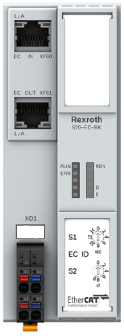
rexroth
A Bosch Company

S20 bus coupler for EtherCAT®

R911372200
Edition 05

Data sheet S20-EC-BK



EtherCAT® connection
modular extensions possible using S20 modules

12 / 2023

1 Description

The bus coupler is intended for use within an EtherCAT® network and represents the link to the S20 system.
Up to 63 S20 devices can be connected to the bus coupler.
EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.
A corresponding ESI file is available for integrating the S20 station into the programming system.
This file can be downloaded at www.boschrexroth.com/electrics.

Features

- 2 Ethernet ports (with integrated switch)
- Rotary encoding switch
- Automatic addressing
- Station mapped as a modular EtherCAT® device using a modular device profile (MDP)
- Station can be mapped as a block device
- Acyclic data communication (mailbox protocols)
- Cyclic (synchronous) data communication
- The typical cycle time of the S20 system bus is around 10 µs
- Runtime in bus coupler is negligible (almost 0 µs)
- IOL-CONF supported (from index AD1)

Abbreviations used

CoE	CAN application protocol over EtherCAT®
DC	Distributed clocks
FoE	File access over EtherCAT®
EoE	Ethernet over EtherCAT®

This data sheet is only valid in association with the application description for the S20 system, material number R911335988.

Make sure you always use the latest documentation.
It can be downloaded under www.boschrexroth.com/electrics.

2 Table of contents

3 Ordering data

Description	Type	MNR	Pcs./Pkt.
S20 bus coupler for EtherCAT®	S20-EC-BK	R911173906	1

Accessories	Type	MNR	Pcs./Pkt.
S20 bus base module	S20-BS-BK	R911173392	5

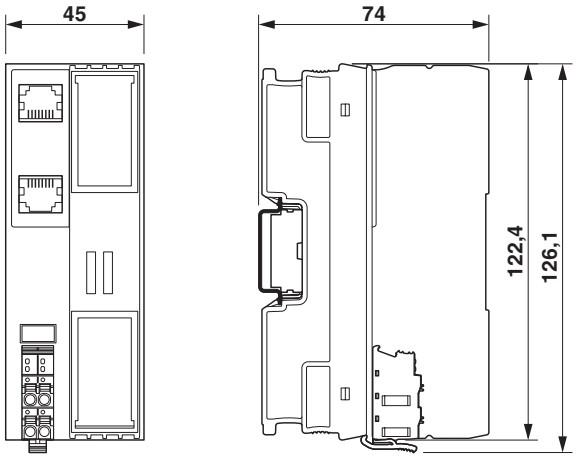
Documentation	Type	MNR	Pcs./Pkt.
Application description S20: System and Installation	DOK-CONTRL- S20*SYS*INS-AP..-EN-P	R911335988	1
Application description S20: Error Messages	DOK-CONTRL- S20*DIAG*ER-AP..-EN-P	R911344826	1
Application description S20 bus coupler for EtherCAT® S20-EC-BK	DOK-CONTRL- S20*EC*BK**-AP..-EN-P	R911385711	1
Project planning manual Security manual	DOK-IWORKS- SECURITY***-PR..-EN-P	R911342562	1

Additional ordering data

For additional ordering data (accessories), please refer to the product catalog at www.boschrexroth.com/electrics.

4 Technical data

Dimensions (nominal sizes in mm)



Width	45 mm
Height	126.1 mm
Depth	74 mm
Note on dimensions	The depth applies when a TH 35-7.5 DIN rail is used (in accordance with EN 60715).

General data	
Color	Housing: light grey (RAL 7035)
Weight	177 g (with connector and bus base module)
Ambient temperature (operation)	-25 °C ... 60 °C (Mounting position: wall mounting on horizontal DIN rail) -25 °C ... 55 °C (Mounting position: any)
Ambient temperature (storage/transport)	-40 °C ... 85 °C
Permissible humidity (operation)	5 % ... 95 % (non-condensing)
Permissible humidity (storage/transport)	5 % ... 95 % (non-condensing)
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	IP20
Protection class	III (IEC 61140, EN 61140, VDE 0140-1)
Overvoltage category	II (IEC 60664-1, EN 60664-1)
Degree of pollution	2 (IEC 60664-1, EN 60664-1)
Mounting type	DIN rail mounting
Mounting position	any (observe temperature derating)

Connection data: S20 connector	
Connection method	Push-in connection
Conductor cross section, rigid	0.2 mm² ... 1.5 mm²
Conductor cross section, flexible	0.2 mm² ... 1.5 mm²
Conductor cross section [AWG]	24 ... 16
Stripping length	8 mm

Observe the specifications for the conductor cross sections in the application description for the S20 system, material number R911335988.

Interface: EtherCAT®	
Number of interfaces	2
Connection method	RJ45 jack (Auto negotiation and autocrossing)
Transmission speed	100 Mbps (full duplex)
Cycle Time	100 µs
Transmission physics	Ethernet in RJ45 twisted pair
Transmission length	max. 100 m

Interface: Local bus	
Number of interfaces	1
Connection method	Bus base module
Transmission speed	100 Mbps

Interface: Service	
Number of interfaces	1
Connection method	USB type C (from index AD1) Micro USB type B (up to index AC1)

System limits of the bus coupler	
Amount of process data	1024 Byte (for each data direction)
IN process data for I/O modules that can be aligned	1024 Byte
OUT process data for I/O modules that can be aligned	1024 Byte
Number of local bus devices that can be connected	max. 63

NOTICE **Electronics may be damaged when overloaded**

Observe the logic current consumption of each device when configuring anS20 station. It is specified in every module-specific data sheet. The current consumption can differ depending on the individual module. The permissible number of devices that can be connected therefore depends on the specific station structure.

