PROFINET® / PROFIBUS®
User Guide

Rev. 1.0

for ENGEL devices with PROFINET® / PROFIBUS® support

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Underlying Specifications

ENGEL firmware for devices with fieldbus application is basically based on the CANopen® standards and specifications which are published by the CANopen® user and manufacturer organisation CiA® (CAN in Automation). For PROFINET® and PROFIBUS® applications PROFIdrive protocol is translated into DSP402. The intention of this guide is not to replace the specification; it only describes the implementation of the standards in ENGEL devices. Thus, knowledge of the specification is assumed.

As far as possible, the functionality of the devices complies with the specifications:

Profile-PROFIdrive_3172_V41_May06

CiA® DS 301 V 4.01 Application layer and communication profile

CiA® DSP 402 V 2.0: CANopen device profile drives and motion control

Deviating definitions are explained in this guide.

The standards can be purchased from:

PROFIBUS® Nutzerorganisation e.V.
Haid-und-Neu-Str. 7
76131 Karlsruhe
Germany
Phone: +49 721 9658590
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E-Mail: info@profibus.com
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E-Mail: headquarters@can-cia.org
Website: www.can-cia.org

For further information about the functionality of the ENGEL devices, their installation, setup procedure and operation, please check the operating manuals on our website:

ENGEL - Products

All operating manuals are available for download on our homepage or can be ordered directly at:

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Document History

Document	Date (dd/mm/yy)	Rev	Change
PROFINET® User Guide V 1.0	28/06/16	1.0	1st revision during implementation

Content Page

1 General

The firmware of all ENGEL devices, which communicate via fieldbus, is based on CANopen® standard DSP402. Communication via PROFINET® / PROFIBUS® is achieved by using communication modules (HMS Anybus® CompactCom™ 40er-series), which translate from PROFIdrive to DSP402.

2 Data Exchange

In PROFIdrive architecture the ENGEL devices resemble an Axis type Drive Object (DO) which contains the following items:

- General state machine
- Axis control task
- Parameter manager with parameter data base

The DO can be accessed via:

- Acyclic Data Exchange
- Cyclic Data Exchange
- Clock Synchronous Operation (not supported by ENGEL)
- Alarm Queue (not supported by ENGEL)

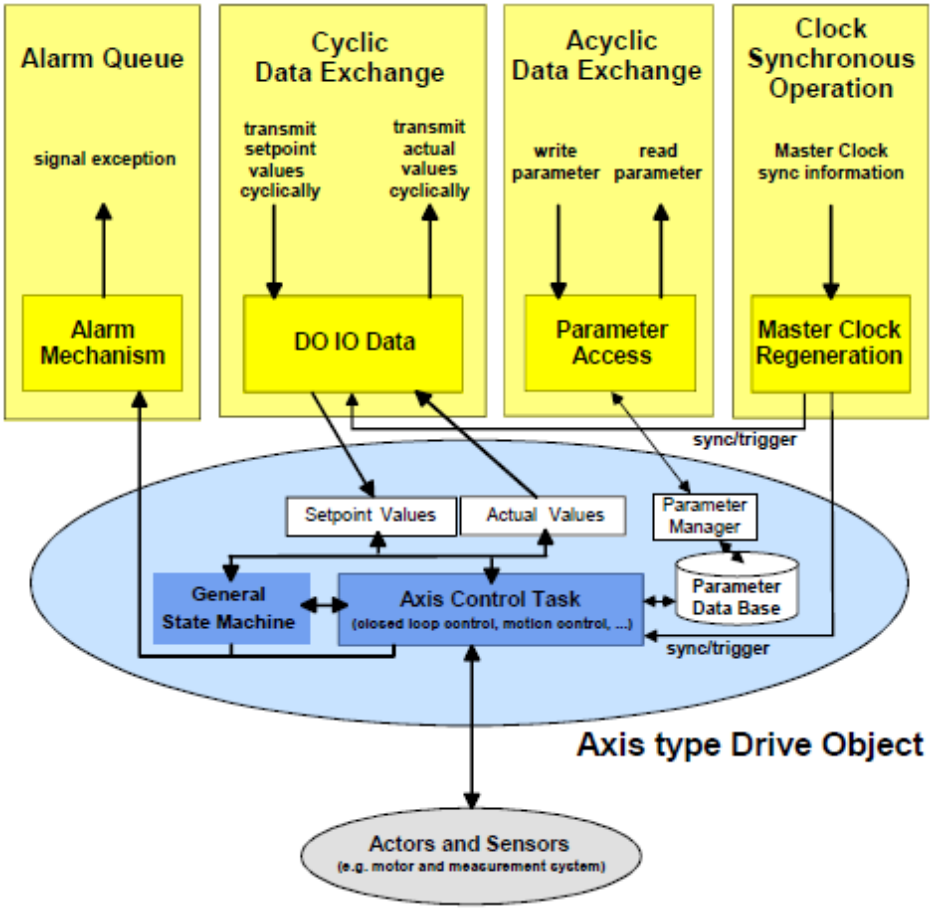


Figure 2-1: Structure of Axis type Drive Object

3 Acyclic Data Exchange

The Acyclic Data Exchange is used for not time critical read or write operations like configuration of the drive. To access the parameters of the drive a special parameter protocol has to be used. Figure 3-1 shows the structure of the parameter request and Figure 3-2 the structure of the parameter response.

Block definition	Byte n+1	Byte n	n
Request Header	Request Reference	Request ID	0
	Axis-No. / DO-ID	No. of Parameters = n	2
1st Parameter Address	Attribute	No. of Elements	4
	Parameter Number (PNU)		
	Subindex		
nth Parameter Address	...		4 + 6 × (n-1)
1st Parameter Value(s)	Format	No. of Values	4 + 6 × n
(only for request	Values		
"Change parameter")	...		
nth Parameter Values	...		
			4 + 6 × n +...+ (Format_n × Qty_n)

Figure 3-1: Parameter Request

Block definition	Byte n+1	Byte n	n
Response Header	Request Ref. mirrored	Response ID	0
	Axis-No. / DO-ID mirrored	No. of Parameters = n	2
1st Parameter Value(s)	Format	No. of Values	4
(only after request	Values or Error Values		
"Request")	...		
nth Parameter Values	...		
			4 + ... + (Format_n × Qty_n)

Figure 3-2: Parameter Response

The following table shows the coding and a short description of the field elements. For detailed description see PROFIdrive standard chapter 6.2.3 (Profile-PROFIdrive_3172_V41_May06).

Field	Data Type	Value (hex.)	Description
Request Reference	Unsigned8	0x01…0xFF	Identification Number given by the master
Request ID	Unsigned8	0x01 0x02	Request Parameter Change Parameter
Response ID	Unsigned8	0x01 0x02 0x81 0x82	Request parameter positive Change parameter positive Request parameter negative Change parameter negative
Axis-No. / DO-ID	Unsigned8	0x00 0x01…0xFE	Device-Representative DO-ID-Number
No. of Parameters	Unsigned8	0x01…0x27	No. of parameters which shall be read/written
Attribute	Unsigned8	0x10 0x20	Value Description
No. of Elements	Unsigned8	00x00…0xEA	Number of array elements or length of string
Parameter Number (PNU)	Unsigned16	0x0001…0xFFFF	Parameter Address
Subindex	Unsigned16	0x0000…0xFFFF	addresses array element
Format	Unsigned8	 0x41 0x42 0x43	e. g. Byte Word Double Word
No. of Values	Unsigned8	0x00…0xEA	No. of values
Values	Unsigned16	0x0000…0x00FF	If the response is negative, error values are entered instead of values.

