AKD™

PROFINET RT Communication

Edition: A, October 2011

Valid for Hardware Revision C

Part Number 903-200012-00

Original Documentation

Keep all manuals as a product component during the life span of the product.
Pass all manuals to future users and owners of the product.

Record of Document Revisions:

Revision	Remarks
A, 10/2009	Launch version

Hardware Revision (HR)

Hardware Revision	Firmware	WorkBench	Remarks
A	M_01-03-zz-zzz	1.3.0.zzzzz	Start revision
C	≥ M_01-03-00-011	≥ 1.3.0.zzzzz	STO certified
	≥ M_01-05-xx-yyy	≥ 1.5.0.zzzzz	PROFINET RT released

Current patents:

US Patent 5,646,496 (used in control card R/D and 1 Vp-p feedback interface)

US Patent 5,162,798 (used in control card R/D)

US Patent 6,118,241 (used in control card simple dynamic braking)

Technical changes which improve the performance of the device may be made without prior notice!

Table of Contents

1 General

1.1 About this Manual

This manual, *AKD PROFINET Communication*, describes the installation, setup, range of functions, and software protocol for the PROFINET AKD product series. All AKD PROFINET drives have built-in PROFINET functionality; therefore an additional option card is not required.

A digital version of this manual (pdf format) is available on the CD-ROM included with your drive. Manual updates can be downloaded from the Kollmorgen™ website.

Related documents for the AKD series include:

- *AKD Quick Start*. This guide provides instructions for basic drive setup and connection to a network.
- *AKD Installation Manual*. This manual provides instructions for installation and drive setup.
- *AKD Users Manual*. This manual describes how to use your drive in common applications. It also provides tips for maximizing your system performance with the AKD.
- *AKD Parameter and Command Reference Guide*. This guide provides documentation for the parameters and commands used to program the AKD.
- *AKD PROFINET RT Communication Profile*. This manual describes how to use your drive in PROFINET RT applications.

Additional documentation:

- Profile-PROFIdrive (PI group, Profile-PROFIdrive_3172_v41_May06.pdf)

1.2 Target Group

This manual addresses personnel with the following qualifications:

- Installation: only by electrically qualified personnel.
- Setup: only by qualified personnel with extensive knowledge of electrical engineering and drive technology
- Programming: Software developers, project-planners

The qualified personnel must know and observe the following standards:

- ISO 12100, IEC 60364 and IEC 60664
- National accident prevention regulations

⚠ WARNING	**During operation there are deadly hazards, with the possibility of death, severe injury or material damage. The operator must ensure that the safety instructions in this manual are followed. The operator must ensure that all personnel responsible for working with the servo drive have read and understand the manual.**

1.3 Symbols used

Warning Symbols

Symbol	Indication
⚠ DANGER	Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
⚠ WARNING	Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
⚠ CAUTION	Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
NOTICE	Indicates situations which, if not avoided, could result in property damage.
NOTE	This is not a safety symbol. This symbol indicates important notes.

Drawing symbols

Symbol	Description	Symbol	Description
	Signal ground		Diode
	Chassis ground		Relays
	Protective earth		Relays switch off delayed
	Resistor		Normal open contact
	Fuse		Normal closed contact

1.4 Abbreviations Used

Abbreviation	Meaning
Cat	Category
DO	Drive object
DU	Data Unit
GSD	Device description file
GSDML	GSD Markup Language
HMI	Human machine interface
ID	Identifier
I/O	Input / Output
IRT	Isochronous Real-Time
LED	Light emitting diode
PAP	Programm Ablauf Protokoll (program sequence protocol)
PLC	Programmable logic control
PNU	Parameter number
RT	Real-Time
STW	Control word
ZSW	Status word

2 Safety

2.1 Safety Instructions

⚠ DANGER	During operation there are deadly hazards, with the possibility of death, severe injury or material damage. Do not open or touch the equipment during operation. Keep all covers and cabinet doors closed during operation. Touching the equipment is allowed during installation and commissioning for properly qualified persons only. • During operation, drives may have uncovered live components, depending on their level of enclosure protection. • Control and power connections may be live, even though the motor is not rotating. • Drives may have hot surfaces during operation. Heat sink can reach temperatures above 80°C.
⚠ WARNING	Electronic equipment can fail. The user is responsible for ensuring that, in the event of a failure of the servo amplifier, the drive is set to a state that is safe for both machinery and personnel, for instance with the aid of a mechanical brake. Drives with servo amplifiers and PROFINET are remote-controlled machines. They can start to move at any time without previous warning. Take appropriate measures to ensure that the operating and service personnel is aware of this danger. Implement appropriate protective measures to ensure that any unintended start-up of the machines cannot result in dangerous situations for personnel or machinery. Software limit-switches are not a substitute for the hardware limit-switches in the machine.
NOTICE	Install the drive as described in the *Installation Manual*. Never break any of the electrical connections to the drive while it is live. This can result in destruction of the electronics
NOTICE	The PROFINET Ethernet cable must be connected to the service interface on X11.

2.2 Use as directed

Drives are components that are built into electrical plants or machines and can only be operated as integral components of these plants or machines. The manufacturer of the machine used with a drive must generate a risk assessment for the machine and take appropriate measures to ensure that unforeseen movements cannot cause personnel injury or property damage.

- Observe the chapters "Use as directed" and "Prohibited use" in the *AKD Installation Manual*.
- The PROFINET interface serves only for the connection of the *AKD* directly or via a switch to a network with PROFINET connectivity.

2.3 Prohibited use

Other use than that described in chapter “Use as directed” is not intended and can lead to personnel injuries and equipment damage. The drive may not be used with a machine that does not comply with appropriate national directives or standards. The use of the drive in the following environments is also prohibited:

- potentially explosive areas
- environments with corrosive and/or electrically conductive acids, alkaline solutions, oils, vapors, dusts
- ships or offshore applications

3 Installation and Setup

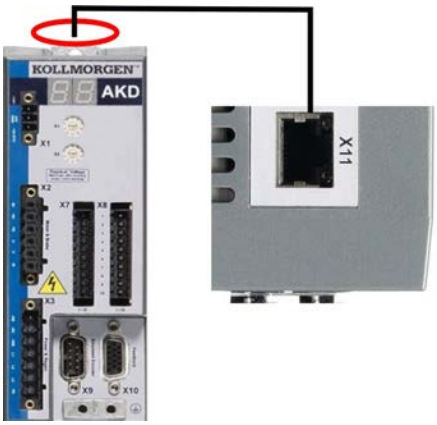
3.1 Safety Instructions

⚠ DANGER	Never disconnect any electrical connections to the drive while the drive is live. There is a danger of electrical arcing with damage to contacts and serious personal injury. Wait at least seven minutes after disconnecting the drive from the main supply power before touching potentially live sections of the equipment (e.g. contacts) or undoing any connections. Capacitors can still have dangerous voltages present up to 7 minutes after switching off the supply power. To be sure, measure the voltage in the DC Bus link and wait until it has fallen below 40 V. Control and power connections can still be live, even if the motor is not rotating.
⚠ WARNING	Electronic equipment can fail. The user is responsible for ensuring that, in the event of a failure of the servo amplifier, the drive is set to a state that is safe for both machinery and personnel, for instance with the aid of a mechanical brake. Drives with servo amplifiers and PROFINET are remote-controlled machines. They can start to move at any time without previous warning. Take appropriate measures to ensure that the operating and service personnel is aware of this danger. Implement appropriate protective measures to ensure that any unintended start-up of the machines cannot result in dangerous situations for personnel or machinery. Software limit-switches are not a substitute for the hardware limit-switches in the machine.
NOTICE	Install the drive as described in the *Installation Manual*. The wiring for the analog setpoint input and the positioning interface, as shown in the wiring diagram in the *Installation Manual*, is not required. Never break any of the electrical connections to the drive while it is live. This action can result in destruction of the electronics.
NOTICE	The drive's status must be monitored by the PLC to acknowledge critical situations. Wire the FAULT contact in series into the emergency stop circuit of the installation. The emergency stop circuit must operate the supply contactor.

NOTE	Use WorkBench to alter drive settings. Any other alterations will invalidate the warranty.
NOTE	Because of the internal representation of the position-control parameters, the position controller can only be operated if the final limit speed of the drive does not exceed: **rotary** at sinusoidal² commutation: 7500 rpm at trapezoidal commutation: 12000 rpm. **linear** at sinusoidal² commutation: 4 m/s at trapezoidal commutation: 6.25 m/s
NOTE	All the data on resolution, step size, positioning accuracy etc. refer to calculatory values. Non-linearities in the mechanism (backlash, flexing, etc.) are not taken into account. If the final limit speed of the motor must be altered, then all the parameters that were previously entered for position control and motion blocks must be adapted.

3.2 PROFINET Onboard

Connection to the PROFINET Network via X11.



Connect the service interface (X11) of the drive to an Ethernet interface on the PROFINET Master directly or via a network switch, **while the supply to the equipment is switched off.**

Confirm that the link LED on the AKD (the green LED on the RJ45 connector) and on your Master or Switch are both illuminated. If both lights are illuminated, then you have a good electrical connection.

PROFINET RT and WorkBench can operate simultaneously if a switch is used.

