TMCM-1617-GRIP-REF HW & CoE FW Manual

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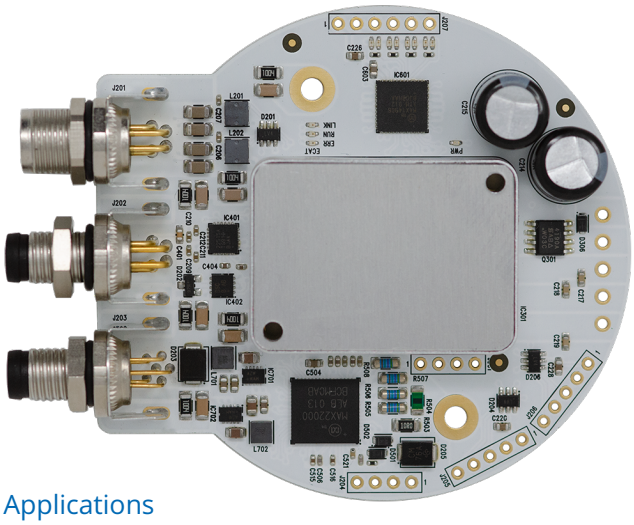
The TMCM-1617-GRIP-REF is an open source hardware reference design for the TMCM-1617 BLDC servo drive. To be used in robotic gripper applications, the board is designed in a standard gripper electronics form-factor. It is able to control a BLDC motor via EtherCAT®, IO-Link® or Trinamic's RS-485 based TMCL protocol. In addition, the board features configurable analog output and input channels as well as configurable digital output and input channels using Maxim Integrated MAX22000 and MAX14906 industrial IO solutions.



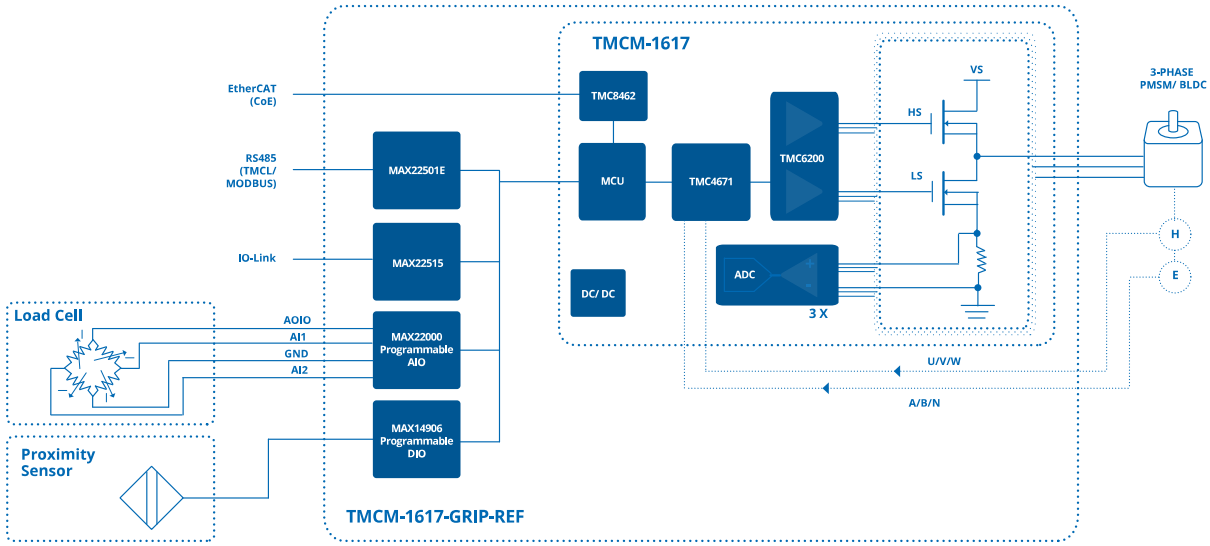
Applications

- Robotic Grippers

Features

- Single axis BLDC servo driver for up to 2.5 A RMS motor current
- +24 V Nominal Supply Voltage (+20 V to +28 V)
- Digital Hall sensor interface
- ABN encoder interface
- 4 Digital +24 V I/O (highside switch, push-pull driver, or a Type 1 and 3, or Type 2 digital input)
- 1 Analog output (±12.5 V output voltage range, or ±25 mA or ±2.5 mA output current range)
- 1 Differential analog input (±15 V, ±2.5 V, ±500 mV, ±250 mV, and ±125 mV input voltage ranges)

Simplified Block Diagram



Read entire documentation.

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Contents

1 Order Code

Order Code	Description
TMCM-1617-GRIP-REF	Robotic Gripper Reference Design.

Table 1: Order code

2 Featured Parts

- TMCM-1617 - Low weight, miniaturized single axis servo drive for 3-phase BLDC motors
- MAX22000 - Industrial Software Configurable Analog I/O
- MAX14906 - Quad-Channel Industrial Digital Output, Digital Input
- MAX22515 - IO-Link Transceiver with Integrated Protection
- MAX17552 - 60V, 100mA, Ultra-Small, High-Efficiency, Synchronous Step-Down DC-DC Converter
- MAX22501 - 100Mbps Half-Duplex RS-485/RS-422 Transceivers

3 Mechanical Information

3.1 Module Size

The TMCM-1617-GRIP-REF is designed in a standard gripper electronics form-factor. The module has 2 mounting holes for M3 screws.

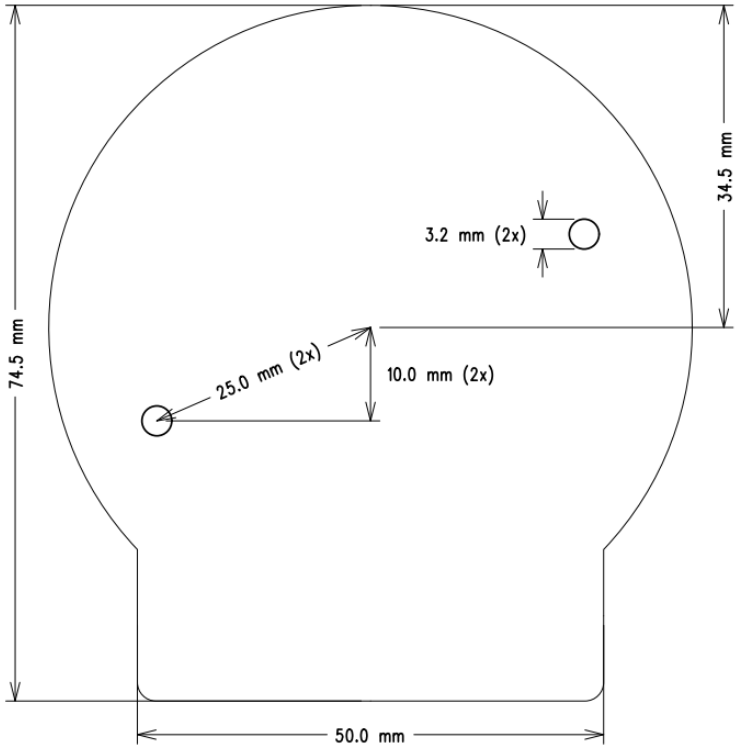


Figure 1: TMCM-1617-GRIP-REF dimensions

3.2 Mounting a Heat Sink

The aluminum housing of TMCM-1617 has 2 mounting holes for M2.5 screws/bolts that allow mounting a heat sink. A thermal gap pad (electrically isolating) is recommended between the housing and the heat sink for proper heat transfer.