Example: If the user wants e. g. to read the Firmware Revision of the used device, the following parameter request has be sent:

Byte (dec.)	Value (hex.)	Description
0	0x01	Request ID: Request Parameter
1	0x01	Request Reference: e. g. 1
2	0x01	No. of Parameters: 1
3	0x00	Device-Representative
4	0x01	No. of Elements: 1
5	0x10	Attribute: Value
6 7	0x18 0x10	PNU: 0x1018 Identity Object
8 9	0x00 0x03	Subindex: 4

4 Cyclic Data Exchange

Cyclic data exchange is used for time critical transmission / reception of data values like setpoint and actual values between the master and the slave. In PROFIdrive different standard telegrams (1-20) for different kind of drive profiles are defined. For these telegrams the communication module will translate the PROFIdrive signals into DSP402.
For vendor specific telegrams no translation takes place; the signals / objects will be sent completely transparent.

4.1 Modes of Operation

PROFIdrive standard telegrams support only two operating modes:

- **Velocity Mode** (standard telegram 1)
- **Positioning Mode** (standard telegram 9)

In order to operate ENGEL devices for e. g. in **Torque Mode** the ENGEL telegram 100 can be used. It gives the user the flexibility to change various parameters, which have no match in PROFIdrive, during operation.

Modes of operation	DSP402	PROFIdrive	Telegram
Positioning Mode	1	2	9, ENGEL 100
Velocity Mode	3	1	1, ENGEL 100
Torque Mode	4	-	ENGEL 100
Homing Mode	6	2	9, ENGEL 100
Speed Control with dynamic current limitation	-3	-	ENGEL 100
Current Control with dynamic speed limitation	-4	-	ENGEL 100
Turntable Mode	-5	-	ENGEL 100

4.2 PROFIdrive Parameters

The following table shows how the PROFIdrive parameters are structured.

PNU	Description
0 - 899	Device specific
900 - 999	PROFIdrive specific
1 000 - 59 999	Device specific
60 000 - 60 999	Reserved for PROFIdrive
61 000 - 63 900	Reserved for PROFIdrive (PROFINET specific)
64 000 - 65 535	Reserved for PROFIdrive

4.2.1 Supported PROFIdrive specific PNUs

The following table shows the PROFIdrive specific PNUs, which are handled by the communication module.

PNU	Type	Description
918	Mandatory for Homogeneous PROFIBUS DPslaves, other optional	PROFIBUS DP node address
922	Mandatory	Telegram selection
930	Mandatory	Operating mode
944	Mandatory	Fault message counter
947	Mandatory	Fault number
964	Mandatory	Drive Unit identification
965	Mandatory	Profile identification number: 0x0329 (PROFIdrive V4.1)
975	Mandatory	DO identification
980 - 989	Mandatory	No. list of defined parameter

4.2.2 PROFIdrive parameters 1 000 (0x03E8) - 59 999 (0xEA5F)

All CANopen® parameters 0x03E8 - 0xEA5F are mapped one-to-one to the PROFIdrive parameters 0x03E8 - 0xEA5F . This means the PNU for a parameter request is equal to the object number defined by DSP402 standard. DSP-Objects will be presented in this document in the following way: e. g. ***Statusword (6041h)***

For a complete object list and description see the CANopen® User Guide on our website **ENGEL - Products**.

4.3 Telegrams

For cyclic data exchange PROFIdrive standard telegram 1 and 9 and ENGEL specific telegram 100 are available. To choose a certain telegram Parameter P922 has to be written via **acyclic data exchange** to the respective telegram number. For description of the signals / objects see chapter 5 Device Control and chapter 6 DSP Objects (ENGEL telegram).

4.3.1 Standard telegram 1

Standard telegram 1 is used in **Velocity Mode**. If this telegram is used, the communication module will automatically set DSP-object ***Modes of Operation (6060h***, *chapter 4.1)* to 3.

IO Data Number	Master to Slave (Setpoint)		Slave to Master (Actual Values)
1	STW1		ZSW1
2	NSOLL_A		NIST_A

4.3.2 Standard telegram 9

Standard telegram 9 is used for positioning tasks. If this telegram is used, the communication module will automatically set DSP-object ***Modes of Operation (6060h***, *chapter 4.1)* to 1 (**Positioning Mode**) or 6 (**Homing Mode**) dependent on Bit11 of ***STW1*** *(chapter 6.1)*.

IO Data Number	Master to Slave (Setpoint)	Slave to Master (Actual Values)
1	STW1	ZSW1
2	SATZANW	AKTSATZ
3	STW2	ZSW2
4 5	MDI_TARPOS	XIST_A
6 7	MDI_VELOCITY	
8	MDI_ACC	
9	MDI_DEC	
10	MDI_MOD	

4.3.3 ENGEL telegram 100

For some applications the standard telegram may not be sufficient. To give you more flexibility, ENGEL has implemented telegram 100, where the DSP-objects will be sent completely transparent.