3.2.1 LED functions

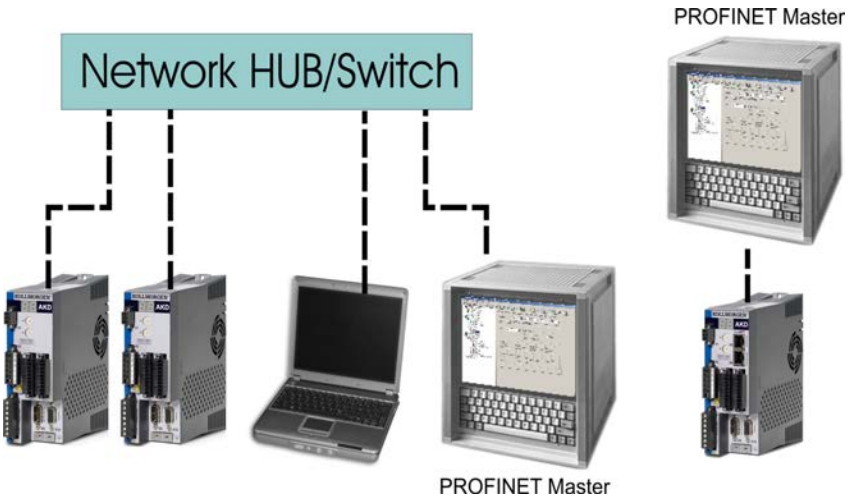
The communication status is indicated by the built-in LEDs.

Connector	LED#	Name	Function
X11	LED1	IN port Link	ON = active, OFF= not active
	LED2	RUN	ON = running, OFF = not running

3.2.2 Connection technology

You can connect to the PROFINET network using RJ-45 connectors. Use standard Cat. 5 Ethernet cables for either connection configuration.

3.2.3 Network Connection Examples



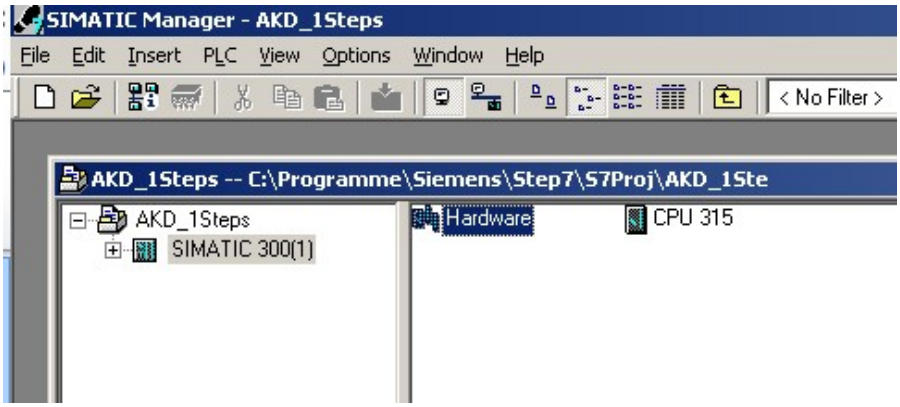
3.3 Guide to Setup

⚠ WARNING	**Only professional personnel with extensive knowledge of control and drive technology are allowed to setup the drive.**
⚠ CAUTION	**Make sure that any unintended movement of the drive cannot endanger machinery or personnel.**

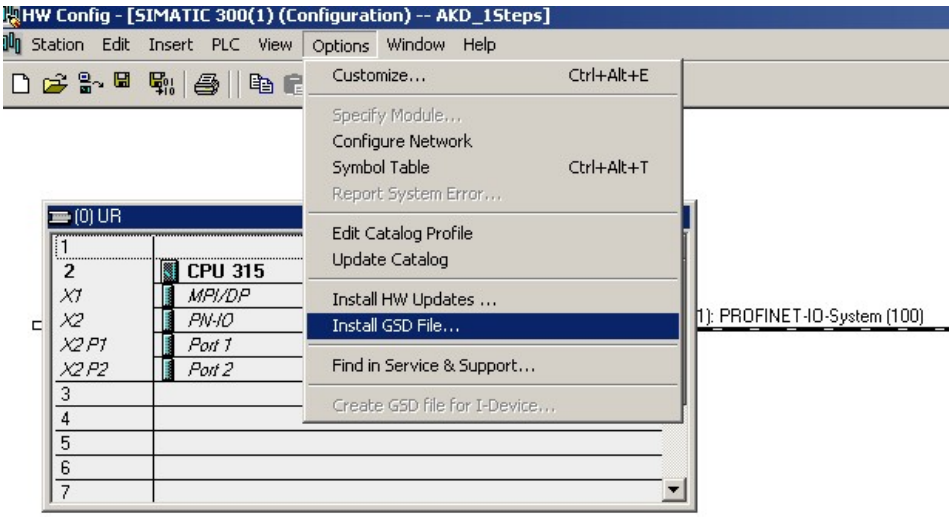
1. Check assembly/installation. Check that all the safety instructions in the product manual for the drive and this manual have been observed and implemented. Check station address and baud rate setting.
2. Connect PC,start WorkBench. Use the setup software WorkBench to set the parameters for the drive.
3. Setup basic functions. Start up the basic functions of the drive and optimize the current, speed and position controllers. This section of the setup is described in the in the online help of the setup software.
4. Save parameters. When the parameters have been optimized, save them in the drive.

3.4 Setup Step 7

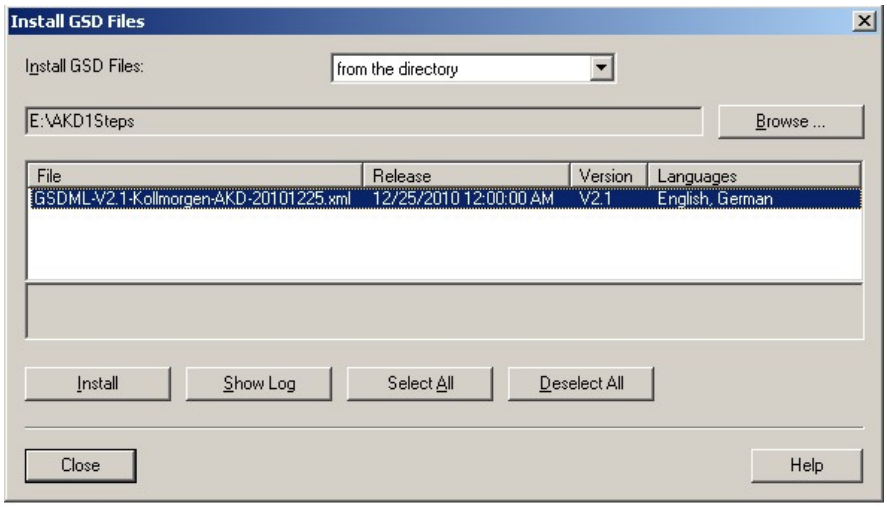
1. Start the SIMATIC Manager.
2. Open the hardware manager (double click on Hardware).



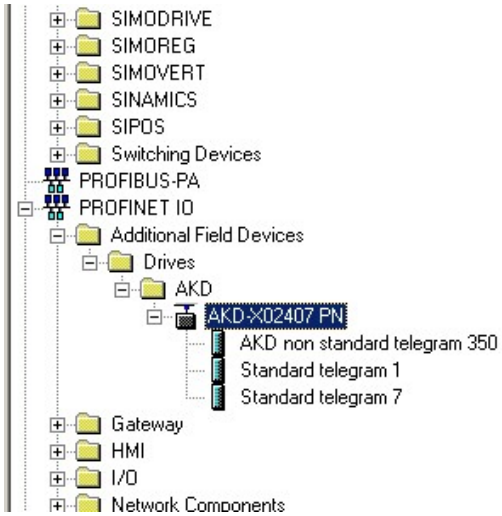
3. Go to Options and click "Install GSD Files". Here also the GSDML files for PROFINET devices can be installed.:



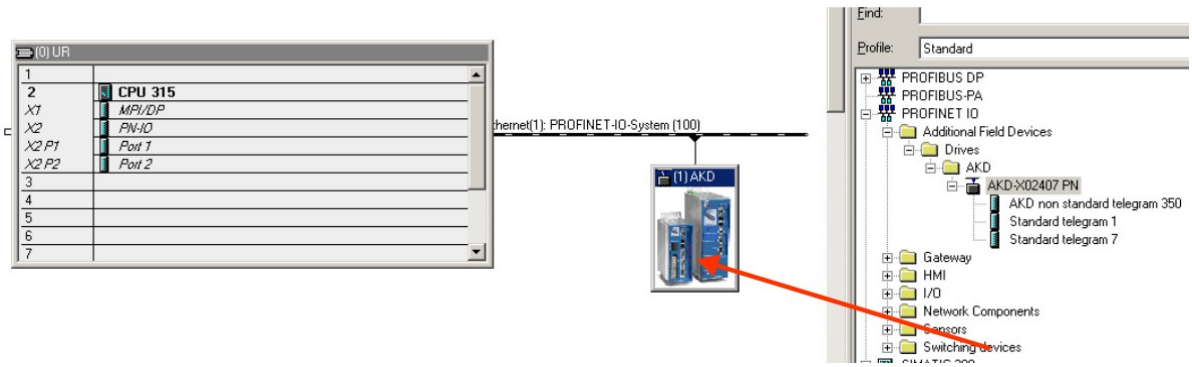
4. Browse for the latest AKD GSDML file and click on install:



