Indu-Sol GmbH – Specialist in Industrial Networks

PB-Q^{ONE}

User Manual

Diagnostic and service tools for PROFIBUS

PROFIBUS PROFINET INDUSTRIAL ETHERNET CAN DeviceNet SafetyBUS p AS-i INTERBUS EMC WIRELESS

Revision overview

Date	Revision	Change(s)
10/10/2017	0	First version

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1 Introduction

1.1 General

The ***PB-Q^{ONE}*** is an easy to use, powerful measuring device for comprehensive inspection of PROFIBUS master systems. It offers separate testing of the physical condition of the bus (signal quality) and the telegram traffic. The device can be used for acceptance measurement on new systems for inclusion in the acceptance report, as well as for targeted troubleshooting of existing systems.

Its integrated master simulator enables testing of the communication quality without a need for the PLC to be operational. This enables pre-inspection of complete systems and their parts during the commissioning stage, with the goal of providing stable bus systems for trouble-free production in the long term.

The device is connected to a PC or notebook via a USB interface, which also provides the power supply. It is controlled with the “Indu-Sol Suite” software.

1.2 Functional overview

The ***PB-Q^{ONE}*** is designed to assist you with inspection, troubleshooting, and the isolation of root causes. To this end, it offers the following functions:

- Feedback-free bus coupling at suitable existing measuring points during running operation
- Automatic detection of the baud rate
- Automatic identification of all devices on a bus system (LiveList)
- Device and measuring-point-based display of signal ratios:
  - General quality value
  - Signal to noise ratio and slope gradient
  - Oscilloscope display with selection options for detailed evaluation
- Long-term monitoring of all devices (continuous measurement) with minimum, maximum, and average quality values
- Editable measuring point and segment management
- Wear inspection by comparing current readings with stored measurements
- Integrated master simulator for inspection of system without a master (commissioning phase)
- Real-time monitoring of the entire data traffic and checking for telegram errors, with entries into the event list
- In-depth telegram analysis with option for variable trigger setting
- Easy documentation of measurements in the form of an acceptance report and topology plan

1.3 Scope of supply

The scope of supply comprises the following individual parts:

- Measuring device ***PB-Q^{ONE}***
- D-Sub 9-pin adapter cable (for connecting to a PROFIBUS system)
- USB cable (2 m)
- CD with operating software “Indu-Sol Suite” and device manual

Please check the contents are complete before putting into operation.

Figure 1: ***PB-Q^{ONE}*** delivery condition

1.4 System requirements

The following Windows versions are supported: Windows 7, Windows 8, Windows 10.

The following minimum hardware requirements apply for the PC or notebook used:

- CPU: Dual Core, Core I3 or better
- RAM: 4 GB
- Screen resolution: ≥ 1024x768 pixels (XGA)
- Graphics: DirectX 9.0c capable graphic board (supported by most on-board graphic boards)
- USB interface: 2.0 (no other devices should be connected to the USB hub)

1.5 Safety information

- Never open the housing of the ***PB-Q^{ONE}***
- Opening the housing immediately voids any warranty
- If you suspect that the device is defective, then return it to the supplier

2 Commissioning

2.1 Software installation

The PC software “Indu-Sol Suite” includes the required USB driver and needs to be installed on the PC or notebook before the ***PB-Q^{ONE}*** is connected for the first time.

The “Indu-Sol Suite” software is included on a CD-ROM. The installation requires administrator rights. If the CD-ROM does not start automatically after inserting, then manually start the “setup.exe” file in the main directory.
Future updates can be found on the Internet at www.indu-sol.com, under downloads.

The installation is performed after selecting the language, agreeing to the end user licence agreement, and making the installation settings. Then the software is fully available for the following measurements.

2.2 Connect device to PC

Use the included USB cable for connection to the PC or notebook, including power supply.

Preferably connect the device directly to a USB port on the PC or notebook. Connecting via external USB hubs or docking stations of notebooks may cause problems.

3 Connection to the PROFIBUS system

3.1 Basics

3.1.1 Warning about measurements on running systems

Caution: When connecting a measuring device, effects on the system to be inspected cannot be ruled out completely. With unstable PROFIBUS systems, malfunctions of the system may occur in rare cases. Always observe the connection information!

3.1.2 Connection types for PROFIBUS devices

Depending on the device version, there are different ways to connect bus modules to a PROFIBUS network:

- Connecting via plug-in connectors
  - D-Sub plug-in connector, usually with an integrated terminal resistor, and optionally with an additional service jack
  - M12 screw-in connector in the field for higher IP ratings
  - Special manufacturer-specific hybrid plug-in connectors for routing the power supply over the bus in conjunction with special cables
- Direct cable connection via terminals

Due to the typical linear structure of the PB networks, the available measuring points are usually limited to the connecting points of the bus devices. Alternatively, the use of additional measuring points (e.g. Profibus measurement adapter, PBMA) may be viable.

