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1 Revision History

	Date of Modification	Modifications, Additions or Explanations	Editor
00	08/08/00	Version 2 of the Technical Guidelines for regulated INTERBUS fiber optic systems.	A. Pape
01	11/15/00	Corrections relating to comparison with OPC interface	A. Pape/M. Echterhoff

2 Table of Contents

3 General

Fiber optics are playing an increasingly important role in transmission technology. This solution is particularly useful in environments with high levels of interference and in potentially explosive environments. In addition to the technical advantages of data transmission using fiber optics, the availability of systems that support this transmission medium is also decisive for its possible applications in a plant. However, a high level of availability can only be ensured if all manufacturers use the same technical and functional data for the interface.

The new version of the Technical Guidelines for Optical Transmission Technology for INTERBUS supports the latest technology for the INTERBUS fiber optic system including comprehensive optical diagnostics and regulation options via the system. The introduction of a new slave protocol chip (SUPI 3 OPC) and a revision of the fiber optic interface were required to ensure optimum implementation of the latest system functions. This version of the guidelines takes this implementation into account.

A standard for INTERBUS for the physical layer of IEC 61158 is currently being prepared, in which INTERBUS is also specified as a Type 8 fieldbus including optical transmission technology. The Technical Guidelines for Optical Transmission Technology for INTERBUS should therefore be seen as an addition to the international INTERBUS standard, and document the detailed implementation of a standardized interface.

In addition to the definition of fiber optic and system-specific parameters, such as attenuation, jitter, bit distortion, and bit error rate, this transmission medium is also integrated into the INTERBUS system. Particularly effective features are the INTERBUS ring structure and the repeater function offered by each remote bus device, which considerably reduce expenditure on technology because star couplers and special repeaters are not required.

These Technical Guidelines for Optical Transmission Technology not only specify the technical data, but also discuss data transmission using fiber optics with regard to the entire INTERBUS system. This includes application notes and component suggestions.

4 Reference Source

The technical guidelines for optical transmission technology in the INTERBUS system as well as the guidelines for INTERBUS can be ordered from the INTERBUS Club e. V. at the following address:

INTERBUS Club Deutschland e. V.
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Phone: +49 - 72 29 - 69 96 28
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Or on the Internet at:

http://www.interbusclub.com

5 Data Transmission Using Fiber Optics

Data transmission using fiber optics offers several advantages for the user. In particular, immunity to electromagnetic interference is a key advantage of fiber-based transmission technology. The transmitter and receiver are electrically isolated from one another, which means that compensating currents cannot flow via the data cable. Interference caused by potential shifts is also prevented. For potentially explosive environments, fiber optic technology is often the only safe way of making systems suitable for use in these areas. At the same time, this medium allows for high data transmission rates in future because the transmission capacity of the light channel is extremely high. Connecting the system is quick and easy. The assembly technology for plastic fibers has now become so simple that the installation effort is barely a consideration. This means that a fiber optic interface can be more cost-effective than complex interference protection measures.

6 Fiber Optics in the INTERBUS System

6.1 Suitability

In terms of bus topology, the INTERBUS system is ideal for transmission using fiber optics. The ring structure supports full duplex data transmission and provides a unidirectional data flow on a physical transmission channel. This means that it is very easy to replace RS-485 interface transmitters and receivers with fiber optic transmitters and receivers. Every remote bus device can also act as a converter between fiber optics and RS-485. In addition, the repeater function offered by every INTERBUS remote bus device provides unlimited system expansion and eliminates the need for special repeaters. The INTERBUS ring structure also provides a simple structure in another respect. Star or T-couplers, which are used to connect devices to the bus in multi-drop systems, are not required.

Another advantage of fiber optic transmission using INTERBUS is the unique diagnostic option for the optical transmission path that is provided in chip generation SUPI 3 OPC (Optical Power Control) or later. This diagnostic option regulates the optical power, measures the path length, and thus offers monitoring and control of the cable attenuation. These processes are completed online without affecting the data flow, so that the evaluation of this diagnostic data via software and the automatic adjustments made to counteract increases in attenuation further enhance operational reliability and therefore system availability.

6.2 Area of Application

The best use of fiber optic technology is in the two-wire remote bus. These guidelines therefore refer only to the INTERBUS two-wire protocol.

Nothing changes for the user when fiber optic technology is used. Bus topology, configuration, and programming of the system remain the same. The fiber optic technology is absolutely transparent in INTERBUS. This permits the combined use of optical fibers, copper cables, and other transmission media, without any modifications or additional expenditure by the end user. Due to this transparency, it is even possible to remove the fiber optic interface from the device and implement it in a separate unit.

In order to use the optical diagnostics offered by the INTERBUS system for chip generation SUPI 3 OPC or later, this separate unit must have an appropriate protocol chip.

6.3 Special Features

Based on the technical specifications of these guidelines, polymer (plastic) fibers can be used to cover distances of up to 50 m (worst-case scenario) and HCS (Hard Clad Silica with a glass fiber core and a plastic sheath) fibers can be used to cover distances of up to 300 m. This provides a total expansion of up to 75 km for a dedicated fiber optic network. However, these values have little meaning in practice because real-life systems do not cover such large geographical areas.

What is important is that both polymer fiber and HCS fiber can be used in the defined transmit and receive components. This means that mixed operation or a later change in the medium is supported without problems.

In the INTERBUS ring system, an end identifier is required for the last device. With fiber optic transmission technology, the last device in the ring is determined by automatic interface recognition of the slave protocol chip for chip generation SUPI 3 OPC or later, which also shuts down the transmitter diode for the outgoing interface and therefore increases the service life of this component.

6.4 Exclusions

Old SUPI 3 fiber optic components are no longer supported by these guidelines. Device combinations, in which devices with a SUPI 3 chip and the old fiber optic interface are connected to devices with a SUPI 3 OPC chip and the new fiber optic interface, can be used without problems.

7 Interface Between Protocol Chip and Medium-Dependent Sublayer

The following sections of these guidelines are based on the sections of IEC 61158-2 that describe the physical layer of the Type 8 fieldbus. Only features relevant to the optical transmission are described below. For the basics, definitions of terms, and all other information, please refer to IEC 61158.

The definitions in these guidelines refer to both the incoming and outgoing interface and to the optional second outgoing (branch) interface. The guidelines therefore include both standard slaves and bus masters and bus couplers.

For data transmission between two devices, code transparency is required from the protocol chip output to the protocol chip input.

7.1 Overview of Relevant Services

IEC 61158 defines various services, which connect the medium-dependent sublayer (implemented on the optical level) with the protocol chip. The services are defined as logical signals and are implemented as physical signals.

Not all services are relevant for the implementation of an optical interface because they are implemented physically in the protocol chip. These services are therefore not described in more detail.

Table 1: Services for connection to the medium-dependent sublayer

Service	Abbreviation	Direction
Data Out	DO	From the protocol chip
Data In	DI	To the protocol chip

NOTE 1:
Only the services that are relevant for the optical interface are shown here.

7.2 Description of the Relevant Services

7.2.1 Data Out (DO)

This service transmits the signals from the protocol chip to the medium-dependent sublayer.

7.2.2 Data In (DI)

This service transmits the signals from the medium-dependent sublayer to the protocol chip.

7.3 Time Response

The IBS SUPI 3 OPC INTERBUS slave protocol chip can correctly decode a bit using the signal distortion* shown in Figure 1. Clock deviation over 13 bits must be within the range 500 kbps ±0.1% or 2 Mbps ±0.1%.