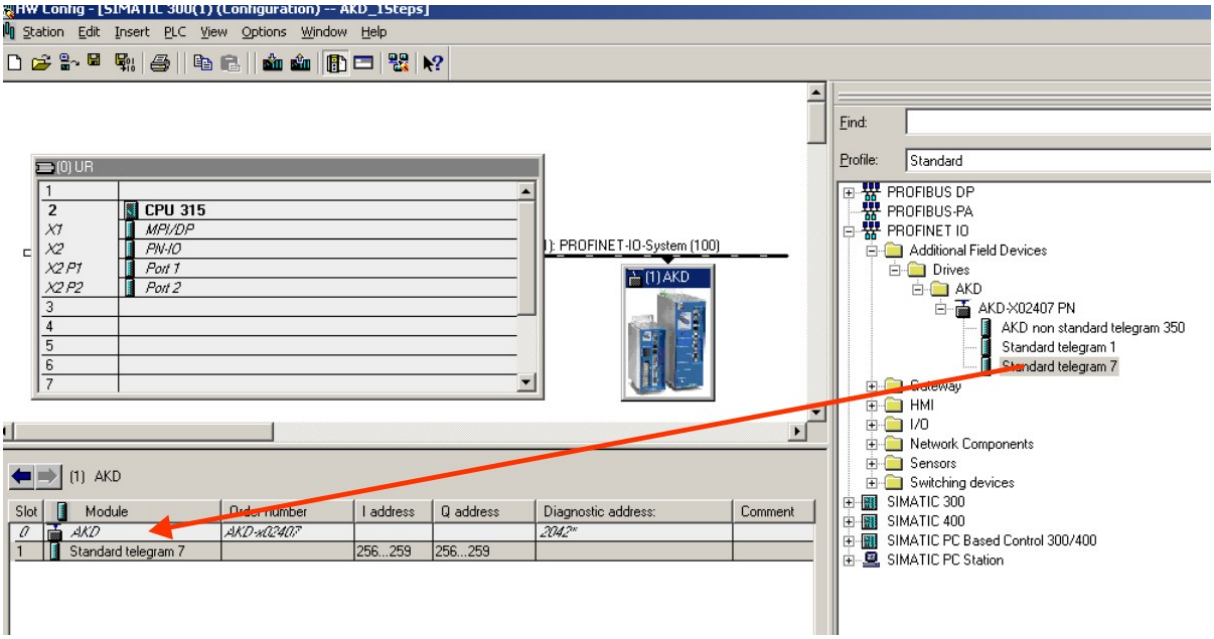
5. The AKD GSDML file is installed now and can be found in the SIMATIC hardware catalog. Open PROFINET I/O->Additional Fieldbus Devices->Drives->AKD



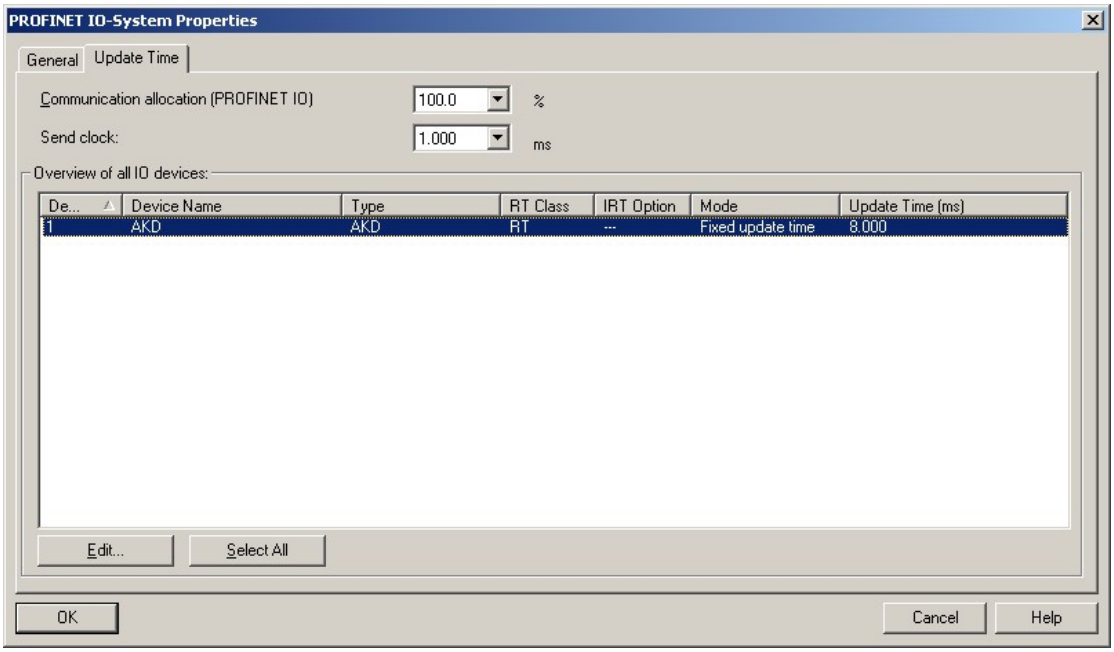
6. Click on the AKD device (not a telegram) and connect it to the PLC (drag and drop)



7. Now configure the telegram, for example telegram 7 for use in position mode.
   Drag and drop telegram 7 into slot 1.



8. Double click on the PROFINET network (line which connects PLC and AKD) and configure the update time. Click OK for closing this window.



9. Save and compile the hardware configuration.

3.5 Parameter Configuration with PROFIdrive over PROFINET IO

The AKD is defined as an I/O Device in PROFINET IO. A PLC or other IO-Controller establishes a connection via a so called application relations (AR). Within this AR, different profiles like PROFIdrive, PROFIsafe etc. can be used for the communication. The PROFIdrive profile, which AKD supports, is defined as Application Process Identifier (API) 0x3A00.

Within the AR, further addressing needs to done. PROFINET IO divides each device in so called slots and subslots. Sub 0 refers to the device itself and returns all generic data like vendor name, software and hardware version. The subslots within the device can be used with different real and virtual modules. Each module a functional component, which for example can be a digital I/O or Telegram with Position values.

AKD provides several virtual modules, which can be used in Slot 1 and are used for the real time data exchange.

For read or write parameters to or from the AKD, the global base mode parameter access can be used (see PROFIdrive chapter 8.6). The parameter manager is accessed through Slot 1 and a non real time channel needs to be used for this purpose. The AKD supports the record data 47, which is used to address the Parameter numbers (PNUs).
Base mode parameter access shows the construction of the telegram:

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)

The following PROFIdrive services are supported:

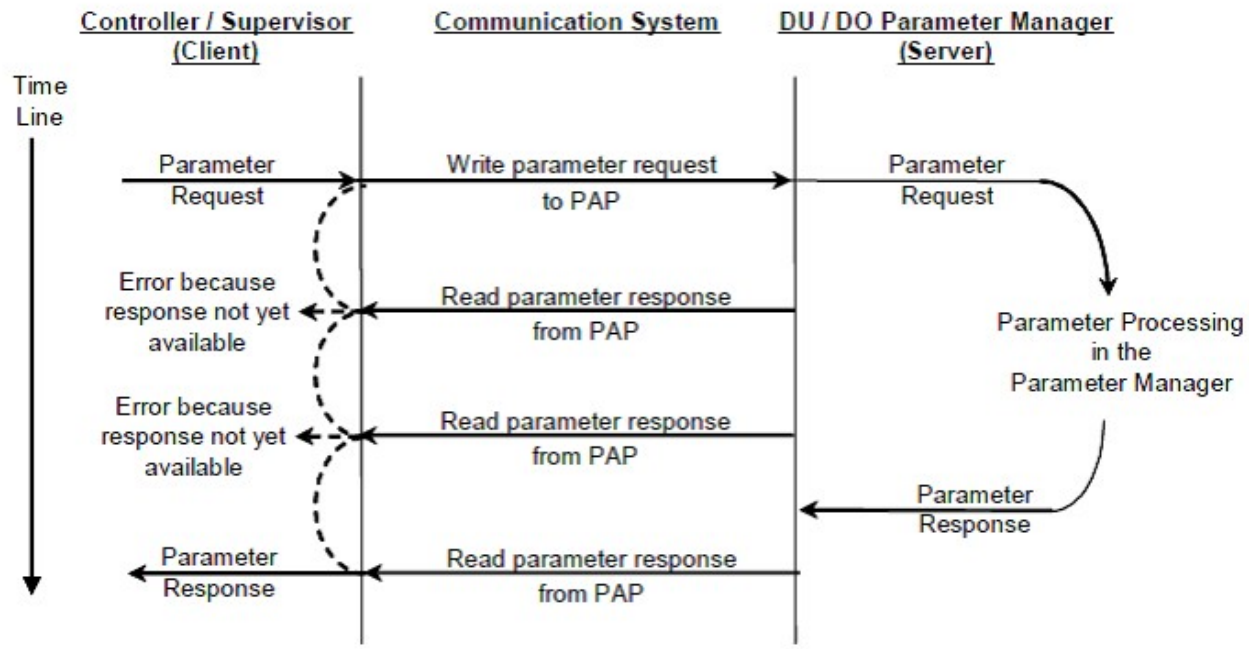
- Single parameter value request
- Multiple parameter value request
- Single parameter change request
- Multiple parameter change request

Record data fields

The table shows the structure and the supported fields in the AKD for a parameter request.

Field	Data type	Values	Comment
Request reference	Unsigned8	0x00 reserved 0x01 – 0xFF	
Request ID	Unsigned8	0x01 Request parameter 0x02 Change parameter	
Response ID	Unsigned8	0x01 Request parameter (+) 0x02 Change parameter (+) 0x81 Request parameter (-) 0x82 Change parameter (-)	
Axis / DO-ID	Unsigned8	0x00	one Axis
No. of Parameters	Unsigned8	0x01.. 0x27	
Attribute	Unsigned8	0x00 reserved 0x10 Value 0x20 Description	
No. of Elements	Unsigned8	0x01.. 0xEA Quantity	
Parameter number	Unsigned16	0x0001 .. 0xFFFF PNU	
Subindex	Unsigned16	0x0000 .. 0xFFFE	

3.5.1 Parameter configuration



3.5.2 Example for writing the operation mode

For writing the operation mode an acyclic change parameter value request needs to be send from the IO-Controller/Supervisor to the AKD.