EtherCAT®	
Mailbox protocols	CAN application protocol over EtherCAT®, File access over EtherCAT®, Ethernet over EtherCAT®
Type of addressing	Auto-increment addressing Fixed position addressing Logical addressing Explicit device ID
Specification	ETG.1000 V1.02

Feed-in of the communications power U_L (the local bus supply (U_{Bus}) is generated from U_L)	
Supply voltage	24 V DC
Supply voltage range	19.2 V DC ... 30 V DC (including all tolerances, including ripple)
Current consumption	typ. 105 mA (without I/O modules, U_L = 24 V, up to index AC1) typ. 85 mA (without I/O modules, U_L = 24 V, from index AD1) max. 570 mA (2.0 A at U_{Bus}, U_L = 24 V, up to index AC1) max. 670 mA (2.5 A at U_{Bus}, U_L = 24 V, from index AD1)
Power consumption	typ. 2.5 W (without I/O modules, U_L = 24 V, up to index AC1) typ. 2 W (without I/O modules, U_L = 24 V, from index AD1) max. 13.7 W (2.0 A at U_{Bus}, U_L = 24 V, up to index AC1) max. 16 W (2.5 A at U_{Bus}, U_L = 24 V, from index AD1)
Surge protection	electronic
Reverse polarity protection	electronic

NOTICE **Electronics may be damaged when overloaded**

Provide external fuses for the 24 V U_L area. If you are using an external fuse, the power supply unit must be able to supply four times the nominal current of the fuse. This ensures that it trips in the event of an error.

Supply of the local bus (U_{Bus})	
Supply voltage	5 V DC (via bus base module)
Power supply unit	max. 2 A (up to index AC1) max. 2.5 A (from index AD1)

Error messages to the higher level control or computer system	
Emergency messages	
Messages via object $10F3_{hex}$ Diagnosis history	

Electrical isolation/isolation of the voltage areas	
Test section	**Test voltage**
Ethernet interface 1 / Ethernet interface 2	1500 V AC, 50 Hz, 1 min.
Ethernet interface 1 / 24 V communications voltage (U_L) feed-in	1500 V AC, 50 Hz, 1 min.
Ethernet interface 2 / 24 V communications voltage (U_L) feed-in	1500 V AC, 50 Hz, 1 min.
Ethernet interface 1 / functional ground	1500 V AC, 50 Hz, 1 min.
Ethernet interface 2 / functional ground	1500 V AC, 50 Hz, 1 min.
24 V communications voltage (U_L) feed-in / functional ground	500 V AC, 50 Hz, 1 min.

Mechanical tests	
Vibration resistance in accordance with EN 60068-2-6/IEC 60068-2-6	5g
Shock in accordance with EN 60068-2-27/IEC 60068-2-27	30g
Continuous shock in accordance with EN 60068-2-27/IEC 60068-2-27	10g

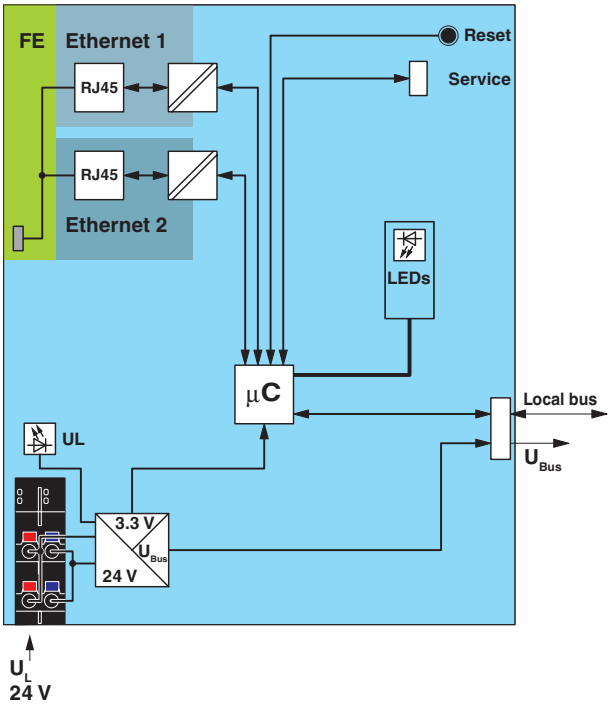
Conformance with EMC Directive 2014/30/EU	
Immunity test in accordance with EN IEC 61000-6-2	
Electrostatic discharge (ESD) IEC 61000-4-2	Criterion B, 6 kV contact discharge, 8 kV air discharge
Electromagnetic fields IEC 61000-4-3	Criterion A, Field intensity: 10 V/m
Fast transients (burst) IEC 61000-4-4	Criterion B, 2 kV
Transient overvoltage (surge) IEC 61000-4-5	Criterion B; DC supply lines: ±0.5 kV/±1.0 kV (symmetrical/ asymmetrical), fieldbus cable shielding: ±1.0 kV
Conducted interference IEC 61000-4-6	Criterion A, Test voltage 10 V
Noise emission test in accordance with EN IEC 61000-6-3	Class B

Approvals

For the current approvals, please visit www.boschrexroth.com/electrics.

5 Internal circuit diagram

Fig. 1 Internal wiring of the terminal points



Key:

FE	Functional ground
Ethernet 1/2	EtherCAT® 1/2
Reset	Reset button
Service	Service interface
Local bus	Local bus
RJ45	RJ45 interface
	Electrical isolation
	Power supply unit
µC	Microcontroller
	LED
	Electrically isolated areas

6 IT security

NOTICE **Unauthorized network access possible**

Connecting devices to a network via Ethernet entails the danger of unauthorized access to the network.

To prevent unauthorized network access, please read the following notes.

If possible, deactivate unused communication channels.

Assign passwords such that third-parties cannot access the bus coupler and make changes without authorization.

Due to its communication interfaces, the bus coupler should not be used in safety-critical applications without additional security appliances.
Therefore, please take additional protective measures in accordance with the IT security requirements and the standards applicable to your application (e.g. virtual networks (VPN) for remote maintenance access, firewalls, etc.) for protection against unauthorized network access.

The operation of installations, systems and machines requires the implementation of an integral concept for state-of-the-art IT security. Bosch Rexroth products are part of this integral concept. Bosch Rexroth product characteristics have to be taken into consideration in an integral IT security concept. The relevant characteristics are documented in the IT security guideline DOK-IWORKS-SECURITY***-PR..-EN-P (R911342562).