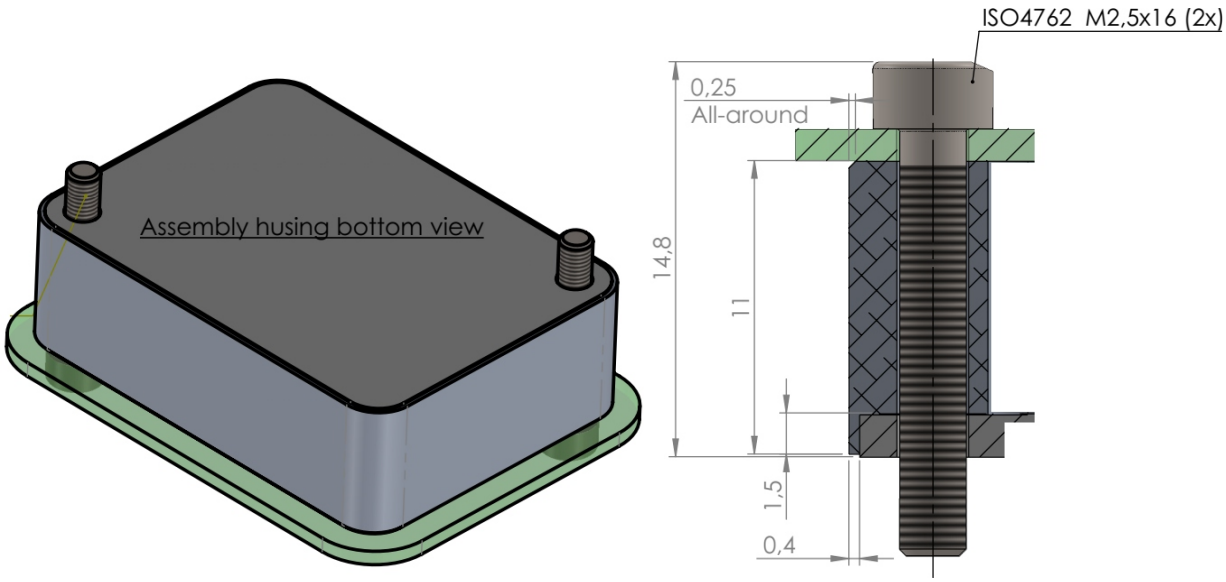


Figure 2: Heat sink mounting

4 Connectors and LEDs

The TMCM-1617-GRIP-REF comes with 3 connectors:

- EtherCAT® (in)
- IO-Link
- Supply and RS485

The connectors for other interfaces are not mounted to allow the user to choose between mounting standard 2.54/3.81 mm headers or connecting wires directly to the board:

- Motor
- Brake output
- Hall sensor
- Encoder
- Analog I/O
- Digital I/O
- Programming

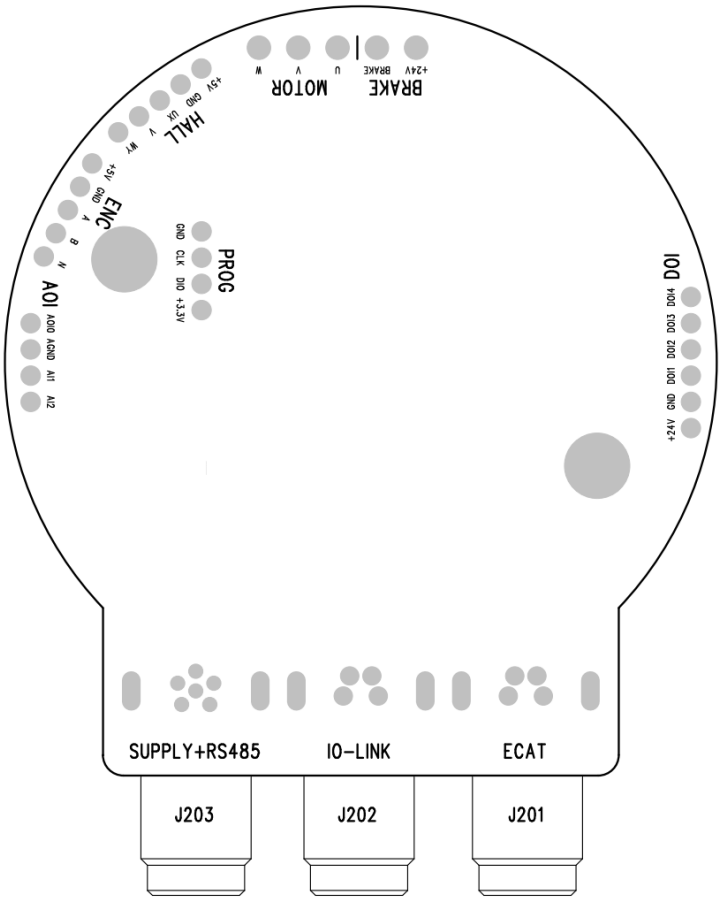
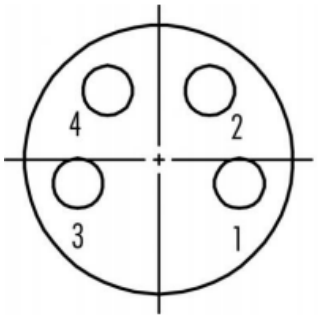


Figure 3: TMCM-1617-GRIP-REF connectors (bottom view)

4.1 EtherCAT® Connector and LEDs

Connector: 4-pin female M8 (Binder 86 6618 1121 00004).



Pin	Signal	Description
1	TP	Transmit line (non-inverting)
2	RP	Receive line (non-inverting)
3	RN	Receive line (inverting)
4	TN	Transmit line (inverting)

Figure 4: EtherCAT® connector (J201)

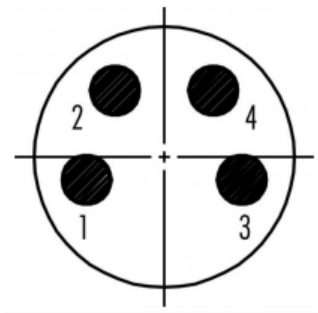
The EtherCAT® interface includes 3 status LEDs.

Label	Description
RUN	EtherCAT® status LED, green
ERR	EtherCAT® error LED, red
IN	EtherCAT® in LED, green

Table 2: EtherCAT® LEDs (D303-D305)

4.2 IO-Link Connector

Connector: 4-pin male M8 (Binder 86 6319 1121 00004).

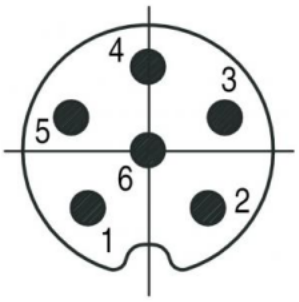


Pin	Signal	Description
1	V24	Supply input
2	DI	Auxiliary digital input
3	GND	Supply and signal ground
4	C/Q	IO-Link transceiver input/output

Figure 5: IO-Link connector (J202)

4.3 Supply And RS485 Connector and PWR LED

Connector: 6-pin male M8 (Binder 86 6319 1121 00006).



Pin	Signal	Description
1	RS485 B	RS485 interface (inverting)
2	RS485 A	RS485 interface (non-inverting)
3	+24V	Supply input
4	+24V	Supply input
5	GND	Supply ground
6	GND	Supply ground

Figure 6: Supply and RS485 connector (J203)

There is a blue status LED on the board indicating that the board is powered.

4.4 Motor Connector

Connector: 3-pin 3.81mm standard header.

Connector	Signal	Description
1	U	Motor phase U
2	V	Motor phase V
3	W	Motor phase W

Table 3: Motor connector (PTH203-PTH205)

4.5 Brake Output Connector

Connector: 2-pin 3.81mm standard header.

Connector	Signal	Description
1	+24V	Supply output
2	Brake	PWM controlled low-side output

Table 4: Brake output connector (PTH206-PTH207)

4.6 Hall Sensor Connector

Connector: 5-pin 2.54mm standard header.

Pin	Signal	Description
1	+5V	Supply output for external sensor
2	GND	Signal and supply ground
3	U	Digital Hall sensor input, U channel, internal 4.7k Ω pull-up to +5V
4	V	Digital Hall sensor input, V channel, internal 4.7k Ω pull-up to +5V
5	W	Digital Hall sensor input, W channel, internal 4.7k Ω pull-up to +5V

Table 5: Hall sensor connector (J206)

4.7 Encoder Connector

Connector: 5-pin 2.54mm standard header.

Pin	Signal	Description
1	+5V	Supply output for external sensor
2	GND	Signal and supply ground
3	A	Digital quadrature/incremental encoder, A channel, internal 4.7k Ω pull-up to +5V
4	B	Digital quadrature/incremental encoder, B channel, internal 4.7k Ω pull-up to +5V
5	N	Digital quadrature/incremental encoder, N channel, internal 4.7k Ω pull-up to +5V

Table 6: ABN Encoder connector (J205)

4.8 Analog I/O Connector

Connector: 4-pin 2.54mm standard header.

Pin	Signal	Description
1	AOI0	Analog input/output
2	AGND	Analog ground
3	AI1	Analog input
4	AI2	Analog input

Table 7: Analog I/O connector (J204)

The table below describes the different I/O modes and available connections.

Mode	Connection
Analog Output Voltage Mode (AOVM)	AOI0 to AGND
Analog Output Current Mode (AOCM)	AOI0 to AGND
Analog Input Voltage Mode (AIVM)	AOI0, AI1 or AI2 to GND for single-ended AI1 to AI2 for differential
Analog Input Current Mode (AICM)	AI1 to AI2

Table 8: Analog I/O modes

4.9 Digital I/O Connector and LEDs

Connector: 6-pin 2.54mm standard header.