If the user wants to write e.g. the operation mode to position mode (DRV.OPMODE 2) over PROFINET, the PNU 930 needs to be written with value 0x0002. The PROFIdrive base parameter access (see "Position Units" (=> p. 35)) describes the procedure.

Change parameter request (Operation mode):

Byte (dec)	Value (hex)	Description
0	0x05	Request reference: e.g. 5
1	0x02	Request ID: Change parameters
2	0x00	Axis: 0 (the AKD parameter manager)
3	0x01	No of Parameter: 1
4	0x10	Attribute: Value
5	0x01	No. of Elements
6	0x03	PNU: 930 Operation mode
7	0xA2	
8	0x00	Subindex: 0
9	0x00	
10	0x42	Format: Word
11	0x01	No of Values: 1
12	0x02	Operation mode
13	0x00	

The AKD answers with a positive response without values:

Byte (dec)	Value (hex)	Description
0	0x05	Request reference: e.g. 5
1	0x02	Request ID: Change parameters
2	0x00	Axis: 0 (the AKD parameter manager)
3	0x01	No of Parameter: 1
4	0x00	Format
5	0x00	No. of Values 0

4 PROFINET IO

4.1 Introduction

PROFINET IO is a real time protocol based on Ethernet. It is used as high level network for industrial automation applications. PROFINET IO is very similar to PROFIbus and focuses on the data exchange for programmable controller.

A PROFINET IO network consists of following devices:

- IO controller: This is typically the PLC, which controls the whole application.
- IO device: a decentralized IO device (e.g. drive, encoder, sensor), which is controlled by the IO controller.
- IO supervisor: HMI (human machine interface) or PC for diagnostic purposes or commissioning.

The real time channel (RT) is used for IO data and alarm mechanism. In PROFINET IO RT (conformance class A and B), the RT data is transferred via a prioritized Ethernet frame. No special hardware is required. Due to this prioritization a cycle time < 10ms can be achieved.

- PROFINET IO IRT is used for higher timing requirements. Cycle times < 1ms is possible, but also special hardware for IO Devices and switches are required.

All diagnostic and configuration data is transferred via the non real time channel (NRT). The well known UDP protocol is used for this purpose. Anyhow, no timing determinism can be guaranteed and typical the cycle times can be > 100ms.

4.2 Restrictions and requirements

4.2.1 Conformance Classes

AKD support Conformance Classes A and B. This means PROFIdrive parameters can be configured over the PROFINET network, fault can be delivered and cyclic data channel functions. However, the synchronization between axes can not take place since it is a part of Conformance Class C.

4.2.2 Cycle time of RT data

AKD fastest cycle time for the PROFINET cyclic data is 8 milliseconds.

4.2.3 Connector

PROFINET network connector in the AKD is the same RJ45 connector used for the service functions. This connector is numbered as X11 on the AKD's top panel.

4.2.4 Network topology

AKD can be connected as an I/O device on the PROFINET network in two manners:

1. As the last node in the network (since AKD has only one connector) in a line topology
2. As another node on the network in star topology (using a switch)

5 PROFIDRIVE over PROFINET IO

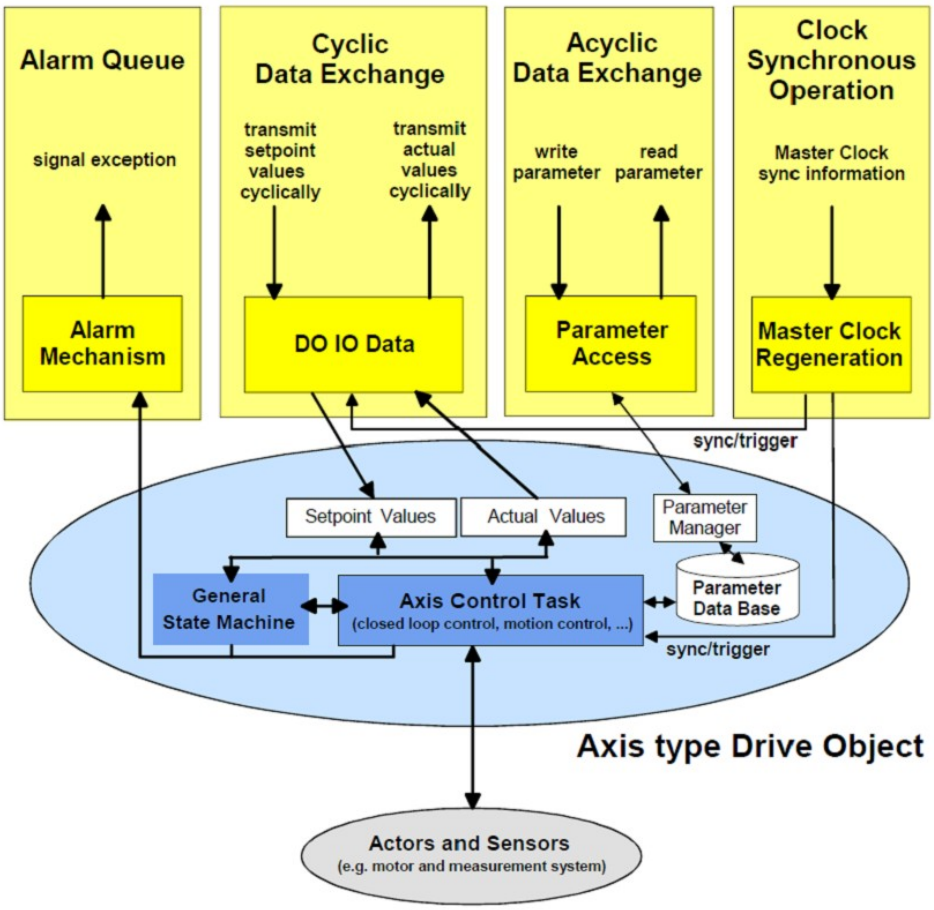
5.1 Introduction

The AKD supports the PROFIdrive profile for accessing and configuring standard and manufacture parameters via PROFINET IO to start/stop/configuring motion control tasks.

The profile defines as main element the Drive Object (DO), which is controlling the motion task related parameters. It is important to understand that PROFIdrive is only a user profile, which can be used with PROFINET IO.

Note that the AKD supports all mandatory functionality of the PROFIdrive profile, but naturally not all optional functionality. This chapter describes the supported optional elements.

5.2 AKD as Drive Object (DO)



The drive object contains the following items:

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

Multiple communication channels are used for read/write data values over PROFINET IO. The drive object can be accessed via:

- Cyclic data exchange
- Acyclic data exchange
- Alarm queue (currently not supported)
- Clock synchronous operation (currently not supported)

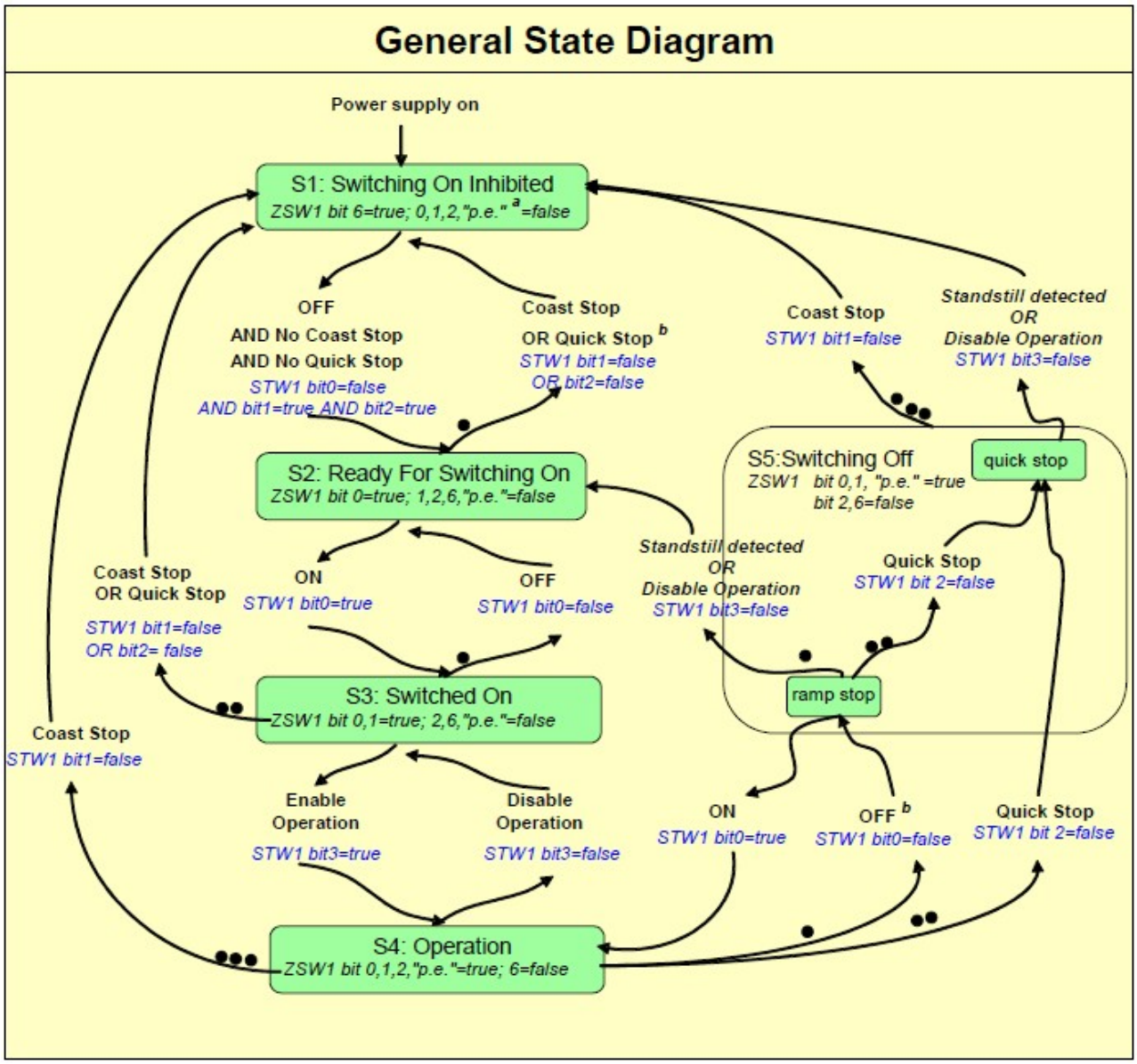
The cyclic data exchange includes the transmission/reception of data values like set point values (e.g. Position set point, velocity set point or control word) and actual values (actual position value, actual velocity or status word) between the master and the drive object. These values are called IO data and are transferred in real time.

