

AXL E EC DI16 M12 6P

**Axioline E EtherCAT® device, plastic housing,
16 inputs, 24 V DC,
M12 fast connection technology**



Data sheet
8541_en_03

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1 Description

The Axioline E device is designed for use within an EtherCAT® network.

It is used to acquire digital signals.

EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

Abbreviations used

- CoE: CAN application layer over EtherCAT®
- DC: distributed clocks
- FoE: file access over EtherCAT®

EtherCAT® features

- 2 Ethernet-Ports
- Automatic addressing
- Identification:
 - Rotary coding switch for assigning the ID for the "Explicit Device ID" mechanism
 - Configured Second Station Alias

- Hot Connect
- Acyclic data communication (CoE and FoE mailbox protocols)
- Supports the EtherCAT® cycle time of min. 100 µs
- Supports distributed clocks (jitter << 1 µs)
- Specification: ETG.1000 V1.02
- Device description by means of ESI
- Firmware can be updated

Axioline E features

- Connection to EtherCAT® network using M12 connectors (D-coded)
- Transmission speed 100 Mbps
- Connection of digital sensors using M12 connectors (A-coded)
- Diagnostic and status indicators
- Short-circuit and overload protection of the sensor supply
- IP65/67 degree of protection



This data sheet is only valid in association with the associated user manual.



Make sure you always use the latest documentation.
It can be downloaded from the product at phoenixcontact.net/products.

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3 Ordering data

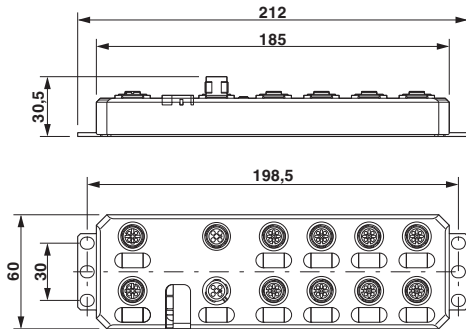
| Description | Type | Order No. | Pcs. / Pkt. |
|--|-----------------------------------|-----------|-------------|
| Axioline E-EtherCAT® device in a plastic housing with 16 digital inputs, 24 V DC, M12 fast connection technology | AXL E EC DI16 M12 6P | 2701521 | 1 |
| Accessories | Type | Order No. | Pcs. / Pkt. |
| An M12 screw plug for the unoccupied M12 sockets of the sensor/actuator cable, boxes and flush-type connectors (Protection and sealing elements) | PROT-M12 | 1680539 | 5 |
| Snap-in markers, Sheet, white, unlabeled, can be labeled with: THERMOMARK CARD, BLUEMARK CLED, BLUEMARK LED, TOPMARK LASER, Mounting type: snapped into marker carrier, Lettering field: 7 x 10 mm (Marking) | UCT-EM (7X10) | 0830765 | 10 |
| Documentation | Type | Order No. | Pcs. / Pkt. |
| User manual, English: Axioline E: system and installation | UM EN AXL E SYS INST | - | - |
| Application note, English: Updating the firmware of Axioline E-EtherCAT® devices with TwinCAT® | AH EN FIRMWARE UPDATE AXL E EC | - | - |

Additional ordering data

For additional accessories, visit phoenixcontact.net/products.

4 Technical data

Dimensions (nominal sizes in mm)



| | |
|--------------------|--|
| Width | 60 mm |
| Height | 185 mm |
| Depth | 30.5 mm |
| Note on dimensions | The height is 212 mm including fixing clips. |

General data

| | |
|---------------------------------|------------------|
| Housing material | Pocan® |
| Color | anthracite |
| Weight | 480 g |
| Ambient temperature (operation) | -25 °C ... 60 °C |



CAUTION: Risk of burns

If the device is used at an ambient temperature above 50°C, the contact temperature of metal surfaces may exceed 70°C.

| | |
|--|---|
| Ambient temperature (storage/transport) | -25 °C ... 85 °C |
| Permissible humidity (operation) | 5 % ... 95 % |
| Permissible humidity (storage/transport) | 5 % ... 95 % |
| Air pressure (operation) | 70 kPa ... 106 kPa (up to 3000 m above sea level) |
| Air pressure (storage/transport) | 70 kPa ... 106 kPa (up to 3000 m above sea level) |
| Degree of protection | IP65/IP67 |
| Protection class | III, IEC 61140, EN 61140, VDE 0140-1 |

Connection data

| | |
|-------------------|---------------|
| Connection method | M12 connector |
|-------------------|---------------|

Interface EtherCAT®

| | |
|------------------------------|-----------------------------------|
| Number | 2 |
| Connection method | M12 connectors, D-coded |
| Designation connection point | Copper cable |
| Number of positions | 4 |
| Transmission speed | 100 MBit/s (with autonegotiation) |
| Cycle Time | < 100 µs |

EtherCAT®

| | |
|--------------------|--|
| Equipment type | EtherCAT® slave |
| Mailbox protocols | CANopen® over EtherCAT®, File access over EtherCAT® |
| Type of addressing | Auto-increment addressing Fixed position addressing Logical addressing |
| Specification | ETG.1000 V1.02 |

