received command controlling the power drive system finite state automaton (PDS FSA). The CiA-402 state machine can be controlled using this object. Please refer to figure 4 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 180: 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 181: 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 182: Command Coding

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

Table 183: Object Description (6040_h in hm Mode)

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

Table 184: Entry Description (6040_h in hm Mode)

8.2.2 Object 6041_h: Status Word

This object provides the status of the PDS FSA. It reflects the status of the CiA-402 state machine. Please refer to figure 4 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 185: Structure of the Status Word in hm Mode

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

Table 186: 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 187: Operation Mode specific Bits in hm Mode

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

Table 188: State Coding

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

Table 189: Object Description (6041_h in hm Mode)

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

Table 190: Entry Description (6041_h in hm Mode)

8.2.3 Object $606C_h$: Velocity Actual Value

This object shows the actual velocity value derived from the velocity sensor.

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

Table 191: Object Description ($606C_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Velocity Actual Value	no	-2147483648	2147483647	0	[rpm]	R

Table 192: Entry Description ($606C_h$)

8.2.4 Object $607C_h$: Home Offset

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

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

Table 193: Object Description ($607C_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Home Offset	no	-2147483648	2147483647	0		RW

Table 194: Entry Description ($607C_h$)

8.2.5 Object 6098_h: Homing Method

The actual homing method.

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

Table 195: Object Description (6098_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Homing Method	no	0	35	0		RW

Table 196: Entry Description (6098_h)

8.2.6 Object 6099_h: Homing Speeds

This object indicates the configured speeds used during fast and slow homing procedure. 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 609Ah) to search for the exact switch point. When the switch point has been found the motor will be stopped at that point.

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

Table 197: Object Description (6099_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	Fast Homing Speed	no	0	4294967295	0		RW
2	Slow Homing Speed	no	0	4294967295	0		RW

Table 198: Entry Description (6099_h)

8.2.7 Object $609A_h$: Homing Acceleration

This object indicates the configured acceleration and deceleration to be used during homing operation.

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

Table 199: Object Description ($609A_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Homing Acceleration	no	0	100000	2000	[rpm/s]	RW

Table 200: Entry Description ($609A_h$)

8.2.8 Object 2100_h: Home Offset Display

This object shows the home offset. The value is given in encoder or hall increments.

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

Table 201: Object Description (2100_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Home Offset Display	no	-2147483648	2147483647	0		R

Table 202: Entry Description (2100_h)

8.3 How to start a Homing in hm Mode

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

- Select hm mode by writing 6 to object 6060_h.
- Write 6 to object 6040_h to switch to READY_TO_SWITCH_ON state.
- Write 7 to object 6040_h to switch to SWITCHED_ON state.
- Write 15 to object 6040_h to switch to OPERATION_ENABLED state.
- Select homing method 17 (left end switch) (or 18 (right end switch)) by writing 17 (or 18) to object 6098_h.
- Set the homing speeds by writing e.g. 500 to object 6099_h sub index 1 and e.g. 200 to object 6099_h sub index 2.
- Write 31 to object 6040_h to start the homing process.
- Press and release the home switch.
- When homing has finished, write 15 to object 6040_h again.

9 Cyclic synchronous Torque Mode

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

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

- Demand value input directly via an object.
- Monitoring and limiting the torque.

9.1 Detailed Object Specifications

9.1.1 Object 6040_h: Control Word

This object indicates the received command controlling the power drive system finite state automaton (PDS FSA). The CiA-402 state machine can be controlled using this object. Please refer to figure 4 for detailed information. The cyclic synchronous torque mode does not use any mode specific bits of the control word.

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

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

Table 203: Structure of the Control Word in cst Mode

Command Coding						
Command	Bits of Control Word					Transitions
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	x	1	1	0	2,6,8
Switch on	0	0	1	1	1	3
Switch on & enable operation	0	1	1	1	1	3, 4
Disable voltage	0	x	x	0	x	7,9,10,12
Quick stop	0	x	0	1	x	7,10,11
Disable operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4, 16
Fault reset	0-to-1	x	x	x	x	15

Table 204: Command Coding

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

Table 205: Object Description (6040_h in cst Mode)

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

Table 206: Entry Description (6040_h in cst Mode)

9.1.2 Object 6041_h: Status Word

This object provides the status of the PDS FSA. It reflects the status of the CiA-402 state machine. Please refer to figure 4 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 207: Structure of the Status Word in cst Mode

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

Table 208: Trinamic Specific Bits

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

Table 209: Operation Mode specific Bits in cst Mode

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

Table 210: State Coding

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

Table 211: Object Description (6041_h in cst Mode)

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

Table 212: Entry Description (6041_h in cst Mode)

9.1.3 Object 6071_h: Target Torque

This object gives the target motor current.

Object Description			
Index	Name	Object Type	Data Type
6071_h	Target Torque	Variable	SIGNED32

Table 213: Object Description (6071_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Target Torque	no	-15000	15000	0	[mA]	RW

Table 214: Entry Description (6071_h)

9.1.4 Object 6077_h: Torque Actual Value

The actual motor current.

Object Description			
Index	Name	Object Type	Data Type
6077_h	Torque Actual Value	Variable	SIGNED32

Table 215: Object Description (6077_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Torque Actual Value	no	-2147483648	2147483647	0		R

Table 216: Entry Description (6077_h)

9.1.5 Object $60B2_h$: Torque offset

The actual set torque offset.