The acyclic data is used for configuring the drive, which typically is not time critical. Each DO has an own parameter manager, which handles the access. The non real time channel is used for this in PROFINET IO.

The alarm queue is used for signaling the master an exception situations, which are generated through the state machine or the axis control task itself (not supported in AKD).

The clock synchronous operation requires PROFINET IRT (conformance class C), which is currently not supported by the AKD.

5.3 General State Machine



5.4 Control word bits

The S7 application must set the bits in control word 1 to go through the PROFIdrive standard state machine to enable mode (complying with the PROFIdrive standard 6.3.2). Bits 0-3 control the state machine state.

The control word (STW1) defines the following general functions:

General Control Word Bits		
Bit Number	Description	Comment
0	STW1 on	ON / OFF
1	STW1 no coast stop	drive will not coast stop if this bit is set
2	STW1 no quick stop	drive will not execute quick stop if this bit is set
3	STW1 enable operation	drive will enable and execute command if all preconditions are set
7	Fault acknowledge	set this bit to reset faults in the drive
10	control by PLC	when not set no command will be accepted from the PLC

In velocity mode:

STW1 Special bits (Velocity mode)		
Bit Number	Description	Comment
4	Enable ramp generator of the drive	Use DRV.ACC and DRV.DEC
5	unfreeze the ramp generator in the drive	if frozen, the drive stays at current velocity without continuing to ramp up or down
6	Enable set point	Drive accepts set point from the master. If this bit is not set, the velocity will be 0
8	Jog 1 on/off	Not implemented
9	Jog 2 on/off	Not implemented
11-15	Device specific	Not implemented

Control word 1 must also set bits 4,5,6 (for speed control – in velocity operation mode) to enable ramp generator and bit 10 to set the drive to be controlled by the PLC.

Bit 7 is used to acknowledge fault. The AKD will clear the fault and go automatically to S1 state after a fault is cleared.

Speed control Optional bits 8, 9 (JOG bits) are not implemented.

In position mode:

STW1 Special bits (Position mode)		
Bit Number	Name	Description
4	Do Not Reject Traversing Task	Positive edge signal at bit 6 activated an traversing task. MT.MOVE is send.
5	No Intermediate Stop	Traversing task can be interrupted and start again with this bit.
6	Activate Traversing Task	Positive edge signal starts a traversing task.
8	Jog 1 On	Not implemented
9	Jog 2 On	Not implemented.
11	Start Homing Procedure	Homing mode is active. If this bit is cleared, the homing is aborted and the drive stops.
12-15	Device-specific	Not implemented.

5.5 Status word bits

All status word1 bits are implemented according to the PROFIdrive standard.

For application class 1 (speed control) and 3 (position mode) all mandatory bits are implemented.

The status word (ZSW1) defines the following functions:

General Status Word Bits		
Bit Number	Description	Comment
0	ZSW1 drive ready to switch on	Ready To Switch On /Not Ready To Switch On
1	ZSW1 drive ready to operate	Ready To Operate / Not Ready To Operate
2	ZSW1 operation enabled	Operation Enabled (drive follows velocity set point) / Operation Disabled
3	Fault present	A fault is present in the drive
4	coast stop not activated	No coast stop is executed
5	quick stop not activated	No quick stop is executed
6	Switching on inhibited	
7	warning present	
9	control requested by the master	

In velocity mode:

ZSW1 Special bits (Velocity mode)		
Bit Number	Description	Comment
8	velocity error within range	
10	target velocity reached	
11-15	Device specific	Not Implemented

In position mode:

ZSW1 Special bits (Position mode)		
Bit Number	Name	Description
8	Following error in range	Error window (PL.ERR and PL.ERRWTHRESH).
10	Target position reached	DRV.MOTIONTASK Bit 0 (motion task active)
11	Home position set	DRV.MOTIONTASK Bit 1 & 2 (Homing finished)
12	Traversing Task acknowl-edgment	On positive edge, traversing task acknowledged or set point accepted.
13	Drive stopped	No motion task is active. Axis is not moving.
14-15	Device specific	Not Implemented

5.6 Supported PNU's

List of all supported PROFIdrive PNU's

The table mentions all supported PROFIdrive specific parameters. The access needs to be done via base mode parameter access described in "Parameter Configuration with PROFIdrive over PROFINET IO" (=> p. 17).

PNU	Name	Data type	Description
915	DO IO Data configuring (set point telegram)	Array of U16	
916	DO IO Data configuring (actual value telegram)	Array of U16	
922	Telegram selection	U16	The PROFIdrive telegram used for the IO connection can be configured.
923	List of all parameters for signals	Array of U16	All supported signals and their corresponding PNU's.
930	Operating mode	U16	
944	Fault message counter	U16	
947	Fault number	Array of U16	All active faults.
964	Drive Unit Identification	Array of U16	Indices 0 – 4
965	Profile identification number		
975	DO identification		
980 to 989	Number list of defined parameter	Array of U16	

List of all manufacturer specific PNU's

The table shows all manufacture specific signals. All supported PROFIdrive and manufacture specific signals can be mapped into telegram 0 (dynamic telegram configuration).

PNU	Name	Data type	Description
1	STW1	U16	I/O control word
2	ZSW1	U16	I/O status word
5	NSOLL_A	S16	Velocity set point value
6	NIST_A	S16	Velocity actual value
32	SATZANW	U16	Motion task selection
33	AKTSATZ	U16	Actual motion task running
52	ITIST_GLATT	U16	Active Current (torque)

Supported Formats:

Format	Data type
0x41	Byte
0x42	WORD
0x43	DWORD

5.7 Telegram configuration

The telegram configuration is made according to the PROFIdrive standard. The PROFIdrive parameters used in the configuration are: P922, P923, P915, P916 (see PROFIdrive profile, page 110). The following PROFIdrive signals are changing the corresponding AKD signals:

Signal No.	Signal name	PROFIdrive signal name	AKD signal
1	Control word 1	STW1	Control word 1
2	Status word 1	ZSW1	Status word 1
5	Speed A	NSOLL_A	VL.CMD
6	Speed actual value	NIST_A	VL.FB
32	Traversing block selection	SATZANW	MT.MOVE
33	Actual traversing block	AKTSATZ	MT.PARAMS
34	MDI target position	MDI_TARPOS	MT.P*
35	MDI velocity	MDI_VELOCITY	MT.V*
36	MDI acceleration	MDI_ACC	MT.ACC*
37	MDI deceleration	MDI_DEC	MT.DEC*
38	MDI mode	MDI_MODE	MT.CNTL*
52	Active current (torque)	ITIST_GLATT	IL.FB

*Attention: The PROFIdrive signals are not mapped 1:1 to the AKD signals. The unit conversion for PROFIdrive nees to be used.

Either the predefined standard telegrams can be used for accessing the signals or a free mapping can be used with telegram 0.

The signals are also available in the PNU list. Each signal can be read/write with the same PNU number. For instance, signal “Speed actual value” is also available with PNU 6.

5.8 Velocity Mode (Application class 1)

In this mode, the drive is controlled via a primary set point (speed set point). The speed control is completely in the drive controller.

The field bus is merely the transmission medium between the automation system and the drive controller. The Cyclic Data Exchange Communication Service is used.

Example

This example demonstrates enabling the drive and executing motion in velocity mode using standard telegram 1. This means that the master needs to send 32 bits (16 control word and 16 velocity command) and read back 32 bits (16 status word and 16 velocity feedback)

1. Send control word bits as follows to move the state machine to S1:
   0000_0100_0111_0000. Velocity command can be zero (it is ignored at this phase)
2. Send control word bits as follows to move the state machine to S2:
   0000_0100_0111_0110. Velocity command can be zero (it is ignored at this phase)
3. Send control word bits as follows to move the state machine to S3:
   0000_0100_0111_0111. Velocity command can be zero (it is ignored at this phase)
4. Send control word bits as follows to move the state machine to S4 and enable the drive:
   0000_0100_0111_1111. Velocity command is used now, set it to 0x00A3 (1 rps)

5.9 Position Mode (Application class 3)

In this application class the Drive Object (DO) provides a closed position control loop with its own position interpolation. The motion tasks, which are configured by MT parameters in AKD, can be accessed.

