Servo Controller
SE-24

- **EtherCAT Manual**

Complementary document to the Operating Instructions

This manual is a complementary document to the operating instructions and applies to:

Type	Order No.
SE-24 EtherCAT	50315436

Assembly and initial start-up may be carried out by qualified personnel only and according to these operating instructions.

Version of this documentation: SE-24-EtherCAT-Manual vers. 1.3 en. 12.08.2014

⚠ CAUTION	
	As this manual is a complementary document to the operating instructions it alone is not sufficient to carry out installation and commissioning of the device. Please pay attention to the notes in *1.1 Documentation*

Symbols:

DANGER	
	**Indicates imminent danger.** **Disregard of this information can result in death or serious personal injuries (invalidity).**

WARNING	
	Indicates a possible dangerous situation. Disregard of this information can result in death or serious personal injuries (invalidity).

CAUTION	
	Indicates a possibly dangerous situation. Disregard of this information can result in damage to property or light to medium personal injuries.

NOTE	
	Indicates general notes, useful operator tips and operating recommendations which don't affect safety and health of the personnel.

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Table of Contents

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1 General

1.1 Documentation

For the Servo Controllers of the SE-24 series are considerably documentations available. There are main documents and complementary documents.

The documents contain safety instructions that must be followed

Main document:

present	documentation / description
☐	▪ **SE-24 Operating Manual** Description of the technical data and the functions of the device as well as notes on the plug assignment, installation and operation of the SE-24 servo controller. It is meant for persons who want to get familiar with the SE-24 servo controller.

⚠ CAUTION	
	**The operating manual is the main document and must be read by all means before installation and start-up of all devices of the SE-24 series independent of the respective model.**

Complementary documents to the operating manual:

present	documentation / description
☐	▪ **SE-24 Software Manual** Description of the “afagTools” parameterization program.
☐	▪ **SE-24 IO Manual** Description of the I/O control of the SE-24 servo controller.
☐	▪ **SE-24 Profibus Manual** Description of the fieldbus control of the SE-24 servo controller under PROFIBUS-DP.
☐	▪ **SE-24 programming example Siemens S7 V5.5** Description to the programming example for Siemens S7 V5.5.
☐	▪ **SE-24 programming example Siemens TIA V12.0** Description to the programming example for Siemens TIA V12.0.

☒	▪ **SE-24 EtherCAT Manual** Description of the fieldbus control of the SE-24 servo controller under EtherCAT.
☐	▪ **SE-24 programming example Beckhoff TwinCAT 2** Description to the programming example for Beckhoff TwinCAT 2.
☐	▪ **SE-24 CANopen Manual** Description of the fieldbus control of the SE-24 servo controller under CANopen.

These documents are available for download on our homepage:

www.afag.com

2 Safety instructions

⚠ CAUTION	
	**The safety instructions in the operating manual must be followed.** **The operating manual is the main document and must be read by all means before installation and start-up of all devices of the SE-24 series independent of the respective model.**

3 EtherCAT

3.1 System overview

EtherCAT is a fieldbus system based on Ethernet which sets new speed standards and is to operate like a fieldbus thanks to its flexible topology (line, tree, star) and simple configuration.

The EtherCAT protocol is transmitted with a special standardized Ethernet type directly in the Ethernet frame according to IEEE802.3. Broadcast, Multicast and cross-communication between the slaves are possible.

With EtherCAT data exchange is based on a mere hardware machine. Therefore a special hardware is used on the slave-side which processes the Ethernet telegram according to the EtherCAT protocol. These hardware protocol interpreters are offered either in form of an ASIC (Application Specific Integrated Circuit) or an FPGA (Field Programmable Gate Array) with the corresponding software.

3.2 Specifications

Description	EtherCAT
Physical layer	100 Base-Tx EtherCAT
Baud rate	100Mbit/s
Cable type	CAT5
Cable length	max. 100m
Supported communication protocol	CoE (CANopen over EtherCAT)

3.3 Protocol

The EtherCAT fieldbus system exclusively defines a new protocol for the transmission layer. Is does not define an own user or device protocol. EtherCAT is able to transmit different existing and proven user and device protocols via the EtherCAT protocol (tunnelling).