3.1.3 Adapter cable

The standard scope of supply of the ***PB-Q^{ONE}*** includes the 9-pin D-Sub adapter cable. An M12 adapter kit is available as an optional accessory.

Use only the short original cables with special pin allocation for connecting to a PROFIBUS network. No more than two D-Sub connectors must be cascaded to the service jack at a time.

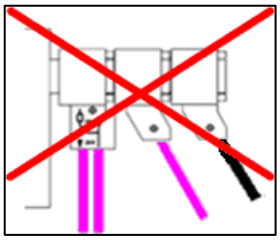


Figure 2: Improper cascading of D-Sub connectors

The use of active connecting cables with integrated repeaters for measurement is not possible.

3.1.4 Measuring locations

In principle, the ***PB-Q^{ONE}*** is able to perform measurements at any point in a PROFIBUS system. Please note that the use of repeaters and converters (OLM, data light barriers, wireless transmission) creates separate physical **segments** that need to be **evaluated individually**.

A complete and in-depth analysis of the overall PROFIBUS system requires measurements to be performed at the **beginning** and the **end** of each physical segment. If problems are detected that cannot immediately be classified clearly, then at least one additional measurement should be performed in the middle.

3.2 Connection versions

3.2.1 Measurements during system downtime

If D-Sub connectors with an additional service jack are present on all bus devices, then the ***PB-Q^{ONE}*** is simply connected there as shown in the image. If a D-Sub connector without a service jack is installed, then the D-Sub adapter cable can be inserted below. Note that cascading more than two D-Sub connectors should be avoided at all cost.

For M12 connection technology, the M12 adapter cable (optional) is looped into the bus.

For all connection versions requiring adapter installation, the bus must be opened. This causes short-term disruptions in communication, which is why a system shutdown is required.

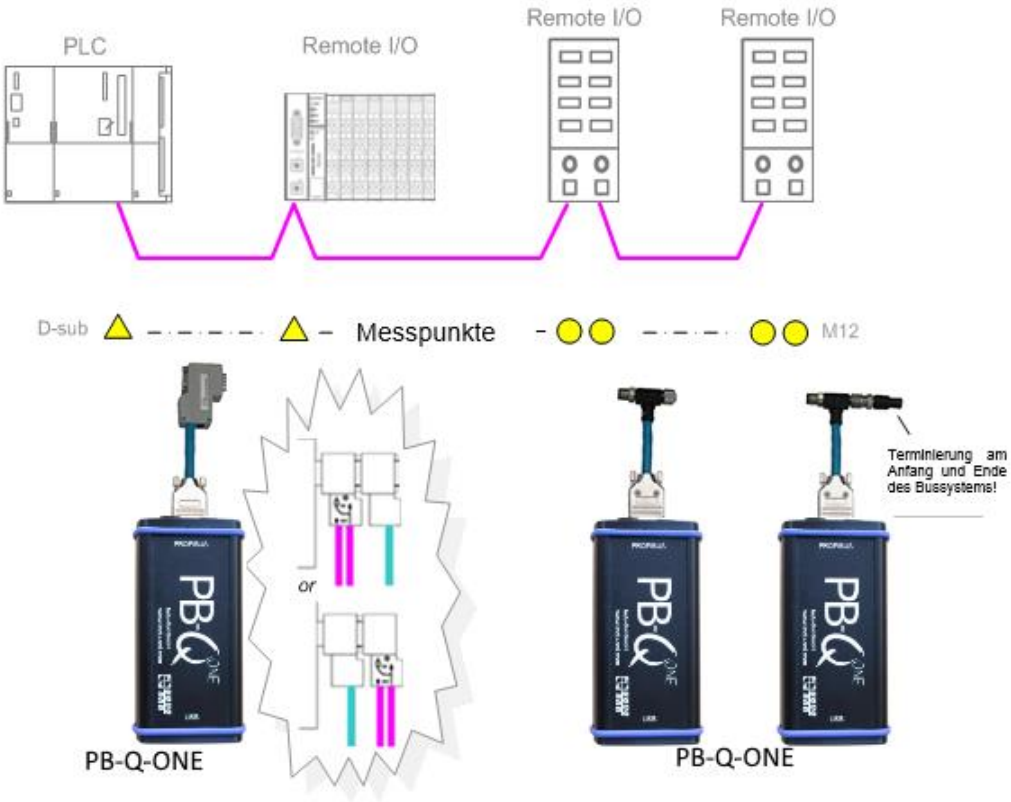


Figure 3: Measuring points during system downtime

3.2.2 Measurements on the running system

No intervention into the master system is possible on running systems, as this would automatically lead to bus faults and loss of production. The ***PB-Q^{ONE}*** can only be connected and run at the existing measuring points (e.g. PB connector with service jack on the CPU). In order to be able to perform a status quo analysis under production conditions on all existing segment ends, this should be considered during the system planning stage. If the use of appropriate connectors is not possible, then measuring adapters (e.g. PBMA – IP20, PBMX – IP67) can be used.