Pin	Signal	Description
1	+24V	Supply output
2	GND	Signal and supply ground
3	DOI1	Digital input/output
4	DOI2	Digital input/output
5	DOI3	Digital input/output
6	DOI4	Digital input/output

Table 9: Digital I/O connector (J207)

The digital I/O interface includes 8 status LEDs (1 green status LED and 1 red error LED per channel).

4.10 Programming Connector

Connector: 4-pin 2.54mm standard header.

Pin	Signal	Description
1	+3.3V	Supply output
2	SWDIO	SWD data input/output
3	SWCLK	SWD clock input
4	GND	Signal and supply ground

Table 10: Programming connector (J301)

5 Operational Ratings and Characteristics

5.1 Absolute Maximum Ratings

Parameter	Min	Max	Unit
Supply voltage		+28	V
Motor phase current RMS		2.5	A
Ambient temperature	-30	+60	° C
Max load on +5V supply outputs		100	mA
Max load on +3.3V supply output		50	mA

Table 11: Absolute Maximum Ratings

NOTICE

Never Exceed the absolute maximum ratings! Stresses above those listed under "'Absolute Maximum Ratings"' may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

5.2 Electrical Characteristics (Ambient Temperature 25° C)

The basic electrical characterics of the IO-Link interface are given in the table below. For complete information refer to Maxim Integrated MAX22515 IO-Link transceiver datasheet.

Parameter	Symbol	Min	Typ	Max	Unit
Supply voltage	$V24$	8	24	36	V
C/Q and DI input voltage range	V_{IN}	V_{V24} - 36		36	V
C/Q and DI input threshold high	V_{TH}	10.8		12.5	V
C/Q and DI input threshold low	V_{TL}	8.8		10.5	V
C/Q and DI input hysteresis	V_{HYS}		2		V
C/Q driver current limit	I_{CL}	210	240	270	mA

Table 12: IO-Link Electrical Characteristics

The basic electrical characterics of the RS485 interface are given in the table below. For complete information refer to Maxim Integrated MAX22501E RS485 transceiver datasheet.

Parameter	Symbol	Min	Typ	Max	Unit
Driver common-mode output voltage	V_{OC}		2.5	3	V

Driver differential output voltage	V_{OD}	1.5			V
Receiver common-mode voltage range	V_{CM}	-15		15	V
Receiver differential input threshold high	V_{TH_H}	50		200	mV
Receiver differential input threshold low	V_{TH_L}	-200		-50	mV
Receiver differential input hysteresis	V_{HYS}		250		mV

Table 13: RS485 Electrical Characteristics

Parameter	Symbol	Min	Typ	Max	Unit
Input threshold high	V_{TH}		1.9		V
Input threshold low	V_{TL}		1.1		V
Input hysteresis	V_{HYS}		0.8		V
Input bandwidth	f_U		34		kHz

Table 14: Hall Sensor Electrical Characteristics

Parameter	Symbol	Min	Typ	Max	Unit
Input threshold high	V_{TH}		1.9		V
Input threshold low	V_{TL}		1.1		V
Input hysteresis	V_{HYS}		0.8		V
Input bandwidth	f_U		3.4		MHz

Table 15: Encoder Electrical Characteristics

The basic electrical characterics of the analog I/O interface are given in the table below. For complete information refer to Maxim Integrated MAX22200 datasheet.

Parameter	Symbol	Min	Typ	Max	Unit
Input voltage range	V_{IN}		$\pm$12.5		V
Input voltage linear range	V_{IN}	-10.5		10.5	V
Output current range	I_{OUT}		$\pm$25		mA
Output current linear range	I_{OUT}	-21		21	mA

Table 16: Analog I/O Electrical Characteristics

The basic electrical characterics of the digital I/O interface are given in the table below. For complete information refer to Maxim Integrated MAX14906 datasheet.

Parameter	Symbol	Min	Typ	Max	Unit
Input threshold high	V_{TH}	6.7		8.0	V
Input hysteresis	V_{HYS}		1.2		V
Output high-side on-resistance	R_{ON_HS}		120	240	mΩ
Output low-side on-resistance	R_{ON_LS}		1	3	Ω

Table 17: Digital I/O Electrical Characteristics

6 Preface

This document specifies objects and modes of operation of the Triamic TMCM-1617-GRIP-REF stepper motor control module with CANopen-over-EtherCAT (CoE) firmware. The CoE firmware is designed to fulfill the EtherCAT® version of the CANopen DS402 standards. The EtherCAT® conformance has also been tested. This manual assumes that the reader is already familiar with the basics of EtherCAT® and the CoE protocol (especially DS402).

6.1 General Features of this CoE Implementation

Main Characteristics

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

SDO Communication

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

PDO Communication

- Producer
- Consumer
- RPDOs
  - Dynamic mapping with max. 6 mapping entries.
  - Default mappings: manufacturer specific.
- TPDOs
  - Dynamic mapping with max. 9 mapping entries.
  - Default mappings: manufacturer specific.

Sync managers

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

Further Characteristics

- Emergency: producer

6.2 Abbreviations used in this Manual

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

Table 18: Abbreviations used in this Manual

6.3 Firmware Update

The software running on the microprocessor consists of two parts, a boot loader and the CoE firmware itself. Whereas the boot loader is installed during production and testing at TRINAMIC and remains untouched throughout the whole lifetime, the CoE firmware can easily be updated by the user. The new firmware can either be loaded into the module via file transfer over EtherCAT (FoE) or via the firmware update function of the TMCL-IDE, using the RS-485 interface of the module.

7 Communication

7.1 Reference Model

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

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

The application and the application layer interact with service primitives.

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

Table 19: 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 20: Service Types

7.2 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 7.

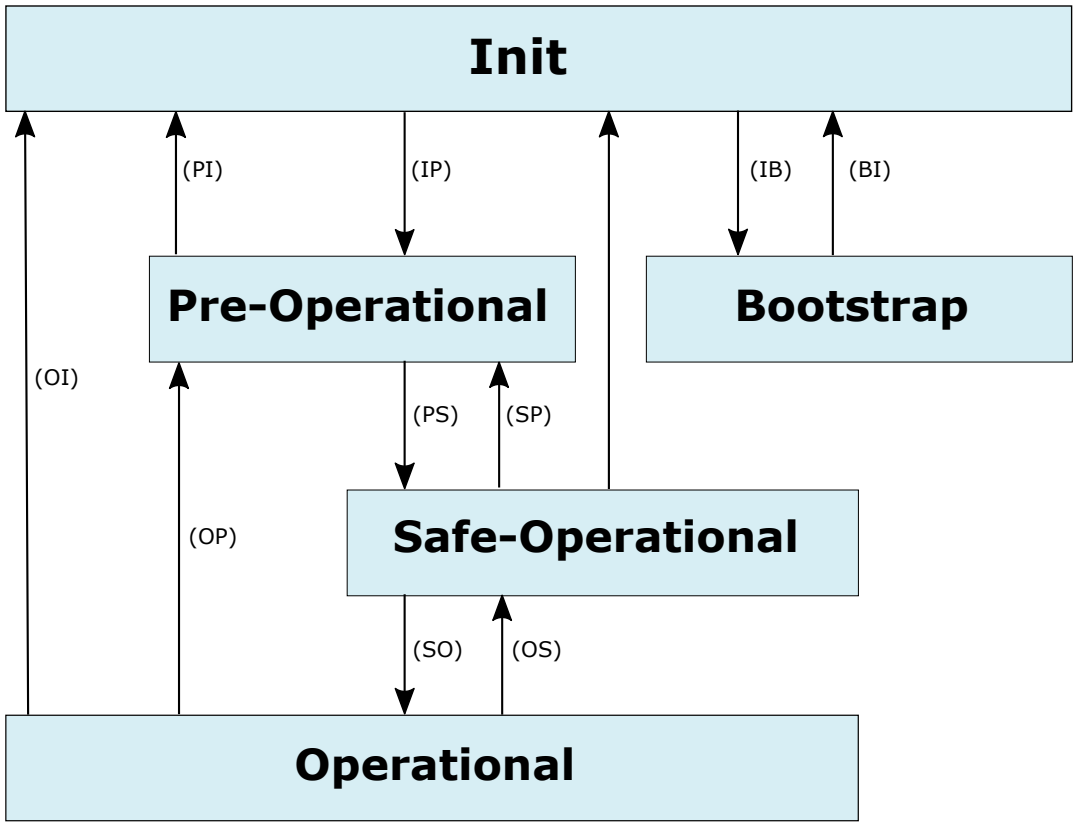


Figure 7: NMT State Machine

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

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

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

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

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

switch to Safe-Operational state.