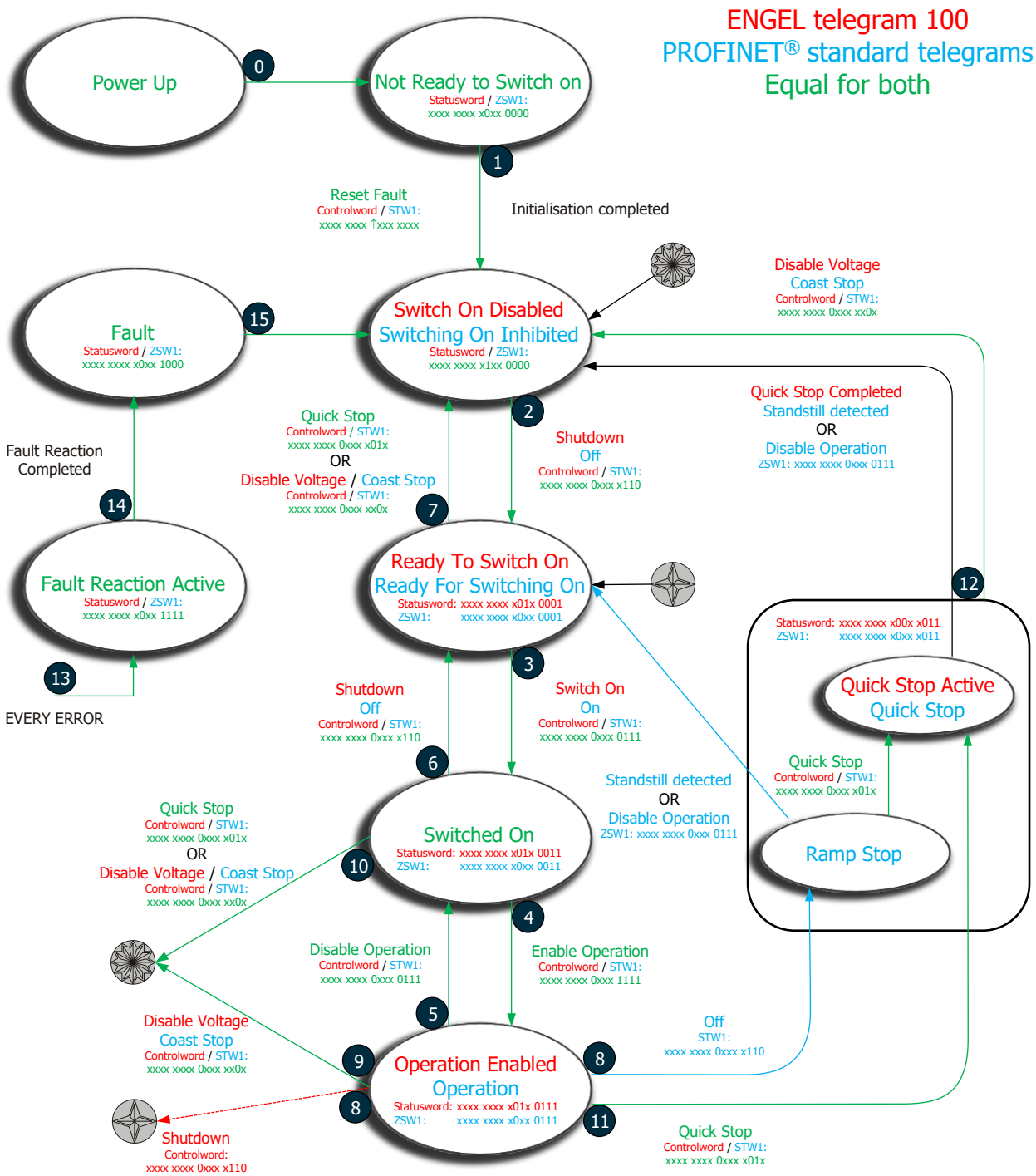
IO Data Number	Master to Slave (Setpoint)	Slave to Master (Actual Values)
1	Controlword (6040h)	Statusword (6041h)
2	Low Byte: Modes of Operation (6060h) High Byte: reserved	Low Byte: Modes of Operation Display (6061h) High Byte: reserved
3	Target Torque (6071h)	Position Actual Value (6064h)
4	Target Position (607Ah)	
5		Velocity Demand Value (606Bh)
6	Profile Velocity (6081h)	
7		Velocity Actual Value (606Ch)
8	Profile Acceleration (6083h)	
9		Current Actual Value (6078h)
10	Profile Deceleration (6084h)	DC-link circuit voltage (6079h)
11		
12	Dynamic Speed Limit (2003h)	Digital Inputs (60FDh)
13	Dynamic Torque Limit (2004h)	
14	Digital Outputs (60FEh): Physical Outputs (Sub1)	Analogue Inputs 16-Bit (6C01h): AI1 (Sub1)
15		Analogue Inputs 16-Bit (6C01h): AI2 (Sub2)
16	Digital Outputs (60FEh): Bit Mask (Sub2)	Encoder Position Value (7004h)
17		Error Code (200Ch)
18	Target Velocity (60FFh)	
19		

5 Device Control

5.1 General State Machine

The device control is performed by a state machine which is almost identical for DSP402 and PROFIdrive. State changes are triggered by internal events such as the occurrence of an error or external demand by means of *Controlword* / *STW1*. *Statusword* / *ZSW1* gives feedback about the actual state. After power-up and initialisation, the drive switches to state Switch On Disabled / Switching On Inhibited automatically. In state Operation Enabled, the drive is fully operational.

There is no functional difference between the states Switch On Disabled / Switching On Inhibited, Ready To Switch On / Ready For Switching On and Switched On for all ENGEL CANopen® devices.



5.1.1 State Transitions

State transitions are either triggered by internal events of the device (e. g. error) or externally by means of the ***Controlword*** (ENGEL telegram 100) or ***STW1*** (Standard telegrams). The following state transitions are possible:

Tran-sition	from… ➔ to…		Event	Action
0	Start ➔	Not Ready To Switch On	Reset, Start Up	initialisation of the drive
1	Not Ready To Switch On ➔ Not Ready To Switch On ➔	Switch On Disabled Switching On Inhibited	Initialisation Finished	communication active
2	Switch On Disabled ➔ Switching On Inhibited➔	Ready To Switch On Ready For Switching On	Shutdown Off	none
3	Ready To Switch On ➔ Ready For Switching On ➔	Switched On Switched On	Switch On On	none
4 *1)	Switched On ➔ Switched On ➔	Operation Enable Operation	Enable Operation	enable power stage
5 *1)	Operation Enabled ➔ Operation ➔	Switched On Switched On	Disable Operation	disable power stage
6	Switched On ➔ Switched On ➔	Ready To Switch On Ready for Switching On	Shutdown Off	none
7	Ready To Switch On ➔ Ready for Switching On ➔	Switch On Disabled Switching On Inhibited	Disable Voltage Or Quick Stop Coast Stop Or Quick Stop	none
8	Operation Enabled ➔ Operation ➔ Ramp Stop ➔ Operation ➔ Ramp Stop ➔	Ready To Switch On Ready For Switching On Quick Stop	Shutdown Off ➔ Standstill detected Off ➔ Quick Stop	disable power stage disable power stage after speed is ramped down to 0 interruption of ramp down and executing quick stop function
9	Operation Enabled ➔ Operation ➔	Switch On Disabled Switching On Inhibited	Disable Voltage Coast Stop	disable power stage
10	Switched On ➔ Switched On ➔	Switch On Disabled Switch On Disabled	Disable Voltage Or Quick Stop Coast Stop Or Quick Stop	none
11	Operation Enabled ➔ Operation ➔	Quick Stop Active Quick Stop	Quick Stop	executing quick stop function
12	Quick Stop Active ➔ Quick Stop ➔ Ramp Stop ➔	Switch On Disabled Switching On Inhibited Switching On Inhibited	Quick Stop Finished Or Disable Voltage Standstill detected Or Coast Stop Or Disable Operation Coast Stop	disable power stage
13	All States ➔	FAULT REACTION ACTIVE	Error	executing fault reaction
14	Fault Reaction Active ➔	Fault	Fault Reaction Finished	disable power stage
15 *2)	Fault ➔	Switch On Disabled	Reset-Command	reset fault

*1) the state changes 4 and 5 enable and disable the power stage. The state transition 4, enable power stage, is only possible when the enable input DI1 is set. Like **Disable Operation**, resetting DI1 will trigger the state transition 5 and disable the power stage.

*2) Bit7 "Fault Reset" must change from low to high. If the cause of error is removed, the error will be reset. The 'Fault Reset'-bit has to be reset by the master after leaving the state **Fault**.

