Ethernet/IP bus interface

for DIOLINE20

Operating instructions

Version 1.00

January 2010

Technik mit System

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1 Safety instructions

Importance of operating instructions

The operating instructions are an integral part of the DIORAIL module product and must be kept ready to hand at all times. This applies until the module is disposed of. If the module is sold or lent out, the operating instructions must be passed on with it.

Copyright

Disclaimer

We have checked the contents of this document for conformity with the hardware and software described. Nevertheless, as discrepancies cannot be ruled out we do not accept liability for complete conformity. The information in this document is checked regularly and any necessary corrections are made in the subsequent editions. We are grateful for any suggestions for improvements.

Friedrich Lütze GmbH & Co. excludes all liability for damage caused by a lack of or insufficient familiarity with the operating instructions. The operator is therefore advised to get written confirmation that staff are fully versant with the instructions.

Modifications or functional changes to the Ethernet/IP bus interface for DIOLINE20 are not permitted for safety reasons. Modifications to the Ethernet/IP bus interface for DIOLINE20 not expressly approved by the manufacturer will thus forfeit any liability claims against Friedrich Lütze GmbH & Co. The same applies if non-original parts or equipment, or parts and equipment not approved by us, are used.

Correct use

Correct use means proceeding as described in the operating instructions.

The Ethernet/IP bus interface for DIOLINE20 may only be used for the scenarios provided for in the technical documents and only in conjunction with the third-party equipment and components recommended and approved by us.

Correct and safe operation of the product assumes proper transport, proper storage, assembly and installation and careful operation and maintenance.

Qualifications of staff

Only qualified staff may perform the following work on DIORAIL modules:

- Installation
- Commissioning
- Operation
- Maintenance

Qualified staff in the context of the safety instructions are people who are authorised to commission, earth and label devices, systems and circuits in accordance with the standards for safety engineering.

The operating staff must be briefed and trained accordingly.

Maintenance of the Ethernet/IP bus interface for DIOLINE20

The Ethernet/IP bus interface for DIOLINE20 itself is maintenance-free. No inspection or maintenance intervals are therefore required for ongoing operation.

Decommissioning and disposal of the Ethernet/IP bus interface for DIOLINE20

The operating company must observe the environmental guidelines of the respective country applicable to the site when decommissioning and disposing of the Ethernet/IP bus interface for DIOLINE20.

A material list is contained in the appendix.

Explanation of symbols in the operating instructions

The operating instructions contain instructions that must be followed to ensure personal safety and avoid damage to property. These instructions are indicated by a warning triangle and graded according to the degree of hazard.

Immediate hazard

to the life and health of people.
Failure to observe these will result in death or extremely serious injuries (crippling).

Potential hazard

to the life and health of people.
Failure to prevent it may result in death or extremely serious injuries.

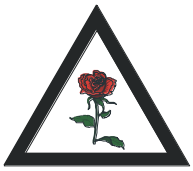
Potentially dangerous situation

Minor injuries may result if it is not averted.
This symbol is also used as a warning against damage to property.

Instructions for correct handling

Designate a situation that could potentially result in damage.

Failure to observe these instructions may cause damage to the product or something in its vicinity.



Environmental protection

Failure to comply with this notice may harm the environment.

Further safety instructions

The Ethernet/IP bus interface for DIOLINE20 corresponds to the current state of the art and complies with the applicable safety regulations and the relevant harmonised
European standards (EN).

Users must observe:

- Pertinent accident prevention regulations
- EC directives or other country-specific regulations
- Generally recognised safety regulations
- General ESD regulations.

The modules must be disconnected from the power supply when carrying out installation or maintenance work (disconnect the mains plug). This can prevent accidents caused by electrical voltages.

Vorsicht

If electrical welding work is carried out on frames on which electrical modules are mounted, all connections to and from these modules must first be disconnected. This is the only way to protect the modules from being destroyed by equalising currents.

Faults of any kind or any other kind of damage must be reported to a responsible person.

Protective and safety devices must not be bypassed or bridged. Dismantled safety devices must be reassembled before commissioning again and must be subjected to a function test.

The modules must be secured against inappropriate or accidental use.

Original information signs, labels, stickers or similar must always be heeded and kept in a legible state.

A DC 24 V power pack is used to supply power to the Ethernet/IP bus interface for DIOLINE20. The operating voltage of DC 24 V is categorised as SELV (safety extra low voltage) and is thus not subject to the EC Low Voltage Directive. Usage of other power supplies is not allowed.

The power is fed to the Ethernet/IP bus interface for DIOLINE20 at X3. The logics supply for the expansion modules is fed on via the L-Bus ribbon cable from interface to interface.

2 Product overview of DIOLINE20

The Ethernet/IP bus interface is a connector between the Ethernet and the DIOLINE20 interface modules.

The DIOLINE20 modules have been designed for use in rail vehicles.

A module network consists of the standardised controller core as the head of each network and a maximum of 10 additional expansion modules from the DIOLINE20 family. The expansions are connected by a flat conductor from interface to interface.
A loose connector without flat conductor is enclosed with the Ethernet/IP head. This is intended to protect the contacts of the expansion slot in the last module of the network.

The DIOLINE20 product family is comprised of a multitude of combinable interface types.

There are both digital and analogue input and output modules.
The description of the interfaces is enclosed with the respective modules.