Object Description			
Index	Name	Object Type	Data Type
$60B2_h$	Torque offset	Variable	SIGNED32

Table 217: Object Description ($60B2_h$)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Torque offset	no	-2147483648	2147483647	0		RW

Table 218: Entry Description ($60B2_h$)

9.2 How to move a Motor in cst Mode

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

- If you do not have any limit switches connected, first disable the limit switch inputs by writing 3 to object 2005_h.
- Select cst mode by writing 10 to object 6060_h.
- Write 6 to object 6040_h to switch to READY_TO_SWITCH_ON state.
- Write 7 to object 6040_h to switch to SWITCHED_ON state.
- Write 15 to object 6040_h to switch to OPERATION_ENABLED state.
- Write the desired torque (e.g. 1000) to object 6071_h to start the motor.
- To stop the motor, write 0 to object 6071_h.

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_h (error register) is part of every emergency object.

Emergency Messages (EMCY) of the TMCM-1633						
Error code	Additional byte					Description
	1	2	3	4	5	
0000_h	0	0	0	0	0	**Fault reset** The fault reset command has been executed.
1000_h	1	0	0	0	0	**Generic error: open load bridge A** The motor driver indicates open load on bridge A. It is possible that the motor cable is broken or that there is an error in the power amplifier itself.
1000_h	2	0	0	0	0	**Generic error: open load bridge B** The motor driver indicates open load on bridge B. It is possible that the motor cable is broken or that there is an error in the power amplifier itself.
2310_h	0	0	0	0	0	**Overcurrent high side** The motor driver indicates an overcurrent on the high side. This can be caused by a short circuit in the driver stage.
2311_h	0	0	0	0	0	**Overcurrent bridge B** The motor driver indicates that there is overcurrent on bridge B. This can be caused by a short circuit in the motor itself or in the motor driver stage.
2312_h	0	0	0	0	0	**Overcurrent bridge A** The motor driver indicates that there is overcurrent on bridge A. This can be caused by a short circuit in the motor itself or in the motor driver stage.
3230_h	0	0	0	0	0	**stallGuard2 error** The actual load value exceeds the stallGuard2 limit.
4310_h	1	0	0	0	0	**Overtemperature pre-warning** The temperature in the motor driver exceeds the pre-warning limit.
4310_h	2	0	0	0	0	**Overtemperature error** The motor driver has been switched off because the temperature limit has been exceeded.
5441_h	0	255	0	0	0	**Shutdown switch active** The enable signal is missing (due to the shutdown switch) and the motor driver has been switched off.
6320_h	0	255	0	0	0	**Parameter error** The data in the received PDO is either wrong or cannot be accepted due to the internal state of the drive.

Error code	Additional byte					Description
	1	2	3	4	5	
8110_h	1	255	0	0	0	**CAN controller overflow** The receive message buffer of the CAN controller hardware is full and some CAN messages are lost.
8110_h	2	255	0	0	0	**CAN Tx buffer overflow** The software CAN transmit buffer is full and thus some CAN messages are lost.
8110_h	3	255	0	0	0	**CAN Rx buffer overflow** The software CAN receive buffer is full and so some CAN messages are lost.
8120_h	0	255	0	0	0	**CAN error passive** The CAN controller has detected communication errors and has entered the CAN Error passive state.
8140_h	0	255	0	0	0	**CAN controller recovered from bus-off state** The CAN controller has detected too many errors and has changed into the bus-off state. The drive has been stopped and disabled. This message is sent after the CAN controller has recovered from bus-off state and is bus-on again.
8611_h	0	0	0	0	0	**Following error** The deviation between motor position counter and encoder position counter has exceeded the following error window.
$ff00_h$	0	0	0	0	0	**Undervoltage** The supply voltage is too low to drive a motor.
$ff01_h$	1	0	0	0	0	**Positive software limit** The actual position is outside the range defined by object $607d_h$.
$ff01_h$	2	0	0	0	0	**Negative software limit** The actual position is outside the range defined by object $607d_h$.
$ff01_h$	3	0	0	0	0	**Positive limit switch** The positive limit switch has been touched outside of the homing function.
$ff01_h$	4	0	0	0	0	**Negative limit switch** The negative limit switch has been touched outside of the homing function.

Table 219: Emergency Messages (EMCY)

11 Figures Index

12 Tables Index

13 Supplemental Directives

13.1 Producer Information

13.2 Copyright

13.3 Trademark Designations and Symbols

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

13.4 Target User

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

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

13.5 Disclaimer: Life Support Systems

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13.6 Disclaimer: Intended Use

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13.7 Collateral Documents & Tools

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

14 Revision History

14.1 Firmware Revision

Version	Date	Author	Description
2.09	28.06.2017	ED	First release.
2.10	17.04.2018	ED	Added support to enable predriver by TMCL command to use the wizards from TMCL-IDE with RS232 interface bypassing the CANopen stack.

Table 220: Firmware Revision

14.2 Document Revision

Version	Date	Author	Description
1.00	28.06.2017	ED	First release.
1.01	19.04.2018	ED	Updated firmware revision history.

Table 221: Document Revision