7 For your safety

7.1 Intended use

Only use S20 modules in accordance with the information in this data sheet and in the application description for the S20 system, material number R911335988.

If the equipment is used in a manner not specified, the protection provided by the equipment may be impaired.

7.2 Qualification of users

The use of products described in this data sheet is oriented exclusively to electrically skilled persons or persons instructed by them. The users must be familiar with the relevant safety concepts of automation technology as well as applicable standards and other regulations.

7.3 Electrical safety

WARNING **Loss of electrical safety**

If used incorrectly, device safety may be impaired.

During installation, startup, and operation, observe the notes in this data sheet and the specifications in the application description for the S20 system, material number R911335988.

7.4 Installation

Only install the S20 modules in a control cabinet or junction box.

NOTICE **Fire hazard**

- The device must be installed in the final protective housing, which provides sufficient resistance to mechanical strain and protection against the spreading of fire in accordance with the standards UL/IEC/EN 61010-1 and UL/IEC/EN 61010-2-201.
- The supply and external circuits intended to be connected to this device shall be galvanically separated from the mains supply or hazardous live voltage by reinforced or double insulation and meet the requirements of SELV/PELV (Class III) circuits of UL/CSA/IEC/EN 61010-1, UL/CSA/IEC/EN 61010-2-201.

NOTICE **Damage to contacts or malfunction**

Physical overloads can result in damage to the terminal points.

- Relieve strain in the connected cables.

8 Connecting EtherCAT® and supply

8.1 Connecting EtherCAT®

Connect EtherCAT® to the bus coupler via an 8-pos. RJ45 connector.

The EtherCAT® connections are directional.

Designation	Direction	Note
XF60	IN	Connecting the cable from the master.
XF61	OUT	Connecting the cable to additional slaves.

Auto crossover
Both Ethernet interfaces are provided with the auto crossover function.

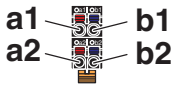
Shielding
The shield of the connected twisted pair cables is electrically connected to the RJ45 socket. When connecting network segments, avoid ground loops, potential transfers, and equipotential bonding currents via the braided shield.

Observe bending radii
The housing dimensions specified under "Dimensions" refer to the bus coupler with I/O connectors without Ethernet connection. When installing the bus coupler in a control box, observe the bending radii of the cables and the connectors used.

If required, use angled RJ45 connectors to maintain these bending radii.

8.2 Connecting the supply voltage - terminal point assignment

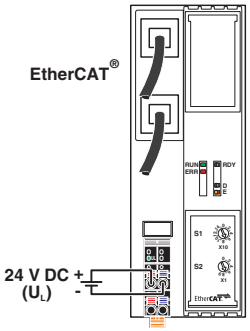
Fig. 2 Terminal point assignment



Terminal point	Color	Assignment	
Supply voltage input			
a1, a2	Red	24 V DC (U_L)	Communications power feed-in (bridged internally)
b1, b2	Blue	GND	Reference potential of the supply voltage (bridged internally)

9 Connection example

Fig. 3 Connection of the cables

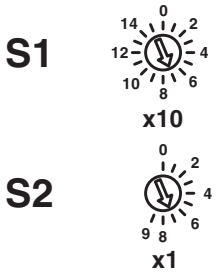


10 Configuration via rotary encoding switch

You can assign the "Device Identification Value" using the rotary coding switches.

Every time you change the switch position, restart the bus coupler. A change of the switch position during operation has no effect.

Fig. 4 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).

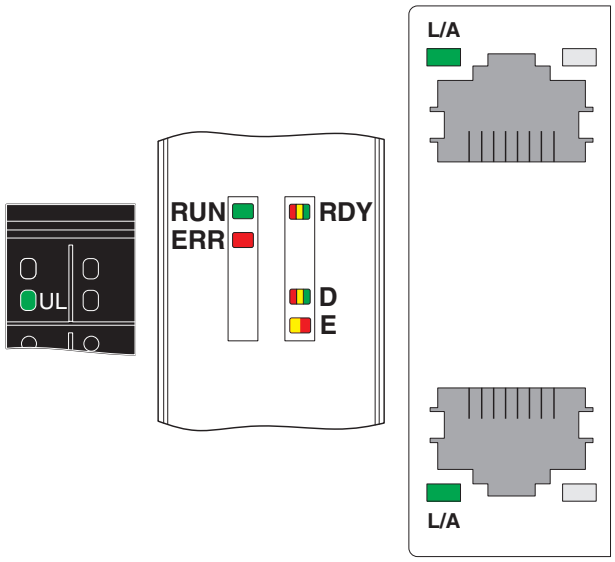
S1	S2	Code	Function
0 ... 15	0 ... 9	01 ... 159	Device Identification Value

Switch position 01 ... 159

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

11 Local diagnostic and status indicators

Fig. 5 Local diagnostic and status indicators



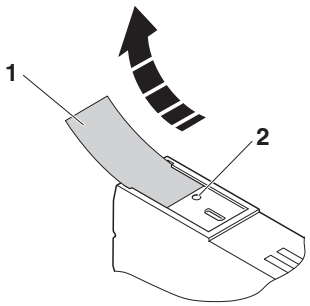
Designation	Color	Meaning	State	Description
UL	Green	U_{Logic}	On	Communications power supply present.
			Off	Communications power supply not present.
RUN	Green	RUN	Off	Bus coupler in Init state
			Flashing slowly (2.5 Hz)	Bus coupler in Pre-Operational state
			Single pulse	200 ms on, 1000 ms off: bus coupler in Safe-Operational state
			On	Bus coupler in Operational state
			Flashing (10 Hz)	Bus coupler in Bootstrap state
ERR	Red	Error	Off	No error
			Flashing slowly (2.5 Hz)	Configuration error, a state transition initiated by the master cannot be executed
			Single pulse	200 ms on, 1000 ms off: local application error
			Double pulse	200 ms on, 200 ms off, 200 ms on, 1000 ms off: watchdog timeout
			On	Critical internal error
RDY	Green/ yellow/ red	Ready	Green on	Device is ready for operation.
			Flashing green/yellow	Communications power undervoltage or surge voltage
				Overtemperature
			Yellow on	Firmware/bus coupler is booting
			Flashing yellow	Firmware update is being performed.
			Flashing yellow/red	Firmware update has failed. Check the firmware file and the settings.
			Flashing red	Faulty firmware
			Red on	Rotary encoding switches are set to an invalid/reserved position.
			Off	Device is not ready for operation.