5.1.2 State Fault: Error Codes

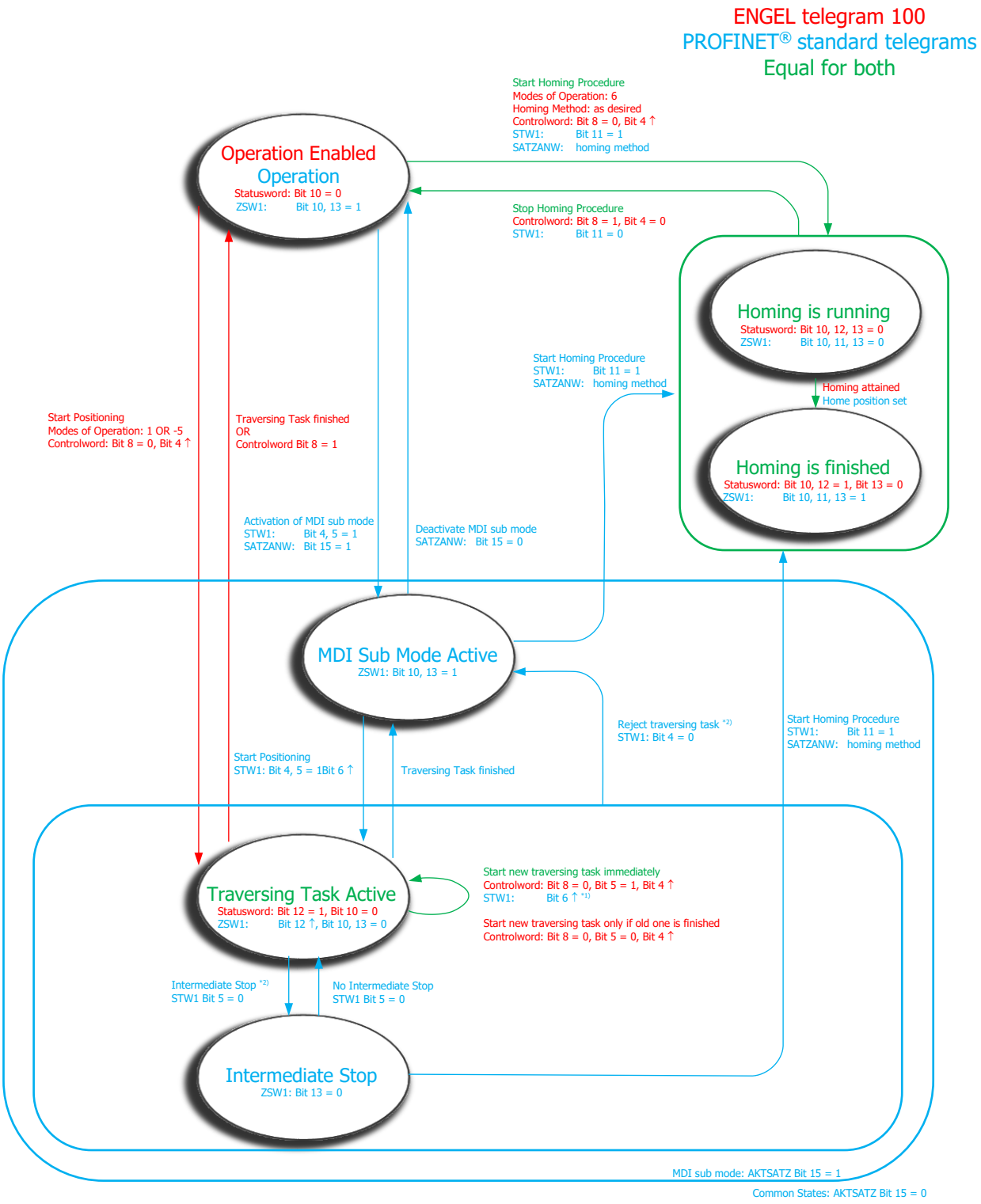
Error Number (200C, chapter) is an CANopen open object, which gives back the number of the actual error. The table shows The following table gives an overview of possible errors. It shows the associated CANopen® error code and also the blinking code, which will be displayed via the device's red status LED.

The CANopen® error code is sent to the master by an emergency message only once, but is also stored in object ***Pre-defined Error Field (1003h,*** *see CANopen® User Guide****)***.

Error number	ENGEL 100	Channel Error Type
1	motor temperature	Over Temperature
2	output stage temperature	Over Temperature
3	internal auxiliary voltage	Overvoltage
4	over-voltage	Overvoltage
5	motor feedback	Error
6	under-voltage phase	Overvoltage
7	over-current protection	Short Circuit
8	EEPROM checksum	Error
9	parameter checksum	Error
10	internal	Error
11	positioning	Error
12	CANopen	Error

5.2 State Machine Positioning Mode

The following state diagram shall illustrate how the **Positioning Mode** is working. To start positioning the drive as to be in the state Operation Enabled / Operation. This means during positioning Bits 0, 1, 2 and 5 of *Statusword* must be 1 and Bits 3 and 6 must be 0. For *ZSW1* Bits 0, 1, 2 must be 1 and Bits 4 and 6 must be 0.



*1) After the setting of Bit 12 (ZSW1) was detected, Bit 6 (STW1) can be cleared. As a result of this Bit 12 (ZSW1) will be clear. Now the start of a new traversing task is possible.

*2) Braking with ramp

6 PROFIdrive Signals

The I/O-signals are normalized according to N2 / N4 data normalization of PROFIdrive. This means 0% corresponds to 0 (0x0) and 100% corresponds to 2^{14} (0x4000) for N2 or 2^{30} (0x4000 0000) for N4. For further details see chapter 5.3.1 of PROFIdrive standard (Profile-PROFIdrive_3172_V41_May06).

6.1 STW1

STW1 is controlword 1 of PROFIdrive standard. It mainly corresponds to DSP-object ***Controlword (6040h***, *chapter 7.1)*. It triggers the state transitions of the drive (see chapter 5) and contains further bits which are operation mode or device specific. The bits which are responsible for the state transitions can be translated one-to one to ***Controlword***, but there are some significant differences in the other bits. As a result of this not all bits of ***STW1*** can be used as described in PROFIdrive standard.

In **Speed Control Mode** Bits 4-6 and Bit 10 are reserved in DSP and therefore have to be handled locally by the communication module. These bits must be set to 1, otherwise no setpoint will be sent to the drive respectively ***STW1*** will not be evaluated.

In **Positioning Mode** Bit 10 is reserved in DSP and therefore have to be handled locally by the communication module. Bit 10 must be set to 1.

Object description:

Signal No.	1
Name	STW1
Object Code	VAR
Data Type	UNSIGNED16
Category	Mandatory

Entry description:

Access	rw
Value Range	UNSIGNED16
Default Value	no

Bit	Description Bit = 1/ Bit = 0
0	ON / OFF (transparent)
1	No Coast Stop / Coast Stop (transparent)
2	No Quick Stop / Quick Stop (transparent)
3	Enable Operation / Disable (transparent)
4-6	Operation mode specific
7	Fault Acknowledge (0 → 1) (transparent)
8	not used
9	not used
10	1
11	Operation mode specific
12-15	Device specific (transparent)

Operation mode specific bits:

Bit	Profile velocity mode	Profile position mode
4	1	Do not Reject Traversing Task / Reject Traversing Task
5	1	No Intermediate Stop / Intermediate Stop
6	1	Activate Traversing Task (0 → 1)
11	Device specific (not used)	Start Homing Procedure / Stop Homing Procedure

Device specific bits:

Bit	Profile velocity mode	Profile position mode
12-15	not used	not used

6.2 ZSW1

ZSW1 is statusword 1 of PROFIdrive standard. It mainly corresponds to DSP-object ***Statusword (6041h****, chapter 7.2****)***. ***ZSW1*** gives you the status of the drive.