3.2.2.1 Connection type D-Sub connector with service jack

If D-Sub connectors with an additional service jack are installed on all bus devices, then the ***PB-Q^{ONE}*** is simply connected there as shown in the image.

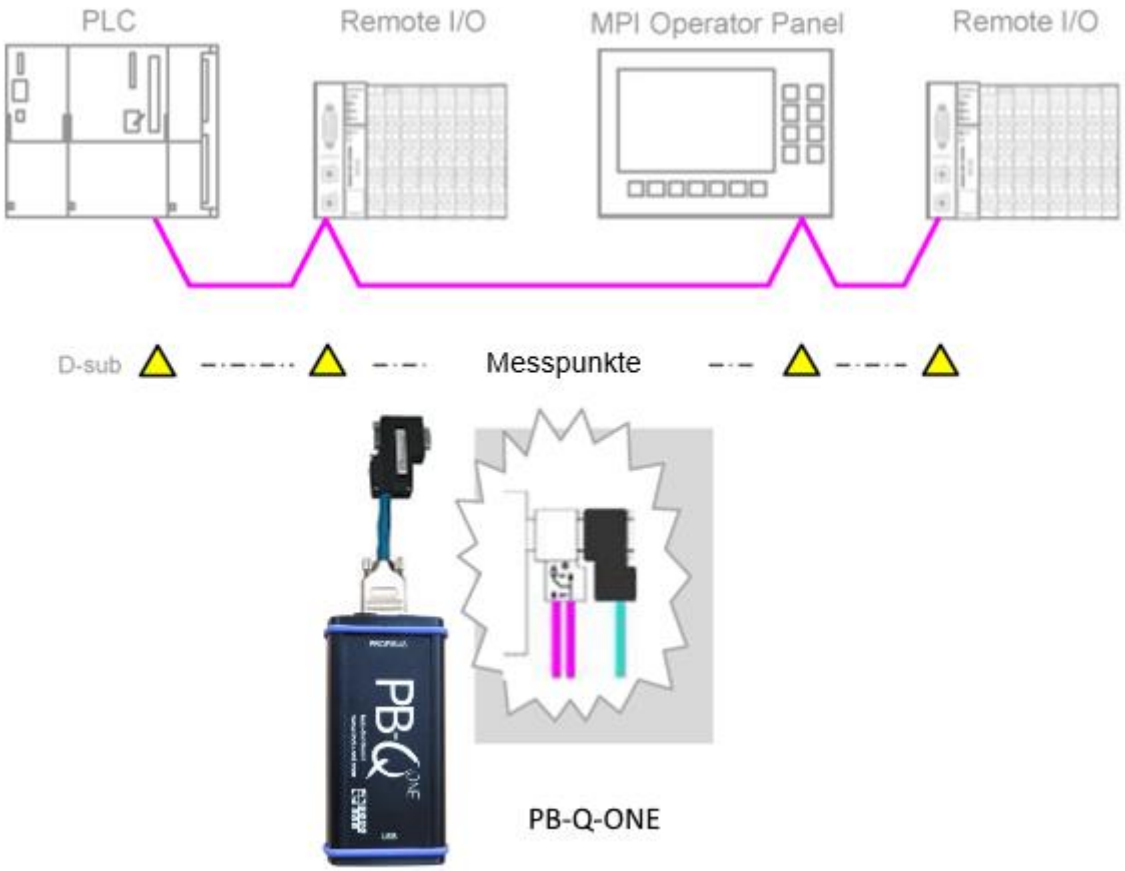


Figure 4: Measuring points via the service jack

3.2.2.2 Connection via permanently installed measuring point PBMA (IP20)

For measurement during running operation, Profibus measuring adapters (PBMA) have been permanently integrated into the system.