In PROFIdrive two different submodes are possible, which allow the controlling device to access motion task parameters via I/O messaging.

Furthermore the general state machine of the drive Axis Object is extended to start/configure/stop a motion task.

“ONLY” in state S4 („Operational“), the extended state machine can be accessed.

5.9.1 Submode „Program mode“

The „Program mode“ can be used to start/switch to a specific predefined motion task via I/O messaging. Telegram 7 ("Standard telegram 7" (=> p. 34)) is used for this purpose. For addressing the motion task signal „SATZANW“ is used. With signal „AKTSATZ“ the actual running motion task number can be read.

Requirements:

- Drive axis state machine needs to be in S4 („Operational“)
- Operation mode needs to be „Position mode“
- Standard telegram 7 needs to be configured
- Axis needs to be homed (ZSW1 Bit 11 set, See also "Status word bits" on page 27)
- Motion task needs to be configured

Start a motion task:

- Set SATZANW to the motion task number, which shall be started
- Set STW1 Bit 4 and 5 to true (Do not reject traversing task and no intermediate stop)
- Set STW1 Bit 6 from zero to one, the motion task will be activated
- ZSW1 Bit 13 will be set to one when the drive is moving
- after the target position is reached, ZSW 1 Bit 10 is set

Abort or error in executing motion task:

- If the following error is not in tolerance range, ZSW1 Bit 8 is set
- For braking with ramp and reject current running motion task, STW1 Bit 4 must be set to false
- For make an intermediate stop, STW1 bit 5 must be set to false

Warning or Fault handling:

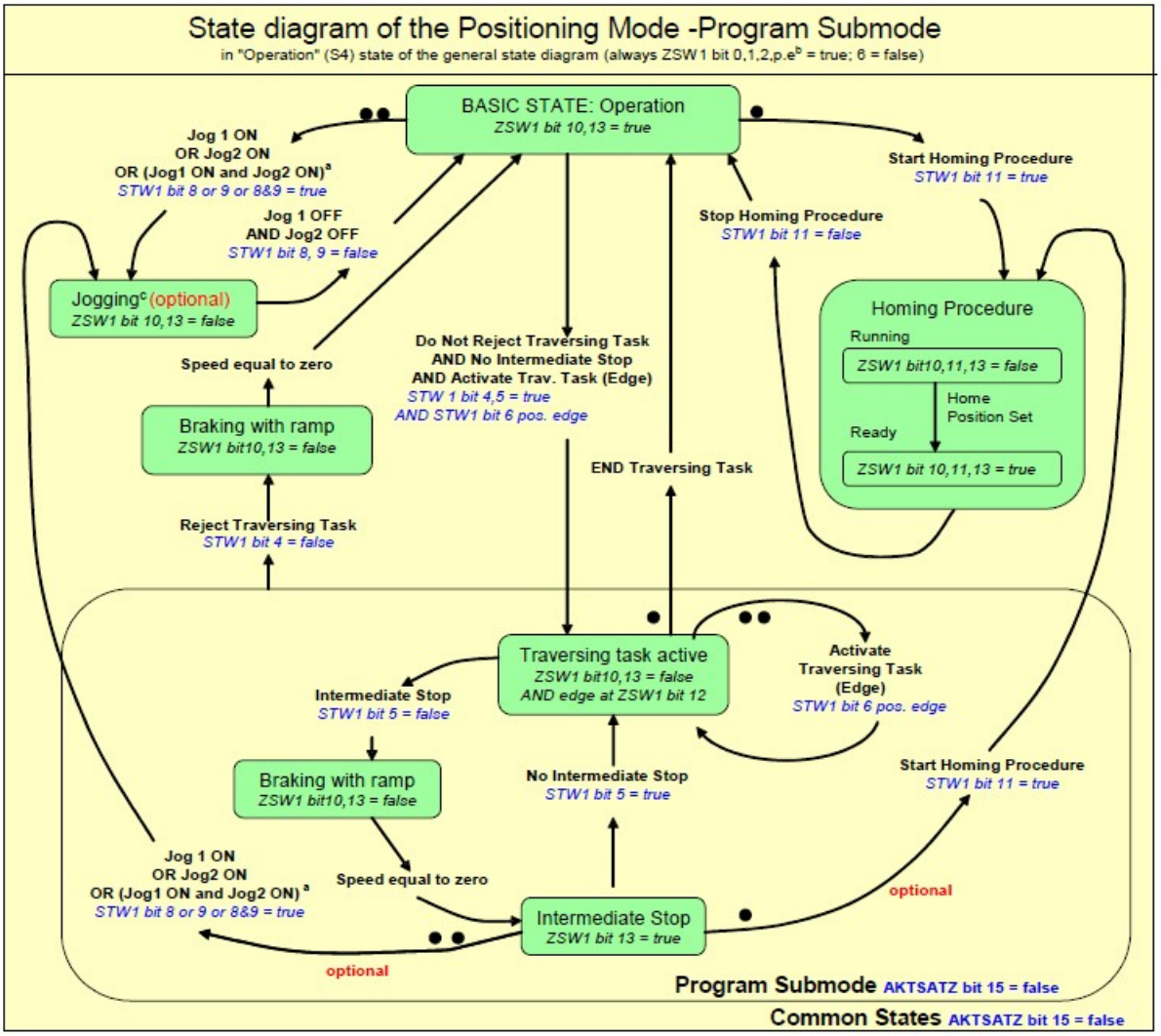
- case of warning, ZSW1 Bit 7 is set (See also "Status word bits" on page 27)
- case of fault, ZSW1 Bit 3 is set (See also "Status word bits" on page 27)

The figure on the next page shows the extension of the general state diagram of DO. The Jog functionality is not supported. The homing procedure can be achieved through bit STW1 Bit 11 (See also "Homing" on page 33).After an intermediate stop, the motion task can be activated again through STW1 Bit 5 set.

If the general state machine of the DO is in “Operational” and the standard telegram 7 is used to configure a motion task, the following sequence can be used to start a motion task:

- Configure a motion task
- Change the general state machine to S4 (Drive is enabled)
- Set SATZANW to the motion task number, which needs to be started
- Used STW1 Bit 4,5 and 6 to start the motiontask. BIT 6 needs to be an edge

The extension of the general state diagram of DO:



5.9.2 Submode „Manual data input (MDI)“

The "manual data input" mode can be used to run a motion task directly configured through IO data. Telegram 9 is used for this purpose and defines the motion task specific signals like acceleration (MID_ACC), deceleration (MID_DEC), velocity (MDI_VEL) and target position (MDI_TAR_POS). With setting bit 15 in signal “SAT-ZANW”, the MDI mode can be activated.

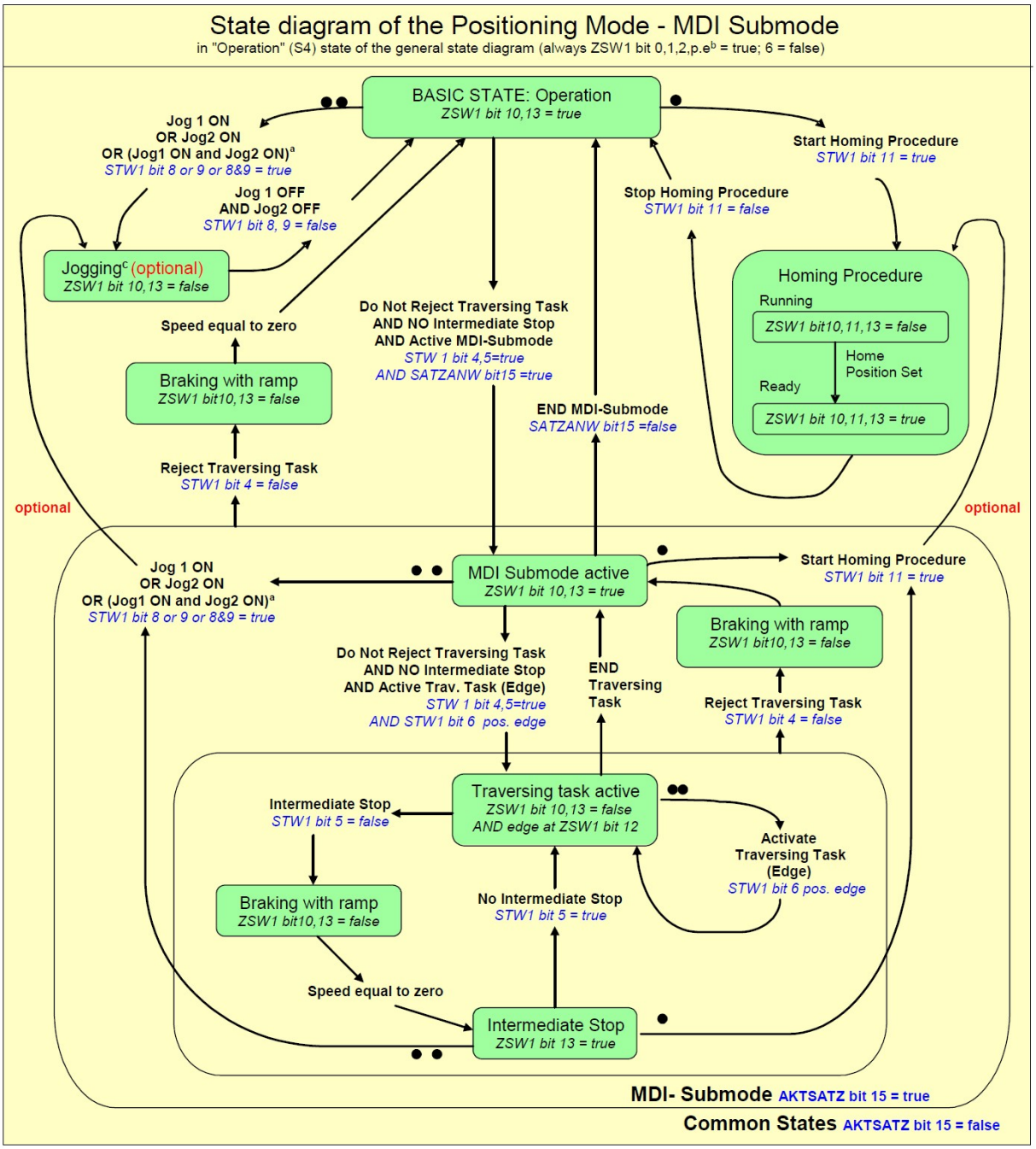
Requirements:

- Drive axis state machine needs to be in S4 („Operational“)
- Operation mode needs to be „Position mode“
- Standard telegram 9 needs to be configured
- Axis needs to be homed (ZSW1 Bit 11 set, See also "Status word bits" on page 28)

Run a motion task:

- Set bit 15 in SATZANW to 1
- Configure all setpoint value in telegram 9 like MDI_ACC, MDI_DEC, MDI_MOD etc..
- Set STW1 Bit 4 and 5 to true (Do not reject traversing task and no intermediate stop)
- Set STW1 Bit 6 from zero to one, the motion task will be activated
- ZSW1 Bit 13 will be set to one when the drive is moving after the target position is reached, ZSW 1 Bit 10 is set

The extension of the state diagram for mdi mode:



5.9.3 Homing

Requirements:

- Drive axis state machine needs to be in S4 („Operational“)
- The appropriate homing mode needs to be configured via HOME.MODE 1001(available also via PNU 1001).
- No motion task is active
- Operation mode needs to be „Position mode“

Home procedure:

- STW1 Bit 11 set to one
- ZSW1 Bit 10, 11 ,13 will be set to false if homing is running
- ZSW1 Bit 10,11,13 will be set to true if homing is finished

Abort homing:

- while the homing is running, clear STW1 Bit 11

If the controller aborts a running home procedure, the home position set flag (ZSW1 Bit 11) remains cleared.

Warning or Fault handling:

- case of warning, ZSW1 Bit 7 is set
- case of fault, ZSW1 Bit 3 is set

Mapping to AKD specific commands:

An activation of the homing procedure via STW1 Bit 11 corresponds to the AKD specific command HOME.SET. When the homing procedure is finished, the AKD set the bits 2 and bit 4 in DRV.MOTIONSTAT. „Only“ if these two bits are set, the PROFIdrive specific homing flag ZSW1 Bit 11 (home position) is set.

5.10 I/O Telegrams

5.10.1 Telegram 0

Telegram 0 is used for the free mapping of PROFIdrive signals into the PROFINET I/O data. With PNU 922 the telegram can be configured. PNU915 defines then set point signals and PNU the actual value signals.

Limitations: The number and kind of signals, which can be mapped, are depending on the configuration of your PROFINET master. The length for input and output values in the IO communication is given through telegram configuration in slot 1.

5.10.2 Standard telegram 1

Typically used for application class 1 (velocity mode). The set point velocity value can be directly controlled by an PROFINET master.

IO Data Number	Set point	Actual values
1	STW1	ZSW1
2	NSOLL_A	NIST_A

5.10.3 Standard telegram 7

Typically used for application class 3 (position mode). Predefined motion tasks can be selected directly via IO data.

IO Data Number	Set point	Actual values
1	STW1	ZSW1
2	SATZANW	AKTSATZ

5.10.4 Standard telegram 9

Typically used for application class 3 (position mode). A motion task can be directly configured via IO data.

IO Data Number	Set point	Actual values
1	STW1	ZSW1
2	SATZANW	AKTSATZ
3	STW2	ZSW2
4	MDI_TARPOS	
5		
6	MDI_VELOCITY	
7		
8	MDI_ACC	
9	MDI_DEC	
10	MDI_MOD	

5.10.5 Manufacturer specific telegram 350

Telegram 350 is typically used for application class 1 (velocity mode). Additonally to telegram 1 the actual current value can be monitored in the IO data.

IO Data number	set point	Actual values
1	STW1	ZSW1
2	NSOLL_A	NIST_A
3		ITIST_GLATT

5.11 Units

5.11.1 Velocity units

Velocity units are normalized according to X2 data normalization of PROFIdrive (hence "set normalization bit x" => 2^x = 100% velocity).

In velocity mode:
The AKD uses x=15 and 100% is the maximum velocity of the AKD hence 12000 rpm.
Thus the velocity units are 2^15 = 12000 rpm.

E.g. if the S7 wants to set a velocity of 60 rpm in the cyclic channel in needs to convert:

(60 / 12000) * 2^15 = 163

In position mode:
For signal MDI_VELOCITY x = 32 and 100% is the maximum velocity of the AKD hence 12000 rpm.
Thus a value of 2^32 for MDI_VELOCITY is equal 12000 rpm.

5.11.2 Position Units

The signal MDI_TARPOS a 32 signed position value. In the default configuration, the resolution per revolution is 2^16 (65536) counts. The number of singleturn bits (default 16) can be changed through PNU 1002.

5.11.3 Acc-/Deceleration Units:

The acceleration signal MDI_ACC and MDI_DEC are normalized in the X2 format. (x = 16 is equal to 100% and means 50000000 rpm /sec^2.)

5.11.4 Current units

Current units are normalized according to N2 data normalization of PROFIdrive (2^14 = 100%).

The AKD's 100% is the maximum current of the AKD hence DRV.IPEAK.

Thus current units are 2^14 = DRV.IPEAK.

E.g. for 3 amps AKD, if the S7 reads a current value of -182 Arms in the cyclic channel from the AKD, it will need to execute the following conversion:

(9 / 2^14) * (-182) = -0.1 Arms

5.12 Alarms

Not implemented yet.

6 Sample Projects

6.1 Sample S7 Project

6.1.1 Introduction

On our website www.kollmorgen.com, you can find an STEP 7 sample project which provides a PROFINET network with an IO-controller and the AKD as IO-device.

The sample project can help you to learn:

- how to enable the drive
- how to write/read a parameter via the acyclic channel
- how the cyclic data exchange is done

The sample project is based on a CPU-315 controller, which easily can be changed to another PROFINET supporting controller.

NOTE	**KOLLMORGEN does not take care for correctness of this example project.**

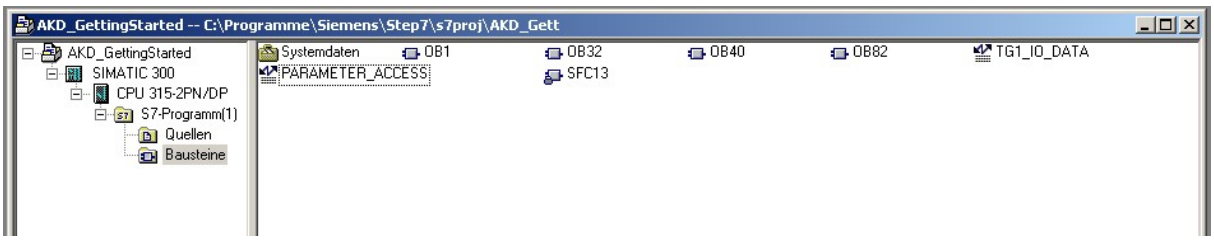
6.1.2 Project description

You will find in the STEP 7 program three organization blocks that need to be implemented.

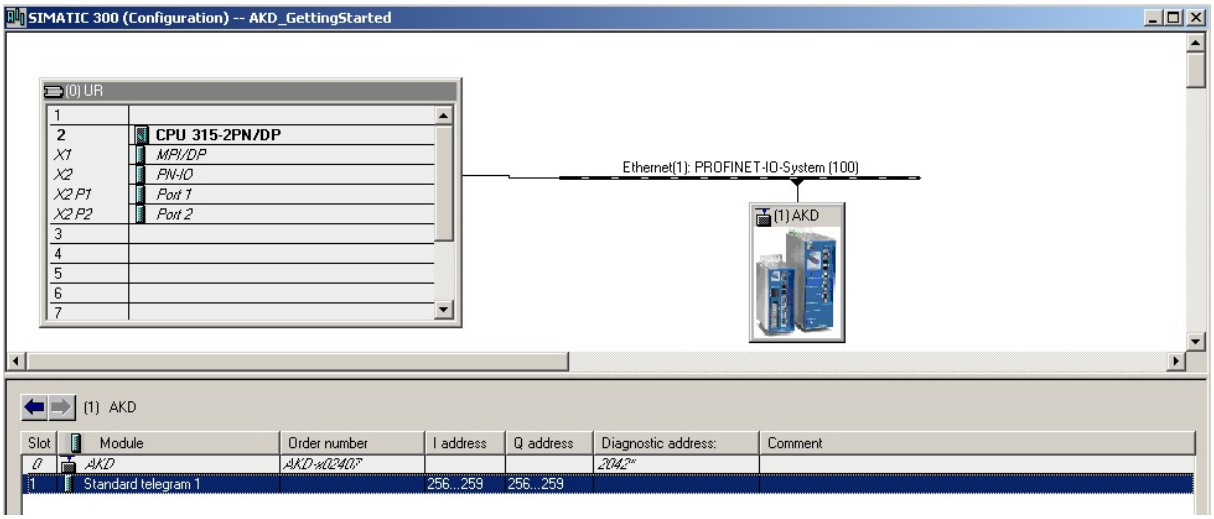
- OB1, which is used for the main program and is a cyclic process.
- OB40, which is used for any process alarm (needs to be implemented the CPU from STOP to RUN).
- OB82, which catches the diagnostic alarms.