The deviation of an individual bit from the nominal bit period of 2 µs (transmission speed 500 kbps) or 500 ns (transmission speed 2 Mbps) may be a maximum of ±25% of the nominal bit period.

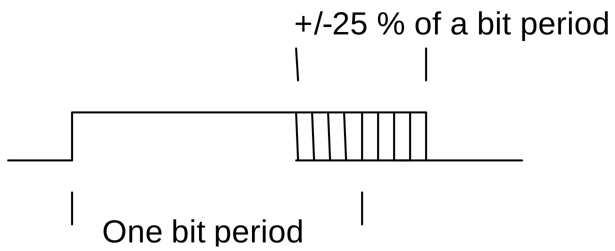


Figure 1: Time response of the MDS sublayer

The permissible pulse duty factor deviation must be taken into account.

The pulse duty factor is defined by:

$$\frac{t_{"0"}}{t_{"0"} + t_{"1"}}$$

$t_{"1"}$ = Duration of logic "1", $t_{"0"}$ = Duration of logic "0"

* All amounts which are caused by sampling errors, distortions due to time recovery components, pulse width distortions due to optical components (transmitter, receiver, and fiber), distortions due to electronics, jitter, etc.

7.4 Transmission Mode

The optical interface must support simultaneous and independent transmit and receive processes.

8 Medium Attachment Unit (MAU)

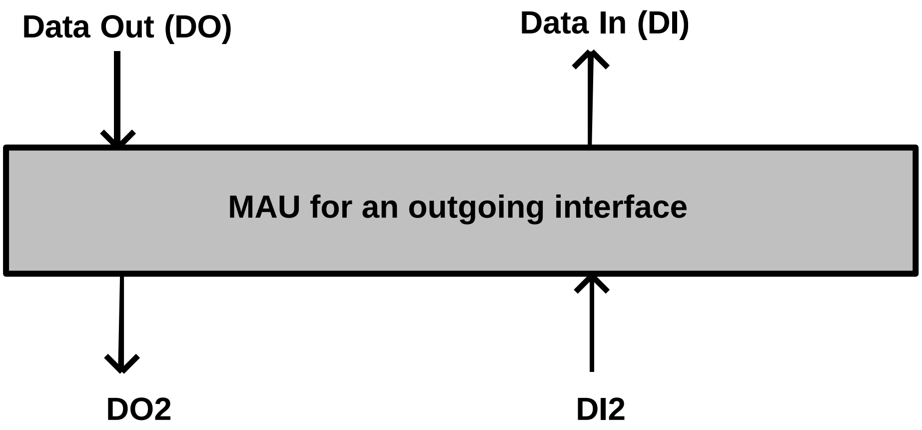


Figure 2: MAU for an outgoing interface

(only relevant services)

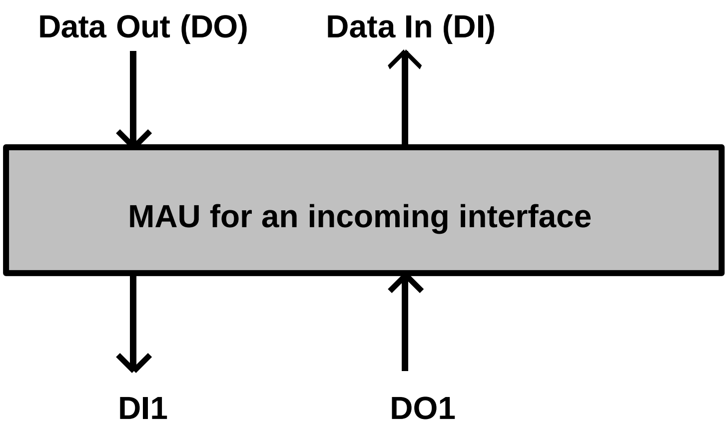


Figure 3: MAU for an incoming interface

8.1 Transmission Speed

For the 500 kbps system, a data rate of 500 kbps ±0.1% or 500 kbaud ±0.1% NRZ is specified. The nominal bit period for this is 2 µs ±0.1%.

For the 2Mbps system, a data rate of 2 Mbps ±0.1% or 2 Mbaud ±0.1% NRZ is specified. The nominal bit period for this is 500 ns ±0.1%.

8.2 Network

A fiber-based MAU operates in a network that comprises the following components:

- Fiber optics
- Plug-in connection
- Devices (with a least one communication element)

8.2.1 Topology

A fiber-based MAU must operate in a remote bus with precisely one other device. A remote bus path consists of two point-to-point connections. The connections are unidirectional. This means that each MAU has precisely one transmitter and one receiver.

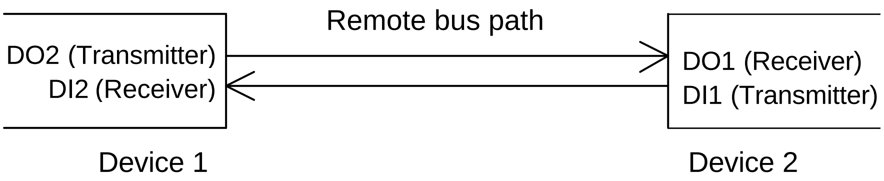


Figure 4: Remote bus path

The length of a remote bus path is determined by the optical parameters.

8.3 Optical Specification

8.3.1 Bit Encoding

The following NRZ bit encoding is specified:

Binary "1" light off
Binary "0" light on

If the bus is not operating, the idle state is specified as binary "0".

8.3.2 Optical Transmitter Data

The specification of the optical power is defined by:

$$P_{dBm} = 10\log(P_{opt}/1\ \text{mW})\ \text{in dBm}$$

The level is measured using a large surface detector after a 1 m reference fiber[1]. The fiber optic cable is fitted with the specified connectors so that the connector attenuation at the transmitter is included in the measured value. The level tolerances apply for the entire ambient temperature range of the transmitter and are taken into account by a corresponding reduction value when setting the level budget.

Optical Transmitter

Table 2: Optical transmitter data (for the temperature range of the application)

	Polymer Fibers	**HCS Fibers**
Maximum peak wavelength	660 nm	660 nm
Spectral half-value width	< 30 nm	< 30 nm
Type of fiber	980/1000 µm	200/230 µm
Numerical aperture NA of the measuring fiber	0.47 +/-0.03	> 0.36
Maximum transmission power binary "1" $P_{Smax"1"}$ (reference fiber measurement)	-43 dBm	-45 dBm
Maximum transmission power binary "0" $P_{Smax"0"}$ (reference fiber measurement)	-2.0 dBm	-8 dBm
Minimum transmission power binary "0" $P_{Smin"0"}$ (reference fiber measurement)	-6.2 dBm	-16.9 dBm
Maximum rise time t_{SAB}	25 ns	25 ns
Maximum fall time t_{SCD}	10 ns	10 ns
Maximum pulse duty factor deviation	-1/+0%	-1/+0%

[1] A reference fiber is a 1 m POF cable (Type A4a according to IEC 60793-2) or a 1 m HCS cable (Type A3c according to IEC 60793-2), assembled with F-SMA connectors at both ends, which has an attenuation α of $1.5 \leq \alpha \leq 2.0$ dB for POF or $1.0 \leq \alpha \leq 1.5$ dB for HCS (measured according to IEC 61300-3-4 Procedure B).