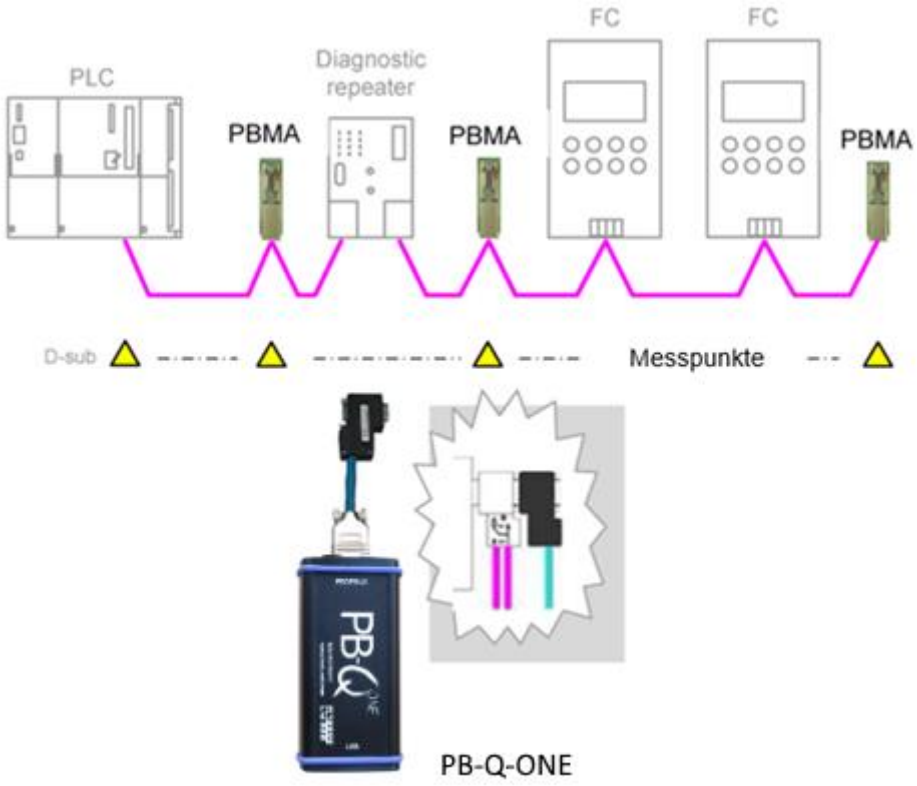


Figure 5: Example of permanently installed measuring points (PBMA)

3.2.2.3 Connection type M12 (IP67)

For measurement during running operation under IP67 conditions, Profibus measuring adapters (PBMX) have been permanently integrated into the system. An M12 adapter (optional) is required for connecting measuring devices.

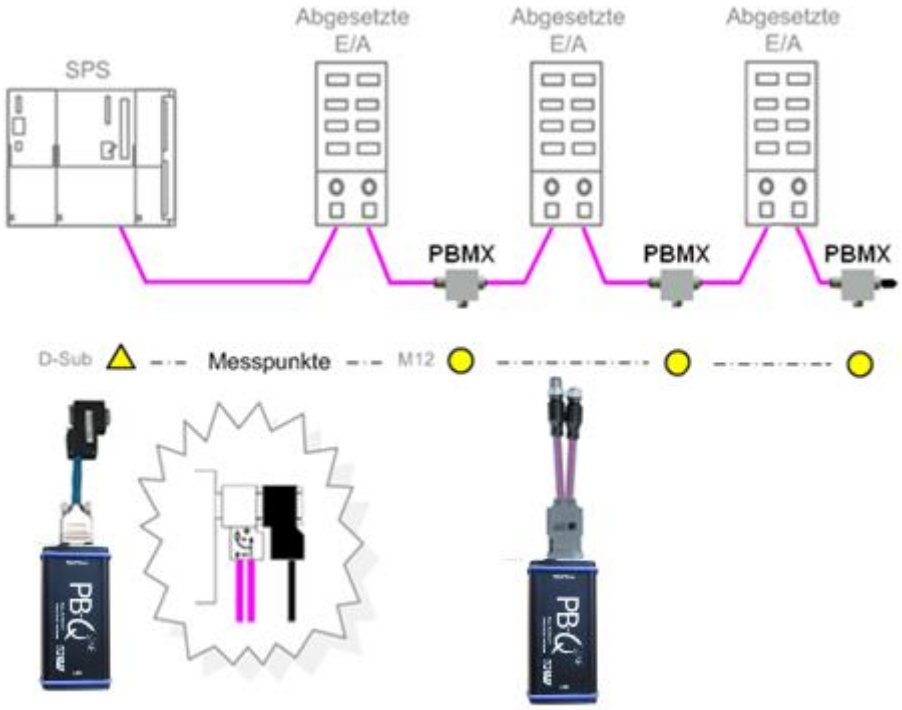


Figure 6: Example of permanently installed IP 67 measuring points (PBMX)

4 Perform and document measurement

4.1 General information

All measurements taken with ***PB-Q^{ONE}*** and the respective entries are summarized in a measurement file (*.pbn) for storage and later retrieval. For a structured analysis of several systems, it is therefore useful to create a separate measurement file for each master system. It can be used as a basis for additional measurements later to provide an easy way of performing before-after comparisons.

The system language can be selected between English and German under “Settings”.