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

7.3 Device Model

A CoE device mainly consists of the following parts:

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

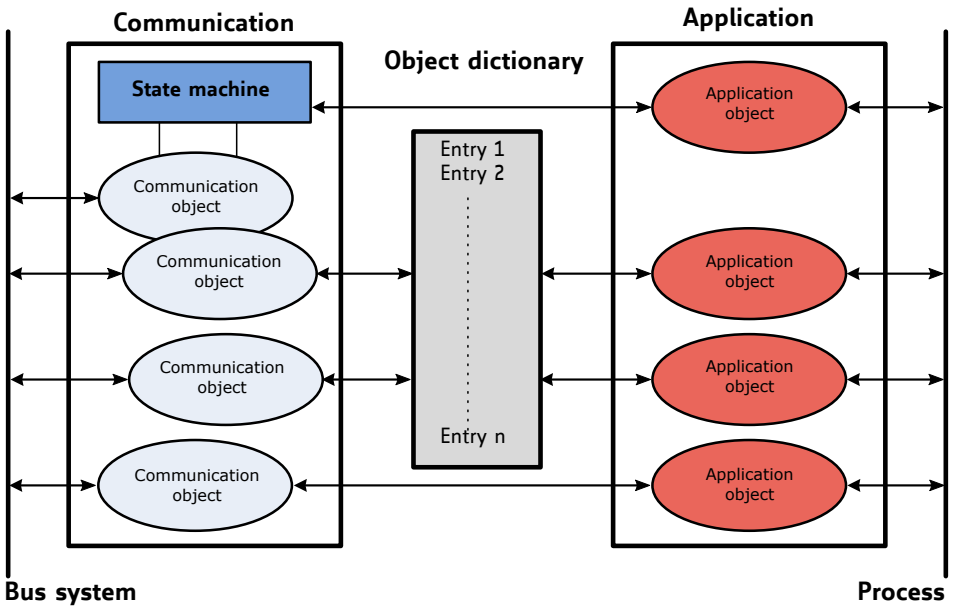


Figure 8: Device Model

7.4 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 21:

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 21: 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-1617-GRIP-REF 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.

8 Communication Area

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

8.1 Detailed Object Specifications

8.1.1 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 22: Object Description (1000_h)

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

Table 23: Entry Description (1000_h)

8.1.2 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 24: Object Description (1001_h)

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

Table 25: 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 26: Error Register Bits

8.1.3 Object 1008_h: Manufacturer Device Name

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

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

Table 27: Object Description (1008_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	—	TMCM-1617-GRIP-REF

Table 28: Entry Description (1008_h)

8.1.4 Object 1009_h: Manufacturer Hardware Version

This object contains the hardware version description.

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

Table 29: 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 30: Entry Description (1009_h)

8.1.5 Object $100A_h$: Manufacturer Software Version

This object contains the software version description.

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

Table 31: 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 32: Entry Description ($100A_h$)

8.1.6 Object 1018_h: Identity Object

The object 1018_h contains general information about the device:

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

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

Table 33: 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	22
03_h	Revision number	ro	no	UNSIGNED32	e.g. 20003_h for version 2.3

Table 34: Entry Description (1018_h)

8.1.7 Object 1600_h: Receive PDO Mapping Parameter

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

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

Table 35: Object Description (1600_h)

Entry Description				
Sub-index	Description	Access	Value Range	Default Value
00_h	Number of mapped application objects in PDO	rw	0…9	Index 1600_h: 4
01_h	Mapping entry 1	rw	UNSIGNED32	60400010_h
02_h	Mapping entry 3	rw	UNSIGNED32	$607A0020_h$
03_h	Mapping entry 4	rw	UNSIGNED32	60710010_h
04_h	Mapping entry 5	rw	UNSIGNED32	$60FF0020_h$
05_h	Mapping entry 2	rw	UNSIGNED32	0_h
06_h	Mapping entry 6	rw	UNSIGNED32	0_h
07_h	Mapping entry 7	rw	UNSIGNED32	0_h
08_h	Mapping entry 8	rw	UNSIGNED32	0_h
09_h	Mapping entry 9	rw	UNSIGNED32	0_h

Table 36: Entry Description (1600_h)

8.1.8 Objects $1A00_h$: Transmit PDO Mapping Parameter

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

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

Table 37: Object Description ($1A00_h$)

Entry Description				
Sub-index	Description	Access	Value Range	Default Value
00_h	Number of mapped aapli-cation objects in PDO	rw	0...9	6
01_h	Mapping entry 1	rw	UNSIGNED32	60410010_h
02_h	Mapping entry 2	rw	UNSIGNED32	60610008_h
03_h	Mapping entry 3	rw	UNSIGNED32	60640020_h
04_h	Mapping entry 4	rw	UNSIGNED32	60770010_h
05_h	Mapping entry 5	rw	UNSIGNED32	$606C0020_h$
06_h	Mapping entry 6	rw	UNSIGNED32	$60FD0020_h$
07_h	Mapping entry 7	rw	UNSIGNED32	0_h
08_h	Mapping entry 8	rw	UNSIGNED32	0_h
09_h	Mapping entry 9	rw	UNSIGNED32	0_h

Table 38: Entry Description ($1A00_h$)

8.1.9 Objects $1C00_h$: Sync Manager Communication Type

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

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

Table 39: Sync Manager Communication Types

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

Table 40: Object Description ($1C00_h$)

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

Table 41: Entry Description ($1C00_h$)

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

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

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

Table 42: Object Description ($1C12_h$)

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

Table 43: Entry Description ($1C12_h$)

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

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

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

Table 44: Object Description ($1C13_h$)

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

Table 45: Entry Description ($1C13_h$)

9 Manufacturer specific Area

The manufacturer segment contains manufacturer specific objects. These objects control the special features of the Trinamic Motion Control device TMCM-1617-GRIP-REF.

9.1 Detailed Object Specifications

9.1.1 Object 2000_h: Device Info

This object provides version information about the motor controller chip used on this module.

Object Description			
Index	Name	Object Type	Data Type
2000_h	Device Info	Variable	Record

Table 46: Object Description (2000_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	MC_Type	no	0	4294967295	0	—	ro
2	MC_Version	no	0	4294967295	0	—	ro
3	MC_Date	no	0	4294967295	0	—	ro
4	MC_Time	no	0	4294967295	0	—	ro
5	MC_Variant	no	0	4294967295	0	—	ro

Table 47: Entry Description (2000_h)

9.1.2 Object 2003_h: Maximum Current

This objects limits the maximum current that is used to drive the motor. The value is given in mA.

Object Description			
Index	Name	Object Type	Data Type
2003_h	Maximum Current	Variable	UNSIGNED32

Table 48: Object Description (2003_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0…3000	0

Table 49: Entry Description (2003_h)

9.1.3 Object 2004_h: Open Loop Current

This object controls the motor current used in open loop mode. The value is given in mA.

Object Description			
Index	Name	Object Type	Data Type
2004_h	Open Loop Current	Variable	UNSIGNED32

Table 50: Object Description (2004_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	no	0…3000	0

Table 51: Entry Description (2004_h)

9.1.4 Object 2006_h: Brake Chopper

With this object the behaviour of the brake chopper output can be set up.