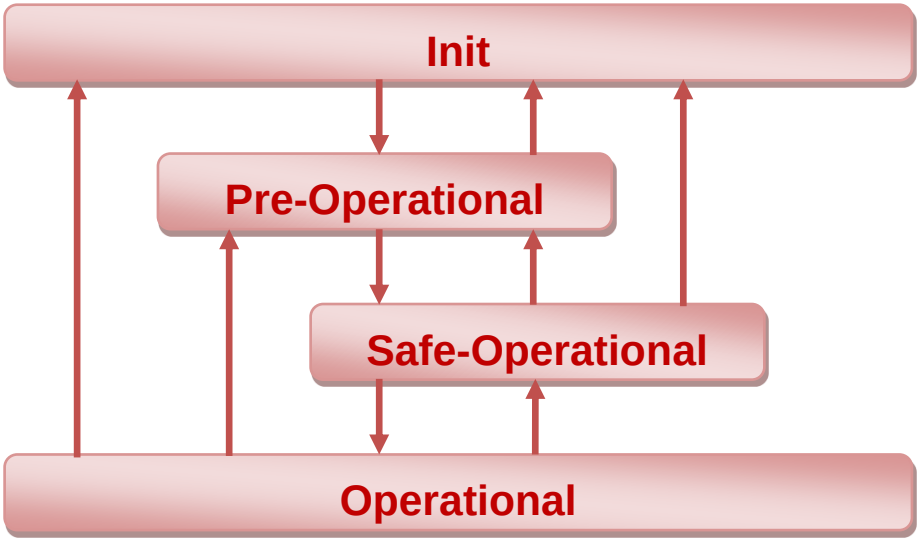
One of these existing protocols is the CANopen protocol which is supported as **CoE (CANopen over EtherCAT)** by EtherCAT and is used in the SE-24 EtherCAT.

3.4 EtherCAT state machine (ESM)

As with nearly all fieldbus connections for servo positioning controllers the connected slave (here the SE-24 EtherCAT servo positioning controller) must first be initialized by the master before it can be used by the master in an application. For this purpose a state machine is specified for the communication which defines a fixed procedure for such an initialization.

Such a state machine is also defined for the EtherCAT interface. Changes between the different conditions of the state machine may only occur between certain conditions and are always initiated by the master. A slave may not change the condition.

Only the following transitions are permitted between the individual conditions of the EtherCAT state machine.



The active functions of each condition are listed in the following table:

State	Services
Init	The EtherCAT fieldbus is synchronized by the master. This also comprises setting of the asynchronous communication between master and slave (mailbox telegram protocol). There is not yet a direct communcation between master and slave. Configuration starts and saved values are loaded. After all devices which are connected to the bus have been configured the system changes to the “Pre-Operational” state.
Pre-Operational	Asynchronous communication between master and slave is active. The master uses this state to set-up a possibly cyclic communication via PDOs and to configure the necessary parameters via the acyclic communication. The master changes to the “Safe-Operational” state after this state was terminated without faults.
Safe-Operational	In this state all devices which are connected to EtherCAT are set in a safe condition. The slave sends the current actual values to the master but ignores new target values from the master and uses safe default values instead. The master changes to the “Operational” state after this state was terminated without faults.
Operational	Acyclic and cyclic communication are active in this state. Master and slave exchange the target and actual values. The SE-24 can be released via the CoE protocol and traversed.

3.5 Documentation about EtherCAT

The EtherCAT fieldbus system means “Ethernet for Controller and Automation Technology“ and was developed by the company Beckhoff Industrie. It is served and supported by the international organisation EtherCAT Technology Group (ETG) and is designed as an open technology which is standardized by the International Electrotechnical Commission (IEC).

Further information, contact addresses etc. can be found at **www.ethercat.org**.

4 Wiring and pin assignment

4.1 Pin assignment

The EtherCAT is connected to the SE-24 servo controller via two d-coded 5 pole M12 sockets.