Supply: Module electronics and sensors (U_S)

| | |
|------------------------------|--|
| Connection method | M12 connector (T-coded) |
| Number of positions | 4 |
| Supply voltage | 24 V DC |
| Nominal supply voltage range | 18 V DC ... 31.2 V DC (including all tolerances, including ripple) |
| Typical current consumption | 190 mA ±15 % (at 24 V DC) |
| Current consumption | max. 12 A |

Supply: Actuators (U_A) for additional devices

| | |
|------------------------------|--|
| Connection method | M12 connector (T-coded) |
| Number of positions | 4 |
| Supply voltage | 24 V DC |
| Nominal supply voltage range | 18 V DC ... 31.2 V DC (including all tolerances, including ripple) |
| Typical current consumption | 3 mA ±15 % (at 24 V DC) |
| Current consumption | max. 12 A |

Digital inputs

| | |
|--|-------------------------------------|
| Number of inputs | 16 (EN 61131-2 types 1 and 3) |
| Connection method | M12 connector, double occupancy |
| Connection method | 2, 3, 4-wire |
| Nominal input voltage | 24 V DC |
| Nominal input current | typ. 3 A |
| Sensor current per channel | typ. 0.75 mA (from U _S) |
| Total sensor current | max. 1.2 A (per device) |
| Input voltage range "0" signal | -30 V DC ... 5 V DC |
| Input voltage range "1" signal | 11 V DC ... 30 V DC |
| Input filter time | < 1000 µs |
| Permissible conductor length to the sensor | 30 m |
| Overload protection, short-circuit protection of sensor supply | Yes |

Electrical isolation/isolation of the voltage areas

| Test section | Test voltage |
|--|------------------------|
| 24 V supply (communications power and sensor supply, digital inputs)/ bus connection (Ethernet 1) | 500 V AC, 50 Hz, 1 min |
| 24 V supply (communications power and sensor supply, digital inputs)/ bus connection (Ethernet 2) | 500 V AC, 50 Hz, 1 min |
| 24 V supply (communications power and sensor supply, digital inputs)/FE | 500 V AC, 50 Hz, 1 min |
| Bus connection (Ethernet 1)/FE | 500 V AC, 50 Hz, 1 min |
| Bus connection (Ethernet 2)/FE | 500 V AC, 50 Hz, 1 min |
| Bus connection (Ethernet 1)/bus connection (Ethernet 2) | 500 V AC, 50 Hz, 1 min |
| 24 V supply (actuator supply)/24 V supply (communications power and sensor supply, digital inputs) | 500 V AC, 50 Hz, 1 min |
| 24 V supply (actuator supply)/bus connection (Ethernet 1) | 500 V AC, 50 Hz, 1 min |
| 24 V supply (actuator supply)/bus connection (Ethernet 2) | 500 V AC, 50 Hz, 1 min |
| 24 V supply (actuator supply)/FE | 500 V AC, 50 Hz, 1 min |

Mechanical tests

| | |
|--|--|
| Vibration resistance in acc. with EN 60068-2-6/IEC 60068-2-6 | 5g |
| Shock in acc. with EN 60068-2-27/IEC 60068-2-27 | 30g, 11 ms period, half-sine shock pulse |
| Continuous shock according to EN 60068-2-27/IEC 60068-2-27 | 10g |

Conformance with EMC Directive 2004/108/EC

Noise immunity test in accordance with EN 61000-6-2

| | |
|--|---|
| Electrostatic discharge (ESD) EN 61000-4-2/IEC 61000-4-2 | Criterion B; 6 kV contact discharge, 8 kV air discharge |
| Electromagnetic fields EN 61000-4-3/IEC 61000-4-3 | Criterion A; Field intensity: 10 V/m |
| Fast transients (burst) EN 61000-4-4/IEC 61000-4-4 | Criterion B, 2 kV |
| Transient surge voltage (surge) EN 61000-4-5/IEC 61000-4-5 | Criterion B; DC supply lines: ± 0.5 kV/ ± 0.5 kV (symmetrical/asymmetrical) |
| Conducted interference EN 61000-4-6/IEC 61000-4-6 | Criterion A; Test voltage 10 V |

Noise emission test as per EN 61000-6-4

| | |
|--|---------|
| Radio interference properties EN 55022 | Class A |
|--|---------|

Approvals

For the latest approvals, please visit phoenixcontact.net/products.