3 Housing/dimensions

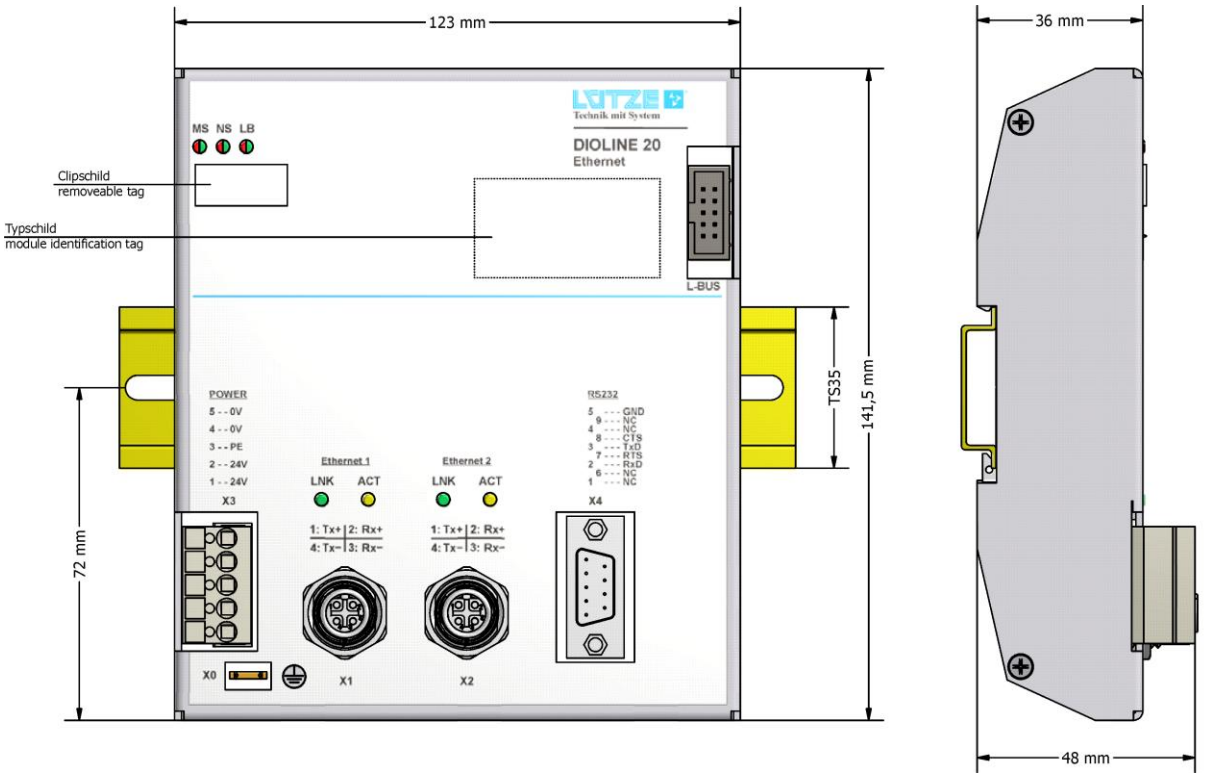


Fig. 1: DIOLINE20 housing of Ethernet/IP bus interface

4 Description of device

The technology

The Ethernet/IP bus interface for DIOLINE20 is based on a microcontroller with an integrated field bus connection.

Both the digital and analogue I/O modules are activated by this basic module.

The system can be used in terminal boxes and control cabinets for mounting on a top hat rail.

Configuration of connections:

- Power supply via 24 V connection (X3).
- PE contact (X0)
- Ethernet bus by means of 4-pin M12 female connectors (X1 and X2)
- RS232 interface for designing with SUB-D connector (X4)
- Connection to expansion modules by ribbon cable (L-Bus).

Potential applications

The Ethernet/IP bus interface for DIOLINE20 is a bus connection module for connection to the Ethernet process bus (network) compliant to IEEE 802.3 10/100BaseTx.

4.1 Technical data of Ethernet/IP bus interface for DIOLINE20

Process bus interface:

- Bus system:
  Ethernet compliant to IEEE 802.3
  10/100BaseTx
- Module type:
  Ethernet/IP communication adapter
- Transmission medium:
  2 x twisted pair cat. 5 compliant to IEEE standard
- Bus connection:
  4-pin M12 socket
  D-coded (X1 and X2)

Field bus interface:

- L-Bus bus system
- Maximum 10 I/O modules can be connected to the L-Bus interface.

RS232 interface:

- X4:
  Male multipoint connector, SUB-D, 9-pin UNC (M3 optional)

Environmental test:

- EMC emitted interference/ interference immunity:
  EN 50121-3-2
- Insulation coordination:
  EN 50124-1
- Vibration/shock resistance:
  EN 61373
  Category 1
  Class B
- Cold/hot/climate
  EN 50155

Supply unit:

- Supply voltage:
  24 V DC (range 16.8 V - 30.0 V)
- Residual ripple:
  max. ±10 %
- Charging rate at DC 24 V:
  nom. 140 mA
  at 16.8 V DC
  200 mA plus charging rate of individual I/O interface;
  protected in the event of a malfunction (internal short circuit or overload at L-Bus connector)
  by 2 A fuse
  ($10*I_N$ for 100 ms or $5*I_N$ for 1s).
  If optional configuration is used without internal fuse, then the power supply must be appropriately protected by an external fuse.
- Connected by 5-pin cage tension spring X3 with pressure point
- Polarity reversal protection: yes

Potential isolation:

- Cutoff voltages:
  Ethernet/IP and electronic
  AC 1500 V
- RS232 and electronic
  AC 500 V

Diagnostics:

- 3 LEDs for following status displays: Module status MS, Network status NS, L-Bus status LB
- LEDs for link and activity compliant to the Ethernet standard for each interface

Other:

- Module size: 141.5 x 123 x 36 mm
- Weight (without connector): 430 g
- Housing: Aluminium
- IP rating: IP 20
- Mounting on a top hat rail
- Installation position: all installation positions allowed
- Operating temperature: -40 to +70 °C (+85 °C for 10 min), complies with EN 50155 Class Tx
- Storage temperature: -40 to +85 °C
- Relative humidity 100 %, brief moisture condensation permissible
- Optional conversion kit of threads on Sub-D connector UNC4/40 in M3