4.1.1 EtherCAT IN [X2d]

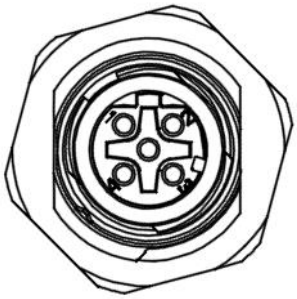


Figure 1: View of the connection [X2d]

X2d, EtherCAT IN		
Flush-type socket, 5 pole M12, d-coded Phoenix: 1419616 SACC-DSI-M12FSD-4CON-M16/0,5		
Pin	**Designation**	**Specification**
1	Tx+	Transmission data +
2	Rx+	Received data +
3	Tx-	Transmission data -
4	Rx-	Received data -
5	n.c.	

4.1.2 EtherCAT OUT [X3d]

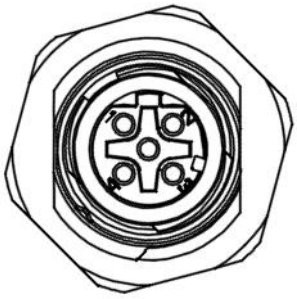


Figure 2: View of the connection [X3d]

X3d, EtherCAT OUT		
Flush-type socket, 5 pole M12, d-coded Phoenix: 1419616 SACC-DSI-M12FSD-4CON-M16/0,5		
Pin	**Designation**	**Specification**
1	Tx+	Transmission data +
2	Rx+	Received data +
3	Tx-	Transmission data -
4	Rx-	Received data -
5	n.c.	

NOTE	
	EtherCAT cabling When constructing the EtherCAT network, follow the advice of the current literature or the following information and instructions without fail, to get a stable and fault-free system. In case of cabling not having been done properly, faults can occur on the EtherCAT during operation, which can result in the servo controller getting switched off with an error message, for reasons of safety.

4.2 Bus cable for EtherCAT

Only use Ethernet cables to connect EtherCAT devices which comply at least with category 5 (Cat5) according to EN 50173 or ISO/IEC 11801. EtherCAT uses 4 leads of the cable for signal transmission.

The following cables of the company Beckhoff should be used for the EtherCAT connection:

EtherCAT cable M12 plug, straight, d-coded, 4 pole M12 plug, straight, d-coded, 4 pole

Beckhoff EtherCAT cable

EtherCAT cable	Order No.	Length in m
	ZK1090-6161-0005	0,5
	ZK1090-6161-0020	2
	ZK1090-6161-0025	2.5
	ZK1090-6161-0050	5
	ZK1090-6161-0100	10

5 EtherCAT connection

5.1 Introduction

Data is transmitted via the **CoE (CANopen over EtherCAT)** protocol. The data is assigned fixed on the slave (in this case the SE-24). Therefore, only the number of data to be transmitted and their assignment must be defined on the master side.

5.2 Baud rate

The SE-24 servo controller automatically detects the baud rate of the Profibus communication and supports speeds up to **max. 100Mbit/s**.

5.3 Control

Two registers are required for operation of the SE-24: the status register which contains the ACTUAL values of the drive, and the control register where the TARGET values are entered.

The signals are described and specified on the following pages.

5.3.1 Status register (actual values)

5.3.1.1 Signal description of the output data of the SE-24 servo controller

Object		Description
ready	*BOOL*	This signal is set when the drive is ready-to-operate and can be energized. If there is a fault in the drive this signal and the signal “drive_enable_ok“ will be reset. The signal “ready” is only set after the error was acknowledged by resetting the signal “drive_enable/fault_res“.
drive_enable_ok	*BOOL*	Power output stage and control are active.
ref_valid	*BOOL*	This signal is set when a valid reference position exists. The signal is not set during an ongoing reference movement. It is set for the first time or once again only after a successfully executed reference movement.
move_ok	*BOOL*	This bit is set depending on the traverse mode. In position mode the signal is set when the actual position is within the position window for a longer time than the set delay time. In current mode the bit is set when the actual current value is within the current value window for a longer time than the set delay time. **Important:** The signal is reset when the signal “start_move” is set. This however happens with a certain delay. Therefore it should be noted that the signal “move_ok” must first be queried for LOW and afterwards for HIGH after a run was started with the signal “start_move”.
error_no	*INT16*	Display of the error which has occurred.
position_value [µm] [°/1000]	*INT32*	Actual position
current_value [mA]	*INT32*	Actual motor current