5 Internal circuit diagram

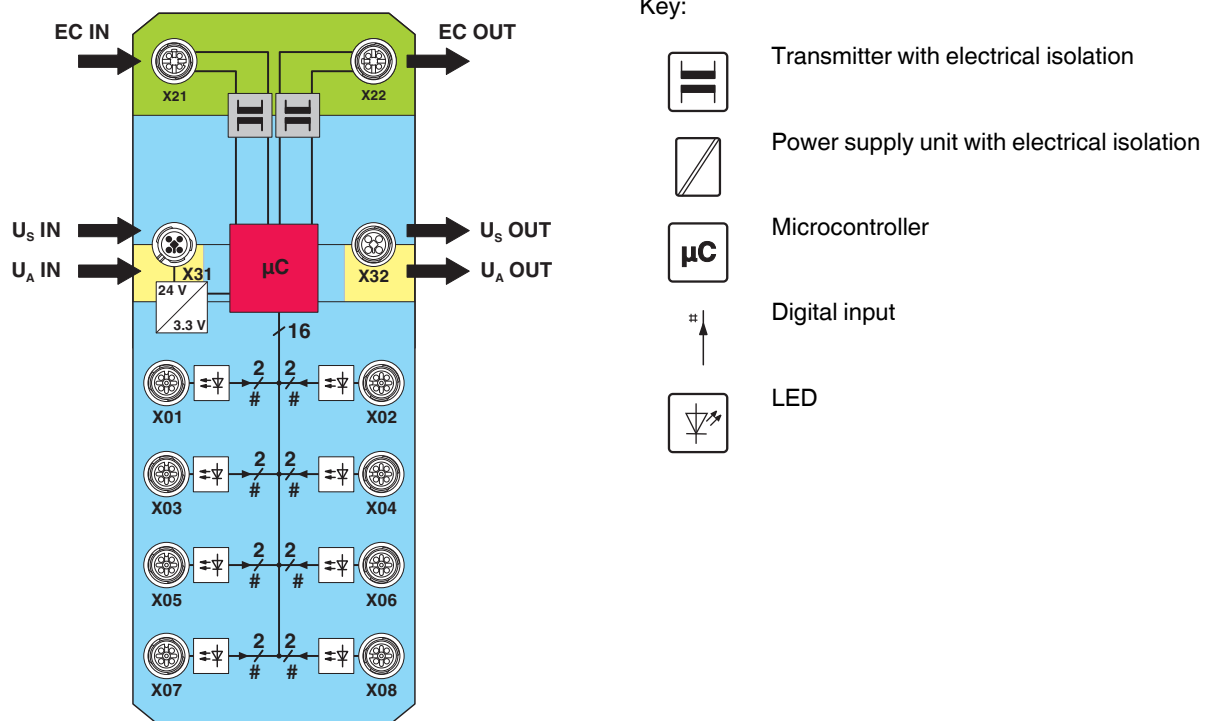


Figure 1 Internal wiring of connections

Key:

| | |
|--------------|---------|
| Green area: | Network |
| Blue area: | U_S |
| Yellow area: | U_A |

6 Pin assignment

6.1 EtherCAT® and power supply connection

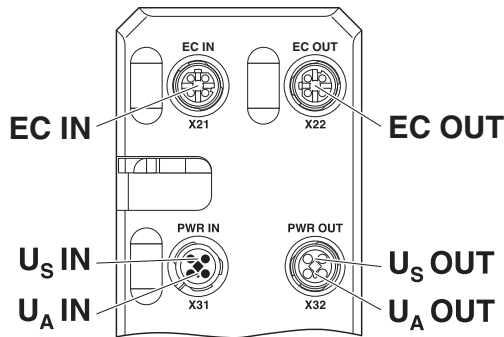


Figure 2 Connections for EtherCAT® and voltage supply

| Designation | Meaning |
|--------------------------|--|
| EC IN (X21) | EtherCAT® IN |
| EC OUT (X22) | EtherCAT® OUT |
| U _S IN (X31) | Power supply IN (logic and sensors) |
| U _A IN (X31) | Power Supply IN (actuators) for additional devices |
| U _S OUT (X32) | Power supply OUT for additional devices |
| U _A OUT (X32) | Power supply OUT for additional devices |



Ground the device by means of the mounting screws.

6.2 EtherCAT® pin assignment

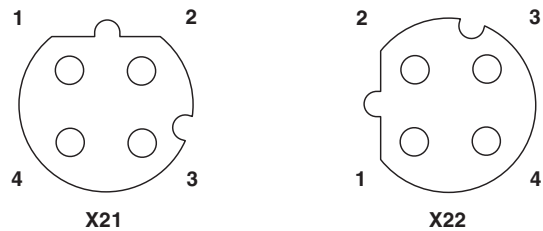


Figure 3 Pin assignment, D-coded

| Pin | EC IN (X21) | EC OUT (X22) |
|-----|-------------|--------------|
| 1 | TX+ | TX+ |
| 2 | RX+ | RX+ |
| 3 | TX- | TX- |
| 4 | RX- | RX- |



The shield is connected to FE in the device.



The thread is used for additional shielding.

6.3 Pin assignment of the power supply U_S/U_A

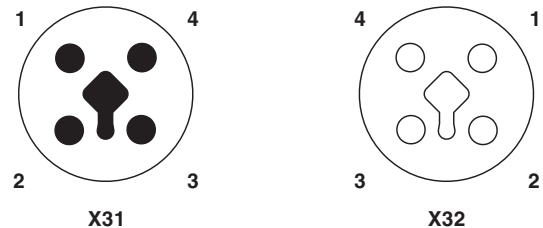


Figure 4 Pin assignment of the power supply, T-coded

| Pin | IN | OUT | Conductor colors |
|-----|----------------------------|----------------------------|------------------|
| 1 | +24 V DC (U _S) | +24 V DC (U _S) | Brown |
| 2 | GND (U _A) | GND (U _A) | White |
| 3 | GND (U _S) | GND (U _S) | Blue |
| 4 | +24 V DC (U _A) | +24 V DC (U _A) | Black |