8.3.3 Optical Receiver Data

The level data for optical receiver sensitivity is read at the end of a reference fiber using a large surface detector. The reference fiber must ensure that no cladding modes affect the measured value. The fiber optic cable is fitted with the specified connectors so that the connector attenuation and the Fresnel reflection loss at the receiver are included in the measured value.

The level tolerances apply for the entire ambient temperature range of the receiver and are taken into account by a corresponding reduction value when setting the level budget.
The receiver sensitivity is based on a bit error rate of 10^{-9}.

Optical Receiver

Table 3: Optical receiver data (for the temperature range of the application)

	Polymer Fibers	**HCS Fibers**
Peak wavelength	660 nm	660 nm
Type of fiber	980/1000 µm	200/230 µm
Numerical aperture NA of the measuring fiber	0.47 +/-0.03	> 036
Maximum receiving power binary "1" $P_{Emax"1"}$	-43 dBm	-45 dBm
Maximum receiving power binary "0" $P_{Emax"0"}$	-2.0 dBm	> -8 dBm
Minimum receiving power binary "0" $P_{Emin"0"}$	-21.6 dBm	-23.0 dBm
Maximum rise time t_{FAB}	50 ns	50 ns
Maximum fall time t_{FCD}	30 ns	30 ns
Maximum pulse duty factor deviation	+/-12.5%	+/-12.5%

8.3.4 Pulse Parameters

The main pulse parameters are:
Rise time, fall time, amplitude and duration of preshoot/overshoot/post-pulse oscillation, pulse width, pulse duty factor and period.

8.3.4.1 Schematic Diagrams

The value of the data signals can be determined using a schematic diagram.
(See Appendix)

8.3.4.2 Transmitter Pulse Parameters

The values t_{SAB} and t_{SCD} are specified as the time in which the optical signal must pass through the range $P_{Smax"1"}$ to $P_{Smin"0"}$ or $P_{Smin"0"}$ to $P_{Smax"1"}$ on a rising or falling edge (10% to 90% or 90% to 10% of the signal level). The maximum permissible pulse duty factor deviation is specified as -1%/+0%.

The criterion for $t_{S"0"}$ is that the signals pass through the 50% values for $P_{Smin"0"}$ of a binary "0". The criterion for $t_{S"0"}$ + $t_{S"1"}$ is that the signal passes through 50% of the relevant rising pulse edges of a binary "010" bit string with a signal level of $P_{Smin"0"}$ for binary "0".

Pulse duty factor:

$$50\% - 1\% \leq \frac{t_S"0"}{t_S"0" + t_S"1"} \text{ x } 100\% \leq 50\% + 0\%$$

t_S = Transmitter bit period

The optical transmitter meets the specified requirements provided the transmitter signal is within the hatched area (see schematic diagram in Appendix).

8.3.4.3 Receiver Pulse Parameters

The values t_{EAB} and t_{ECD} are specified as the time in which the rising or falling edge must pass through the range from 10% to 90% or 90% to 10% of the electrical signal. The maximum permissible pulse duty factor deviation for the receiver is specified as +/-12.5%.

The criterion for $t_{E"0"}$ and for $t_{E"0"}$ + $t_{E"1"}$ is a threshold of 2.4 V (see schematic diagram in Appendix). The measurement is made using the specified transmitter and specified fiber with minimum or maximum fiber length.

Pulse duty factor:

$$50\% - 12.5\% \leq \frac{t_E"0"}{t_E"0" + t_E"1"} \text{ x } 100\% \leq 50\% + 12.5\%$$

t_E = Receiver bit period

The optical receiver meets the specified requirements provided the receiver signal is within the hatched area.

8.4 Interface to the Transmission Medium

The connection to the transmission medium is provided by one incoming (optional) and one or more independent outgoing interfaces.

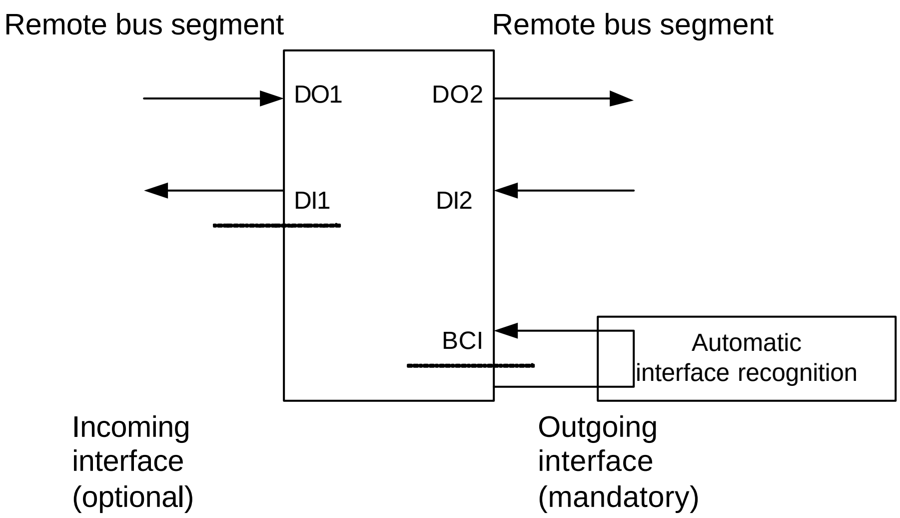


Figure 5: Interface to the transmission medium

8.4.1 Incoming Interface

The incoming interface has 2 signal fibers for connection to the network.

DO1	Receive data cable
DI1	Transmit data cable

8.4.2 Outgoing Interface

The outgoing interface has 2 signal fibers for connection to the network.

DO2	Transmit data cable
DI2	Receive data cable

8.5 Specification of the Transmission Medium

8.5.1 Connectors

The F-SMA fiber optic connector specified for IP20 applications is standardized according to IEC 60874-2 and DIN 47258.

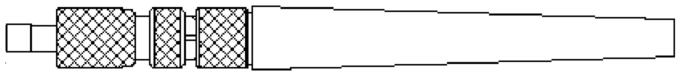


Figure 6: F-SMA connector

The Rugged Line hybrid connector is specified for IP67 applications (manufactured by Phoenix Contact, Order No. 27 31 07 6).

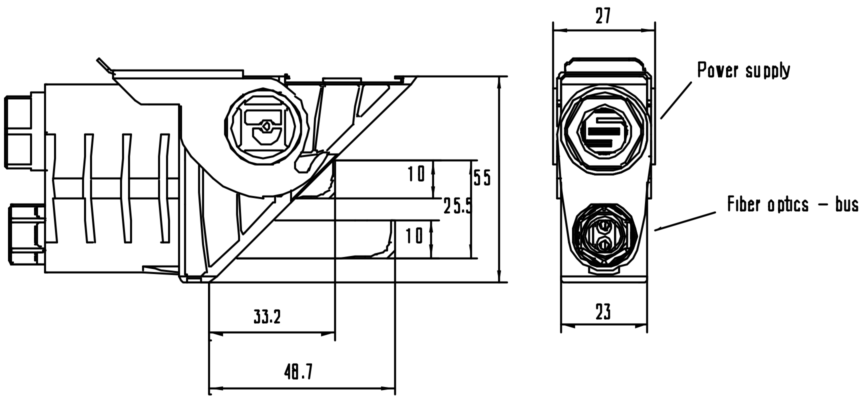


Figure 7: Rugged Line IP67 fiber optic hybrid connector

8.5.1.1 Fiber Optic Cables

A dielectric fiber optic cable with step index refractive index profile is specified as the transmission medium.