Object Description			
Index	Name	Object Type	Data Type
2006_h	Device Info	Variable	Record

Table 52: Object Description (2006_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	Enable	no	0	1	0	—	RW
2	Voltage	no	0	65535	300	1/10 V	RW
3	Hysteresis	no	0	255	5	—	RW

Table 53: Entry Description (2006_h)

9.1.5 Object 2041_h: Torque Mode Settings

Object Description			
Index	Name	Object Type	Data Type
2041_h	Torque Mode Settings	Variable	Record

Table 54: Object Description (2041_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	Torque_P	no	0	65535	0		RW
2	Torque_I	no	0	65535	0		RW
3	PID_Torque_Error	no	-2147483648	2147483647	0	[mA]	R
4	PID_Torque_Error_Sum	no	-2147483648	2147483647	0		R
5	PID_Flux_Error	no	-2147483648	2147483647	0	[mA]	R
6	PID_Flux_Error_Sum	no	-2147483648	2147483647	0		R
7	PHI_E	no	-32678	32767	0		R

Table 55: Entry Description (2041_h)

9.1.6 Object 2042_h: Velocity Mode Settings

Object Description			
Index	Name	Object Type	Data Type
2042_h	Velocity Mode Settings	Variable	Record

Table 56: Object Description (2042_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	P_Parameter	no	0	65535	0		RW
2	I_Parameter	no	0	65535	0		RW
3	PI_Velocity_Error	no	-2147483648	2147483647	0		R
4	PI_Velocity_Error_Sum	no	-2147483648	2147483647	0		R

Table 57: Entry Description (2042_h)

9.1.7 Object 2043_h: Position Mode Settings

Object Description			
Index	Name	Object Type	Data Type
2043_h	Position Mode Settings	Variable	Record

Table 58: Object Description (2043_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	P_Parameter	no	0	65535	0		RW
2	PID_Position_Error	no	-2147483648	2147483647	0		R

Table 59: Entry Description (2043_h)

9.1.8 Object 2050_h: Motor Type

With this object the motor type connected to the module can be set. The following settings are possible:

- Mode 0: no motor
- Mode 1: single phase DC motor
- Mode 3: three phase BLDC motor

Object Description			
Index	Name	Object Type	Data Type
2050_h	Limits	Variable	UNSIGNED8

Table 60: Object Description (2050_h)

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

Table 61: Entry Description (2050_h)

9.1.9 Object 2055_h: Commutation Mode

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

Commutation Modes	
0	FOC — disabled
1	FOC — open loop
2	FOC — digital hall
3	FOC — ABN encoder

Table 62: Commutation Modes

Object Description			
Index	Name	Object Type	Data Type
2055_h	Commutation Mode	Variable	UNSIGNED8

Table 63: Object Description (2055_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Commutation Mode	no	0	1	3		RW

Table 64: Entry Description (2055_h)

9.1.10 Object 2056_h: Motor Pole Pairs

Set this object to the number of pole pairs your motor is equipped with.

Object Description			
Index	Name	Object Type	Data Type
2056_h	Motor Pole Pairs	Variable	UNSIGNED8

Table 65: Object Description (2056_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Motor Pole Pairs	no	1	12	255		RW

Table 66: Entry Description (2056_h)

9.1.11 Object 2057_h: Motor Shaft Direction

Using this object the motor shaft direction can be reversed. Set it to 0 (default value) for normal shaft direction or 1 for reversed shaft direction.

Object Description			
Index	Name	Object Type	Data Type
2057_h	Motor Shaft Direction	Variable	UNSIGNED8

Table 67: Object Description (2057_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Motor Shaft Direction	no	0	1	0		RW

Table 68: Entry Description (2057_h)

9.1.12 Object 2058_h: Position Scaler

Using this object all position values can be scaled. It defines the number of steps per mechanical rotation. With its default value of 65536, a move of 65536 steps leads to one mechanical rotation.

Object Description			
Index	Name	Object Type	Data Type
2058_h	Position Scaler	Variable	SIGNED32

Table 69: Object Description (2058_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Position Scaler	no	-2147483648	2147483647	65536		RW

Table 70: Entry Description (2058_h)

9.1.13 Object 2060_h: ADC Configuration

Using this object the ADC offsets for the coil current measurement can be configured. This is necessary for each new motor type.

Object Description			
Index	Name	Object Type	Data Type
2060_h	ADC Configuration	Variable	Record

Table 71: Object Description (2060_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	ADC_I0_Raw	no	0	65535	0		RO
2	ADC_I1_Raw	no	0	65535	0		RO
3	ADC_I0_Offset	no	0	65535	33500		RW
4	ADC_I1_Offset	no	0	65535	33500		RW
5	ADC_I0	no	-32768	32767	0		RO
6	ADC_I1	no	-32768	32767	0		RO
7	ADC_I2	no	-32768	32767	0		RO

Table 72: Entry Description (2060_h)

9.1.14 Object 2070_h: Hall Sensor Settings

This object sets various parameters of the hall sensors. If the motor is equipped with hall sensors then set the necessary parameters here.

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

Table 73: Object Description (2070_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	Hall Polarity	no	0	1	0		RW
2	Hall Direction	no	0	1	0		RW
3	Hall Interpolation	no	0	1	1		RW
4	Hall PHI_E offset	no	-32768	32767	0		RW

Table 74: Entry Description (2070_h)

9.1.15 Object 2080_h: ABN Encoder Settings

Using this object all necessary encoder parameters can be set. Check and set these parameters if your motor is equipped with an encoder. It is then also possible to choose between different encoder initialization modes.

Encoder Initialization Modes	
0	Estimate offset
1	Use offset
2	Use hall

Table 75: Encoder Initialization Modes

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

Table 76: Object Description (2080_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	Encoder Direction	no	0	1	0		RW
2	Encoder Steps	no	0	65535	8192		RW
3	Encoder Init Mode	no	0	2	0		RW

Table 77: Entry Description (2080_h)

9.1.16 Object 2101_h: Motor Status Flags

This object provides motor status and error flags. This can be a combination of the bits described in table 78.

Motor Status Flags		
Bit	Name	Meaning
0	Overcurrent	Too high current detected.
1	Undervoltage	Supply voltage too low.
2	Overvoltage	Supply voltage too high.
3	Overtemperature	Maximum driver temperature exceeded.
4	Motor halted	Motor stopped.

Bit	Name	Meaning
5	Hall error	Hall sensor error.
6	Driver error	Motor driver error.
7	Init error	Motor initialization error.
8	Stop mode	Motor in stop mode.
9	Velocity mode	Motor operating in velocity mode.
10	Position mode	Motor operating in position mode.
11	Torque mode	Motor operating in torque mode.
12	Emergency stop	Emergency stop active.
14	Position end	Target position reached.
15	Module initialized	Module initialization complete.
17	IIT exceeded	IIT limit exceeded.
18	Brake active	Brake output active.

Table 78: Motor Status Flags (2101_h)

Object Description			
Index	Name	Object Type	Data Type
2101_h	Device State	Variable	UNSIGNED32

Table 79: Object Description (2101_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	ro	no	$0 \ldots 3FFFF_h$	0

Table 80: Entry Description (2101_h)

9.1.17 Object 2102_h: Open Loop Commutation Angle

This object shows the open loop commutation angle. It is mainly used by the Trinamic motor tuning tools.

Object Description			
Index	Name	Object Type	Data Type
2102_h	Open Loop Commutation Angle	Variable	SIGNED16

Table 81: Object Description (2102_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Open Loop Commutation Angle	no	-32768	32767	0		RO

Table 82: Entry Description (2102_h)

9.1.18 Object 2103_h: Encoder Commutation Angle

This object shows the encoder commutation angle. It is mainly used by the Trinamic motor tuning tools.

Object Description			
Index	Name	Object Type	Data Type
2103_h	Encoder Commutation Angle	Variable	SIGNED16

Table 83: Object Description (2103_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Encoder Commutation Angle	no	-32768	32767	0		RO

Table 84: Entry Description (2103_h)

9.1.19 Object 2104_h: Hall Commutation Angle

This object shows the hall sensor commutation angle. It is mainly used by the Trinamic motor tuning tools.

Object Description			
Index	Name	Object Type	Data Type
2104_h	Hall Commutation Angle	Variable	SIGNED16

Table 85: Object Description (2104_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	Hall Commutation Angle	no	-32768	32767	0		RO

Table 86: Entry Description (2104_h)

9.1.20 Object $270E_h$: Analog Inputs

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

Table 87: 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 88: Entry Description ($270E_h$)

9.1.21 Object 2720_h: Digital IO

General digital IO settings. Use subindex 1 to enable all digital outputs and subindex to change digital input mode for all pins that are configured to digital input.

DI Mode	
0	Type 1 ant Type 3
1	Type 2

Table 89: Digital Input Modes

Object Description		
Index	Name	Object Type
2720_h	Digital IO	Record

Table 90: Object Description (2720_h)

Entry Description								
Sub-index	Name	Data Type	PDO Mapping	Min	Max	Default	Unit	Access
1	Enable	BOOL	no	0	1	0	—	RW
2	DI Mode	UNSIGNED8	no	0	1	0	—	RW

Table 91: Entry Description (2720_h)

9.1.22 Object 2721_h: DOIx Pin Mode

For each digital IO pin the mode of operation can be configured.