6.4 Input connection

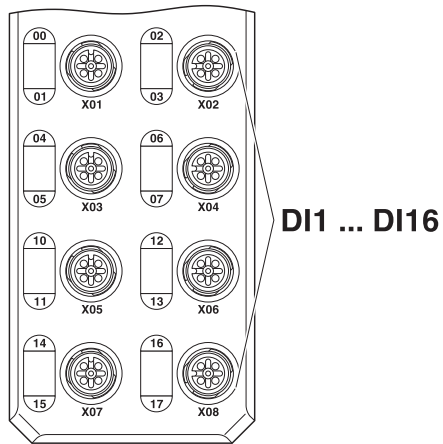


Figure 5 Input connections

| Designation | Meaning |
|----------------------------|-----------------|
| DI1 ... DI16 (X01 ... X08) | Inputs 1 ... 16 |

6.5 Pin assignment of the inputs

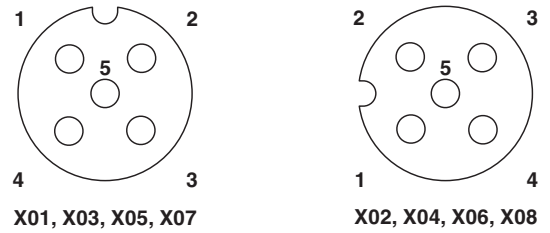


Figure 6 Pin assignment of the inputs, A-coded

| Pin | Input socket |
|-----|-----------------------|
| 1 | +24 V DC (U_S) |
| 2 | Input 2, 4, 6, ... 16 |
| 3 | GND |
| 4 | Input 1, 3, 5, ... 15 |
| 5 | FE |

7 Connection example

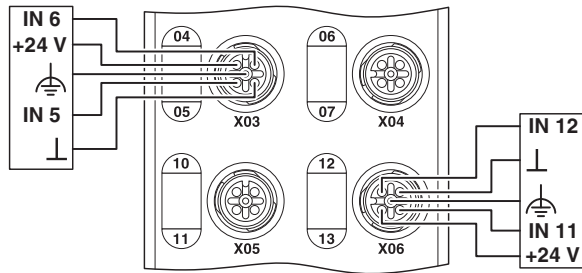


Figure 7 Typical connection of sensors

8 Connection notes



Note: data corruption or loss

Implement the FE connection using mounting screws, in order to ensure immunity to interference.



NOTE: device damage

To ensure IP65/IP67 protection, cover unused sockets with protective caps.



NOTE: Damage to the electronics

Only supply the sensors with the voltage U_S provided at the terminal points.



NOTE: Damage to the electronics

Observe the correct polarity of the supply voltages U_S and U_A in order to prevent damage to the device.



NOTE: Malfunction

When connecting the sensors, observe the assignment of the connections to the EtherCAT[®] input data.



Secure the device to a level surface or to a profile. Do not use this device to bridge gaps, in order to prevent forces being transmitted via the device.



Use standard M5 screws with toothed lock washer and self-locking nuts. Observe the maximum torque of the screws.

9 Identification

In the case of EtherCAT® devices, a distinction is made between address assignment and identification.

Addresses are used for direct communication between the EtherCAT® master and the relevant slave. In doing so, the master assigns each slave a unique 16-bit address.

Identifications are used to uniquely identify a slave in an EtherCAT® network.

Identifications for AXL E EC devices are:

- Device Identification Value
- Configured Second Station Alias

9.1 Configuration via rotary encoding switch (Device Identification Value)

You can configure the address assignment using the rotary coding switch.

After modifying the switch position, restart the device, as the modification to the switch position does not take effect during operation.

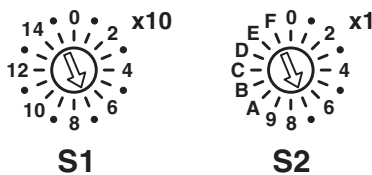


Figure 8 Rotary encoding switch

The code results from the sum of S1 x 10 plus S2 x 1. The image shows code 77 (7 x 10 + 7).

| S1 | S2 | Code | Function |
|----------|----------|------------|-----------------------------|
| 0 ... 15 | 0 ... 09 | 01 ... 159 | Device Identification Value |
| Other | | | Reserved |

Switch position 01 ... 159

Set the EtherCAT® explicit device identification manually with this switch position.



The device is ready for operation after powering up, as soon as the RDY LED lights up green.
 A connection to the device cannot be established in the firmware startup phase.
 As soon as the RDY LED lights up green, a new switch position can be selected on the rotary coding switch and the device can be restarted.

Reserved/invalid switch position

The device starts with the previous settings, e.g., with the settings that were valid before the device was restarted.

9.2 Configured Second Station Alias

For information on how to use the “Configured Second Station Alias” identification, please consult your configuration software.

9.3 Hot Connect

The Hot Connect functionality allows preconfigured sections to be removed from or added to the data traffic before the start or during operation of the system. This can be carried out by disconnecting/connecting the communication line or by switching a device on/off, for example. This is called “flexible topology” or “Hot Connect”.