4.2 Hardware description

4.2.1 Block diagram of the Ethernet/IP bus interface for DIOLINE20

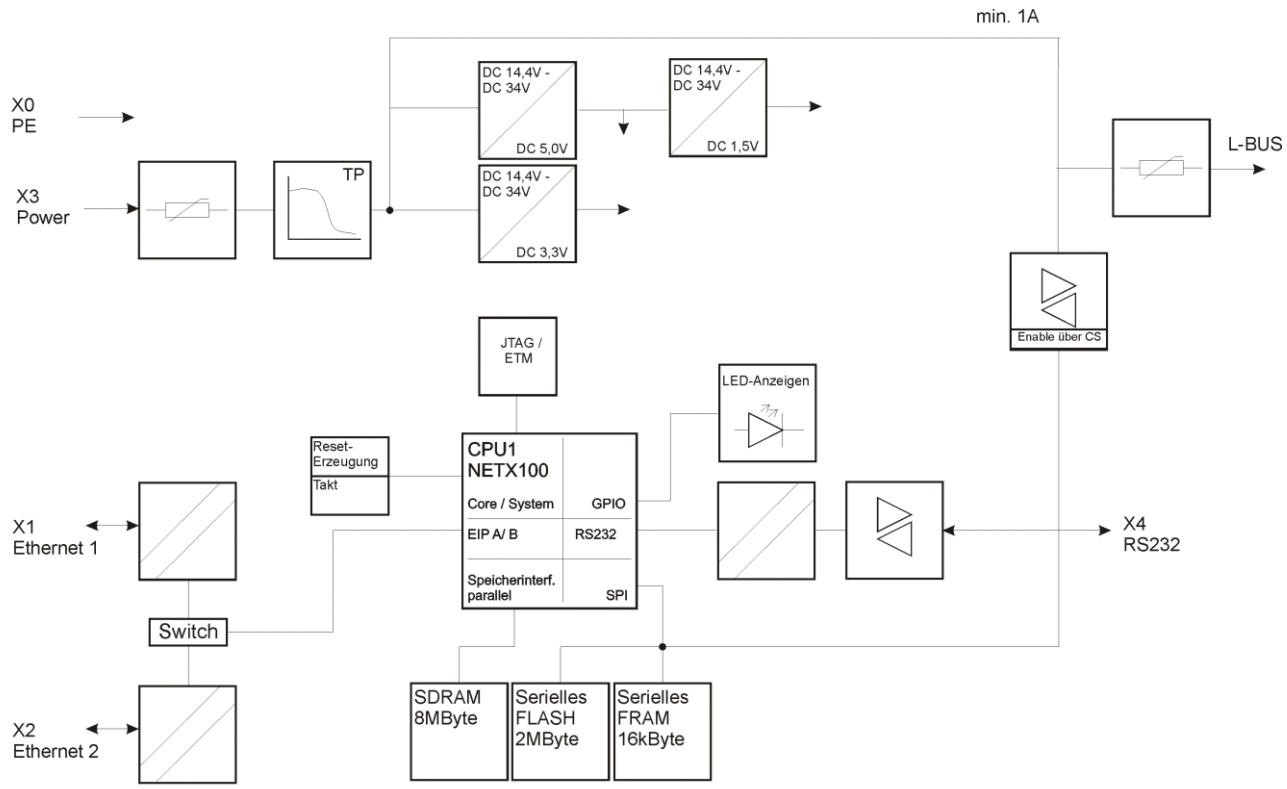
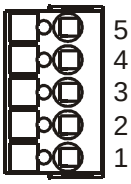


Fig. 2: Block diagram of the Ethernet/IP bus interface for DIOLINE20

4.2.2 Power supply

A DC voltage of 24 V DC must be used for the power supply in accordance with the railway specification EN 50155.



The X3 terminal for the power supply is designed as a 5-pin slot-in terminal with a cage tension spring.

6.3 mm flat-pin connector X0
for PE contact

Fig. 3: Power supply terminals

Pin no.	Signal	Description
1	24 V	24 V supply
2	24 V	24 V supply
3	PE	Earth connection
4	0 V	0 V supply
5	0 V	0 V supply

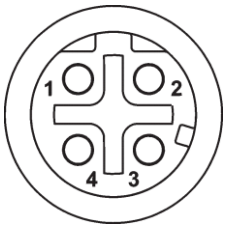
Fig. 4: Pin assignment of power supply terminal

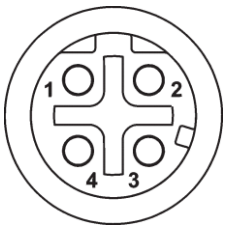
The device must not be operated without the protective conductor connected, as the housing could be live if the device is faulty.

4.2.3 Description of Ethernet interfaces

The standard connection of modules to the Ethernet is by two 4-pin M12 female connectors compliant to IEC 61076-2-101-A1.

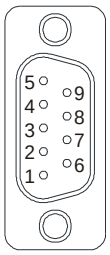
The Ethernet network connections are on the bottom at the front: X1 and X2.

Ethernet 1 connection	Pin no.	Signal	Description
The X1 "Ethernet 1" connector is a 4-pin M12 socket 	1	TX+	Send data +
	2	RX+	Receive data +
	3	TX+	Send data -
	4	RX-	Receive data -
	Housing connector	PE	Shield (connected to the housing)

Ethernet 2 connection	Pin no.	Signal	Description
The X2 "Ethernet 2" connector is a 4-pin M12 socket 	1	TX+	Send data +
	2	RX+	Receive data +
	3	TX+	Send data -
	4	RX-	Receive data -
	Housing connector	PE	Shield (connected to the housing)

The Ethernet 1 and Ethernet 2 interfaces each occupy one port of an internal Ethernet switch.

4.2.4 RS232 interface



The "RS232" X4 connector is a 9-pin SUB-D male multipoint connector.