Two variable tables are included

- TG1_IO_DATA can be used to control easily the IO data between the plc and the AKD
- PARAMETER_ACCESS table is used for read/write PNU's via PROFINET



In the hardware manager, you can see the following setup :



6.1.3 Getting started

1. To use this example project, open the SIMATIC manager and retrieve the project zip file (SimaticManager->File->Retrieve).
2. After the project is loaded, go to the hardware manager and check the communication setup. If no AKD GSDML file is installed, the hardware manager will install it from the project. If there is already an installation of the GSDML file, this step is not required.
3. Check the communication setup for your system in the hardware manager and adapt it to your settings. **The initial setup for AKD is a static IP Address and an IO cycle time of 128 ms. Change the IP addresses for AKD and the PLC to your specific setup.**
4. Verify the hardware configuration in the hardware manager and click the “save and compile” button in your configuration.
   Verify the process-image input and output area of your plc and verify that is greater than 256 byte or change the input/output start address the AKD telegram you choose. By default, the input is copied to start address 256 and the output to start address 256.
5. In this example, the AKD shall be used in velocity mode. Therefore the “Standard Telegram 1” (PROFIdrive) is chosen. The signals control word, speed set point as well as status word and speed actual value are mapped to the IO-Data.
   The AKD has to be set to DRV.OPMODE 1 for this operation.

.

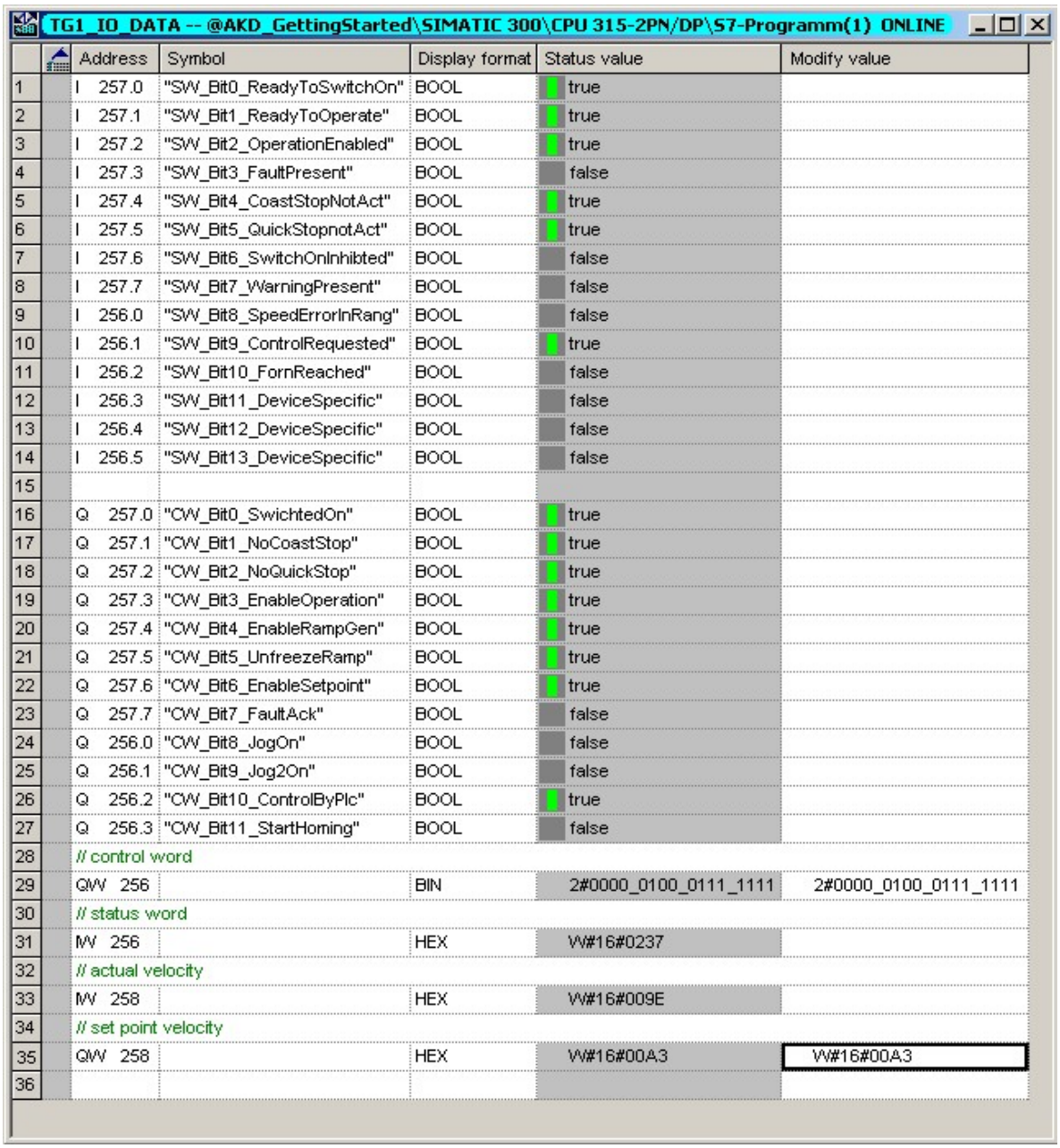
6.1.4 Enable the drive and run in velocity mode

The general state machine of the PROFIdrive (see chapter XX) needs to be toggled to enable the drive. You can find in the variable table “TG1_IO_DATA” all necessary input and output parameters described bit-wise.

To enable the drive, write the following sequence in the control world:

1. QW 2#0000_0100_0000_0000 -> Remote control over field bus
2. QW 2#0000_0100_0000_0110 -> Go to S2 (Switch on inhibited)
3. QW 2#0000_0100_0000_1110 -> Go to S3 (Switched on)
4. QW 2#0000_0100_0000_1111 -> Go to S4 (Operational)

The drive is enabled, if the corresponding bits in the status word are set. TIP: If WorkBench is connected, you will see the drive is enabled.



TG1_IO_DATA -- @AKD_GettingStarted\SIMATIC 300\CPU 315-2PN/DP\S7-Programm(1) ONLINE

	Address	Symbol	Display format	Status value	Modify value
1	I 257.0	"SW_Bit0_ReadyToSwitchOn"	BOOL	true	
2	I 257.1	"SW_Bit1_ReadyToOperate"	BOOL	true	
3	I 257.2	"SW_Bit2_OperationEnabled"	BOOL	true	
4	I 257.3	"SW_Bit3_FaultPresent"	BOOL	false	
5	I 257.4	"SW_Bit4_CoastStopNotAct"	BOOL	true	
6	I 257.5	"SW_Bit5_QuickStopnotAct"	BOOL	true	
7	I 257.6	"SW_Bit6_SwitchOnInhibted"	BOOL	false	
8	I 257.7	"SW_Bit7_WarningPresent"	BOOL	false	
9	I 256.0	"SW_Bit8_SpeedErrorInRang"	BOOL	false	
10	I 256.1	"SW_Bit9_ControlRequested"	BOOL	true	
11	I 256.2	"SW_Bit10_FornReached"	BOOL	false	
12	I 256.3	"SW_Bit11_DeviceSpecific"	BOOL	false	
13	I 256.4	"SW_Bit12_DeviceSpecific"	BOOL	false	
14	I 256.5	"SW_Bit13_DeviceSpecific"	BOOL	false	
15					
16	Q 257.0	"CW_Bit0_SwichtedOn"	BOOL	true	
17	Q 257.1	"CW_Bit1_NoCoastStop"	BOOL	true	
18	Q 257.2	"CW_Bit2_NoQuickStop"	BOOL	true	
19	Q 257.3	"CW_Bit3_EnableOperation"	BOOL	true	
20	Q 257.4	"CW_Bit4_EnableRampGen"	BOOL	true	
21	Q 257.5	"CW_Bit5_UnfreezeRamp"	BOOL	true	
22	Q 257.6	"CW_Bit6_EnableSetpoint"	BOOL	true	
23	Q 257.7	"CW_Bit7_FaultAck"	BOOL	false	
24	Q 256.0	"CW_Bit8_JogOn"	BOOL	false	
25	Q 256.1	"CW_Bit9_Jog2On"	BOOL	false	
26	Q 256.2	"CW_Bit10_ControlByPlc"	BOOL	true	
27	Q 256.3	"CW_Bit11_StartHoming"	BOOL	false	
28	// control word				
29	QW 256		BIN	2#0000_0100_0111_1111	2#0000_0100_0111_1111
30	// status word				
31	IW 256		HEX	W#16#0237	
32	// actual velocity				
33	IW 258		HEX	W#16#009E	
34	// set point velocity				
35	QW 258		HEX	W#16#00A3	W#16#00A3
36					

Now the set point velocity can be set. In the example (see variable table) the value is QW 258 is 0xA3 (60 rpm (see units)).
To start the motion, set Bit 4, 5 and 6 (enable ramp generator, unfreeze ramp generator and enable new set point).

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