Supported types of fiber include:

- Polymer fiber with 980 µm core and 1000 µm cladding diameter, Type A4a according to IEC 60793-2
- HCS fiber with 200 µm core and 230 µm cladding diameter, Type A3c according to IEC 60793-2

8.5.1.2 Optical Fiber Data

Table 4: Optical fiber data

Type of Fiber	Polymer Fibers	HCS Fibers
Refractive index profile	Step index	Step index
Core diameter	980 +/-60 µm	200 +/-4 µm
Cladding diameter	1000 +/-60 µm	230 +0/-10 µm
Numerical aperture NA	0.47 +/-0.03	> 0.36
Attenuation for 660 nm measured with an LED source (< 30 nm half-value width), 50 m long	< 230 dB/km	< 10 dB/km

9 Implementation Examples

9.1 IP20 Applications: F-SMA Connection Method

The implementation example illustrates an INTERBUS fiber optic interface for transmission distances up to 50 m for polymer fiber and up to 300 m (see also footnote on page 24) for HCS fiber. The IBS SUPI 3 OPC should be used as the INTERBUS slave protocol chip.

The HFBR-1505C transmitter used is classified by the manufacturer into optical power classes a, b, and c, and labeled accordingly. This makes it easier to compensate the optical power using the protocol chip.

Table 5: HFBR-1505C transmitter classification (60 mA current, 25°C)

Optical Power Class	Optical Power [dBm]
a	-5.3...-3.3
b	-3.9...-1.9
c	-2.5...-0.5

It is important that, for each protocol chip, only transmitters of the same optical power class are used for the incoming and outgoing interface and the 2nd outgoing interface, if applicable. This means that further compensation using optical power measurement is not required.

9.1.1 Circuit Diagram for the Implementation Example

See Appendix

9.1.1.1 Parts List for the Implementation Example

Table 6: Parts list for the implementation of an F-SMA fiber optic interface

Number	Component			
2	Fiber optic receiver HFBR-2505C (Agilent)			
2	Fiber optic LED HFBR-1505C (Agilent)			
2	R	1R8	0.25 W	1%
2	R	680R	0.25 W	1%
2	R	2k4	0.063 W	1%
1	R	3k3	0.063 W	1%
1	R	15k	0.063 W	1%
2	C	1nF	50 V	10% K
2	C	100nF	50 V	10% K
2	C	1µF	16 V	20% T
2	Zener diode	5V1	0.5 W	
3	Solder bridges			

Number of components = 23

9.1.1.2 Transmitter Circuit Diagram

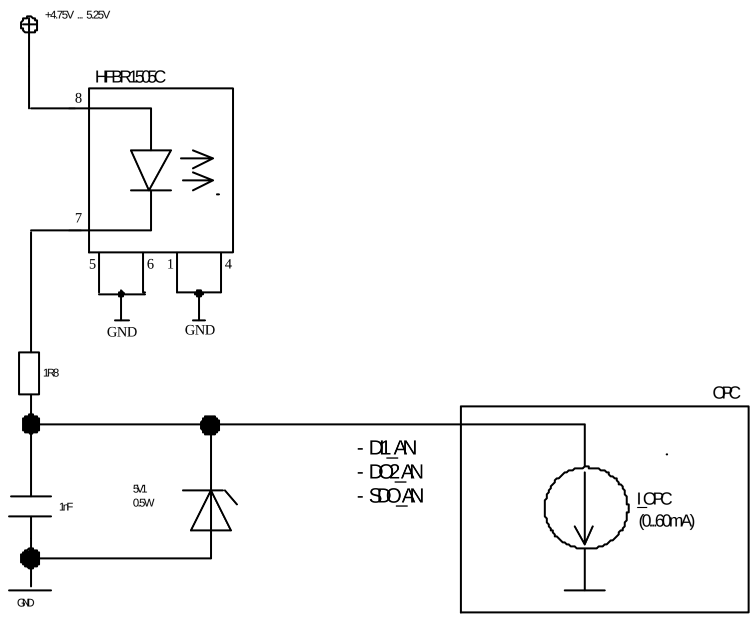


Figure 8: Circuit diagram for transmit LED HFBR-1505C

The Zener diode is an EMI protection measure (burst, surge). The resistor and the capacitor reduce the edge steepness of the very quick transmitter and also attenuate current noise from the SUPI 3 OPC. In terms of layout, all three components should be located as close as possible to the input on the protocol chip.

9.1.1.3 Receiver Circuit Diagram

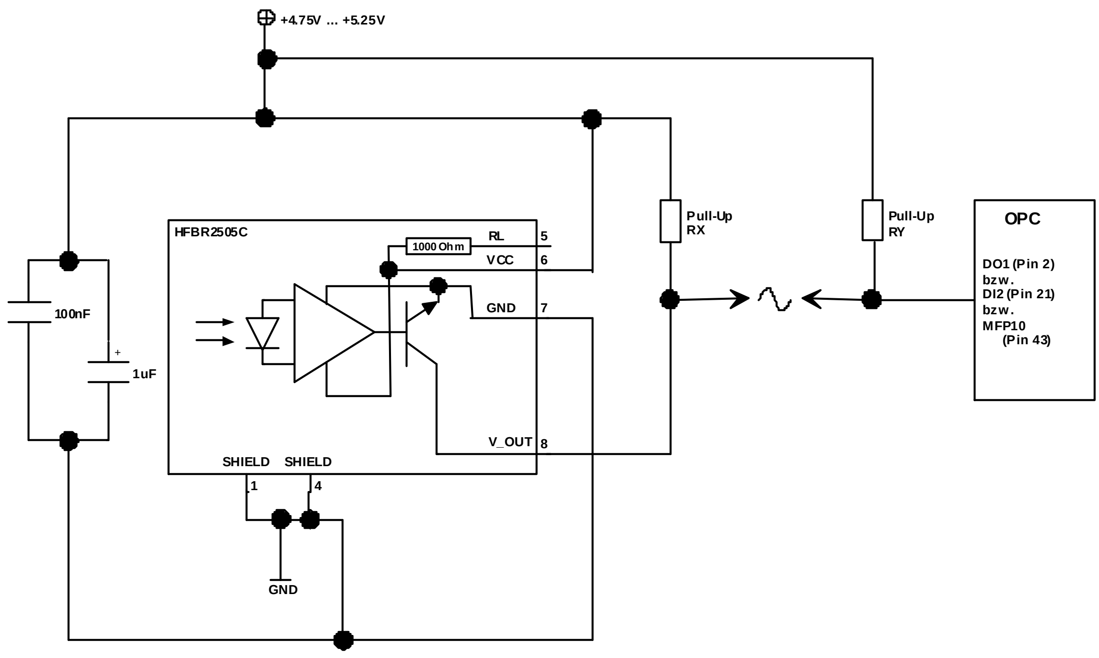


Figure 9: Circuit diagram for receiver HFBR-2505C

Wiring Notes

1. VCC connection:
   For reasons of EMC, pin 6 can be connected to VCC via an inductor and/or a ferrite. This must not adversely affect the function and operation of the receiver.
2. Shield pins:
   Shield pins 1 and 4 must be connected so that the conductive housing of the receiver has a potential connection. However, if the component threaded tube is also screwed to a metal housing, which is grounded, measures must be taken to prevent ground/earth loops. One option is to leave the shield pins unwired.
3. GND connection:
   For reasons of EMC, pin 7 can be connected to ground via an inductor and/or a ferrite. This must not adversely affect the function and operation of the receiver.
4. Signal path to the protocol chip:
   The signal path can only include filter elements for EMI stabilization (resistors, ferrites), which do not cause the system to exceed an additional permitted filter time of maximum 10 ns.
5. Positioning of 100nF/1µF capacitors:
   The pair of capacitors should be positioned directly on the receiver.
6. Definition of pull-up resistor values RX and RY and recommended layout:
   The total resistance of the effective pull-up resistor is in the range 660 Ohm < R < 770 Ohm (including tolerance).
   Recommended layout:
   Signal path from receiver to OPC less than or equal to 5 cm:
   RX = 680 Ohm, RY not required
   Signal path from receiver to OPC greater than 5 cm:
   RX = 1400 Ohm or 1500 Ohm, RY = 1400 Ohm or 1500 Ohm