Pin assignment:

Pin no.	Signal	Description
1	NC	Not used
2	RXD	Receive Data
3	TXD	Transmit Data
4	NC	Not used
5	GND	Ground
6	NC	Not used
7	RTS	Not used
8	CTS	Not used
9	NC	Not used
Housing connector	PE	Shield (connected to the housing)

4.2.5 Indicators

The Ethernet/IP bus interface for DIOLINE20 has the following LEDs to display the current module status:

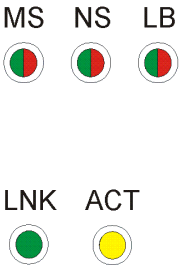


Fig. 5: LED indications

LED	Colour	Meaning
MS	green/red	Module status
NS	green/red	Network status
LB	green/red	L-Bus status
Ethernet 1		
LNK	green	Ethernet 1 Link status
ACT	yellow	Ethernet 1 Activity status
Ethernet 2		
LNK	green	Ethernet 2 Link status
ACT	yellow	Ethernet 2 Activity status

4.3 Functional description

4.3.1 Introduction

The module is used as a bus connector between the realtime Ethernet network "Ethernet/IP" (see [1]) and the Lütze field bus, referred to here as "L-Bus". The physical I/O functionality is provided by the DIOLINE20 modules connected to the L-Bus.

The digital and analogue process data read via the Ethernet/IP or L-Bus are thereby transferred completely and consistently on the L-Bus or Ethernet/IP.

The L-Bus is transparent to the Ethernet/IP network, i.e. the module acts, with regard to the I/O technical data sets, as a highly flexible I/O module that can be individually configured within a wide range.

4.3.2 L-Bus

The L-Bus is a proprietary field bus from Lütze and is used to connect the single I/O submodules (DIOLINE20 modules).
All process data and status information from this bus are consistently mapped asynchronously on the Ethernet/IP; therefore, from the perspective of the other Ethernet/IP users, the L-Bus is transparent.

4.3.3 Ethernet/IP

Ethernet/IP is a realtime Ethernet network protocol based on standard TCP/IP and implemented by the Common Industrial Protocol (CIP) of the (common) application layer.

The modules functions as an Ethernet/IP adapter of "communication adapter" subscriber class (see [1]) and therefore supports the following features:

- Communicates messages (explicit communication of Transport Class 3)
- Communicates messages in realtime (process data) (implicit (multicast) communication of Transport Class 1)
- Supports both input-only and output-only connections
- Supports configuration assembly
- Supports Electronic Key Management
- Supports Repeated Packet Interval (RPI) >= 20 ms
- Supports Quality of Service (QoS) for implicit messages
- Supports star and line shaped network topologies

4.3.3.1 Common Industrial Protocol (CIP)

4.3.3.1.1 Supported objects

4.3.3.1.1.1 Identity object

This object is used to identify a device within the Ethernet/IP network:

Class ID: 0x01					
Instance ID	**Kind of Object**	**Attribute ID**	**Attribute Name**	**Supported Services**	**Content**
0	Class	1	Revision	Get Attribute	<Revision>
		2	Max. Number of Instance ID		1
		6	Max. Number of Class Attribute ID		7
		7	Max. Number of Instance Attribute ID		10
1	Instance	1	Vendor ID	Get/Set Attribute	<Lütze Vendor-ID>
		2	Device Type		12 (Communication Adapter)
		3	Product Code		<Lütze Product Code> = (~~74~~)6423
		4	Revision		<Firmware Major Rev.><Firmware Minor Rev.>
		5	Status		<Device CIP Status> (see [1])
		6	Serial Number		<Lütze serial number>
		7	Product Name		<Lütze Product Name> = Lütze Ethernet/IP-LBus Coupler
		8	State		<Device State Machine Code> (see [1]) = …, 3 (operational), …
		9	Conf. Consist. Value		<Configuration Consist. Flag> (see [1])

4.3.3.1.1.2 Message Router Object

This object is used for unique assignment of explicit messages to an CIP object date.

Unique assignment of a CIP object date within the entire network is ensured by the node address (IP address) and the CIP-Class ID, CIP-Instance ID and CIP-Attribute ID.

4.3.3.1.1.3 Assembly Object

This object defines the supported connection points (application objects) for implicit communication of the module:

Class ID: 0x04					
Instance ID	**Kind of Object**	**Attribute ID**	**Attribute Name**	**Supported Services**	**Content**
0	Class	1	Revision	Get Attribute Single	<Revision>
		2	Max. Number of Instance ID		254
100	Instance	3	Output Data	access via implicit message	see below
		4	Size	Get Attribute Single	see Class #120
101	Instance	3	Input Data	access via implicit message	see below
		4	Size	Get Attribute Single	see Class #120
102	Instance	3	Configuration Data	-	see below

The following additional connection points (Instance IDs) are defined:

- 255: Listen Only Instance
- 254: Input Only Instance, Output Only Instance

The following conditions apply for access of several scanners (Scanner 2 or additional) to the adapter module (assumption: Scanner 1 has an open Exclusive Owner connection):

	Exclusive Owner	Listen Only	Input Only	Output Only
Meaning	Used equally for access to the input data and to exclusively set the output data	Can only exist together with an Exclusive Owner connection and only to access the input data	Exists independently of other connections to access the input data	Used to exclusively set the output data (in principle, this is a slimmed-down Exclusive Owner connection)
Connection ID	Is declined as long as there is already any other Exclusive Owner connection	T→O: Same as for Scanner 1 (Connection 1) O→T: Own, just for Heartbeat (Connection 2)	T→O: Own (Connection 2) O→T: Own, just for Heartbeat (Connection 2)	Is declined as long as there is already any other Exclusive Owner connection
Access rights I/O data	-	Read only (Connection 1)	Read only (Connection 2)	-
Heartbeat	-	Receive via Connection 1 Transmit via Connection 2	Receive and transmit via Connection 2	-
Scanner 1 closes connection	Allows Scanner 2 to be opened	Closes automatically (Connection 1)	T→O: Connection 2 remains O→T: Connection 2 remains	T→O: Own, just for Heartbeat (Connection 2) O→T: Own (Connection 2)
Scanner 1 re-opens an Exclusive Owner connection	Is declined as long as any there is already any other Exclusive Owner connection	re-opens automatically (Connection 1)	T→O: Connection 2 remains O→T: Connection 2 remains	Is declined as long as there is an Output Only connection