DOIx Pin Mode	
0	Digital Output (DO)
1	Digital Input (DI)
2	Low-leakage, High-impedance

Table 92: Digital IO Pin Modes

Object Description			
Index	Name	Object Type	Data Type
2721_h	DOIx Pin Mode	Array	UNSIGNED8

Table 93: Object Description (2721_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	DOI1	no	0	2	0	—	RW
2	DOI2	no	0	2	0	—	RW
3	DOI3	no	0	2	0	—	RW
4	DOI4	no	0	2	0	—	RW

Table 94: Entry Description (2721_h)

9.1.23 Object 2722_h: DOIx Output Mode

For each digital IO pin that is configured as output the output mode can be configured.

DOIx Pin Mode	
0	High-side
1	High-side with 2x inrush current for t_INRUSH time
2	Active clamp push-pull
3	Simple push-pull

Table 95: Digital IO Pin Modes

Object Description			
Index	Name	Object Type	Data Type
2722_h	DOIx Output Mode	Array	UNSIGNED8

Table 96: Object Description (2722_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
1	DOI1	no	0	3	0	—	RW
2	DOI2	no	0	3	0	—	RW
3	DOI3	no	0	3	0	—	RW
4	DOI4	no	0	3	0	—	RW

Table 97: Entry Description (2722_h)

9.1.24 Object 2723_h: DOIx Output Level

For each digital IO pin that is configured as output the output level can be changed.

Bit Definitions	
Bit	Description
0	DOI1
1	DOI2
2	DOI3
3	DOI4

Table 98: Bit Definitions (2723_h))

Object Description			
Index	Name	Object Type	Data Type
2723_h	DOIx Output Level	Var	UNSIGNED8

Table 99: Object Description (2723_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	DOIx Output Level	yes	0	15	0	—	RW

Table 100: Entry Description (2723_h)

9.1.25 Object 2724_h: DOIx Input Status

For each digital IO pin the input status can be retrieved.

Bit Definitions	
Bit	Description
0	DOI1
1	DOI2
2	DOI3
3	DOI4

Table 101: Bit Definitions (2724_h))

Object Description			
Index	Name	Object Type	Data Type
2724_h	DOIx Input Status	Var	UNSIGNED8

Table 102: Object Description (2724_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	DOIx Input Status	yes	0	15	0	—	R

Table 103: Entry Description (2724_h)

9.1.26 Object 2730_h: AOI0 Mode

Sets the mode for the DAC at pin AOI0.

AOI0 Mode	
0	High Impedance
1	Reserved, DO NOT USE!
2	Analog output voltage mode, ±12.5V setting
3	Analog output current mode, ±25mA setting
4	Analog output current mode, ±2.5mA setting

Table 104: AOI0 Modes

Object Description			
Index	Name	Object Type	Data Type
2730_h	AOI0 Mode	Var	UNSIGNED8

Table 105: Object Description (2730_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	AOI0 Mode	no	0	4	0	—	RW

Table 106: Entry Description (2730_h)

9.1.27 Object 2731_h: DAC value

Sets value for the DAC at pin AOI0.

Object Description			
Index	Name	Object Type	Data Type
2731_h	DAC value	Var	SIGNED32

Table 107: Object Description (2731_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	DAC value	yes	-131072	131071	0	—	RW

Table 108: Entry Description (2731_h)

9.1.28 Object 2732_h: DAC Calibration

Gain and offset calibration of the DAC.

Object Description		
Index	Name	Object Type
2732_h	DAC Calibration	Record

Table 109: Object Description (2732_h)

Entry Description								
Sub-index	Name	Data Type	PDO Mapping	Min	Max	Default	Unit	Access
1	Gain	UNSIGNED32	no	0	262143	256250	—	RW
2	Offset	SIGNED32	no	-131072	131071	0	—	RW

Table 110: Entry Description (2732_h)

9.1.29 Object 2740_h: AI1/AI2 Mode

Sets the mode for the ADC at pins AI1/AI2.

AI1/AI2 Mode	
0	Power Down
1	Analog input differential ±25V* (Channel 1)
2	Analog input differential ±2.5V (Channel 2)
3	Analog input differential ±500mV (Channel 2)
4	Analog input differential ±250mV (Channel 2)
5	Analog input differential ±125mV (Channel 2)

*Table 111: AI1/AI2 Modes - *only ±15V can be measured effectively*

Object Description			
Index	Name	Object Type	Data Type
2740_h	AI1/AI2 Mode	Var	UNSIGNED8

Table 112: Object Description (2740_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	AI1/AI2 Mode	no	0	5	0	—	RW

Table 113: Entry Description (2740_h)

9.1.30 Object 2741_h: ADC value

Retrieves the value of the ADC at pin AI1/AI2.

Object Description			
Index	Name	Object Type	Data Type
2741_h	ADC value	Var	SIGNED32

Table 114: Object Description (2741_h)

Entry Description							
Sub-index	Name	PDO Mapping	Min	Max	Default	Unit	Access
0	ADC value	yes	-8388608	8388607	0	—	R

Table 115: Entry Description (2741_h)

9.1.31 Object 2742_h: ADC Ch1 Calibration

Gain and offset calibration of the first ADC channel.

Object Description		
Index	Name	Object Type
2742_h	ADC Ch1 Calibration	Record

Table 116: Object Description (2742_h)

Entry Description								
Sub-index	Name	Data Type	PDO Mapping	Min	Max	Default	Unit	Access
1	Gain	UNSIGNED32	no	0	16777215	256250	—	RW
2	Offset	SIGNED32	no	-8388608	8388607	0	—	RW

Table 117: Entry Description (2742_h)

9.1.32 Object 2743_h: ADC Ch2 Calibration

Gain and offset calibration of the second ADC channel.

Object Description		
Index	Name	Object Type
2743_h	ADC Ch2 Calibration	Record

Table 118: Object Description (2743_h)

Entry Description								
Sub-index	Name	Data Type	PDO Mapping	Min	Max	Default	Unit	Access
1	Gain	UNSIGNED32	no	0	16777215	256250	—	RW
2	Offset	SIGNED32	no	-8388608	8388607	0	—	RW

Table 119: Entry Description (2743_h)

10 Profile Specific Area

The profile segment contains CiA-402 standard motion control objects. These objects control the motion control functions of the TMCM-1617-GRIP-REF. 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 10.1.6) are implemented on the TMCM-1617-GRIP-REF:

- Profile position mode (pp)
- Profile velocity mode (pv)
- Cyclic position mode (csp)
- Cyclic velocity mode (csv)
- Cyclic torque mode (cst)

10.1 Detailed Object Specifications

10.1.1 Object $605A_h$: Quick Stop Option Code

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

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

Table 120: Value Description ($605A_h$)

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

Table 121: Object Description ($605A_h$)

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

Table 122: Entry Description ($605A_h$)

10.1.2 Object $605B_h$: Shutdown Option Code

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

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

Table 123: Value Description ($605B_h$)

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

Table 124: Object Description ($605B_h$)

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

Table 125: Entry Description ($605B_h$)

10.1.3 Object $605C_h$: Disable Operation Option Code

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

Value Definition	
Value	Definition
1	Slow down on slow down ramp

Table 126: Value Description ($605C_h$)

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

Table 127: Object Description ($605C_h$)

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

Table 128: Entry Description ($605C_h$)

10.1.4 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.

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

Table 129: Value Description ($605D_h$)

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

Table 130: Object Description ($605D_h$)

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

Table 131: Entry Description ($605D_h$)

10.1.5 Object $605E_h$: Fault Reaction Option Code

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

Value Definition	
Value	Definition
2	Slow down on quick stop ramp

Table 132: Value Description ($605E_h$)

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

Table 133: Object Description ($605E_h$)

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

Table 134: Entry Description ($605E_h$)

10.1.6 Object 6060_h: Modes of Operation

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

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

Table 135: Value Description (6060_h)

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

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

Table 136: Object Description (6060_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	refer to CiA-402	see table 135	0

Table 137: Entry Description (6060_h)

10.1.7 Object 6061_h: Modes of Operation Display

This object shows the operating mode that is currently set.

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

Table 138: Value Description (6061_h)

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

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

Table 139: Object Description (6061_h)

Entry Description				
Sub-index	Access	PDO Mapping	Value Range	Default Value
0	rw	refer to CiA-402	see table 138	0

Table 140: Entry Description (6061_h)

10.1.8 Object $606A_h$: Sensor Selection Code

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

Value Definition	
Value	Mode
0	Encoder used
-1	No encoder

Table 141: Value Description ($606A_h$)

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

Table 142: Object Description ($606A_h$)

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

Table 143: Entry Description ($606A_h$)

10.1.9 Object $608F_h$: Position Encoder Resolution

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

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

All values are dimensionless.