Object description:

Signal No.	2
Name	ZSW1
Object Code	VAR
Data Type	UNSIGNED16
Category	Mandatory

Entry description:

Access	ro
Value Range	UNSIGNED16
Default Value	no

Bit	Description Bit = 1/ Bit = 0
0	Ready to Switch on / Not Ready to Switch on (transparent)
1	Ready to Operate / Not ready to Operate (transparent)
2	Operation Enabled / Operation Disabled (transparent)
3	Fault Present / No Fault (transparent)
4	Coast Stop Not Activated / Coast Stop Activated (transparent)
5	Quick Stop Not Activated / Quick Stop Activated (transparent)
6	Switching On Inhibited / Switching On Not Inhibited (transparent)
7	Warning Present / No Warning (transparent)
8	Operation mode specific
9	Control Requested / No Control Requested (transparent)
10-13	Operation mode specific
14-15	Device-specific (transparent)

Operation mode specific bits:

Bit	Profile velocity mode	Profile position mode
8	Speed Error Within / Out of Tolerance (not used)	Following Error Within / Out of Tolerance (not used)
10	Target Speed Reached or Exceeded / Target Speed not Reached (transparent)	Target Position Reached / Not at Target Position
11	Device specific (not used)	Home Position Set / Home Position not yet Set
12	Device specific (not used)	Traversing Task Acknowledgement (0 → 1) (transparent)
13	Device specific (not used)	Drive Stopped / Drive Moving

Device specific bits:

Bit	Profile velocity mode	Profile position mode
14-15	not used	not used

6.3 STW2

STW2 is controlword 2 of PROFIdrive standard. This signal will not be evaluated.

6.4 ZSW2

ZSW2 is statusword 2 of PROFIdrive standard. As STW2 will not be evaluated, ZSW2 is 0.

6.5 NSOLL_A

NSOLL_A is the speed setpoint in **Velocity Mode**. The corresponding DSP-object is ***Target Velocity (60FFh,*** *chapter 7.7****)***. The standardization factor of ***NSOLL_A*** is DSP-object ***Max Motor Speed (6080h****, see CANopen® User Guide****)*** / 2^{14} (N2).

Example:
Max Motor Speed = 3000rpm, Target Velocity = 1500 rpm → NSOLL_A = 1500 * 2^{14} / 3000 = 8192 (0x2000)

Object description:

Signal No.	5
Name	NSOLL_A
Object Code	VAR
Data Type	N2
Category	Mandatory

Entry description:

Access	rw
Value Range	-200% ≤ i ≤ (200-2^{-14})%
Default Value	no

6.6 NIST_A

NIST_A is the actual speed value. The corresponding DSP-object is ***Velocity Actual Value (606Ch**, chapter 7.12)*. The standardization factor of ***NIST_A*** is DSP-object ***Max Motor Speed (6080**, see CANopen® User Guide)* / 2^{14} (N2).

Example:
Max Motor Speed = 3000rpm, Velocity Actual Value = 300 rpm → NIST_A = 300 * 2^{14} / 3000 = 1638 (0x0666)

Object description:

Signal No.	6
Name	NIST_A
Object Code	VAR
Data Type	N2
Category	Mandatory

Entry description:

Access	ro
Value Range	-200% ≤ i ≤ (200-2^{-14})%
Default Value	no

6.7 SATZANW

SATZANW is the so-called traversing block selection. It is used in **Positioning Mode** for selecting the homing method, if homing is activated (***STW1*** Bit 11 = 1) and it activates the MDI sub mode. As the communication module only supports MDI sub mode active, Bit 15 must always be 1.

Object description:

Signal No.	32
Name	SATZANW
Object Code	VAR
Data Type	UNSIGNED16
Category	Mandatory

Entry description:

Access	rw
Value Range	UNSIGNED16
Default Value	no

Bit	Description
0-7	Homing Method
8, 9	not used
10-14	Reserved for future use by PROFIdrive profile
15	1 (MDI sub mode active)

Bits 0-7 correspond to DSP-object ***Homing Method (6098h**, see CANopen® User Guide)* and can have the following values:

Data description:

Value	Description
17	Homing on the negative limit switch
18	Homing on the positive limit switch
-17	Homing against a mechanical stop in negative direction
-18	Homing against a mechanical stop in positive direction
1	Homing on the negative limit switch and index pulse
2	Homing on the positive limit switch and index pulse
35	Homing on the current position

6.8 AKTSATZ

AKTSATZ gives back the actual traversing block and if MDI sub mode is activated or not.

Object description:

Signal No.	33
Name	AKTSATZ
Object Code	VAR
Data Type	UNSIGNED16
Category	Mandatory

Entry description:

Access	ro
Value Range	UNSIGNED16
Default Value	no

Bit	Description Bit = 1/ Bit = 0
0-7	actual Homing Method
8, 9	not used
10-14	Reserved for future use by PROFIdrive profile
15	MDI sub mode activated / MDI sub mode deactivated

6.9 MDI_TARPOS

MDI_TARPOS is the target position. The corresponding DSP-object is ***Target Position (607Ah**, chapter 7.5)*. The standardization factor of ***MDI_TARPOS*** is DSP-object ***Position Range Limit (607Bh**, see CANopen® User Guide)* / 2^{30} (N4).

Example:
Position Range Limit = 500000, Target Position = 200 → MDI_TARPOS = 200 * 2^{30} / 500000 = 429496 (0x68DB8)

Object description:

Signal No.	34
Name	MDI_TARPOS
Object Code	VAR
Data Type	N4
Category	Mandatory

Entry description:

Access	rw
Value Range	-200% ≤ i ≤ (200-2^{-30})%
Default Value	no

6.10 XIST_A

XIST_A is the actual position value. The corresponding object in DSP is ***Position Actual Value (6064h**, chapter 7.6)*.

Object description:

Signal No.	28
Name	XIST_A
Object Code	VAR
Data Type	N4
Category	Mandatory

Entry description:

Access	ro
Value Range	-200% ≤ i ≤ (200-2^{-30})%
Default Value	no

6.11 MDI_VELOCITY

MDI_VELOCITY is the movement speed. The corresponding DSP-object is ***Profile Velocity (6081h**, chapter 7.7)*. If homing is active it corresponds to ***Homing Speed (6099h**, see CANopen® User Guide)*. The standardization factor of ***MDI_VELOCITY*** is ***Max Speed*** / 2^{30} (N4). ***Max Speed*** is the minimum of DSP-objects ***Max Profile Velocity (607Fh**, see CANopen® User Guide)* and ***Max Motor Speed (6080h**, see CANopen® User Guide)*.

Example:
Max Profile Velocity = 5000 rpm, Profile Velocity = 2500 rpm → MDI_VELOCITY = 2500 *2^{30} / 5000 = 536870912 (0x20000000)

Object description:

Signal No.	35
Name	MDI-VELOCITY
Object Code	VAR
Data Type	N4
Category	Mandatory

Entry description:

Access	rw
Value Range	0…(200-2^{-30})%
Default Value	no

6.12 MDI_ACC

MDI_ACC is the acceleration at the beginning of the movement. The corresponding DSP-object is ***Profile Acceleration (0x6083**, chapter 7.8)*. The standardization factor of ***MDI_ACC*** is DSP-object ***Max Acceleration (0x60C5)*** / 2^{14} (N2).