Legend:

- O: Originator (Scanner, point-to-point transmitter)
- T: Target (Adapter, multicast transmitter)

4.3.3.1.1.3.1 Structure of output data

Address	Length (bytes)	Description/Coding
0	1	Heartbeat
1	$L_{do} = L_{do1} + … + L_{don}$	Digital output value of digital substation 1 (nearest to EIP coupler): 0 … 0xFF/0xFFFF (0: digital output off; 1 digital output on)
		…
		Digital output value of digital substation n (farthest to EIP coupler): 0 … 0xFF/0xFFFF (0: digital output off; 1 digital output on)
$1 + L_{do}$	$L_{ao} = L_{ao1} + … + L_{aom}$	Analogue output value of analogue substation 1 (nearest to EIP coupler): 0/0x8000 … 0xFFFF/0x7FFF (see module description for concrete data format)
		…
		Analogue output value of analogue substation m (farthest to EIP coupler): 0/0x8000 … 0xFFFF/0x7FFF (see module description for concrete data format)
$L_o = 1 + L_{do} + L_{ao}$	<output assembly size> - L_o	unused

Total length L_{do} of digital output data: $L_{do} = L_{do1} + … + L_{don}$
Total length L_{do} of analogue output data: $L_{ao} = L_{ao1} + … + L_{aom}$
Total length L_o of output data: $L_o = 1 + L_{do} + L_{ao}$

CAUTION: The number of output data specified by the scanner to open the implicit communication must be less than or equal to the total length L_o!

4.3.3.1.1.3.2 Structure of input data

Address	Length (bytes)	Description/Coding
0	1	Heartbeat
1	2	Bit(0): Station Status Bit EIP Coupler: 0: no Error; 1: Station Error
		Bit(1): Station Status Substation 1 (nearest to EIP Coupler): 0: no Error; 1: Station Error
		…
		Bit(N): Station Status Substation N (farthest to EIP Coupler): 0: no Error; 1: Station Error
3	$L_{di} = L_{di1} + … + L_{din}$	Digital input value of digital substation 1 (nearest to EIP coupler): 0 … 0xFF/0xFFFF (0: digital output off; 1 digital output on)
		…
		Digital input value of digital substation n (farthest to EIP coupler): 0 … 0xFF/0xFFFF (0: digital output off; 1 digital output on)
3 + L_{di}	4	Bit pair (0): Digital input validity of digital substation 1 (not supported, always 0): 0: Digital input value is valid; 1 … 3 : Digital input value is unsecure/invalid
		…
		Bit pair (n-1): Digital input validity of digital substation n (not supported, always 0): 0: Digital input value is valid; 1 … 3 : Digital input value is unsecure/invalid
7 + L_{di}	4	Bit pair (0): Digital output validity of digital substation 1 (not supported, always 0): 0: Digital output value is valid; 1 … 3 : Digital output value is unsecure/invalid
		…
		Bit pair (n-1): Digital output validity of digital substation n (not supported, always 0): 0: Digital output value is valid; 1 … 3 : Digital output value is unsecure/invalid
11 + L_{di}	$L_{ai} = L_{ai1} + … + L_{aim}$	Analogue input value of analogue substation 1 (nearest to EIP coupler): 0/0x8000 … 0xFFFF/0x7FFF (see module description for concrete data format)
		…
		Analogue input value of analogue substation m (farthest to EIP coupler): 0/0x8000 … 0xFFFF/0x7FFF (see module description for concrete data format)
11 + L_{di} + L_{ai}	4	Bit pair (0): Analogue input validity of analogue substation 1 (not supported, always 0): 0: Analogue input value is valid; 1 … 3 : Analogue input value is unsecure/invalid
		…
		Bit pair (m-1): Analogue input validity of analogue substation m (not supported, always 0): 0: Analogue input value is valid; 1 … 3 : Analogue input value is unsecure/invalid
15 + L_{di} + L_{ai}	4	Bit (0) pair: Analog output validity of analog substation 1 (not supported, always 0):

		0: Analog output value is valid; 1 … 3 : Analog output value is unsecure/invalid
		…
		Bit pair (m-1): Analog output validity of analog substation m (not supported, always 0): 0: Analog output value is valid; 1 … 3 : Analog output value is unsecure/invalid
$L_i = 19 + L_{di} + L_{ai}$	<input assembly size> - L_i	unused

Total length L_{di} of digital input data: $L_{di} = L_{di1} + … + L_{din}$
Total length L_{ai} of analogue input data: $L_{ai} = L_{ai1} + … + L_{aim}$
Total length L_i of input data: $L_i = 19 + L_{di} + L_{ai}$

CAUTION: The number of input data specified by the scanner when opening the implicit communication must be greater than or equal to the total length L_i!

Except for the station status, the validation information is currently not available and is always set to zero!

4.3.3.1.1.3.3 Structure of configuration data

Address	Length (bytes)	Description/Coding
0	4	Byte 0 … 1: Output Value Hold Time (switch off delay time) in ms 0 … 0xFFFF Byte 2 … 3: unused, always 0
4	4	Byte 0 ID of Substation 1 (nearest to EIP Coupler): 0 … 0xFF
		Byte 1 … 3: unused, always 0
4 + 4	4 * (n-2)	…
4 + 4 * (n-1)	4	Byte 0 ID of Substation n (farthest to EIP Coupler): 0 … 0xFF
		Byte 1 … 3: unused, always 0
L_C = 4 + 4 * n	<configuration assembly size> - L_C	unused

CAUTION: The number of configuration data specified by the scanner when opening the implicit communication must be even!