10 Local status and diagnostic indicators

10.1 Indicators for EtherCAT® and power supply

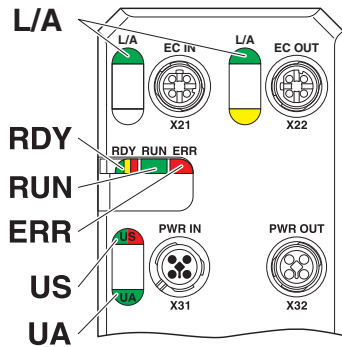


Figure 9 Indicators for EtherCAT® and power supply

| Designation | Color | Meaning | State | Description |
|-------------|--------------------------|---------------|---------------------------|--|
| L/A | Green | Link/Activity | Green ON | Connection present at EC IN/EC OUT. |
| | | | OFF | Connection not present at EC IN/EC OUT. |
| RDY | Green/ yellow/ red | Ready | Green ON | Device is ready for operation. |
| | | | Yellow flashing | Firmware update is being performed. |
| | | | Flashing green/ yellow | Over- or undervoltage at U_S Temperature of the device is in the critical area. And red US LED: sensor supply overload |
| | | | Red ON | Rotary encoding switches are set to an invalid/reserved position. |
| | | | OFF | Device is not ready for operation. |
| | | | | |
| RUN | Green | RUN | OFF | Device is in the Init state. |
| | | | Flashing slowly (2.5 Hz) | Device is in the Pre-Operational state. |
| | | | Single pulse | 200 ms on, 1000 ms off; device is in the Safe-Operational state. |
| | | | Green ON | Device is in the Operational state. |
| | | | Flashing (10 Hz) | Device is in the Bootstrap state. |

| Designation | Color | Meaning | State | Description |
|-------------|-----------|-----------------------|--------------------------|---|
| ERR | Red | Error | ON | Critical error in the device |
| | | | Flashing slowly (2.5 Hz) | Configuration error, a state transition initiated by the master cannot be executed. |
| | | | Single pulse | Local application error |
| | | | Double pulse | Watchdog timeout. The EtherCAT [®] watchdog for monitoring the process data has elapsed. |
| | | | OFF | No error |
| US | Green/red | U _{Sensorik} | Green ON | Communications power/sensor voltage present |
| | | | OFF | Communications power/sensor voltage not present or too low. |
| | | | Red ON | Sensor voltage overload |
| UA | Green | U _{Aktorik} | ON | Actuator voltage present. |
| | | | OFF | Actuator voltage not present. |

10.2 Input indicators

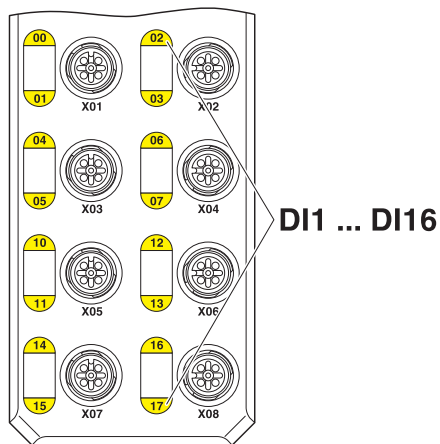


Figure 10 LEDs of the inputs

| Designation | Color | Meaning | State | Description |
|-------------------------|--------|----------------------|-------|-------------------|
| 00 ... 07, 10 ... 17 | Yellow | Status of the inputs | ON | Input is set. |
| | | | OFF | Input is not set. |



The numbering of the LEDs is as follows: the first number specifies the byte, the second number specifies the bit.

11 EtherCAT®

The CAN application layer over EtherCAT® (CoE) mailbox protocol is the basis of the Device Profile and enables parameterization of EtherCAT® devices via the object dictionary. The object dictionary is accessed via CoE using Service Data Object (SDO) services.

The objects implemented on the device are described in the “EtherCAT® object dictionary” section.

12 EtherCAT® object dictionary (CoE objects)

The device object dictionary contains objects which can be addressed via SDO services. The device supports standard objects and manufacturer-specific objects. The standard objects are described in ETG.1000.6 (Application Layer Protocol Specification). The manufacturer-specific objects are listed below.

The objects are addressed using a combination of index and subindex. Subindex 0 lists the number of subindices.

The following applies for the tables below:

Length = Length of the elements in bytes R = Read
 Rights = Access rights W = Write

| Index (hex) | Object name | Data type | Rights |
|------------------------------------|---|-------------|--------|
| Device Identity Objects (1) | | | |
| 1000 | Device Type | UINT32 | RO |
| 1008 | Manufacturer Device Name | STRING | RO |
| 1009 | Manufacturer Hardware Version | STRING | RO |
| 100A | Manufacturer Software Version | STRING | RO |
| 1018 | Identity | IDENTITY | RO |
| Sync Manager Objects | | | |
| 1C00 | Sync Manager Communication Type | UINT8 | RO |
| 1C10 | Sync Manager 0 PDO Assignment (Mail out control register) | UINT16 | RO |
| 1C11 | Sync Manager 1 PDO Assignment (Mail out control register) | UINT16 | RO |
| 1C13 | Sync Manager 3 PDO Assignment (Process data input control register) | UINT16 | RO |
| 1C32 | Sync Parameter of SM2 | SYNC_PAR | RO |
| 1C33 | Sync Parameter of SM3 | SYNC_PAR | RO |
| Device Identity Objects (2) | | | |
| 2001 | Component Name | STRING | RO |
| 2002 | Vendor Name | STRING | RO |
| 2003 | Vendor URL | STRING | RO |
| 2004 | Order Number | STRING | RO |
| 2005 | Manufacturing Date | STRING | RO |
| 2006 | QS Date | STRING | RO |
| 2007 | Installation Location | STRING | R/W |
| 2008 | Operational Hours | UINT32 | RO |
| 2009 | Service Date | STRING | RO |
| 200A | Equipment Ident | STRING | R/W |
| Reset Objects | | | |
| 2F00 | Reset to Factory Settings | UINT8 | R/W |
| PDO Mapping Objects | | | |
| 1A00 | TxPDO Mapping Digital Inputs | PDO Mapping | RO |
| 1A01 | RxPDO Mapping IO Status | PDO Mapping | RO |
| 4000 | Digital inputs | UINT8 | RO |
| 4001 | IO Status | UINT32 | RO |