9.1.2 Technical Data for the Implementation Example

Table 7: Supply voltage

Supply voltage	4.75...5.25 V DC ±5%
Nominal current consumption	90 mA, maximum

Table 8: Fiber optic interface

	Polymer Fibers	**HCS Fibers**
Wavelength at 25°C	650 nm, typical	650 nm, typical
Optical output power at 25°C (OPC control level 15), reference fiber measurement	-5.3 dBm, minimum -2.5 dBm, maximum	-16.0 dBm, minimum -9.0 dBm, maximum
Optical receiver sensitivity (0...70°C)	-21.6 dBm, minimum	-23 dBm, minimum
Overrange (0...70°C), reference fiber measurement	> -2.0 dBm	> -8 dBm
Power reduction due to transmission power drift	-0.02 dB/K, typical	
System reserve	> 3.0 dB	
Transmission length for maximum fiber attenuation Minimum for typical fiber attenuation Typical	 230 dB/km 1…50 m 200 dB/km 1...60 m	 10.0 dB/km 1...300 m 8.0 dB/km 1...400 m
Bit error rate	10^{-9}	10^{-9}
Ambient temperature of transmitter/receiver	0...70°C	0...70°C

Table 9: Fibers

Type of Fiber	Polymer Fibers	HCS Fibers
Refractive index profile	Step index	Step index
Core diameter	980 µm	200 µm
Cladding diameter	1000 µm	230 µm
Numerical aperture	0.47	0.36
Attenuation for 660 nm LED, 50 m long	< 230 dB/km **	< 10 dB/km

Table 10: Fiber optic connectors

Connector type	F-SMA according to IEC 60874-2, DIN 47258

** Complex cable designs have an attenuation value that is around 20 dB/km higher.

9.1.3 Setting the Optical Transmitter Power

9.1.3.1 Requirements

The power of the transmitter LED should be checked once before the final test of the device under the following conditions:

Table 11: Conditions for the power check

Ambient temperature:		15°C…25°C
Bus:		Not active
Compensation cable/ Reference fiber:	Length:	1 m
	Fiber:	Simplex POF, 1 m long
	Connector:	F-SMA
	Attenuation measured according to IEC 61300-3-4:1998 Insertion Procedure B	1.5 dB

9.1.3.2 Setting the Transmission Power

1. Set the solder bridges according to the classification of the transmitter used. All transmitters from the outgoing and (if applicable) incoming and 2nd outgoing interface must be of the same optical power class (see page 17).

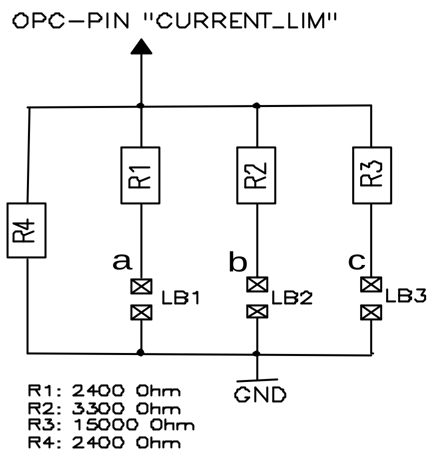


Figure 10: Reference network for the OPC

Table 12: Setting the bridges in the reference network

Class a

Compensation jumper - desired resistance: 1200 Ohm (X: Set)

LB 1	LB 2	LB 3	Resistance (Ohm)
X			1200

Class b

Compensation jumper - desired resistance: 1390 Ohm (X: Set)

LB 1	LB 2	LB 3	Resistance (Ohm)
	X		1389.5

Class c

Compensation jumper - desired resistance: 2070 Ohm (X: Set)

LB 1	LB 2	LB 3	Resistance (Ohm)
		X	2069

2. Check the optical power after module power up (no previous bus operation, no connection to the master): -3.8 dBm ≥ P_{opt} ≥ -7.1 dBm (takes measuring device tolerance into account).

9.1.4 Level Budget for the Implementation Example

Requirements:
- Transmission distance 1...50 m for polymer fibers; 1...300 m for HCS fibers
- Data rate 500 kbaud NRZ or 2 Mbaud NRZ
- Bit error rate 10^{-9}
- Ambient temperature of the transmit and receive elements 0...70°C

Table 13: Level budget

	Polymer Fibers	**HCS Fibers**
Minimum optical output power, 25°C, maximum control level	-5.3 dBm	-16.0 dBm
Maximum optical output power, 25°C, maximum control level	-2.5 dBm	-9.0 dBm
Laser protection class according to DIN EN 60825-1	1	1
Minimum optical output power, 25°C, after OPC power up	-6.8 dBm	-17.5 dBm
Minimum optical output power, 0...70°C, maximum control level	-6.2 dBm	-16.9 dBm
Minimum optical receiver sensitivity, 0...70°C	-21.6 dBm	-23 dBm
Maximum optical overrange, 0...70°C	-2.0 dBm	> -8 dBm
Available attenuation	15.4 dB	6.1dB
- System reserve	-3 dB	
Available attenuation for fiber optics	12.4 dB	3.1 dB
Maximum fiber attenuation per km for 660 nm LED source, 50 m long	230 dB/km	10 dB/km
Typical fiber attenuation per km for 660 nm LED source	200 dB/km	8 dB/km
→ Lowest maximum transmission distance	50 m	300 m
→ Typical maximum transmission distance	60 m	400 m
→ Minimum transmission distance	1 m	1 m

9.2 IP67 Applications: Rugged Line Connection Method

The implementation example for IP67 bus applications illustrates an INTERBUS fiber optic interface for transmission distances up to 50 m (typical) for polymer fiber. The IBS SUPI 3 OPC should be used as the INTERBUS slave protocol chip.