If configuration data exists when opening communication, then these are used for the following purposes or checks:

The Output Value Hold Time specifies the minimum hold (wait) time in milliseconds for the events below until the outputs are switched from the last valid values to the failsafe state (delay connection timeout).
The Output Hold Time is set to a default value (1000 ms) after resetting the device and after the last close of an implicit connection.
Start conditions for the Output Hold Time are:

- Any kind of EIP communication problem
- Heartbeat counter frozen for at least 200 ms

The Output Hold Timer is immediately reset once all triggering events have disappeared.
CAUTION: The shortest period for the Output Hold Time is 10 ms!

The list of IDs of the DIOLINE20 substations is used to check the following circumstances:

- Are all specified modules actually physically attached to the L-Bus?
- Do the physically-connected modules exist in the same order?

CAUTION: If there are discrepancies, then no implicit communication connection is opened!

4.3.3.1.1.3.4 L-Bus technical data set

Number of supported L-Bus substations: N = 1 … 10 (N_{max})

Maximum total length of input data: L_{imax} = 19 + N_{max}*8 = 99 bytes
Actual length of input data:
L_{iact} = <Content of Class ID #120, Instance ID #0, Attribute ID #8> bytes

Maximum total length of output data: L_{omax} = 1 + N_{max}*8 = 81 bytes
Actual length of output data:
L_{oact} = <Content of Class ID #120, Instance ID #0, Attribute-ID #9> bytes

4.3.3.1.1.3.5 Heartbeat

The following specifications apply to the heartbeat counter:

- Output data: incremented by one on each I/O cycle and reset to zero in case of overflow
- Input data: Is checked during each I/O cycle for change; if the counter has still not changed after 10 I/O cycles, then Bit 0 is set to station status and the outputs are switched to failsafe state (taking into account the Output Delay Time)!

4.3.3.1.1.4 Connection Manager Object

This object provides the management functionality as well as operation of explicit and implicit connections.

4.3.3.1.1.5 Ethernet Link Object

This object provides the functionality for configuration of the Ethernet interface (MAC address, baud rate, etc.).

4.3.3.1.1.6 TCP/IP Object

This object provides the functionality for the configuration of the TCP/IP layer (IP address, network mask, gateway address, etc.).

Comment: Attribute #9 (Mcast conf.) and therefore also Attribute #8 (TTL) are currently not implemented and are not supported!

4.3.3.1.1.7 L-Bus Topology Data Object

This object provides the functionality to determine the current, physically connected L-Bus topology (number of substations, IDs, I/O lengths, I/O circuit mimicry):

Class ID: 120					
Instance ID	**Kind of Object**	**Attribute ID**	**Attribute Name**	**Supported Services**	**Content**
0	Class	1	Revision	Get Attribute (Single/All)	not supported
		2	Max. Number of Instance ID		16
		3	Number of Instances		n
		6	Max. Number of Class Attribute ID		9
		7	Max. Number of Instance Attribute ID		4
		8	Total Length of Input Data		1 … n*8 + 19
		9	Total Length of Output Data		1 … n*8 + 1
1 … n	Instance	1	ID of Substation i	Get Attribute (Single/All)	<Substation Identification Byte>
		2	Length of Input Data of Substation i		1 … 8
		3	Length of Output Data of Substation i		1 … 8
		4	I/O Mimic		0 (digital); 1 (analog)

n: Number of L-Bus substations actually connected by the L-Bus to the Ethernet/IP bus coupler

4.3.3.1.2 Supported services

- UCMM (Unconnected Message Manager)
- Forward_Open
- Get/Set Attribute
- Get/Set Attribute All (only when specified explicitly)

4.3.3.2 TCP/UDP (IPv4)

This protocol is implemented compliant to the standard.

4.3.3.3 DHCP

This protocol is implemented compliant to the standard (RFC 2131, RFC 2132).

The module transmits a DHCP Discover in cycles until an IP address is assigned by the DHCP server. The request is sent at the following times after DHCP initialisation:
0 s, 2 s, 4 s, 6 s, 8 s, 10 s, 12 s, … .
As soon as an IP address has been assigned, the Ethernet/IP stack reinitialises with the new IP address (this can take anywhere from 10 s to 15 s).

The DHCP client behaves acc. to the following standard after the new IP address is assigned:
- A Renew (unicast) is run after 50% of the lease time (=T1)
- If the Renew fails then a Rebind to any server (broadcast) is run after 87.5% (=7/8) of the lease time (=T2)
- If even this Rebind fails then the stack looses its IP address and shuts down

The following behavior of the DHCP client should be noted regarding Renew and Rebind:
The responding DHCP server must run an ACK with the same IP address, otherwise the stack shuts down! However, this can happen at any time during a Rebind, mainly if another DHCP server responds. It might therefore be useful to only use one DHCP server.

4.3.3.4 BOOTP

This protocol is implemented compliant to the standard.

4.3.3.5 IGMP

This protocol is implemented compliant to the standard.

4.3.3.6 ICMP

This protocol is implemented compliant to the standard.

4.3.4 I/O design

Both buses run independently and non-synchronised to each other.

The internal I/O cycle time to transmit the buffered bas data to the other respective bus is 10 ms (the time is calculated from the minimum transmission time on the L-Bus and the maximum RPI for Ethernet/IP).