Example:
Max Acceleration = 3000 rpm/s, Profile Acceleration = 600 rpm/s → MDI_ACC = 600 * 2^{14} / 3000 = 3276 (0x0CCC)

Object description:

Signal No.	28
Name	XIST_A
Object Code	VAR
Data Type	N2
Category	Mandatory

Entry description:

Access	ro
Value Range	0…(200-2^{-14})%
Default Value	no

6.13 MDI_DEC

MDI_DEC is the deceleration at the end of the movement. The corresponding DSP-object is ***Profile Deceleration (0x6084**, chapter 7.9)*. The standardization factor of ***MDI_DEC*** is DSP-object ***Max Deceleration (0x60C6)*** / 2^{14} (N2).

Example:
Max Deceleration = 3000 rpm/s, Profile Deceleration = 600 rpm/s → MDI_DEC = 600 * 2^{14} / 3000 = 3276 (0x0CCC)

Object description:

Signal No.	28
Name	XIST_A
Object Code	VAR
Data Type	N2
Category	Mandatory

Entry description:

Access	ro
Value Range	0…(200-2^{-14})%
Default Value	no

6.14 MDI_MOD

Object description:

Signal No.	28
Name	XIST_A
Object Code	VAR
Data Type	UNSIGNED16
Category	Mandatory

Entry description:

Access	ro
Value Range	UNSIGNED16
Default Value	no

Bit	Description
0	Absolute / Relative positioning mode = 1 Absolute positioning. The target position in the signal ***TARPOS*** defines the absolute target position for the motion. = 0 Relative positioning. The target position in the signal ***TARPOS*** defines the relative target position for the motion related to the actual axis position.
1	Positive Modulo positioning direction 1 = For a modulo Axis the absolute position shall be reached by a motion in the positive direction. This command is only valid for a rotating modulo axis. 0 = If bits 1 and 2 are both 0, the target position of a modulo axis shall be reached by the shortest path.
2	Negative Modulo positioning direction 1 = For a modulo Axis the absolute position shall be reached by a motion in the negative direction. This command is only valid for a rotating modulo axis. 0 = If bits 1 and 2 are both 0, the target position of a modulo axis shall be reached by the shortest path.
3-15	Reserved for future use by PROFIdrive profile

7 DSP Objects (ENGEL telegram)

In this chapter the DSP objects which are used for telegram 100, are described. For the description of other DSP objects see CANopen® User Guide.

7.1 Controlword (6040h)

The master uses ***Controlword*** to control the drive. The state machine is switched by the commands described in chapter 5.1.1 State Transitions. Further bits are used for positioning and activate the HALT command.

Object description:

INDEX	6040h
Name	Controlword
Object Code	VAR
Data Type	UNSIGNED16
Category	Mandatory

Entry description:

Access	rw
Value Range	UNSIGNED16
Default Value	no

Bit	Description Bit = 1/ Bit = 0
0	Switch on / Switch off
1	Enable Voltage / Disable Voltage
2	Quick Stop / No Quick Stop
3	Enable Operation / Disable Operation
4-6	Operation mode specific
7	Fault Reset (0 → 1)
8	Halt / No Halt
9-10	reserved
11-12	Manufacture specific
14-15	Device-specific

Operation mode specific bits:

Bit	Turntable mode	Profile position mode	Profile velocity mode	Profile torque mode	Homing mode
4	New set-point	New set-point	reserved	reserved	Homing operation start
5	Change set immediately	Change set immediately	reserved	reserved	reserved
6	abs/rel	abs/rel	reserved	reserved	reserved

ENGEL specific bits:

Bit	Turntable mode	Profile position mode	Profile velocity mode	Profile torque mode	Homing mode
11	directional/optimal	reserved	reserved	reserved	reserved
12	cw/ccw	reserved	reserved	reserved	reserved

Data Description:

Bit #	Function	Description
4	New set-point Homing operation start	**Positioning Mode**: transition 0 → 1 starts the positioning **Homing Mode:** transition 0 → 1 starts the homing
5	Change set immediately	**Positioning Mode**: Bit=0: A new positioning process does not start until the preceding one is finished (target_reached=1) Bit=1: A new positioning process starts instantly; a preceding one will be cancelled
6	abs/rel	Bit=0: set position in ***Target Position*** (chapter 7.5) is absolute Bit=1: set position in ***Target Position*** (chapter 7.5)is relative
8	HALT	**Positioning Mode**: Bit=1: The drive decelerates down to the speed 0 and holds the achieved position. Bit=0: A cancelled positioning process can be started over by setting Bit 4 (It is not allowed to reset Bit 8 and to set Bit 4 simultaneously). **Velocity Mode** and **Torque Mode:** Bit=1: The drive decelerates down to the speed 0 and holds the achieved position. Bit=0: The drive continues the movement.
11	directional/optimal	(**Turntable Mode** only; Bit6=0) Bit=0: set position is approached as defined in Bit 12 (cw/ccw) Bit=1: set position is approached over the shortest range
12	cw/ccw	(**Turntable Mode** only; Bit6=0; Bit11=0) Bit=0: set position is approached clockwise Bit=1: set position is approached counter-clockwise

7.2 Statusword (6041h)

Statusword shows the state of the drive, the meaning of the single bits can be seen in the state diagrams in chapter 5.1 General State Machine and chapter 5.2 State Machine Positioning Mode.

Object description:

INDEX	6041h
Name	Statusword
Object Code	VAR
Data Type	UNSIGNED16
Category	Mandatory

Entry description:

Access	ro
Value Range	UNSIGNED16
Default Value	no

Bit	Description Bit = 1/ Bit = 0
0	Ready to switch on / Not Ready to switch on
1	Switched on / Switched off
2	Operation enabled / Operation disabled
3	Fault / No Fault
4	Voltage enabled / Voltage disabled
5	No Quick Stop / Quick Stop
6	Switch on disabled / Switch on enabled
7	Warning / No Warning
8	Manufacturer specific
9	Remote / No Remote
10	Target reached / Target not reached
11	Internal limit active / Internal limit not active
12	Operation mode specific
13	Operation mode specific
14	Manufacturer specific
15	Manufacturer specific

Operation mode specific bits:

Bit	Profile Position Mode	Profile Velocity Mode	Profile Torque Mode	Homing Mode
12	Set-point acknowledge	Speed	reserved	Homing attained
13	Following Error	Max Slippage Error	reserved	Homing Error

Data Description:

Bit #	Function	Description
12	Set-point acknowledge	**Positioning Mode**: Bit = 0: Previous set-point already processed, waiting for new set-point Bit 1 = Previous set-point still in process
	Speed	**Velocity Mode**: Bit 0: Speed is not equal 0 Bit 1: Speed is equal 0
	Homing attained	**Homing Mode:** Bit 0: Homing not attained Bit 1: Homing attained
13	Following Error	**Positioning Mode**: Bit=0: No Following Error Bit=1: Following Error
	Max Slippage Error	**Velocity Mode**: Bit 0: Max slippage not reached Bit 1: Max slippage reached
	Homing Error	**Homing Mode:** Bit 0: No Homing Error Bit 1: Homing Error

Device status according to the state machine:

Value (binary)	State
xxxx xxxx x0xx 0000b	Not Ready To Switch On
xxxx xxxx x1xx 0000b	Switch On Disabled
xxxx xxxx x01x 0001b	Ready To Switch On
xxxx xxxx x01x 0011b	Switched On
xxxx xxxx x01x 0111b	Operation Enabled
xxxx xxxx x00x 0111b	Quick Stop Active
xxxx xxxx x0xx 1111b	Fault Reaction Active
xxxx xxxx x0xx 1000b	Fault

7.3 Modes of Operation (6060h)

To switch the actual chosen operation mode, the master has to write the corresponding value to this object. The drive acknowledges the transition by writing the new mode to ***Modes of Operation Display (0x6061***, *chapter 7.4***)**.