5.3.1.2 Output telegram of the SE-24 servo controller

TX PDO 1 (2 Byte)															
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ready	drive_enable_ok	ref_valid	move_ok												

TX PDO 2 (2 Byte)															
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
error_nr (16bit)															

TX PDO 3 (4 Byte)																											
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
position_value (µm, °/1000, 32bit)																															

TX PDO 4 (4 Byte)																															
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
current_value (mA, 32bit)																															

5.3.2 Control register (target values)

5.3.2.1 Signal description of the input data of the SE-24 servo controller

Object		Description
drive_enable / fault_res	*BOOL*	This signal is assigned twice. Controller release = Hi-active / Error acknowledgement = Lo-active LOW => Motor is not energized, errors are acknowledged. Change 0=>1, if there is no error the motor will be energized during a change from LOW to HIGH and remains controlled until an error occurs or the signal is set to LOW. If this input is only set for the first time after a restart the offset angle of the commutation position will be defined (only for motors **without** Hall-effect probe). Change 1=>0, if there is an error the controller tries to acknowledge the pending errors. This is only possible after the cause for the error was rectified.
start/stop_ref	*BOOL*	A rising edge causes a reference run to be executed. A falling edge aborts the reference run. The sequence is as follows: Setting of the signal “drive_enable/fault_res”, wait until the signal “drive_enable_ok” is at HIGH. Then set the signal “start/stop_ref”, the reference run is executed. Wait until the signal “ref_ok” is at HIGH, the reference run is terminated. The controller is now ready for positioning.
start/stop_move	*BOOL*	A rising edge signals that a new movement order should be undertaken and started. In case of a falling edge the SE-24 is stopped quickly. This input has no influence during a reference run. Precondition is however that no error is pending, that controller release is active and a successful reference run was carried out, i.e. the outputs “ready”, “drive_enable_ok” and “ref_valid” must be set.
mode	*BOOL*	Operating mode: position / current mode LOW = position controller mode HIGH = current controller mode
pos_nr	*INT4*	Position set (binary) which should be approached. The position sets (1-15) are preconfigured with the tool window “Positioning sets” in the “Manual operation" tool of the “afag Tools” parameterization software. **Caution: When the movement is made using the position sets, the values of the „mode“, „move_relative“, „target_position“, „velocity“, „deceleration“, „acceleration“ and „target_current“ objects are ignored.**

jog_pos		*BOOL*	When the input is set the drive accelerates with the acceleration set for the Jog mode to a pre-parameterized positive movement speed. In case of a falling edge at this input, the drive brakes to a standstill with the deceleration set for the quick-stop. This input has no effect during the reference-, position or current run.
jog_neg		*BOOL*	When the input is set the drive accelerates with the acceleration set for the Jog mode to a pre-parameterized negative movement speed. In case of a falling edge at this input, the drive brakes to a standstill with the deceleration set for the quick-stop. This input has no effect during the reference-, position or current run.
move_relativ		*BOOL*	Change from absolute to relative. LOW=absolute, HIGH=relative
target_position	**[µm]** **[°/1000]**	*INT32*	Target position The position target value is interpreted as an absolute or relative position depending on the signal “move_relative”.
velocity	**[mm/s]** **[°/s]**	*INT16*	Target movement speed
deceleration	**[mm/s^2]** **[°/s^2]**	*INT16*	Target deceleration
acceleration	**[mm/s^2]** **[°/s^2]**	*INT16*	Target acceleration
target_current	**[%]**	*INT16*	Target current The moment target value is determined by the higher level control system (in % of the positive current limiting). It defines the moment with which the drive should move.