The L-Bus throughput is calculated as:

$N_{bytes\ gross} = 2 * N_{I/O\ bytes} + 5$

$T_{LBus\ frame} = T_{bytetime} + T_{gap}$

$T_{bytetime} = N_{bytes\ gross} * 8 * 1\ \mu s$ (where SPI Clock = 1 MHz; 8 bits/byte)

$T_{gap} = N_{bytes\ gross} * 40\ \mu s + 2\ ms$ (where byte gap = 40 µs/byte; frame gap = 2 ms/frame)

e.g. where $N_{I/O\ bytes} = 80$ follows:

$T_{L\text{-}Bus\ frame} = 165*8\ \mu s + 165*40\ \mu s + 2\ ms = 1.32\ ms + 6.6\ ms + 2\ ms < 10\ ms$

The theoretical maximum delay time between physical event and reaction on the Ethernet/IP network is:

$T_{maxdelay} = T_{L\text{-}Bus\ frame} + T_{I/O\ cycle} + T_{RPI} + T_{latency}$

$T_{maxdelay} = 10\ ms + 10\ ms + T_{RPI} + x\ \mu s$

$T_{maxdelay} \approx 20\ ms + T_{RPI}$

The theoretical minimum delay time is:

$T_{mindelay} = T_{RPI} + T_{latency}$

$T_{mindelay} \approx T_{RPI}$

4.3.5 Safety concept

The following tests are run during initialisation:

- LED test
- FRAM test

The following specifications apply regarding the implicit I/O data communication:

Status	Cause					
	invalid configuration (Keying, Configuration Assembly or I/O Assembly Lengths)	**Interrupted EIP communication**	**RPI violation**	**Faulty L-Bus communication**	**Status bit of L-Bus substation i is set**	**Non-incremented heartbeat counter (Output Assembly)**
Implicit Ethernet/IP communication	offline	offline	offline	online	online	online
Input Assembly	-	-	-	Status Block Bit 0 = 1	Status Block Bit i = 1	Status Block Bit 0 = 1
I/O data	Failsafe (Out-put data)	Failsafe (Output data)	Failsafe (Output data)	Failsafe (In-put data)	ok (Values from Slave i may be unsure)	Failsafe (Output data)
MS-LED/ NS-LED (see below)	green/ green flashing	green/ red flashing	green/ red flashing	green/ green	green/ green	green/ green
LB-LED (see below)	green	green	green	red	green	green

If a fault is detected (see above), then a failsafe state might occur, which then forces the following I/O behavior:

- If there is a communication fault over the Ethernet/IP or a violation of the heartbeat mechanism, then the outputs affected are switched off internally within the module i.e. they are set to digital value 0_b or analog value 0 and transmitted in this form over the L-Bus.
- If there is an L-Bus communication fault, then the outputs affected are switched off internally within the module i.e. they are set to digital value 0_b or analog value 0 and transmitted in this form over the Ethernet/IP network.

4.3.6 State of LED indications

All LEDs (MS-LED, NS-LED and LB-LED) light up green when
- the module has a valid network configuration (e.g. IP address) and
- the module has opened implicit communication and
- no error states exist.

If at least one of these conditions is not met, then at least one LED lights up red or at least one LED flashes red or green:

Cause	MS-LED	NS-LED	LB-LED
Module has detected an unrecoverable error with regard to Ethernet/IP	red	x	x
Module has detected a recoverable error with regard to Ethernet/IP	red flashing	x	x
No valid network configuration (IP address) exists	green flashing	x	x
IP address already exists within the network	x	red	x
Implicit communication faulty (e.g. timeout)	x	red flashing	x
No implicit communication opened	x	green flashing	x
L-Bus communication faulty	x	x	red
No error states exist, Valid network configuration exists, Implicit communication opened	green	green	green

Comments:

a) „x“ means: LED is not affected by the cause indicated

4.3.7 Network and CIP configuration

Item	Method / Values
IP address	1: Assigned by DHCP server 2. Assigned by BOOTP server 3. Default address (factory setting: 192.168.1.69)
Network mask	1: Assigned by DHCP server 2. Assigned by BOOTP server 3. Default address (factory setting: 255.255.255.0)
Gateway address	1: Assigned by DHCP server 2. Assigned by BOOTP server 3. Default address (factory setting: 0.0.0.0)
Auto negotiation	on
Baud rate	by auto negotiation
Half/Full duplex	by auto negotiation
Network Address Settings Protocol	DHCP
Keying	supported
RPI (I/O cycle time)	>= 20 ms

4.3.8 Monitor program

The module contains a monitor program for configuration and diagnostics of the module. This monitor program communicates with a terminal application through dialogs and commands.

Physical communication is via the serial interface of the module, whereby the following interface parameters must be set on the other side:

Baud rate	9600 bd
No. of data bits	8
No. of stop bits	1
No. of parity bits	0
Handshake	no

The monitor provides the following commands (the dialogue language is English):

Command	Parameter	Description
ipconfig	ip [IP address] | mask [network mask] | gw [gateway address]	Display or set defaults of the network configuration (IP address, network mask, gateway address)
factory	-	Reset network configuration to factory settings
reset	-	Restart the module (warm start))
status	-	Display status of module