12.1 Device Identity Objects (device rating plate)

The device has objects for identification. They contain information about the manufacturer and device and make up the device rating plate.

The objects that form the device rating plate are described below.

| Index (hex) | Subindex | Object name | Data type | Rights | Meaning/value |
|-------------|----------|-------------------------------|-----------|--------|---|
| 1000 | - | Device Type | UINT32 | RO | 00000000 _{hex} (0) |
| 1008 | - | Manufacturer Device Name | STRING | RO | Product name |
| 1009 | - | Manufacturer Hardware Version | STRING | RO | Hardware version, version ID |
| 100A | - | Manufacturer Software Version | STRING | RO | Firmware version, version ID |
| 1018 | Identity | | | | |
| | 00 | Number of entries | UINT8 | RO | Number of object subindices |
| | 01 | Vendor ID | UINT32 | RO | 00000084 _{hex} (132) |
| | 02 | Product Code | UINT32 | RO | Order No. |
| | 03 | Revision Number | UINT32 | RO | Device revision, version ID |
| | 04 | Serial number | UINT32 | RO | Serial number |
| 2001 | - | Component Name | STRING | RO | Digital EtherCAT [®] I/O devices |
| 2002 | - | Vendor Name | STRING | RO | Phoenix Contact |
| 2003 | - | Vendor URL | STRING | RO | www.phoenixcontact.com |
| 2004 | - | Order Number | STRING | RO | Order No. |
| 2005 | - | Manufacturing Date | STRING | RO | YYYY-MM-DD T HH:MM:SS Z (date and time of manufacture) |
| 2006 | - | QS Date | STRING | RO | YYYY-MM-DD T HH:MM:SS Z (date and time of final manufacturing test) |
| 2007 | - | Installation Location | STRING | R/W | User-defined device installation location |
| 2008 | - | Operational Hours | UINT32 | RO | Operating hours counter |
| 2009 | - | Service Date | STRING | RO | YYYY-MM-DD T HH:MM:SS Z (date and time of a service) |
| 200A | - | Equipment Ident | STRING | R/W | User-defined device name |

12.2 Sync Manager Objects

The EtherCAT[®] protocol provides two types of communication, these are:

- Mailbox mode
- and buffered mode.

The mailbox mode is used for acyclic transmission of commands to slaves. If a slave receives a mailbox message, this must be processed first before anything else can be processed.

In contrast, the buffered mode enables the master and slave to use a shared data area. The master and slave can read or write data in this area (buffer) at any time.

The sync manager manages the data exchange for both processes to ensure there are no data collisions.

A detailed description of all registers can be found in the “EtherCAT[®] Slave Controller” description from the EtherCAT[®] user organization (www.EtherCAT.org).

12.3 Reset Objects

The device can be reset to its factory settings. To do so, use the following object:

| Index (hex) | Subindex | Object name | Data type | Rights | Meaning/value |
|-------------|----------|---------------------------|-----------|--------|--|
| 2F00 | - | Reset to Factory Settings | UINT8 | R/W | 00_{hex} = Normal operation (default) |
| | | | | | 01 _{hex} = Reset device |
| | | | | | Other = Reserved |



The reset is carried out once the device is restarted.

12.4 PDO mapping objects

In addition to the cyclic input process data, the device is equipped with further status and diagnostics data that can be added to the cyclic process image. This data has a total length of 4 bytes (object 1A01_{hex}).

PDO Mapping Register

| Index (hex) | Subindex | Object name | Data type | Rights | Meaning/value | |
|-----------------|-------------------------------------|-------------------|-----------|--------|--|--|
| 1A00 | TxPDO mapping digital inputs | | | | | |
| | 00 | Number of entries | UINT8 | RO | 02 _{hex} (2) | |
| | 01 | | UINT32 | RO | Bit 31 ... bit 16 | Index of the input data object (4000 _{hex}) |
| | | | | | Bit 15 ... bit 8 | Subindex of the input data object (01 _{hex}) |
| | | | | | Bit 7 ... bit 0 | Subindex length of the input data object (8) |
| | 02 | | UINT32 | RO | Bit 31 ... bit 16 | Index of the input data object (4000 _{hex}) |
| | | | | | Bit 15 ... bit 8 | Subindex of the input data object (02 _{hex}) |
| Bit 7 ... bit 0 | | | | | Subindex length of the input data object (8) | |
| 1A01 | TxPDO mapping IO status | | | | | |
| | 00 | | UINT8 | RO | 01 _{hex} (1) | |
| | 01 | | UINT32 | RO | Bit 31 ... bit 16 | Index of the IO status object (4001 _{hex}) |
| | | | | | Bit 15 ... bit 8 | Subindex of the IO status object (01 _{hex}) |
| Bit 7 ... bit 0 | | | | | Subindex length of the IO status object (32) | |