Designation	Color	Meaning	State	Description
D	Red/ yellow/ green	Diagnostics of local bus communication		
		Run	Green on	The station is ready to operate; communication within the station is OK. All data is valid. An error has not occurred.
		Active	Flashing green	The station is ready to operate. Communication within the station is ok. The data are **not** valid. The controller or higher-level network is not providing valid data. The module is not malfunctioning.
			Flashing green/red	A rest system will be operated; at least one device of the configuration is not available.
		Ready	Yellow on	The station is ready to operate. No data are being exchanged.
			Flashing yellow	Access via DTM in I/O check mode
			Flashing yellow/red	Local bus error during active I/O check
			Flashing red	Local bus error on startup
				Possible causes:
				The configuration cannot be generated. Information from one device is missing.
				Chip version of a device is <V1.1
				The desired and actual configuration are different
				No local bus device connected
				The maximum number of local bus devices is exceeded.
			Red on	The station is ready for operation but has lost connection to at least one device.
				Possible causes:
				Communication error
				Local bus device has been removed or configured device is missing.
				Reset at a local bus device
				Serious device error at a local bus device (local bus device can no longer be reached)
		Power down	Off	Device is in (power) reset or in energy-saving mode.
E	Yellow/ red	Error	Yellow on	I/O warning at a local bus device
			Red on	I/O error at a local bus device
			Off	No I/O messages present.
L/A	Green	Link/Activity	Green on	Connection present at EC IN/EC OUT.
			Flashing green	Transmission or reception of Ethernet telegrams at EC IN / EC OUT.
			Off	Connection not present at EC IN/EC OUT.

12 Reset button

The reset button is located beneath the top marking label on the bus coupler.

Fig. 6 Reset button



1 Marking field

2 Reset button

The reset button has the following functions:

- Restarting the bus coupler
- Resetting of the default settings

12.1 Restarting the bus coupler

Restart the bus coupler by pressing the reset button during ongoing operation.

The outputs of the station are set to the parameterized substitute values.

The process image of the inputs is not re-read.

12.2 Restoring the default settings

If you wish to restore the default settings, proceed as follows:

- Disconnect the power to the module.
- Press and hold the reset button.
- Switch on the power.
- When the RDY LED flashes red/green, release the button.

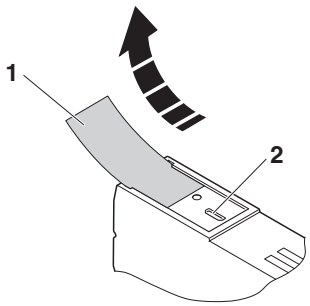
During the reset process the RDY LED lights up yellow.

When the bus coupler is fully started and ready to operate, the RDY LED lights up green.

13 Service interface

The service interface is located beneath the top marking field on the bus coupler.

Fig. 7 Service interface



1 Marking field

2 Service interface

The service interface can be used to connect the bus coupler to a PC via USB.

NOTICE **Damage to the USB interface**

In PCs, the USB ports are usually not electrically isolated from the rest of the hardware. This does not cause any problems for USB devices that do not have their own reference ground. However, if you connect grounded devices (e.g., the bus coupler), ground loops with undesired compensating currents may occur. These compensating currents can impair data transmission and, in extreme cases, destroy the interfaces.

Recommendation:

Connect the USB interface of the bus coupler to your PC in such a way that it is electrically isolated.
To do this, use a USB isolator.

14 MAC address

A MAC address has already been assigned in preparation for a future firmware update with the function extension to EoE.

15 Parameter data

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

S20 modules are parameterized via objects intended for this purpose in the CoE object dictionary. Each S20 module has two tunnel objects, via which the parameters can be set (object $20nn_{hex}$) and read (object $30nn_{hex}$). These tunnel objects can be used to parameterize the S20 modules in EtherCAT® system startup via the EtherCAT® engineering functionality of the StartUp or Init commands.

In the event of an error in the local bus, you can parameterize whether the local bus continues to run in the remaining system or whether it enters the stop state.

The objects implemented on the bus coupler are described in the "Object dictionary" section.

16 Substitute value behavior

If EtherCAT® communication fails or an error occurs in the local bus, all S20 station outputs are set to the parameterized substitute values.

17 Synchronizing the application

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

1. SM Synchronous
2. DC Synchronous

17.1 SM Synchronous

In this mode, the EtherCAT® communication system and the local bus operate asynchronously. The local bus is in Auto-Run mode and runs with the minimum possible cycle time for the current module configuration.

17.2 DC Synchronous

In this mode, the bus cycle of the local bus is synchronized to the EtherCAT® cycle.

The implemented distributed clock unit is used to synchronize the processes in a temporal manner.

If you want to use the DC Synchronous mode of the bus coupler, make sure that there is at least one module in the S20 station that supports local bus synchronization.

If you set DC Synchronous mode and there is no module in the S20 station that supports local bus synchronization, the bus coupler refuses the change in state from PRE-OP to SAFE-OP with "AL status code" 0028_{hex} (SyncMode not supported).

The LEDs indicate this state:

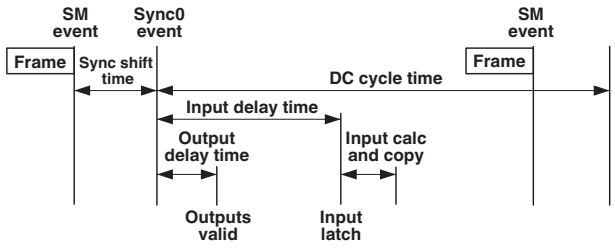
LED	State	Meaning
Bus coupler		
RUN	Flashing slowly (2.5 Hz)	Bus coupler in Pre-Operational state
ERR	Flashing slowly (2.5 Hz)	Configuration error, a state transition initiated by the master cannot be executed
D	Flashing green	The station is ready to operate. Communication within the station is ok. The data are **not** valid. The controller or higher-level network is not providing valid data. The module is not malfunctioning.
Local bus device		
D	Flashing green	Active

Implementing DC Synchronous mode

In synchronous operation, the time points for outputting and reading process data from the individual I/O modules of the SS20 station are synchronized with the higher-level network. This synchronization is by means of EtherCAT® Distributed Clocks (DC).
A requirement for this is that bus-synchronous operation is supported by the module. All modules that do not support bus-synchronous operation continue running asynchronously, as in the SM Synchronous operating mode.
For information on which modules support bus-synchronous operation and the minimum cycle time that is possible, please refer to the module-specific documentation.