9.2.1 Circuit Diagram for the Implementation Example

See Appendix

9.2.1.1 Parts List for the Implementation Example

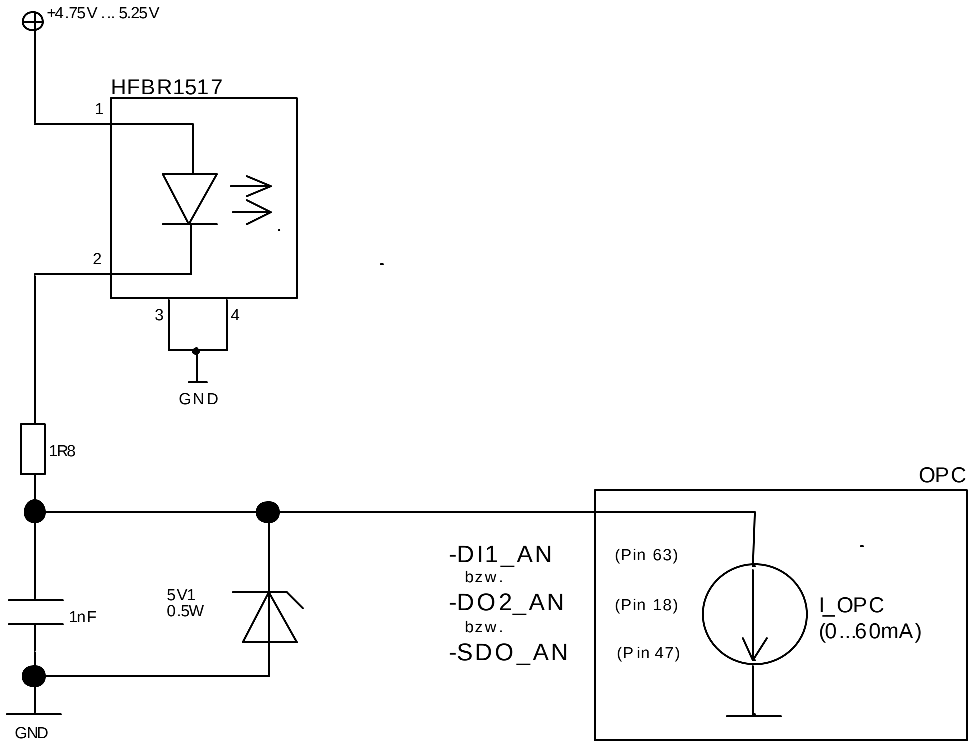
Table 14: Parts list for the implementation of a Rugged Line fiber optic interface

Number	Component			
2	Fiber optic receiver HFBR-2541 (Agilent)			
2	Fiber optic LED HFBR-1517 (Agilent)			
2	R	1R8	0.25 W	1%
2	R	680R	0.25 W	1%
1	R	1k2	0.063 W	1%
2	C	1nF	50 V	10% K
2	C	100nF	50 V	10% K
2	C	1µF	16 V	20% T
2	Zener diode	5V1	0.5 W	

Number of components = 17

9.2.1.2 Transmitter Circuit Diagram

Figure 11: Circuit diagram for transmit LED HFBR-1517



The Zener diode is an EMI protection measure (burst, surge). The resistor and the capacitor reduce the edge steepness of the very quick transmitter and also attenuate current noise from the SUPI 3 OPC. In terms of layout, all three components should be located as close as possible to the input on the protocol chip.

9.2.1.3 Receiver Circuit Diagram

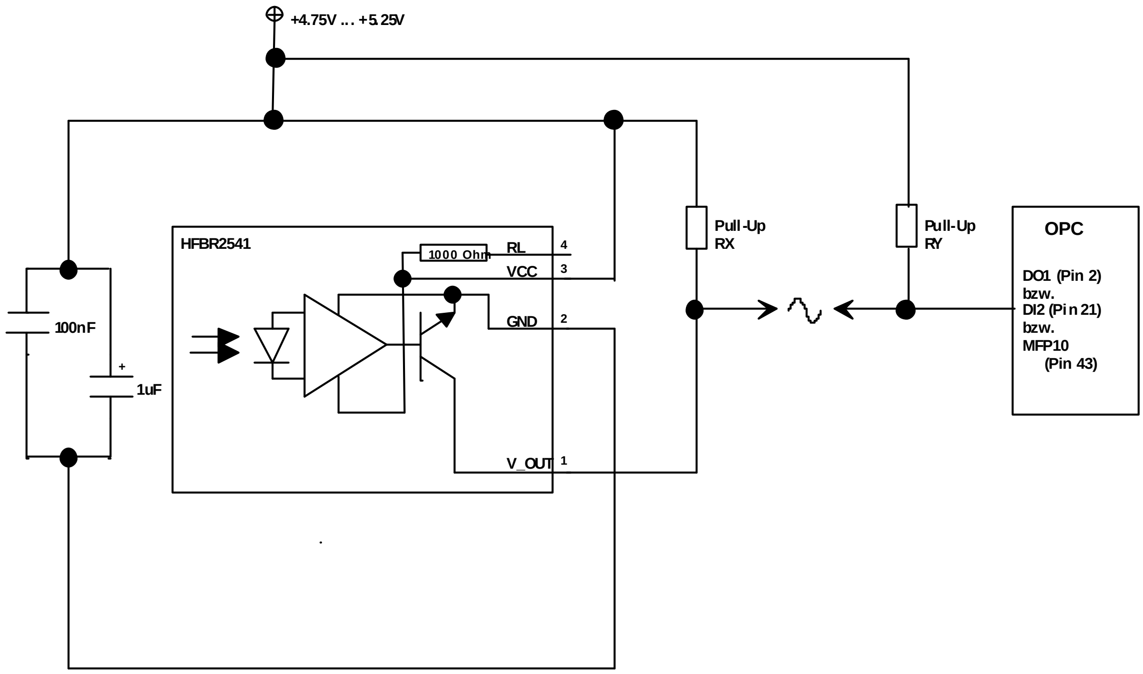


Figure 12: Circuit diagram for receiver HFBR-2541

Wiring Notes

1. VCC connection:
   For reasons of EMC, pin 3 can be connected to VCC via an inductor and/or a ferrite. This must not adversely affect the function and operation of the receiver.
2. GND connection:
   For reasons of EMC, pin 2 can be connected to ground via an inductor and/or a ferrite. This must not adversely affect the function and operation of the receiver.
3. Signal path to the protocol chip:
   The signal path can only include filter elements for EMI stabilization (resistors, ferrites), which do not cause the system to exceed an additional permitted filter time of maximum 10 ns.
4. Positioning of 100nF/1µF capacitors:
   The pair of capacitors should be positioned directly on the receiver.
5. Definition of pull-up resistor values RX and RY and recommended layout:
   The total resistance of the effective pull-up resistor is in the range 660 Ohm < R < 770 Ohm (including tolerance).
   Recommended layout:
   Signal path from receiver to OPC less than or equal to 5 cm:
   RX = 680 Ohm, RY not required
   Signal path from receiver to OPC greater than 5 cm:
   RX = 1400 Ohm or 1500 Ohm, RY = 1400 Ohm or 1500 Ohm

9.2.2 Technical Data for the Implementation Example

Table 15: Supply voltage

Supply voltage	4.75...5.27 V DC ±5%
Nominal current consumption	90 mA, maximum

Table 16: Fiber optic interface

	Polymer Fibers
Wavelength at 25°C	650 nm, typical
Optical output power at 25°C (OPC control level 15)	-4.9 dBm
Optical receiver sensitivity (0...70°C)	-20.6 dBm, minimum
Overrange (0...70°C)	> -2.0 dBm
Power reduction due to transmission power drift	0.02 dB/K, typical
System reserve	3 dB
Transmission length for maximum fiber attenuation Minimum for typical fiber attenuation Typical	 230 dB/km 1...50 m 200 dB/km 1...60 m
Bit error rate	10^{-9}
Ambient temperature of transmitter/receiver	0...70°C

Table 17: Fibers

Type of Fiber	**Polymer Fibers**
Refractive index profile	Step index
Core diameter	980 µm
Cladding diameter	1000 µm
Numerical aperture	0.47
Attenuation for 660 nm LED, 50 m long	< 230 dB/km

Table 18: Fiber optic connectors

Connector type	IBS RL PLUG-LK/POF (see Figure 7)

9.2.3 Setting the Optical Transmitter Power

9.2.3.1 Requirements

The power of the transmitter LED should be checked once before the final test of the device under the following conditions:

Table 19: Conditions for the power check

Ambient temperature:		15°C…25°C
Bus:		Not active
Compensation cable:	Length:	1 m
	Fiber:	Duplex POF, 1 m long
	Connector:	RL connector on one side, F-SMA on the other side

9.2.3.2 Setting the Transmission Power

There is no need to set the optical power or carry out compensation for a Rugged Line interface if the minimum reference resistor of 1.2 kOhm is connected at the Current_Lim pin of the SUPI 3 OPC INTERBUS slave protocol chip (see circuit diagram example).