PDO register

| Index (hex) | Subindex | Object name | Data type | Rights | Meaning/value | | |
|-------------|-----------------------|---------------------------------|-----------|--------|-----------------------|--|--------------------------------|
| 4000 | Digital inputs | | | | | | |
| | 00 | Number of entries | UINT8 | RO | 02 _{hex} (2) | | |
| | 01 | Digital inputs bit 0 ... bit 7 | UINT8 | RO | Bit 7 ... bit 0 | Digital input 8 (X04.2) ... digital input 1 (X01.4) | |
| | 02 | Digital inputs bit 8 ... bit 15 | UINT8 | RO | Bit 7 ... bit 0 | Digital input 16 (X08.2) ... digital input 9 (X05.4) | |
| 4001 | IO status | | | | | | |
| | 00 | Number of entries | UINT8 | RO | 01 _{hex} (1) | | |
| | 01 | | UINT32 | RO | Bit 31 ... bit 16 | Reserved | |
| | | | | | | Bit 5 | Undervoltage of sensor supply |
| | | | | | | Bit 4 | Surge voltage of sensor supply |

13 EtherCAT® State Machine: AL Objects

The device has a state machine, called the EtherCAT® State Machine (ESM).

The EtherCAT® master sends state change requests to the AL control register of the slave. The slave displays the current state in the AL status register and make additional error codes available in the AL status code register in the event of errors.

13.1 AL control and AL status register

If the master writes to the AL control register, then the corresponding state transition is triggered in the device state machine by the slave. The AL status register reflects the current state of the slave.

| Index (hex) | Object name | Data type | Rights | Meaning/value | |
|------------------|-----------------------------------|-----------|--------|------------------|---|
| 0120 | AL Control | UINT16 | R/W | Bit 0 ... bit 3 | State (AL status requested by master) |
| | | | | | 01 _{hex} = Init (I) |
| | | | | | 02 _{hex} = Pre-Operational (P) |
| | | | | | 03 _{hex} = Bootstrap (B) |
| | | | | | 04 _{hex} = Safe-Operational (S) |
| | | | | | 08 _{hex} = Operational (O) |
| | | | | Bit 4 | Acknowledge (Master acknowledge bit) |
| | | | | | 00 _{hex} = Parameter Change of the AL Status Register will be unchanged. |
| | | | | | 01 _{hex} = Parameter Change of the AL Status Register will be reset. |
| | | | | Bit 5 ... bit 7 | Reserved |
| | 00 _{hex} = Shall be zero | | | | |
| 0130 | AL Status | UINT16 | RO | Bit 0 ... bit 3 | AL Status (AL status requested by master) |
| | | | | | 01 _{hex} = Init (I) |
| | | | | | 02 _{hex} = Pre-Operational (P) |
| | | | | | 03 _{hex} = Bootstrap (B) |
| | | | | | 04 _{hex} = Safe-Operational (S) |
| | | | | | 08 _{hex} = Operational (O) |
| | | | | Bit 4 | Change (Error Flag, Master acknowledge bit) |
| | | | | | 00 _{hex} = Confirmation of state in AL Control Register |
| | | | | | 01 _{hex} = A change has happened or an error occurred. |
| | | | | Bit 5 ... bit 7 | Reserved |
| Bit 8 ... bit 15 | Application Specific | | | | |
| | Reserved | | | | |
| 0134 | AL Status Code | UINT16 | RO | Bit 0 ... bit 15 | All Status Code (send by slave) |

13.2 AL Status Code Register

If the state transition requested by the master is not possible, then the slave sets an error flag in the AL status register (bit 4) and writes an error code to the AL status code register.

| AL status code (hex) | Description | State or transition | Resulting state |
|----------------------|---|--------------------------------|-------------------|
| 0000 | No error | Any | Current state |
| 0001 | Unspecified error | Any | Any + E |
| 0011 | Invalid requested state change | I→S, I→O, P→O O→B, S→B, P→B | Current state + E |
| 0012 | Unknown requested state | Any | Current state + E |
| 0015 | Invalid Mailbox Configuration for Bootstrap | I→B | I + E |
| 0016 | Invalid Mailbox Configuration for Pre-Operational State | I→P | I + E |
| 0017 | Invalid Sync Manager Configuration | P→S, S→O | Current state + E |
| 001B | Sync Manager Watchdog | O, S | S + E |
| 001D | Invalid output configuration | O, S P→S | S + E P + E |
| 001E | Invalid input configuration | O, S, P→S | P + E |