In general, with a preselected DC cycle time, only the I/O modules whose update rate (plus local bus cycle time) is less than the DC cycle time are operated synchronously. Only then do these I/O modules supply a new value in every DC cycle.

Fig. 8 Synchronization model



The figure shows the synchronization model of the S20 bus coupler for EtherCAT®.
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).
The delay times depend on the S20 modules used as well as the size of the S20 station. They are calculated by the bus coupler during startup and are then constant.

Example:

Let's assume:

EtherCAT® cycle time	=	2 ms
Sync shift time	≈	400 µs

This results in the following times for “Outputs valid” and “Input latch”.

Outputs:

Outputs valid	=	$t_{SyncShift}$	+	$t_{OutputDelay}$
560.360 µs	=	400 µs	+	160.360 µs

Inputs:

Input latch	=	$t_{SyncShift}$	+	$t_{InputDelay}$
1313.920 µs	=	400 µs	+	913.920 µs

Where:

Outputs valid	Time at which the outputs are available for the process
Input latch	Time at which recording the input data is completed
$t_{SyncShift}$	Sync shift time
$t_{OutputDelay}$	Output delay time (CoE standard object 1C32:09)
$t_{InputDelay}$	Input delay time (CoE standard object 1C33:09)

Please observe the following when parameterizing the bus coupler for operation in DC Synchronous mode:

Select “Sync shift time”, i.e., the interval between “SM event” and “Sync0 event”, between 10% and 30% of the cycle time as far as possible.

The shortest EtherCAT® bus cycle must not be shorter than the maximum synchronization time of the modules located in the local bus that can be synchronized.

Object $F102_{hex}$ can be used to specify which modules of the local bus operate bus-synchronously (see “Objects for the status of bus-synchronous operation”).

18 Object dictionary

The bus coupler object dictionary contains objects which can be addressed via SDO services. These are defined in the ETG standards. Objects with a module-specific design are subsequently described in detail.

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:

	Meaning	Representation	Numbering starts with
Length	Maximum length of the elements in bytes		
Rights	Access rights		
R	Read		
W	Write		
nn	Number of the module addressed	Hexadecimal (hex)	00 for module 1
n	Number of the module addressed	Decimal (dec)	1 for module 1

Note the offset of 1 when counting the modules and the hexadecimal representation of the module number in the indices.
$n_{dec} = nn_{hex} + 1$

Examples:

Module in the local bus	n_{dez}	nn_{hex}
1	1	00
10	10	9
11	11	0A
33	33	20

18.1 CoE standard objects

Index (hex)	Name	Defined in standard
1000	Device type	ETG.1000.6
1008	Device name	ETG.1000.6
1009	Hardware version	ETG.1000.6
100A	Software version	ETG.1000.6
1018	Identify	ETG.1000.6
10F1	Error settings	ETG.1020
10F3	Diagnosis history	ETG.1020
10F8	Timestamp	ETG.1020
1C00	SyncManager type	ETG.1000.6
1C12	RxPDO assign	ETG.1000.6
1C13	TxPDO assign	ETG.1000.6
1C32	SM output parameter	ETG.1020
1C33	SM input parameter	ETG.1020
F000	Modular device profile	ETG.5001.1
F030	Configured module ident list	ETG.5001.1
F050	Detected module ident list	ETG.5001.1

ETG.1000.6 Application layer protocol specification
ETG.1020 EtherCAT® protocol enhancements
ETG.5001.1 Modular device profile part 1

18.2 Module-specific CoE objects

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning	
16nn	01	Module n RxPDO Mapping		4	R	Bit 31 ... bit 16	Index of the associated output data object (e.g., 7010_{hex} for module 2)
						Bit 15 ... bit 8	Subindex of the associated output data object
						Bit 7 ... bit 0	Subindex length of the associated output data object
1Ann	01	Module n TxPDO Mapping		4	R	Bit 31 ... bit 16	Index of the associated input data object (e.g., 6010_{hex} for module 2)
						Bit 15 ... bit 8	Subindex of the associated input data object
						Bit 7 ... bit 0	Subindex length of the associated input data object
6nn0	01	Module n Inputs	Octet string	Depending on module	R	n module input process data	
7nn0	01	Module n Outputs	Octet string	Depending on module	R	n module output process data	
9nn0		Module n Identification				Identification of module n	E.g., module 1: 9000_{hex}, module 2: 9010_{hex} etc.
	0A	Module ident	UINT32	4	R	Unique number for module identification (connection to device description)	
	0B	Slot	UINT16	2	R	Location of the module in the S20 station, beginning with 1	
Ann0		Module n DiagState				Diagnostics	Read access to PDI object 0018_{hex} in the S20 module n via the PDI channel
	01	No	UINT16	2	R	Error number	See data sheet on the module.
	02	Prio	UINT8	1	R	Priority	See data sheet on the module.
	03	Channel/group/module	UINT8	1	R	Channel/group/module	See data sheet on the module.
	04	Code	UINT16	2	R	Error code	See data sheet on the module.
	05	MoreFollows	UINT8	1	R	More follows	See data sheet on the module.
	06	Text	Visible String	51	R	Text	See data sheet on the module.

18.3 CoE objects for identification (device rating plate)

PDI objects are stored on each S20 module for identification purposes. They contain information about the manufacturer and module and make up the device rating plate.

This information can be accessed using the bus coupler via EtherCAT®.

The following tables describe the detail on the device rating plate on objects in EtherCAT®.