9.2.4 Level Budget for the Implementation Example

Requirements:
- Transmission distance 1...50 m polymer fiber
- Data rate 500 kbaud NRZ or 2 Mbaud NRZ
- Bit error rate 10^{-9}
- Ambient temperature of the transmit and receive elements 0...70°C

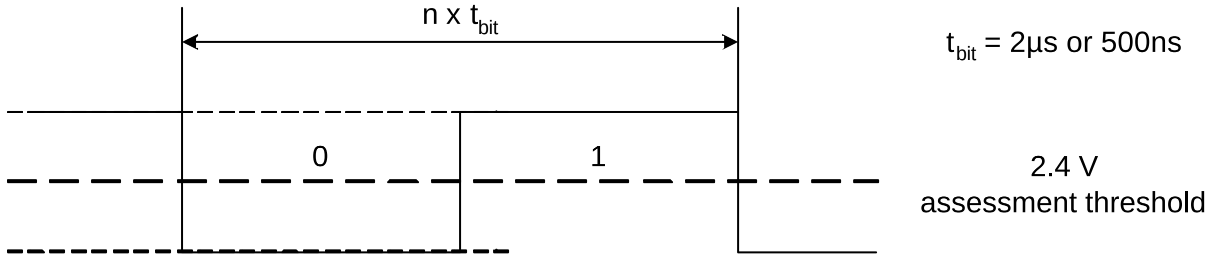
Table 20: Level budget

	Polymer Fibers
Typical optical output power, 25°C, maximum control level	-4.9 dBm
Maximum optical output power, 25°C, maximum control level	-2.0 dBm
Laser protection class according to DIN EN 60825-1	1
Typical optical output power, 25°C, after OPC power up	-6.4 dBm
Typical optical output power, 0...70°C, maximum control level	-5.8 dBm
Minimum optical receiver sensitivity, 0...70°C	-20.6 dBm
Maximum optical overrange, 0...70°C	-2.0 dBm
Typical available attenuation	14.8 dB
- System reserve	-3 dB
Available attenuation for fiber optics	11.8 dB
Maximum fiber attenuation per km for 660 nm LED source, 50 m long	230 dB/km
Typical fiber attenuation per km for 660 nm LED source	200 dB/km
→ Lowest maximum transmission distance	50 m, typical
→ Minimum transmission distance	1 m