In “GSD management”, the *.gsd files of each Profibus device are stored in the system. This file defines the characteristic communication features of the relevant slave. The ***PB-Q^{ONE}*** uses this information for detecting the device type as well as manufacturer-specific information.

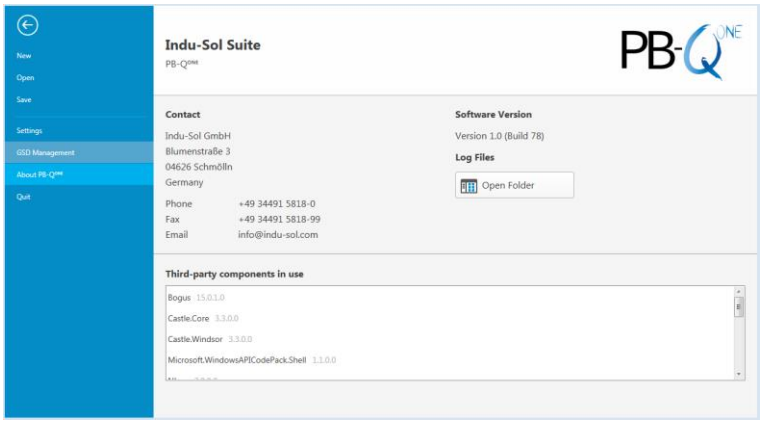


Figure 7: File management

4.2 Network

4.2.1 Topology

After connecting the ***PB-Q^{ONE}*** to the computer via USB, connecting the measuring adapter to the Profibus system, and starting the software, the network overview is displayed with the detected baud rate (Figure 8).

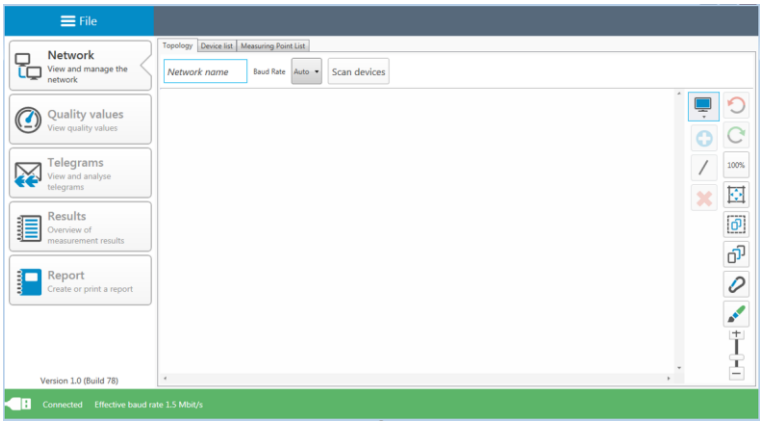


Figure 8: Home screen

The system designation can be entered in the field “Network name”. The function “Scan devices” lists the detected devices in ascending order of address (Figure 9). This is the basis for future measurement steps.

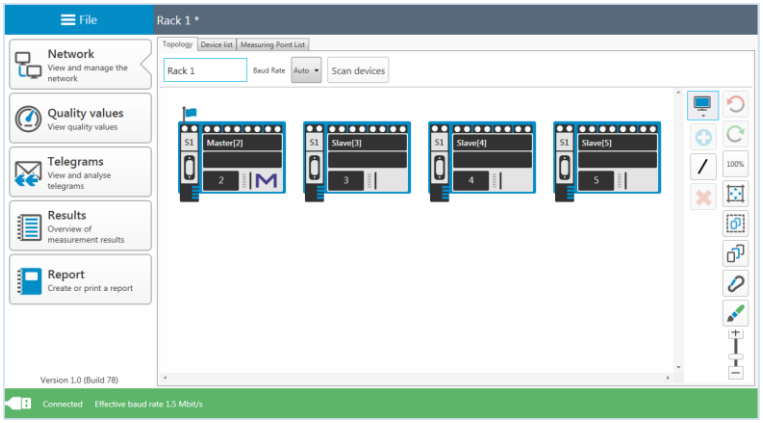


Figure 9: Device list

The topology plan is a prerequisite for structured measurements and creating a detailed system description. In the topology overview, a complete representation of the actual system structure with device descriptions, segmentation and measuring points can be realised. Selecting individual devices enables more detailed naming (e.g. with device type, equipment identifier). The tools in the drop-down menu enable the integration of additional modules without a dedicated Profibus address (measuring points, repeaters, optical fibre converters, wireless converters) and the connection of the overall system (Figure 10).