Detail of manufacturer-specific information

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning (code in hex)	
9nn1		Module n Manufacturer Information				Detail of manufacturer-specific information from the PDI objects for identification (device rating plate)	
	01	VendorName	Visible String	15	R	0001	Vendor name
	02	Vendor ID	Visible String	6	R	0002	Vendor ID
	03	VendorText	Visible String	48	R	0003	Vendor text
	04	VendorURL	Visible String	29	R	0012	Vendor URL

Detail of module-specific information

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning (code in hex)	
9nn2		Module n Module Information				Detail of module-specific information from the PDI objects for identification (device rating plate)	
	01	ProductName	Visible String	Max. 58	R	0007	Product name
	02	Serial number	Visible String	11	R	0008	Serial number
	03	ProductText	Visible String	Max. 58	R	0009	Product text
	04	OrderNumber	Visible String	8	R	000A	Item No.
	05	HW BuildDate	Visible String	10	R	000B.1	Hardware version, date of version
	06	HW Version	Visible String	Max. 40	R	000B.2	Hardware version, version ID
	07	FW BuildDate	Visible String	10	R	000C.1	Firmware version, date of version
	08	FW Version	Visible String	Max. 40	R	000C.2	Firmware version, version ID
	09	PDI BuildDate	Visible String	10	R	000D.1	Parameter channel version, date of version
	0A	PDI Version	Visible String	Max. 40	R	000D.2	Parameter channel version, version ID
	0B	DeviceType	Octet string	8	R	0037	Device type

18.4 Objects for access to PDI objects (tunnel objects)

Parameter and diagnostic data as well as other information is transmitted as objects via the PDI channel of the S20 station.

You can access the PDI objects of the modules of a station via EtherCAT®. Objects $20nn_{hex}$ and $30nn_{hex}$ are used, with which a tunnel method can be implemented.

For the meaning of the error message in Error class, Error code, and Additional error code, please refer to the application description “S20: diagnostic registers and error messages”, material number R911344826.

Subslot field: Acyclic objects of subordinate systems

Objects of devices from subsystems can be accessed in the same way as PDI objects.

Examples of devices from subsystems are IO-Link devices on a lower level than an IO-Link master (such as S20-IOL-8).

To address an I/O device in the lower-level system, use the “Subslot” field. With IO-Link, ISDU access requires the port number (1 ... n).

For a description of the objects, please refer to the specification of the relevant lower-level system or to the data sheet of the connected device.

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning	
20nn		Module n PDI Write Tunnel				Write access to the PDI objects in S20 module n via the PDI channel Mapping to PDI write service (service code 01_{hex}) at slot n	
	01	Command	Octet string	250	R/W	Data for the PDI write request	
						Byte 0	Subslot
						Byte 1, 2	PDI object index
						Byte 3	PDI object subindex
						Byte 4	Length of the data to be written
						Byte 5 ... n	User data (max. 245 bytes)
	02	Status	UINT8	1	R	Status of the last write access	
						01_{hex}	Last access completed successfully (positive confirmation received)
						03_{hex}	Last access not completed successfully (negative confirmation received)
	03	Response	Octet string	9	R	Result of the last write access Data for PDI write response	
						Byte 0	Subslot
						Byte 1, 2	PDI object index
						Byte 3	PDI object subindex
						Byte 4	Length (= 0)
						Positive confirmation	
						Byte 5 ... 8	0
						Negative confirmation	
						Byte 5	Error class
						Byte 6	Error code
						Byte 7, 8	Additional error code

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning	
30nn		Module n PDI Read Tunnel				Read access to PDI objects in the S20 module n via the PDI channel Mapping to PDI read service (service code 00_{hex}) at slot n	
	01	Command	Octet string	4	R/W	Data for PDI read request	
						Byte 0	Subslot
						Byte 1, 2	PDI object index
						Byte 3	PDI object subindex
	02	Status	UINT8	1	R	Status of the last read access	
						01_{hex}	Last access completed successfully (positive confirmation received)
						03_{hex}	Last access not completed successfully (negative confirmation received)
	03	Response	Octet string	250	R	Result of the last read access Data for PDI read response	
						Byte 0	Subslot
						Byte 1, 2	PDI object index
						Byte 3	PDI object subindex
						Byte 4	Length
						Positive confirmation	
						Byte 5, 6	0
						Byte 7 ... n	Data for PDI read response
						Negative confirmation	
						Byte 5	Error class
						Byte 6	Error code
						Byte 7, 8	Additional error code

18.5 Object for S20 bus diagnostics ($F100_{hex}$)

CoE object $F100_{hex}$ can be used to request the status information of the S20 master.

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning
F100		Bus coupler diag info				Read access to diagnostic information of the S20 master
	01	Bus state	UINT16	2	R	Current state of the local bus
	02	Error_Code	UINT16	2	R	Error code according to the current bus state
	03	Add_Error_Info	UINT16	2	R	Additional error information

“Bus state” mirrors the diagnostic status register. Detailed information on this can be found in the application description “S20: Diagnostics Register and Error Messages”, material number R911344826.

“Error_Code” indicates the error code of module errors. For the meaning of the error codes, please refer to the data sheet of the relevant module or the application description “S20: diagnostic registers and error messages”, material number R911344826.

“Add_Error Info” indicates the position of the module in question.

The data for object $F100_{hex}$ is also provided in the cyclic input data of the S20 station (see also “Process data of the bus coupler”).

18.6 Object for the status of bus-synchronous operation ($F102_{hex}$)

The object $F102_{hex}$ contains information about which local bus modules operate bus-synchronously.

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning
F102		Modules used in synchronization				During operation in DC Synchronous mode, indicates which S20 modules are operated bus-synchronously
	01		UINT8	1	R	Position of the modules that are operated bus-synchronously in the local bus starting with 1; $n \leq 63$
	...		UINT8	1	R	
	n		UINT8	1	R	

18.7 Objects for bus coupler configuration ($F800_{hex}$ ... $F805_{hex}$)

The bus coupler has objects which are used for the configuration of the bus coupler. Write access to these objects is only possible in the PREOP state.

The contents of the objects are stored retentively in the bus coupler and are therefore still available after the bus coupler is restarted.

When reset to the default settings, these objects return to their default values.