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

Table 144: Object Description ($608F_h$)

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

Table 145: Entry Description ($608F_h$)

10.1.10 Object $60FD_h$: Digital Inputs

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

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

Table 146: Object Description ($60FD_h$)

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

Table 147: Entry Description ($60FD_h$)

10.1.11 Object 6502_h: Supported Drive Modes

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

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

Table 148: Value Definition (6502_h)

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

Table 149: Object Description (6502_h)

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

Table 150: Entry Description (6502_h)

11 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 10.1.6) for information about how to choose an operation mode. Object 6061_h (section 10.1.7) shows the operation mode that is set.

11.1 Detailed Object Specifications

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

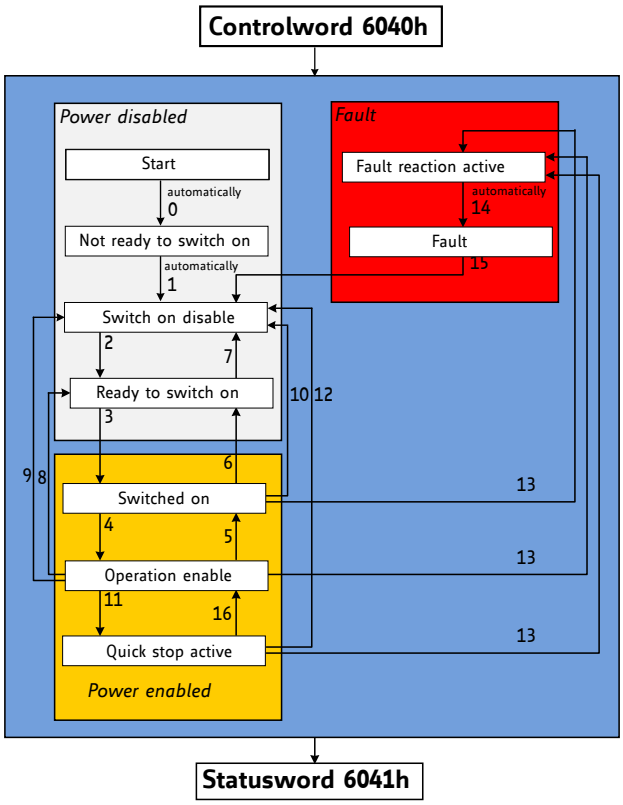


Figure 9: DS402 Finite State Machine

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.

11.1.1 Object 6040_h: Control Word

This object indicates the received command controlling the power drive system finite state automaton (PDS FSA). The CiA-402 state machine can be controlled using this object. Please refer to figure 9 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 151: 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 152: 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 153: Command Coding

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

Table 154: 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 155: Entry Description (6040_h in pp Mode)

11.1.2 Object 6041_h: Status Word

This object provides the status of the PDS FSA. It reflects the status of the CiA-402 state machine. Please refer to figure 9 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 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 157: 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 158: 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 159: State Coding

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

Table 160: 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 161: Entry Description (6041_h in pp Mode)

11.1.3 Object 6062_h: Position Demand Value

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

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

Table 162: Object Description (6062_h)

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

Table 163: Entry Description (6062_h)

11.1.4 Object 6063_h: Position Actual Internal Value

This object provides the demanded position value. The value is given in microsteps. It is the same as object 6062_h.

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	Access	PDO Mapping	Value Range	Default Value
0	ro	Refer to CiA402-3	SIGNED32	no

Table 165: Entry Description (6063_h)

11.1.5 Object 6064_h: Position Actual Value

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

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

Table 166: Object Description (6064_h)

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

Table 167: Entry Description (6064_h)

11.1.6 Object 6065_h: Following Error Window

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

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

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

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

Table 168: Object Description (6065_h)

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

Table 169: Entry Description (6065_h)

11.1.7 Object 6067_h: Position Window

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

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

Table 170: Object Description (6067_h)

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

Table 171: Entry Description (6067_h)

11.1.8 Object 6068_h: Position Window Time

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

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

Table 172: Object Description (6068_h)

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

Table 173: Entry Description (6068_h)

11.1.9 Object $606C_h$: Velocity Actual Value

This object shows the actual velocity value of the motor. The value is given in units of pps.

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

Table 174: Object Description ($606C_h$)

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

Table 175: Entry Description ($606C_h$)

11.1.10 Object $607A_h$: Target Position

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

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

Table 176: Object Description ($607A_h$ in pp Mode)

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

Table 177: Entry Description ($607A_h$ in pp Mode)

11.1.11 Object $607D_h$: Software Position Limit

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

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

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

Table 178: Object Description ($607D_h$)

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

Table 179: Entry Description ($607D_h$)

11.1.12 Object 6081_h: Profile Velocity

This object indicates the configured velocity normally attained at the end of the acceleration ramp during a profiled motion and is valid for both directions of motion. The profile velocity is the maximum velocity used when driving to a new position. It is given in units of pps^2.

Object Description			
Index	Name	Object Type	Data Type
6081_h	Profile Velocity	Variable	UNSIGNED32

Table 180: Object Description (6081_h)

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

Table 181: Entry Description (6081_h)

11.1.13 Object 6082_h: End Velocity

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

Object Description			
Index	Name	Object Type	Data Type
6082_h	End Velocity	Variable	UNSIGNED32

Table 182: Object Description (6082_h)

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

Table 183: Entry Description (6082_h)

11.1.14 Object 6083_h: Profile Acceleration

This object indicates the configured acceleration. Object 6083_h sets the maximum acceleration to be used in profile position and profile velocity mode.
This value is given using pps^2 units.
In profile velocity mode, this object also sets the deceleration to be used (the deceleration ramp is always the same as the acceleration ramp in pv mode).

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

Table 184: Object Description (6083_h)

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

Table 185: Entry Description (6083_h)

11.1.15 Object 6084_h: Profile Deceleration

This object indicates the configured deceleration. Object 6084_h sets the maximum deceleration to be used in profile positioning mode.
This value is given in units of pps^2.

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

Table 186: Object Description (6084_h)

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

Table 187: Entry Description (6084_h)

11.1.16 Object 6085_h: Quick Stop Deceleration

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

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

Table 188: Object Description (6085_h)

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

Table 189: Entry Description (6085_h)

11.1.17 Object $60F2_h$: Positioning Option Code

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

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

Table 190: Bit Definitions of Object $60F2_h$

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

Table 191: Object Description ($60F2_h$)

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

Table 192: Entry Description ($60F2_h$)

11.2 How to move a Motor in pp Mode

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

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

12 Profile Velocity Mode

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

The profile velocity mode covers the following sub-functions:

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

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

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

12.1 Detailed Object Specifications

12.1.1 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 9 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 193: 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 194: Command Coding

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

Table 195: 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 196: Entry Description (6040_h in pv Mode)

12.1.2 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 9 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 197: 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 198: 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 199: 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 200: State Coding

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

Table 201: 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 202: Entry Description (6041_h in pv Mode)

12.1.3 Object 6062_h: Position Demand Value

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

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

Table 203: Object Description (6062_h)

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

Table 204: Entry Description (6062_h)

12.1.4 Object 6063_h: Position Actual Internal Value

This object provides the demanded position value. The value is given in microsteps. It is the same as object 6062_h.

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

Table 205: Object Description (6063_h)

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

Table 206: Entry Description (6063_h)

12.1.5 Object 6064_h: Position Actual Value

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

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

Table 207: Object Description (6064_h)

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

Table 208: Entry Description (6064_h)

12.1.6 Object 6065_h: Following Error Window

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

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

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

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

Table 209: Object Description (6065_h)

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

Table 210: Entry Description (6065_h)

12.1.7 Object $606C_h$: Velocity Actual Value

This object shows the actual velocity value of the motor. The value is given in units of pps.

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

Table 211: Object Description ($606C_h$)

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

Table 212: Entry Description ($606C_h$)

12.1.8 Object $607D_h$: Software Position Limit

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

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

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

Table 213: Object Description ($607D_h$)

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

Table 214: Entry Description ($607D_h$)

12.1.9 Object 6083_h: Profile Acceleration

This object indicates the configured acceleration. Object 6083_h sets the maximum acceleration to be used in profile position and profile velocity mode.
This value is given using pps^2 units.