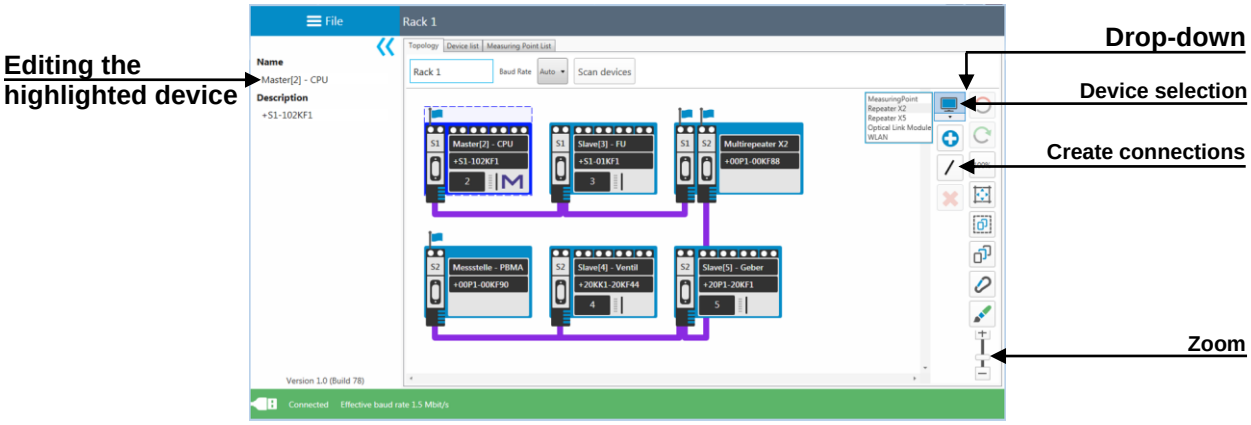


Figure 10: Topology

Segment and measuring points are assigned by selecting the relevant connection points of the end devices. After defining the measuring point and allocation to a segment, the relevant segment number is automatically assigned to all modules connected in this segment (Figure 11).

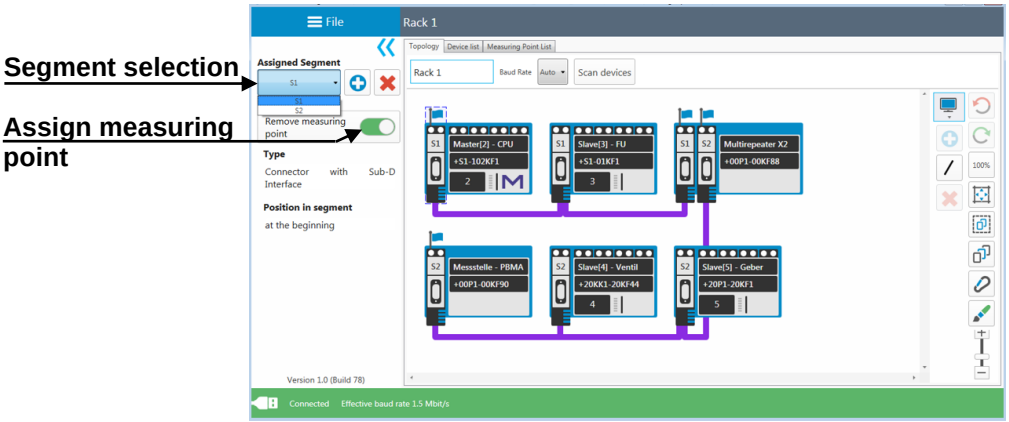


Figure 11: Assign measuring points

4.2.2 Device list

The “Device list” sub-item provides a complete overview of all topology entries in table form. Inputs as well as search and sorting functions can be performed here.

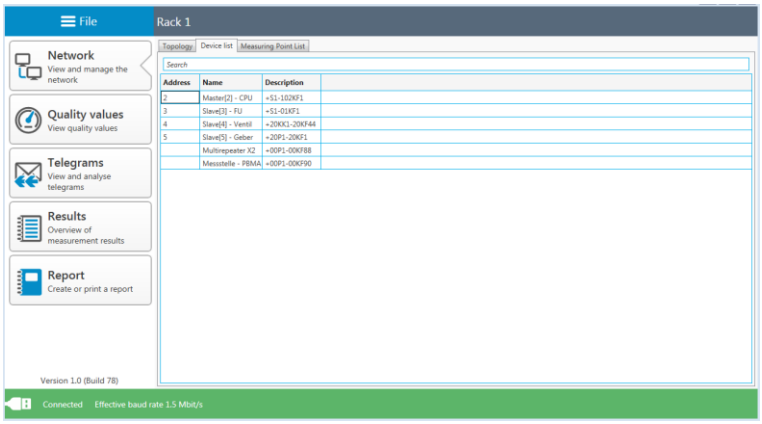


Figure 12: Device list

4.2.3 List of measuring points

The list of measuring points is a segment-specific overview of all measuring points in the system. The entries in the “Topology” tab are the starting point. For completion and better definition of the list, the measuring point type (e.g. connector with Sub-D interface, PBMA) as well as the position on the segment (at the beginning or end) can be assigned via the relevant drop-down menu.