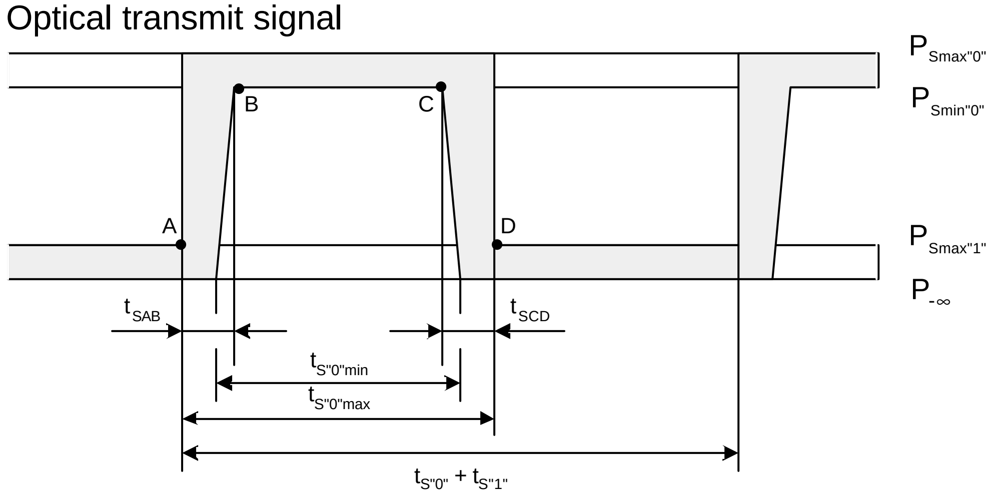
10 Appendix

10.1 Schematic Diagrams

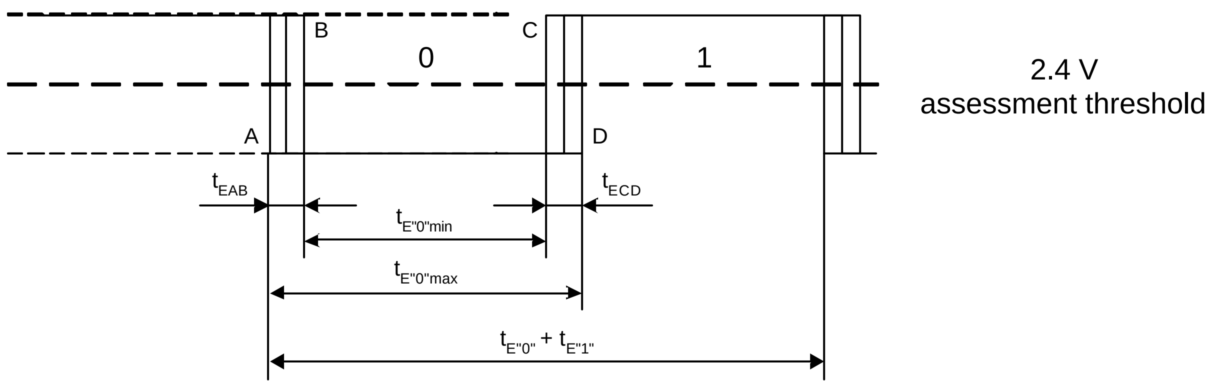
Electrical transmit signal



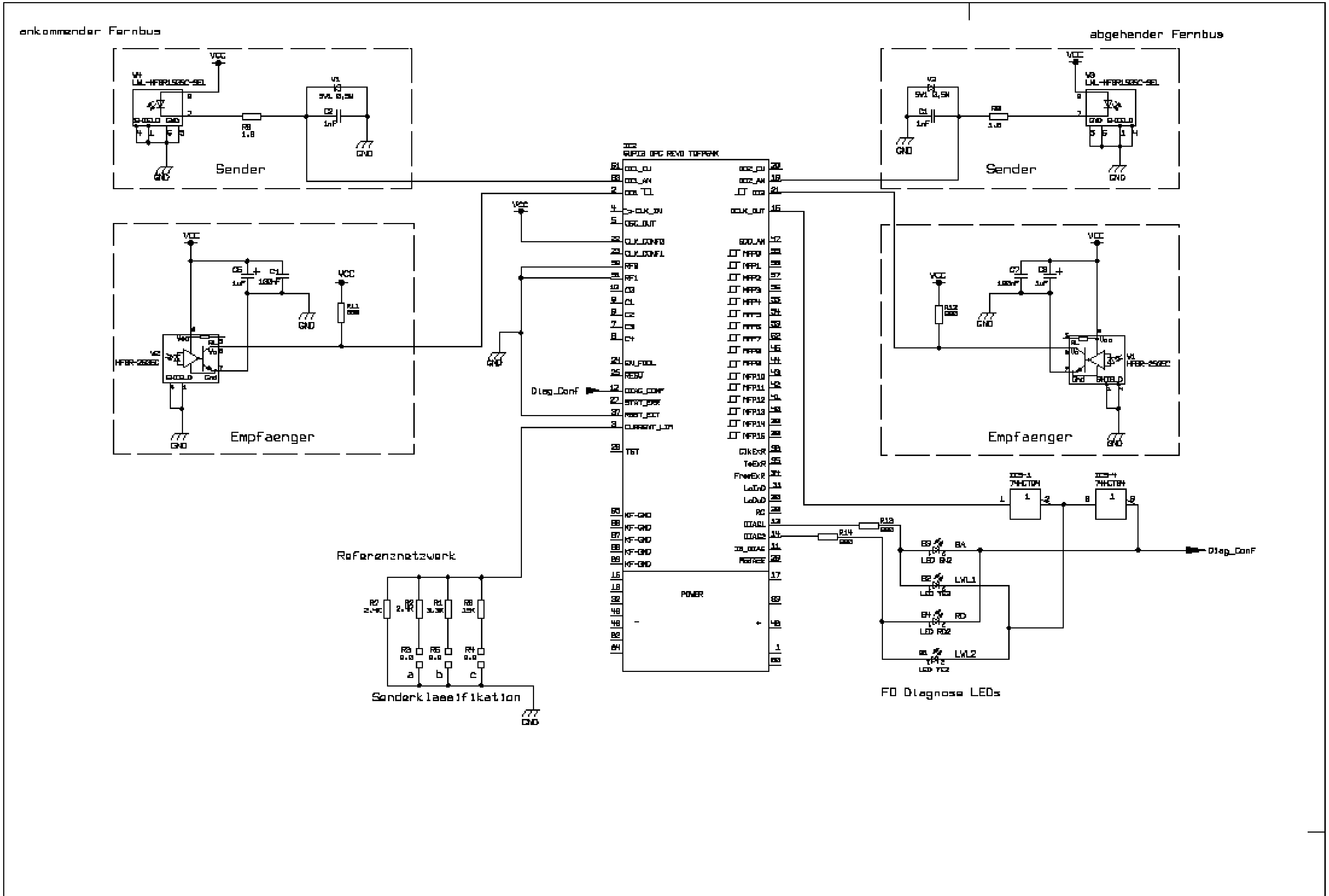
Optical transmit signal



Electrical receiver signal



10.2 Circuit Diagrams for the Implementation Examples



Schaltplan			Massstab:								
Schaltplan OPC-LWL-Interface (F-SMA)	Anzahl Blaetter: 2	Blatt Nr.: 1	gepr			01	Anpassung Referenznetzwerk	15.11.00			
PHOENIX CONTACT · 97 73 425 · Z.Nr.:	Anzahl Kopien:	Kopie Nr.:	gezeich			00	Neuerstellung	09.08.00			
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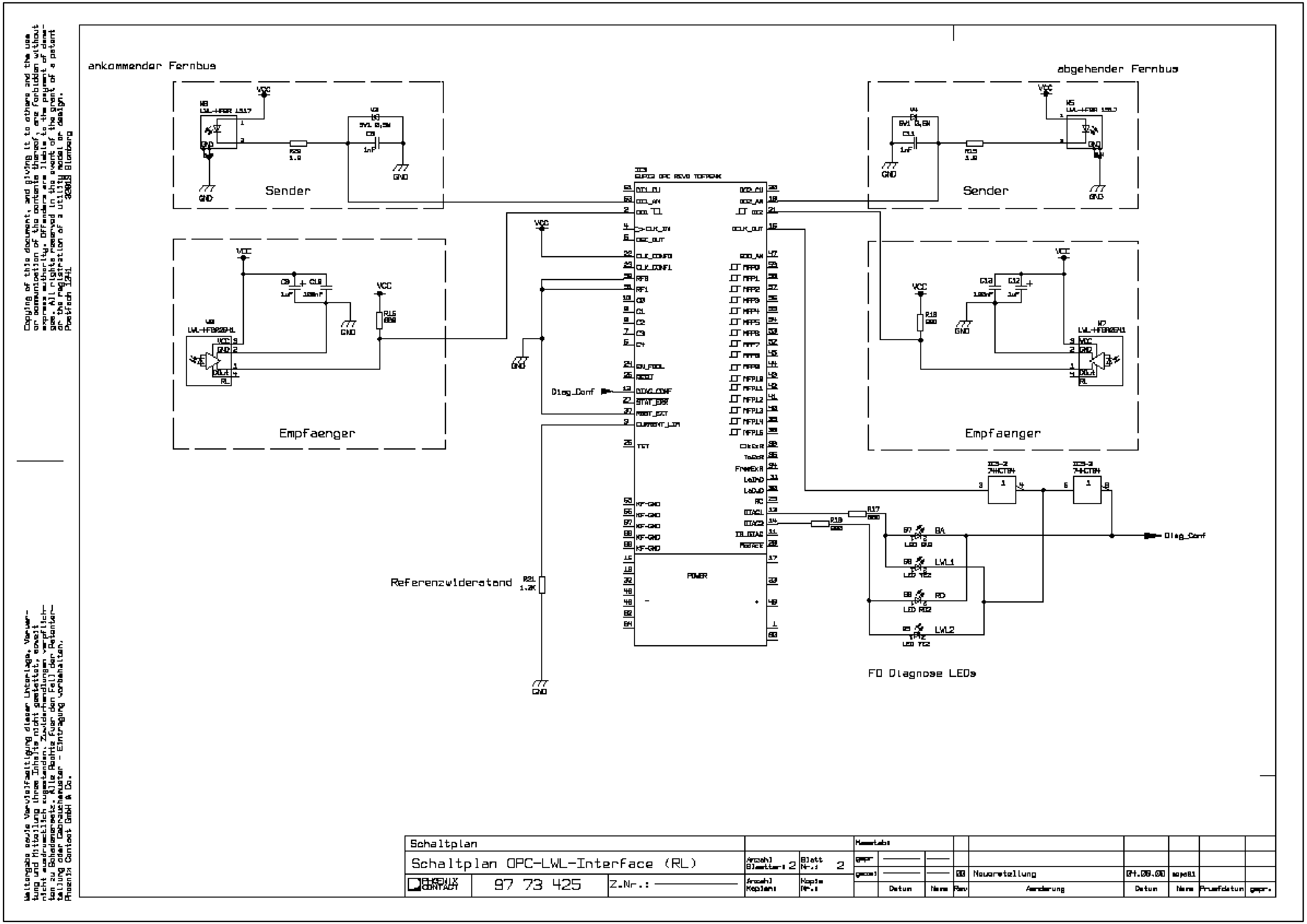

ankommender Fernbus
abgehender Fernbus
Sender
Sender
Empfaenger
Empfaenger
VCC
GND
Diag_Conf
Referenzwiderstand
POWER
FO Diagnose LEDs
BA
LWL1
RD
LWL2
Schaltplan
Schaltplan OPC-LWL-Interface (RL)
97 73 425
Z.Nr.:
Neuerstellung
Datum
Name
Aenderung
Pruefdatum