Object $F800_{hex}$ can be used to configure the byte sequence of the transmitted process data.

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning	
F800		Endian settings				Byte sequence setting for a process data length of 16, 32 or 64 bits. The EtherCAT® standard specifies Little Endian format, S20 uses Big Endian.	
	01	Swap Word	Boolean	0.1	R, R/W in PreOP	Byte sequence for a process data length of 16 bits	
						True	Little endian (Default)
						False	Big endian
	02	Swap DWord	Boolean	0.1	R, R/W in PreOP	Byte sequence for a process data length of 32 bits	
						True	Little endian (Default)
						False	Big endian
	03	Swap LWord	Boolean	0.1	R, R/W in PreOP	Byte sequence for a process data length of 64 bits	
						True	Little endian (Default)
						False	Big endian

Object $F801_{hex}$ can be used to specify the bus coupler response in the event of a bus error.

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning	
F801		Leave OP on bus-fail				Parameterization of the response to an S20 bus error	
	00		Boolean	0.1	R, R/W in PreOP		
						True	In the event of an S20 bus error, the bus coupler switches to the SAFEOP ERR state; in addition a diagnosis is entered.
						False	(Default) In the event of an S20 bus error, the bus coupler remains in the OP state; only a diagnosis is entered.

Object $F802_{hex}$ can be used to check the connected module configuration.

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning	
F802		Validate module configuration				Validation of the module configuration	
	00		Boolean	0.1	R, R/W in PreOP	True	(Default) During the transition from PREOP to SAFEOP, the bus coupler checks the module configuration.
						False	The bus coupler does not check the module configuration.

In order for the module configuration to be checked, the master must write the object $F030_{hex}$ with the expected module configuration during the state transition from PREOP to SAFEOP. If this is not done, validation cannot be carried out. When the object is written, it must be done so correctly and consistently. The content of the object $F030_{hex}$ is reset during a state transition from SAFEOP to PREOP.

You can read the cycle time of the local bus with the object $F803_{hex}$.

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning
F803	00	Bus cycletime	UINT32	4	R	Local bus cycle time displayed in nanoseconds (ns)

With the $F804_{hex}$ object, you can configure the behavior of the bus coupler in the event of a local bus error.

From index AD1

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning	
F804	00	Behaviour on local bus error	UINT8	2	R, R/W in PreOP	Behavior in the event of an error in the local bus (from index AD1)	
						00_{hex}	Output substitute values (default)
						01_{hex}	Continue to operate the residual system

In case a fault occurs in the local bus, you can parameterize the behavior of the outputs of the I/O modules that can be reached. You have the following options:

The outputs output the parameterized substitute values.

The outputs remain in operation.

A fault in the local bus can be caused by a bus interruption or a missing I/O module.

The inputs of all I/O modules that can be reached can always be read in.

Configure the behavior via object $F804_{hex}$.

With the object $F805_{hex}$, you can set the access rights for the IOL-CONF software.

From index AD1

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning	
F805	00	IOL-CONF access mode	UINT8	2	R, R/W in PreOP	Access right IOL-CONF (from index AD1)	
						00_{hex}	Full access (default)
						01_{hex}	Read only
						02_{hex}	Deactivated

19 Process data

19.1 Process data of the bus coupler

In addition to the cyclic IN and OUT process data, which is defined by the connected S20 modules, the bus coupler itself has data which is inserted in the cyclic process image. This data has a total length of 8 bytes.

In accordance with the EtherCAT® standard, this data appears before the IN process data of the first S20 module in the process image (SyncManager 3 bytes 0 ... 7). The objects for the corresponding PDO mapping can be found in $1AFF_{hex}$.

Process data byte 0 and 1 (word 0) are assigned the “New massages available” bit (index $10F3_{hex}$, subindex 04) of the “Diagnosis history” object.

Process data words 1 ... 3 contain status and diagnostic information for the S20 bus coupler and can also be called via acyclic services using CoE. They appear in the form of object $F100_{hex}$.

Word 0, byte 0							
7	6	5	4	3	2	1	0
Reserved							New Diagnosis Message

Word 0, byte 1							
7	6	5	4	3	2	1	0
Reserved							

Word 1	
Byte 3	Byte 2
Localbus bus state	

Word 2	
Byte 5	Byte 4
Local bus Error_Code	

Word 3	
Byte 7	Byte 6
Local bus Add_Error Info	

“Local bus bus state” mirrors the diagnostic status register. Detailed information on this can be found in the application description “S20: Diagnostics Register and Error Messages”, material number R911344826.

“Local bus Error_Code” indicates the error code of module errors. For the meaning of the error codes, please refer to the data sheet of the relevant module or the application description “S20: diagnostic registers and error messages”, material number R911344826.

“Local bus Add_Error Info” indicates the position of the module in question.

19.2 Process data of the local bus modules

The IN and OUT process data of the modules appear according to their process data description (PDI objects $003B_{hex}$ and $003C_{hex}$ on the module).

For mapping, object $F800_{hex}$ can be used to configure whether process data with a length of 16, 32, and 64 bits is to be transmitted in Big Endian format or in Little Endian format. The configuration is stored retentively in the bus coupler.

20 Diagnostics strategy

20.1 Mechanisms

Different mechanisms are used to diagnose the bus coupler.

Mechanism		**Diagnostics**
EtherCAT® state machine		EtherCAT® system diagnostics
EtherCAT® hardware watchdog		
Emergency messages		Errors are indicated to the master
Diagnostic objects in the CoE object dictionary		Advanced diagnostics, e.g., of I/O errors
	10F1	Error settings
	F100	Bus coupler diag info
	F101	Bus error counters
	F102	Modules used in synchronization
	F802	Validate module configuration
Diagnosis history object		16 diagnostic messages could not be stored
	10F3	Diagnosis history

20.2 EtherCAT® state machine

An error is indicated as follows:

- Error bit in the “AL status code” register is set.
- An error code is written in the “AL status code” register by the slave.