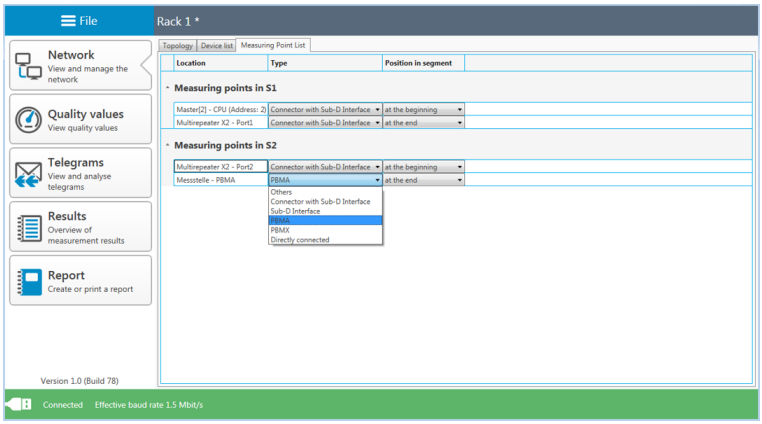


Figure 13: List of measuring points

4.3 Quality values

4.3.1 Standard measurement

The quality values represent the main criterion for evaluating the physical communication conditions. For a complete system analysis, measurements need to be performed in all segments on both ends. The device addresses determined by the “Scan devices” function serve as a reference.

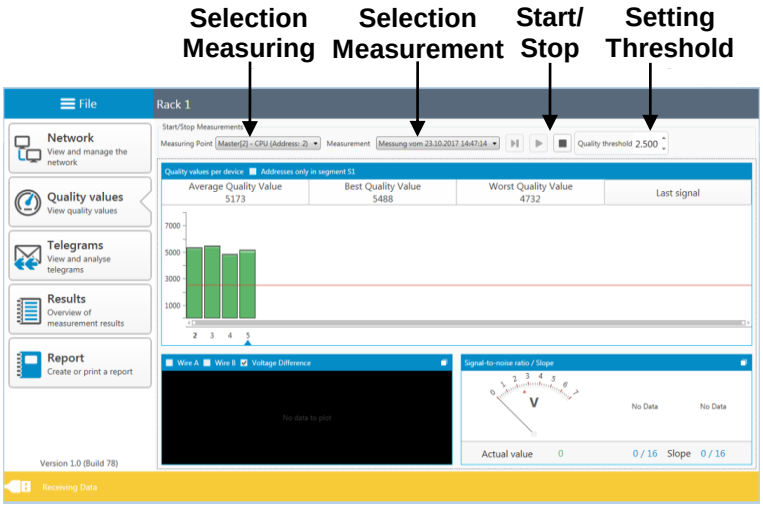


Figure 14: Quality values

Select the measuring point before starting the measurement. Finally, press the relevant start button to decide whether to perform a single or a continuous measurement. Clicking on the stop button terminates these functions and displays the results of the quality values for the overall system. The icons used have the following meaning:

⏭	Start new single measurement	(single cycle with all device addresses)
▶	Start new continuous measurement	(continuous measurement of all devices)
■	Stop measurement	(stops the current measurement)

After completing the measurement, the system automatically outputs a file name suggestion with a time stamp. You may change the name or store the data under the default name (Figure 15). This makes it possible to recall all measurements for the relevant measuring points later.

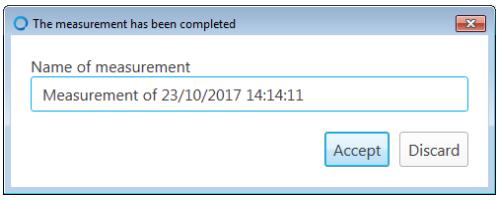


Figure 15: Info measurement finished

4.3.2 Additional functions

There are other useful functions for a more in-depth evaluation, in particular in the event of malfunction.

If the preset quality threshold is not reached, then the affected devices are shown in yellow. Individual addresses can be selected to show all values for the relevant device. In addition, an oscilloscope image is shown in addition to the signal-to-noise ratio and the slope gradient (Figure 16).

Pressing the button to switch signals causes the display to switch between “Last signal” and “Worst signal”.

Figure 16: Low quality values

Every image section can be enlarged to display more details. The oscilloscope overview adds line A, line B, and the measurement function, in addition to showing the evaluation criteria (Figure 17).