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

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

Table 215: Object Description (6083_h)

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

Table 216: Entry Description (6083_h)

12.1.10 Object 6085_h: Quick Stop Deceleration

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

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

Table 217: Object Description (6085_h)

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

Table 218: Entry Description (6085_h)

12.1.11 Object $60FF_h$: Target Velocity

This object indicates the configured target velocity and is used as input for the trajectory generator. Object $60FF_h$ sets the target velocity when using profile velocity mode. The drive then accelerates or decelerates to that velocity using the acceleration and deceleration set by objects 6083_h and 6084_h. The values are given in pps units.

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

Table 219: Object Description ($60FF_h$)

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

Table 220: Entry Description ($60FF_h$)

12.2 How to move a Motor in pv Mode

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

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

13 Cyclic synchronous Position Mode

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

The main control parameters are the target position (object $607A_h$, see section 13.1.7) and the interpolation time period (object $60C2_h$, see section 13.1.10). The drive automatically sets the velocity in such a manner that the next target position is reached within the interpolation time period. Acceleration and deceleration ramps are not used in this mode.

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

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

13.1 Detailed Object Specifications

13.1.1 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 9 for detailed information. The cyclic synchronous position mode does not use any mode specific bits of the control word.

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

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

Table 221: Structure of the Control Word in csp Mode

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

Table 222: Command Coding

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

Table 223: Object Description (6040_h in csp Mode)

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

Table 224: Entry Description (6040_h in csp Mode)

13.1.2 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 9 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 225: Structure of the Status Word in csp Mode

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

Table 226: Trinamic Specific Bits

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

Table 227: Operation Mode specific Bits in csp Mode

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

Table 228: State Coding

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

Table 229: Object Description (6041_h in csp Mode)

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

Table 230: Entry Description (6041_h in csp Mode)

13.1.3 Object 6062_h: Position Demand Value

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

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

Table 231: Object Description (6062_h)

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

Table 232: Entry Description (6062_h)

13.1.4 Object 6063_h: Position Actual Internal Value

This object provides the demanded position value. The value is given in microsteps. It is the same as object 6062_h.

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

Table 233: Object Description (6063_h)

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

Table 234: Entry Description (6063_h)

13.1.5 Object 6064_h: Position Actual Value

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

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

Table 235: Object Description (6064_h)

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

Table 236: Entry Description (6064_h)

13.1.6 Object $606C_h$: Velocity Actual Value

This object shows the actual velocity value of the motor. The value is given in units of pps.

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

Table 237: Object Description ($606C_h$)

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

Table 238: Entry Description ($606C_h$)

13.1.7 Object $607A_h$: Target Position

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

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

Table 239: Object Description ($607A_h$ in csp Mode)

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

Table 240: Entry Description ($607A_h$ in csp Mode)

13.1.8 Object $607D_h$: Software Position Limit

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

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

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

Table 241: Object Description ($607D_h$)

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

Table 242: Entry Description ($607D_h$)

13.1.9 Object $60B0_h$: Position Offset

This object provides an offset to the target position (object $607A_h$, see section 13.1.7)). The value is given in microsteps and will be added to the target position.

Object Description			
Index	Name	Object Type	Data Type
$60B0_h$	Offset Torque	Variable	SIGNED32

Table 243: Object Description ($60B0_h$)

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

Table 244: Entry Description ($60B0_h$)

13.1.10 Object $60C2_h$: Interpolation Time Period

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

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

Table 245: Object Description ($60C2_h$)

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

Table 246: Entry Description ($60C2_h$)

14 Cyclic synchronous Velocity Mode

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

The main control parameters are the target velocity (object $60FF_h$, see section 14.1.4) and the interpolation time period (object $60C2_h$, see section 14.1.7). The drive automatically sets the acceleration in such a manner that the next target velocity is reached within the interpolation time period. Acceleration and deceleration ramps are not used in this mode.

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

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

14.1 Detailed Object Specifications

14.1.1 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 9 for detailed information. The cyclic synchronous velocity mode does not use any mode specific bits of the control word.

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

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

Table 247: Structure of the Control Word in csv Mode

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

Table 248: Command Coding

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

Table 249: Object Description (6040_h in csv Mode)

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

Table 250: Entry Description (6040_h in csv Mode)

14.1.2 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 9 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 251: Structure of the Status Word in csv Mode

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

Table 252: Trinamic Specific Bits

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

Table 253: Operation Mode specific Bits in csv Mode

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

Table 254: State Coding

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

Table 255: Object Description (6041_h in csv Mode)

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

Table 256: Entry Description (6041_h in csv Mode)

14.1.3 Object $606C_h$: Velocity Actual Value

This object shows the actual velocity value of the motor. The value is given in units of pps.

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

Table 257: Object Description ($606C_h$)

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

Table 258: Entry Description ($606C_h$)

14.1.4 Object $60FF_h$: Target Velocity

In csv mode the target velocity specifies the velocity that is to be reached within the interpolation time period. The values are given in pps units.

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

Table 259: Object Description ($60FF_h$)

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

Table 260: Entry Description ($60FF_h$)

14.1.5 Object $607D_h$: Software Position Limit

This object indicates the configured maximal and minimal software position limits. These parameters define the absolute position limits for the position demand value and the position actual value. Every new target position is checked against these limits. The limit positions are always relative to the machine

home position. Before being compared with the target position, they are corrected internally by the home offset as follows:

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

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

Table 261: Object Description ($607D_h$)

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

Table 262: Entry Description ($607D_h$)

14.1.6 Object $60B1_h$: Velocity Offset

This object provides an offset to the target velocity (object $60FF_h$, see section 14.1.4)). The value will be added to the target velocity.

Object Description			
Index	Name	Object Type	Data Type
$60B1_h$	Velocity Offset	Variable	SIGNED32

Table 263: Object Description ($60B1_h$)

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

Table 264: Entry Description ($60B1_h$)

14.1.7 Object $60C2_h$: Interpolation Time Period

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

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

Table 265: Object Description ($60C2_h$)

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

Table 266: Entry Description ($60C2_h$)

15 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 of the torque.
- Limiting the position using the software limits or the hardware limit switches.

15.1 Detailed Object Specifications

15.1.1 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 9 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 267: 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 268: Command Coding

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

Table 269: 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 270: Entry Description (6040_h in cst Mode)

15.1.2 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 9 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 271: 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 272: 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 273: 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 274: State Coding

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

Table 275: 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 276: Entry Description (6041_h in cst Mode)

15.1.3 Object 6062_h: Position Demand Value

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

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

Table 277: Object Description (6062_h)

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

Table 278: Entry Description (6062_h)

15.1.4 Object 6063_h: Position Actual Internal Value

This object provides the demanded position value. The value is given in microsteps. It is the same as object 6062_h.

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

Table 279: Object Description (6063_h)

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

Table 280: Entry Description (6063_h)

15.1.5 Object 6064_h: Position Actual Value

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

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

Table 281: Object Description (6064_h)

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

Table 282: Entry Description (6064_h)

15.1.6 Object 6071_h: Target Torque

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

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

Table 283: Object Description (6071_h)

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

Table 284: Entry Description (6071_h)

15.1.7 Object 6077_h: Torque actual Value

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

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

Table 285: Object Description (6077_h)

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

Table 286: Entry Description (6077_h)

15.1.8 Object $607D_h$: Software Position Limit

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

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

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

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

Table 287: Object Description ($607D_h$)

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

Table 288: Entry Description ($607D_h$)

15.1.9 Object $60B2_h$: Torque Offset

This object provides an offset to the torque value. It will be added to the target torque (object 6071_h, see section 15.1.6).

Object Description			
Index	Name	Object Type	Data Type
$60B2_h$	Offset Torque	Variable	SIGNED16

Table 289: Object Description ($60B2_h$)

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

Table 290: Entry Description ($60B2_h$)

15.1.10 Object $60C2_h$: Interpolation Time Period

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

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

Table 291: Object Description ($60C2_h$)

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

Table 292: Entry Description ($60C2_h$)

16 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-1617-GRIP-REF						
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	
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 293: Emergency Messages (EMCY)

17 Figures Index

18 Tables Index

19 Supplemental Directives

19.1 Producer Information

19.2 Copyright

19.3 Trademark Designations and Symbols

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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.

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19.7 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.

20 Revision History

20.1 Hardware Revision

Version	Date	Author	Description
1.0	12.02.2021	MM	

Table 294: Hardware Revision

20.2 Firmware Revision

Version	Date	Author	Description
1.01	06.05.2021	BP	Launch release.

Table 295: Firmware Revision

20.3 Document Revision

Version	Date	Author	Description
1.01	07.05.2021	MM/BP	Launch release.

Table 296: Document Revision