The following codes are implemented on the bus coupler:

AL status code (hex)	Meaning
0000	No error: There is no error.
0011	Invalid requested state change: The state change requested is invalid.
0012	Unknown requested state: The state requested does not exist.
0015	Invalid mailbox configuration in Bootstrap: Error in the SyncManager configuration for mailbox communication in Bootstrap.
0016	Invalid mailbox configuration in PreOP: Error in the SyncManager configuration for mailbox communication in PreOP.
0019	No valid outputs: The outputs are invalid. Enable data output request failed.
001A	Multiple synchronization error: Recurring synchronization error. Master communication faulty.
001B	SyncManager watchdog: The hardware watchdog which monitors the SyncManager process data has expired.
001D	Invalid output configuration: Error in the SyncManager configuration for output process data.
001E	Invalid input configuration: Error in the SyncManager configuration for input process data.
0024	Invalid input mapping: The parameterized PDO mapping for the input process data is faulty (e.g., process data that is not available was included in the mapping).
0025	Invalid output mapping: The parameterized PDO mapping for the output process data is faulty (e.g., process data that is not available was included in the mapping).
0026	Inconsistent settings: The inconsistent settings parameterized by the master lead to a fault during the status transition (e.g., check of the module lists downloaded by the master fails).
0027	Freerun not supported: The bus coupler does not support Freerun.
0028	SyncMode not supported: There is no module in the S20 station that supports local bus synchronization.
002B	No valid inputs or outputs: Process data invalid. Error in the local bus.
002C	Fatal synch error: The Sync0 watchdog, which monitors the synchronization status, has expired.
002D	No sync error: Sync0 signal generation is active.
0030	Invalid DC sync configuration
0032	PLL error: Synchronization not possible. Master jittering too high or DC configuration faulty.
0033	DC sync io error: I/O is no longer synchronized. (From index AD1)
0034	DC sync I/O error: Too many SyncManager events missed. (From index AD1)
0036	DC sync0 cycle time: The DC Sync0 cycle time is too short.
0050	EEPROM no access: EEPROM access failed.
0051	EEPROM error: EEPROM error (checksum in the IP-Cor configuration range is incorrect)
0070	Detected module ident list does not match: The configured module list ($F030_{hex}$) does not match the detected module list ($F050_{hex}$).

20.3 Emergency messages

Emergency messages are an unverified service based on CoE. As such, all errors can be indicated to the master by the slave, taking the form of messages which are specified in ETG.1000.6.

Detail of S20 bus and I/O errors on a CoE emergency message:

CoE emergency message	2 bytes	1 byte	5 bytes			
	Error code	Error reg	Data			
S20 bus error	2 bytes	1 byte	2 bytes	2 bytes		1 byte
	1000_{hex}	80_{hex}	Slot number	Error code		0
S20 I/O error	2 bytes	1 byte	2 bytes	1 byte	1 byte	1 byte
	Error code	80_{hex}	Slot number	Location	Priority	0

CoE emergency message

Error code (hex)	**Meaning**	
00xx	Error reset or no error	
10xx	Generic error	
20xx	Current	
21xx		Current, device input side
22xx		Current inside the device
23xx		Current, device output side
30xx	Voltage	
31xx		Mains voltage
32xx		Voltage inside the device
33xx		Output voltage
40xx	Temperature	
41xx		Ambient temperature
42xx		Device temperature
50xx	Device hardware	
60xx	Device software	
61xx		Internal software
62xx		User software
63xx		Data set
70xx	Additional modules	
80xx	Monitoring	
81xx	Communication	
82xx	Protocol error	
8210		PDO not processed due to length error
8220		PDO length exceeded
90xx	External error	
A0xx	ESM transition error	
F0xx	Additional functions	
FFxx	Device specific	

The errors which could occur in the S20 system are separated into two groups with different message structures.

S20 I/O error

For the error codes for S20 I/O errors, please refer to the data sheets for the I/O modules.

S20 bus error

The error codes for S20 bus errors have the emergency error code 1000_{hex} (generic error) as standard.

The S20 error code is displayed in the “Emergency Message” data area.

For the meaning of the error codes for the S20 bus errors and S20 I/O errors, please refer to the application description “S20: diagnostic registers and error messages”, material number R911344826.

20.4 Diagnosis history $10F3_{hex}$

The object $10F3_{hex}$ is implemented as a ring memory in Overwrite mode. The last 16 diagnostic messages are always stored; older messages are deleted.

The error codes of the S20 bus and I/O errors are stored in the object's diagnostic messages.

The following table shows the structure of a diagnostic message from the S20 bus coupler for EtherCAT® as well as detailing specific S20 information.

Index (hex)	Sub-index	Object name	Data type	Length	Rights	Meaning
10F3		Diagnosis history				Diagnostic statistics
	01	Maximum messages	UINT8	1	R	Maximum number of messages
	02	Newest message	UINT8	1	R	Newest message
	03	Newest acknowledged message	UINT8	1	R/W	Newest acknowledged message Writing a "0" deletes the message from the ring memory.
	04	New messages available	Boolean	0.1	R	New message present
	05	Flags	UINT16	2	R/W	Setting for the behavior of the object. See ETG.1020

20.5 Diagnostic objects in the CoE object dictionary

The Diagnosis History Object enables a diagnosis station-wide.

For module-specific diagnostics, the module diagnostics objects (PDI object 0018_{hex}) are displayed in the CoE object dictionary of the bus coupler (CoE objects $A000_{hex}$ to $A3F0_{hex}$).

21 EoE: Ethernet over EtherCAT®

Ethernet over EtherCAT® is anEtherCAT® protocol. With this protocol, you can transport Ethernet data traffic in the EtherCAT® segment. Here, Ethernet communication is tunneled from the master/TAP via the EtherCAT® protocol.

Via a specified EtherCAT® path, the EtherCAT® master assigns the IP parameters incl. MAC address to the bus coupler.

The MAC address assigned via EtherCAT® does not have to be the same as the MAC address on the housing.

22 Key changes in the firmware versions

Only the firmware changes that result in a significant extension to the functions are listed here.

Index AD1

Addition of the following CoE objects (hex):

F804	Behaviour on local bus error
F805	IOL-CONF access mode

Extension of the AL status code (hex)

0033	DC sync io error
0034	DC sync io error

After downloading the firmware: Automatic restart in Bootstrap mode

Support of EoE

Support for IOL-CONF

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