14 Process data

14.1 TxPDO Mapping Digital Inputs

| Byte | Input process data | | | | | | | | | | | | | | | |
|------------|--------------------|----|-----|----|-----|----|-----|----|--------|----|-----|----|-----|----|-----|----|
| | Byte 0 | | | | | | | | Byte 1 | | | | | | | |
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| IN | 07 | 06 | 05 | 04 | 03 | 02 | 01 | 00 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 |
| Connection | X04 | | X03 | | X02 | | X01 | | X08 | | X07 | | X06 | | X05 | |
| Pin | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 4 |
| DI | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 |

Key:

- Bit: Process data assignment
- IN: LED marking
- DI: Input of the device

14.2 TxPDO Mapping IO Status

| Bit 31 ... bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------------------|--|----------|----------|----------|-------|-------|
| Reserved | Supply of the module electronics and sensors (U_S) | | | Reserved | | |
| Reserved | Undervoltage | Overload | Reserved | | | |

15 Emergency messages

Emergency messages are messages that are actively sent from the device to the EtherCAT[®] master if certain events/problems occur. They are an unverified service which is based on CoE. In this way, all errors can be indicated to the master by the slave. This takes the form of messages which are specified in ETG.1000.6.

An emergency message is structured as follows:

| CoE emergency message | | |
|-----------------------|----------------|-----------------|
| 2 bytes | 1 byte | 5 bytes |
| Error code | Error register | Diagnostic data |

The following emergency messages are supported by the device:

| Error code (hex) | Error register | Diagnostic data (hex) | Localization | Meaning |
|------------------|----------------|-----------------------|--------------|----------------------------|
| 3001 | Bit 2 set | 00, 01, 00, 00 | Device level | Supply voltage overcurrent |
| 3002 | Bit 2 set | 00, 02, 00, 00 | Device level | Supply surge voltage |
| 3003 | Bit 2 set | 00, 03, 00, 00 | Device level | Supply undervoltage |
| 4001 | Bit 4 set | 00, 06, 00, 00 | Device level | Overtemperature |



The device sends emergency messages for an incoming and outgoing error. Once the problem has been solved, an emergency message with the error code 0000_{hex} (reset error) is sent by the slave. The value of the corresponding bit in the error register is then 0. The diagnostic data value does not change.

16 Synchronization

There are two modes for synchronizing the application which can be selected in the engineering system.

- SM Synchronous (process data update when an SM event occurs)
- DM Synchronous (process data update when a SYNC0 event occurs)

16.1 SM Synchronous

In this mode, the EtherCAT[®] communication system and the I/Os operate asynchronously. The I/Os are in Auto-Run mode and run with the minimum cycle time possible for the current device configuration. This mode is set by default in the device.

16.2 DC Synchronous

In this mode, the I/Os are synchronized with the EtherCAT[®] cycle.

The implemented Distributed Clocks unit is used for the time synchronization of processes.

In synchronous operation, the time points for outputting and reading the process data of the individual I/Os are synchronized with the higher-level network. EtherCAT[®] Distributed Clocks (DC) are used for this synchronization.

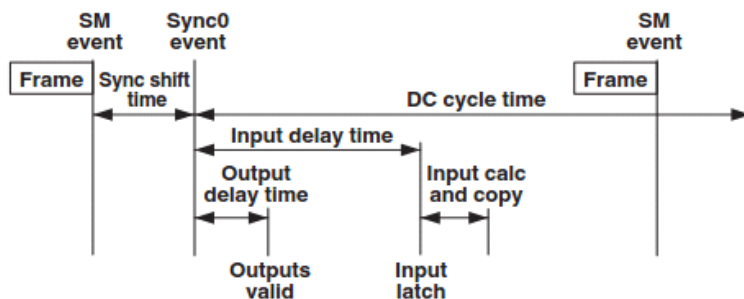


Figure 11 Synchronization model

The figure shows the synchronization model of the EtherCAT[®] device. The “DC Sync0 event” is used for synchronization. After the “Sync0 event” has occurred and a fixed delay time (output delay time) has elapsed, the process data is output.

The inputs are likewise read after a fixed delay (input delay time).



In order to activate DC Synchronous mode in TwinCAT[®], it must be selected in the DC tab under Operation Mode and the slave must be started up again by means of the EtherCAT[®] master. TwinCAT[®] should be operated in Run mode.

17 Restoring the default settings

The following option is available for restoring the default settings:

- Write the value “1” to CoE object 2F00_{hex}. After powering on again, the device is in the default settings.

18 Firmware started

Once you have connected the power, the firmware is started.

After completion of the boot process of the firmware, the RDY LED lights up green or flashes depending on the bus status.

19 Firmware update

It is possible to carry out a firmware update via EtherCAT®.

The File Access over EtherCAT® (FoE) mechanism is used for this, which is provided via your engineering system.

For detailed instructions for the firmware update with TwinCAT®, please refer to AH EN FIRMWARE UPDATE AXL E EC.

The application note can be downloaded at phoenixcontact.net/products.

20 Device description file (ESI)

In the case of EtherCAT®, a device description file is required for various configuration tools.

This file is called EtherCAT® Slave Information (ESI).

A single ESI file is provided for all AxioLine E EtherCAT® devices.

21 Endianness

EtherCAT® uses Little Endian format. All variables, parameters, and data in this document are in Little Endian format (Intel), i.e., LSB/MSB.

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