5.3.2.2 Input telegram of the SE-24 servo controller

RX PDO 1 (2 Byte)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
drive_enable / fault_res	start/stop_ref	start/stop_move	mode	pos_nr_bit0	pos_nr_bit1	pos_nr_bit2	pos_nr_bit3	jog_pos	jog_neg	move_relative					

RX PDO 2 (4 Byte)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
target_position (µm, °/1000, 32bit)																															

RX PDO 3 (2 Byte)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
velocity (mm/s, °/s 16bit)															

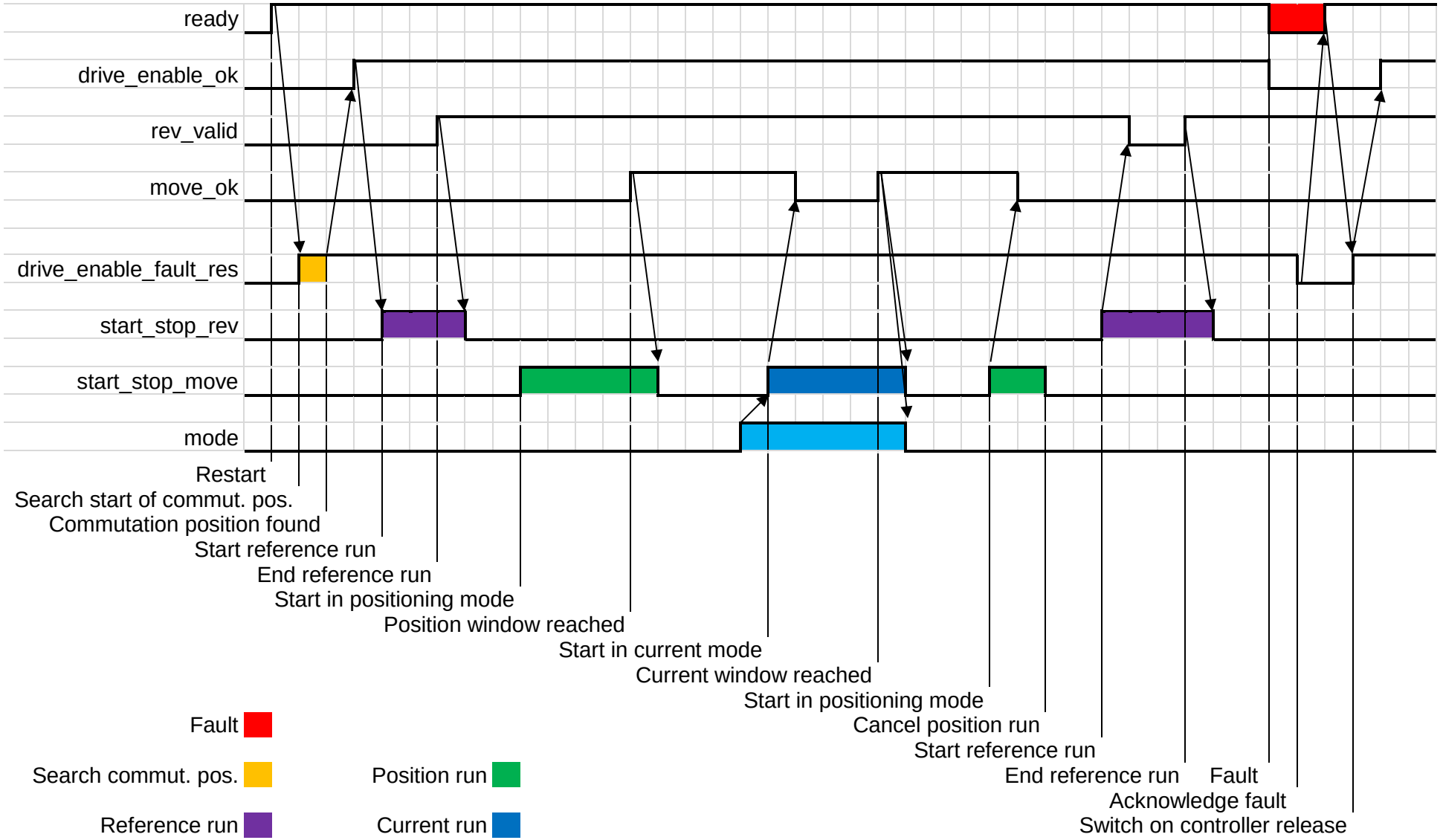
RX PDO 4 (4 Byte)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
deceleration (mm/s^2, °/s^2, 16bit)																acceleration (mm/s^2, °/s^2, 16bit)															

RX PDO 5 (2 Byte)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
target_current (%, 16bit)															

6 Signal diagram



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