Notice:
Changing the mode of operation is not possible, when the HALT-bit (Bit 8 of ***Controlword 0x6040***, *chapter 7.1*) is set!

Object description:

INDEX	6060h
Name	Modes of Operation
Object Code	VAR
Data Type	INTEGER8
Category	Mandatory

Entry description:

Access	rw
Value Range	See table
Default Value	1 (Positioning Mode)

Data Description:

Data	Mode of operation
-5	Turntable Mode
-4	Current Control with dynamic speed limitation
-3	Speed Control with dynamic current limitation
0	reserved
1	Positioning Mode
3	Velocity Mode
4	Torque Mode
6	Homing Mode

7.4 Modes of Operation Display (6061h)

Displays the actual mode of operation:

Object description:

INDEX	6061h
Name	Modes of Operation Display
Object Code	VAR
Data Type	INTEGER8
Category	Mandatory

Entry description:

Access	ro
Value Range	See table
Default Value	1 (Positioning Mode)

Data description, see ***Modes of Operation (0x6060***, *chapter 7.3***)**

7.5 Target Position (607Ah)

Target Position = set value for the target position. The target is approached according to the specified parameters ***Profile Velocity (0x6081 Profile Acceleration (6083h***, *chapter 7.8)* and ***Profile Deceleration (6084h,*** *chapter 7.9)*. Depending on Bit6 (abs/rel) in ***Controlword (6040h***, *chapter 7.1)*, ***Target Position*** is considered absolute or relative.

Object description:

INDEX	607Ah
Name	Target Position
Object Code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry description:

Access	rw
Value Range	INTEGER32
Default Value	no

Scaling factor: 12 Bit angle resolution, 20 Bit revolution counter, i.e. 1000h ≡ 1 revolution

7.6 Position Actual Value (6064h)

Actual position in user defined units.

Object description:

INDEX	6064h
Name	Position Actual Value
Object Code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry description:

Access	ro
Value Range	INTEGER32
Default Value	no

Scaling factor: 12 Bit angle resolution, 20 Bit revolution counter, i.e. 1000h ≡ 1 revolution

7.7 Profile Velocity (6081h)

Nominal speed set-point in **Positioning Mode**.

Notice: This object does *not* take effect in **Velocity Mode**.

Object description:

INDEX	6081h
Name	Profile Velocity
Object Code	VAR
Data Type	UNSIGNED32
Category	Mandatory

Entry description:

Access	rw
Value Range	1 … Max. Value *(see below)*
Default Value	no

Subindex 1 (Numerator) and Subindex 2 (Denominator) of ***Velocity Encoder Factor (6094h***, *see CANopen® User Guide)* define the Scaling Factor and limit the permissible Max. Value of ***Profile Velocity*** as follows:

Scaling Factor = (Numerator / Denominator) rpm

Max. Value = $$\frac{2^{31}-1}{Numerator \times 2^{(17-\log_2 Denominator)}}$$

With Numerator = 1 and Denominator = 2, the default values are:

Default Scaling Factor = 0.5 rpm
Default Max. Value = 32767 (≡ 16383.5 rpm)

7.8 Profile Acceleration (6083h)

Acceleration ramp used as speed ramp in **Velocity Mode** and **Positioning Mode**.
The ramp can be switched between linear and sine-squared ramp. This is done via ***Motion Profile Type (6086h**, see CANopen® User Guide**)***.
Depending on the chosen ***Motion Profile Type*** the units of ***Profile Acceleration*** are different:
Linear ramp => speed change per time [10rpm/sec]
Sine-squared ramp => ramp time [ms]

Object description:

INDEX	6083h
Name	Profile Acceleration
Object Code	VAR
Data Type	UNSIGNED32
Category	Mandatory

Entry description:

Access	rw
Value Range	lin.: 1...32767 sin²: 16...32767
Default Value	Stored value
non volat. storable	yes

Scaling factor: depends on the used ***Motion Profile Type (6086h**, see CANopen® User Guide**)***.

for linear ramp: Acceleration: a = x · 10 rpm/s

for sine-squared ramp: Acceleration Time $T_a = \frac{10^5}{x} ms = \frac{100}{x} s$

7.9 Profile Deceleration (6084h)

Deceleration ramp used as speed ramp in **Velocity Mode** and **Positioning Mode**.

The ramp can be switched between linear and sine-squared ramp. This is done via ***Motion Profile Type (6086h**, see CANopen® User Guide**)***.

Depending on the chosen ***Motion Profile Type*** the units of ***Profile Deceleration*** are different.

Object description:

INDEX	6084h
Name	Profile Deceleration
Object Code	VAR
Data Type	UNSIGNED32
Category	Optional

Entry description:

Access	rw
PDO Mapping	possible
Value Range	
Default Value	Stored value
non volat. storable	yes

Scaling factor: see ***Profile Acceleration (6083h**, chapter 7.8**)***

7.10 Target Velocity (60FFh)

Nominal speed set-point in **Velocity Mode**.

Note: This object does *not* take effect in **Positioning Mode**.

The drive follows the speed set-point according to the acceleration and deceleration ramp.
If Bit 8 (HALT-Bit) in ***Controlword (6040h***, *chapter 7.1)* is set, ***Target Velocity*** is written to 0.

Object description:

INDEX	60FFh
Name	Target Velocity
Object Code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry description:

Access	rw
Value Range	Min. Value … Max. Value (see below)
Default Value	no

Subindex 1 (Numerator) and Subindex 2 (Denominator) of ***Velocity Encoder Factor (6094h,*** *see CANopen ® User Guide)* define the Scaling Factor and limit the permissible Min. Value / Max. Value of ***Target Velocity*** as follows:

Scaling Factor = (Numerator / Denominator) rpm

Min. Value = - Max. Value

Max. Value = $$\frac{2^{31}-1}{Numerator \times 2^{(17-\log_2 Denominator)}}$$

With Numerator = 1 and Denominator = 2, the default values are:

Default Scaling Factor = 0.5 rpm
Default Min. Value = -32767(≡ -16383.5 rpm)
Default Max. Value = 32767(≡ 16383.5 rpm)

7.11 Velocity Demand Value (606Bh)

Current speed set-point of the trajectory generator.

Object description:

INDEX	606Bh
Name	Velocity Demand Value
Object Code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry description:

Access	ro
Value Range	INTEGER32
Default Value	no

Scaling factor: 2 ≡ 1rpm

7.12 Velocity Actual Value (606Ch)

Actual motor speed. If a gear is mounted to the drive, the output speed is associated with the motor speed via the gear ratio.

Object description:

INDEX	606Ch
Name	Velocity Actual Value
Object Code	VAR
Data Type	INTEGER32
Category	Mandatory

Entry description:

Access	ro
Value Range	INTEGER32
Default Value	no

Scaling factor: 2 ≡ 1rpm

7.13 Target Torque (6071h)

Target Torque is the torque set-point, which is given here as the torque producing current i_q. To convert the current into the available torque at the shaft, it has to be multiplied by the torque constant of the motor and possibly by the ratio of a mounted gear.