4.3.9 EDS

```
$ EZ-EDS Version 3.3 Generated Electronic Data Sheet

$ ******************************************************************************
$
$ File:   Luetze_EIP_LBus-Coupler.EDS
$
$ Author: Friedrich Luetze GmbH & Co. KG, D-71384 Weinstadt, Germany
$         transportation@luetze.com

$ Date:   20.08.09
$
$ ******************************************************************************
$
$ ATTENTION:
$
$  Changes in this file can cause configuration or communication problems.
$
$ ******************************************************************************
$
$ Changes:
$
$  Version  Date       Name   Description
$ ------------------------------------------------------------------------
$
$  1.0      20.08.09   JH     created
$
$ ******************************************************************************

[File]
        DescText = "EDS-File for Luetze Ethernet/IP Adapter";
        CreateDate = 08-20-2009;
        CreateTime = 16:00:00;
        ModDate = 10-19-2009;
        ModTime = 16:00:00;
        Revision = 1.0;
```

```
[Device]
        VendCode = 53;
        VendName = "Luetze";
        ProdType = 12;
        ProdTypeStr = "Communications Adapter";
        ProdCode = 6423;
        MajRev = 1;
        MinRev = 1;
        ProdName = "Luetze EtherNet/IP-LBus Coupler";
        Catalog = "EtherNet/IP Adapter";


[Device Classification]
        Class1 = EtherNetIP;

[Params]
        Param1 =
              0,                $ reserved, shall equal 0
              ,,                $ Link Path Size, Link Path
              0x0000,             $ Descriptor
              0xC7,             $ Data Type
              2,                $ Data Size in bytes
              "input size",       $ name
              "",               $ units
              "",               $ help string
              19,99,19,           $ min, max, default data values
              ,,,,              $ mult, div, base, offset scaling
              ,,,,              $ mult, div, base, offset links
              ;                 $ decimal places
        Param2 =
              0,                $ reserved, shall equal 0
              ,,                $ Link Path Size, Link Path
              0x0000,             $ Descriptor
              0xC7,             $ Data Type
              2,                $ Data Size in bytes
              "output size",      $ name
              "",               $ units
```

```
        "",                 $ help string
        1,81,1,             $ min, max, default data values
        ,,,,                $ mult, div, base, offset scaling
        ,,,,                $ mult, div, base, offset links
        ;                   $ decimal places
    Param3 =
        0,                  $ reserved, shall equal 0
        ,,                  $ Link Path Size, Link Path
        0x0000,             $ Descriptor
        0xC7,               $ Data Type
        2,                  $ Data Size in bytes
        "conf size",        $ name
        "",                 $ units
        "",                 $ help string
        8,44,8,             $ min, max, default data values
        ,,,,                $ mult, div, base, offset scaling
        ,,,,                $ mult, div, base, offset links
        ;                   $ decimal places


[Connection Manager]
    Connection1 =
        0x04010002,         $ Trigger and Transport
        0x44644405,         $ Point Multicast
        ,Param2,,           $ OT RPI Size format
        ,Param1,,           $ TO rpi size format
        Param3,,            $ TODO config 1
        ,,                  $ TODO config 2
        "Data, In/Out       ",  $ connection name
        "Explicit Owner",       $ help string
        "20 04 24 66 2C 64 2C 65";    $ path

    Connection2 =
        0x01010002,         $ Trigger and Transport
        0x44244305,         $ Point Multicast
        ,0,,                $ OT RPI Size format
        ,Param1,,           $ TO rpi size format
        Param3,,            $ TODO config 1
```

```
        ,,                  $ TODO config 2
        "Listen only",      $ connection name
        "Listen only",      $ help string
        "20 04 24 66 2C FF 2C 65";    $ path

    Connection3 =
        0x02010002,         $ Trigger and Transport
        0x44244305,         $ Point Multicast
        ,0,,                $ OT RPI Size format
        ,Param1,,           $ TO rpi size format
        Param3,,            $ TODO config 1
        ,,                  $ TODO config 2
        "Input only",       $ connection name
        "Input only",       $ help string
        "20 04 24 66 2C FE 2C 65";    $ path

    Connection4 =
        0x04010002,         $ Trigger and Transport
        0x44643405,         $ Point Multicast
        ,Param2,,           $ OT RPI Size format
        ,0,,                $ TO rpi size format
        Param3,,            $ TODO config 1
        ,,                  $ TODO config 2
        "Output only      ",  $ connection name
        "Output only",      $ help string
        "20 04 24 66 2C 64 2C FE";    $ path


[Port]
    Port1 =
        TCP,
        "Ethernet/IP port",
        "20 F5 24 01",
        1;


[Capacity]
```

```
ConnOverhead = .004;          $ Connection Overhead

MaxIOConnections = 3;         $ Maximum number of Class 1 Connections
MaxMsgConnections = 5;        $ Maximum number of Class 3 Connections
TSpec1 = TxRx, 10, 1400;      $ packets per sec @ 10 bytes
TSpec2 = TxRx, 100, 1300;     $ packets per sec @ 100 bytes
TSpec3 = TxRx, 200, 1120;     $ packets per sec @ 200 bytes



$ ******************************************************************************
$ EOF
$ ******************************************************************************
```

5 References

Number	Title	Description
1	The Ethernet/IP Specification, ODVA	Complete Ethernet/IP Specification comprising: Volume 1 (CIP), Volume 2 (Ethernet/IP-Adaption), Volume 7 (Integration of Modbus Devices into the CIP Architecture)

6 Notes on operating digital output modules

(1) Slot status – this is set by the output modules in case of the following errors:
+ Short-circuit of output to GND
+ Output overload / overtemperature
+ Feedback to the output (short to 24 V DC) due to wiring errors or a defect in the module itself.

(2) The outputs (output drivers) cannot be destroyed by short-circuit, overload or feedback. However, we recommend you switch-off as soon as possible to prevent degeneration and concomitant reduction in lifetime.

- Behaviour of the 16 out / 8 in+8 out module:
  Short-circuit is detected by the module and an error alarm is issued via the L-Bus / process bus (slot status etc. see above). Troubleshooting is passed over completely to the application. The module itself does not switch off the outputs. This allows a short-circuit to be driven or switched off. The output driver behaves as described above. We recommend the following procedure to save the module from undue stress.
  (1) Permanent monitoring of slot status and any error signalised.
  (2) If the slot status at an output module is set to "error", then all outputs on this L-Bus module should be switched off whenever this is possible. If the slot status error then disappears, then this is a short-circuit/overload error. If required, single outputs can then be put back into operation to further localise the error. If the slot status error once more occurs, then the last input switched on is most probably the source of the error.
  If all outputs of a group have been switched off and the slot status error continues to be queued, then this is due to feedback caused by the periphery or the module itself is defective.

- Behaviour of the 8 out + diagnostics module (4 potentials)
  Troubleshooting is also passed on completely to the application for this module. It is therefore possible to drive a short-circuit or to switch it off by selecting a channel. The diagnostics state of the outputs is available as a "normal" process variable. Slot status is not used for this module because detailed diagnostics data exist in the process data. We also recommend here that the appropriate output be switched off as soon as possible.
  Data structure of module:
  à 8-bit output data
  à 16-bit input data (8-bit readback data directly from the output terminal +8-bit driver status ("0" = OK ; "1" = short-circuit, overtemperature)

7 Revision history

Version	Amendment
1.00	First issued