Target Torque is scaled to 1/1000 of ***Motor Rated Current (6075h****, see CANopen® User Guide****).***

The current values are given as peak values and correlate to the specification in the motors datasheet and on the name plate.

Object description:

INDEX	6071h
Name	Target Torque
Object Code	VAR
Data Type	INTEGER16
Category	Mandatory

Entry description:

Access	rw
Value Range	INTEGER16
Default Value	0

Notice:
Target Torque must not exceed the set ***Motor Rated Current (6075h****, see CANopen® User Guide****)***; higher values will be limited to ***Motor Rated Current***.

7.14 DC-link circuit voltage (6079h)

Intermediate circuit voltage of the converter given in mV.

Object description:

INDEX	6079h
Name	DC Link Circuit Voltage
Object Code	VAR
Data Type	UNSIGNED32
Category	Optional

Entry description:

Access	ro
Value Range	UNSIGNED32
Default Value	0

7.15 Current Actual Value (6078h)

Actual value of the torque producing current. ***Current Actual Value*** is scaled to 1/1000 of ***Motor Rated Current (6075h**, see CANopen® User Guide**).***

The current values are given as peak values.

Object description:

INDEX	6078h
Name	Current Actual Value
Object Code	VAR
Data Type	INTEGER16
Category	Optional

Entry description:

Access	ro
Value Range	INTEGER16
Default Value	0

7.16 Dynamic Speed Limit (2003h)

Speed limit for operation mode -4 (current control with speed limitation).

Object description:

INDEX	2003h
Name	Dynamic Speed Limit
Object Code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry description:

Access	rw
Value Range	0 … 7FFFh
Default Value	0

Scaling factor: 2 ≡ 1rpm

7.17 Dynamic Torque Limit (2004h)

Torque limit for operation mode -3 (speed control with torque limitation). ***Dynamic Torque Limit*** is scaled to 1/1000 of ***Motor Rated Current (6075h**, see CANopen® User Guide**).***

Object description:

INDEX	2004h
Name	Dynamic Torque Limit
Object Code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry description:

Access	rw
Value Range	UNSIGNED16 (0 … 7FFFh)
Default Value	0

Notice:
Dynamic Torque Limit must not exceed the set maximum current ***Max Current (6073h**, see CANopen® User Guide**)***. Higher values will be limited to ***Max Current***.

7.18 Digital Inputs (60FDh)

The low word contains the states of the digital inputs as defined by the CANopen® profile.
The high word displays the states of all digital inputs.

Object description:

INDEX	60FDh
Name	Digital Inputs
Object Code	VAR
Data Type	UNSIGNED32
Category	Optional

Entry description:

Access	ro
Value Range	UNSIGNED32

Data description:

Bit #	Configuration
0	negative limit switch
1	positive limit switch
2	free
3	free
4	
..	reserved
15	
16	Digital Input DI1
17	Digital Input DI2
18	Digital Input DI3
19	Digital Input DI4
20	Digital Input DI5
21	Digital Input DI6
22	Digital Input DI7
23	Digital Input DI8
24	Digital Input DI9
25	Digital Input DI10

7.19 Digital Outputs (60FEh)

This object allows to switch the drive's digital outputs under user control.

Object description:

INDEX	60FEh
Name	Digital Outputs
Object Code	ARRAY
Data Type	UNSIGNED32
Category	Optional

Entry description:

SUB-INDEX	0
Description	Number of entries
Entry category	Mandatory
Access	ro
Value Range	1…2
Default value	no

SUB-INDEX	1
Description	Physical outputs
Entry category	Mandatory
Access	rw
Value Range	UNSIGNED32
Default value	0

SUB-INDEX	2
Description	Bit Mask
Entry category	Optional
Access	rw
Value Range	UNSIGNED32
Default value	0

Data description:
applies to both sub-index 1 and sub-index 2

Bit #	Configuration
0	
..	reserved
15	
16	Digital Output DO1
17	Digital Output DO2
18	.
..	.
31	.

The actual number of available digital outputs is device-dependent. For more information, please see the specific device's Operating Manual.

The bit mask specified in **Sub-Index 2** allows to select individual digital outputs for user control:

Bit n = 0:	Associated digital output selected for automatic control. (State of digital output is automatically set according to the digital output function assigned during setup procedure.)
Bit n = 1:	Associated digital output selected for user control.

For those digital outputs, which have been selected for user control, states are set according to the bit pattern in **Sub-Index 1**:

Bit n = 0:	Low level output voltage at associated digital output pin (if 'Positive Logic' configured)
Bit n = 1:	High level output voltage at associated digital output pin (if 'Positive Logic' configured)

Please note, that output voltage levels may be reversed, if the appropriate digital output has been configured for 'Negative Logic' during setup procedure. (Please see Operating Manual).

Also note, that ENGEL drives usually have open-collector-style digital outputs. Therefore, a pull-up or pull-down resistor may be required to provide the complementary voltage level. (Please see Operating Manual).

7.20 Analogue Inputs 16-Bit (6C01h)

Allows to read the values of the drive's analogue inputs.

Object description:

INDEX	6C01h
Name	Read Analogue Input 16-Bit
Object Code	ARRAY
Data Type	INTEGER16
Category	Conditional: Device with analogue input

Entry description:

SUB-INDEX	0
Description	Number of Analogue Inputs 16-Bit
Entry category	Mandatory
Access	ro
Value Range	1…2
Default value	no

SUB-INDEX	1
Description	Analogue Input 1
Entry category	Mandatory
Access	ro
Value Range	INTEGER16
Default value	no

SUB-INDEX	2
Description	Analogue Input 2
Entry category	Optional
Access	ro
Value Range	INTEGER16
Default value	no

Scaling factor: 8000h ... 0000h ... 7FFFh ≡ -10V ... 0V ... +10V

7.21 Encoder Position Value (7004h)

Incremental encoder counter (Firmware V3.74 or higher).
This object is only valid for ENGEL devices with incremental encoder interface.

As part of the setup procedure, an incremental encoder may be configured as feedback device for the internal control loop. In those cases, where a different feedback device (e.g. a resolver) is configured, the incremental encoder interface will still remain operational and may serve as an independent position counter.

Object description:

INDEX	7004h
Name	Encoder Position Value
Object Code	VAR
Data Type	INTEGER16

Entry description:

Access	ro
Value Range	INTEGER16
Default Value	no

Scaling factor: $\frac{Encoder\ Position\ Increments}{Revolution} = 4\ x\ \frac{Encoder\ Pulses}{Revolution}$

Please note that ***Encoder Position Value*** will overflow / underflow at the boundaries of the 16-Bit integer range.

7.22 Error Code (200Ch)

Gives the actual error number which corresponds to the LED-Code (see chapter 5.1.2). If no error is active the value is 0.

Object description:

INDEX	200Ch
Name	Error Number
Object Code	VAR
Data Type	UNSIGNED16
Category	Optional

Entry description:

Access	ro
PDO Mapping	possible
Value Range	UNSIGNED16
Default Value	no

Example: over-current failure → ***Error number*** = 7