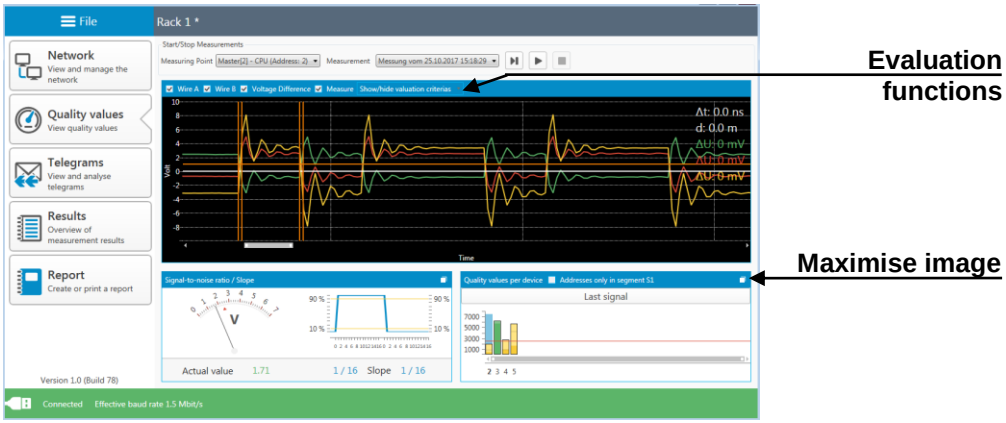


Figure 17: Oscilloscope view

5 Telegrams

This menu item provides access to the telegram monitor of the ***PB-Q^{ONE}***. This enables the evaluation of the entire master system across segments. The recording is started simultaneously with the measurement of the quality values and can be performed as a single measurement or a continuous measurement.

The results of the recording are summarized under Results → Bus communication.

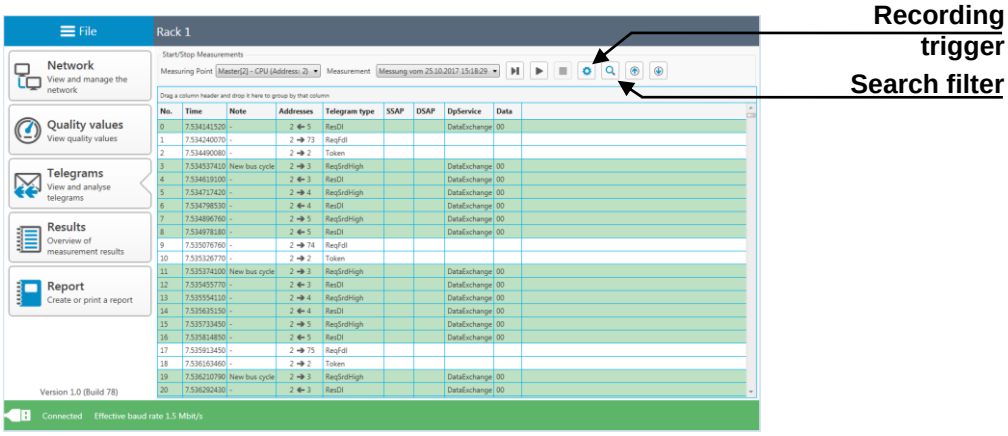


Figure 18: Telegram monitor

By setting special recording triggers (Figure 19) individual telegram types (e.g. error telegrams, repetitive telegrams, diagnostics, failures) and device addresses can be triggered directly. After activating the filter settings and starting a continuous measurement, the entire telegram traffic is analysed in the background. If one of the specified events occurs, then a telegram recording of the preset size is made. Depending on the setting, this may be performed as a one-off or as a repeating process.

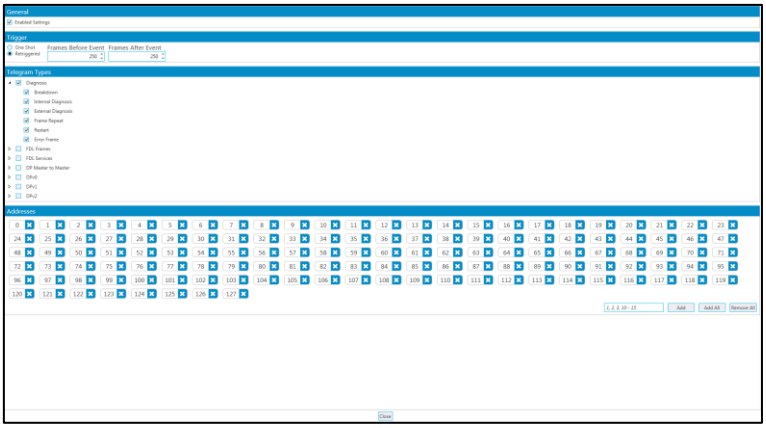


Figure 19: Recording trigger

The search filter has selection criteria for direct investigation of the predefined characteristics (Figure 20).

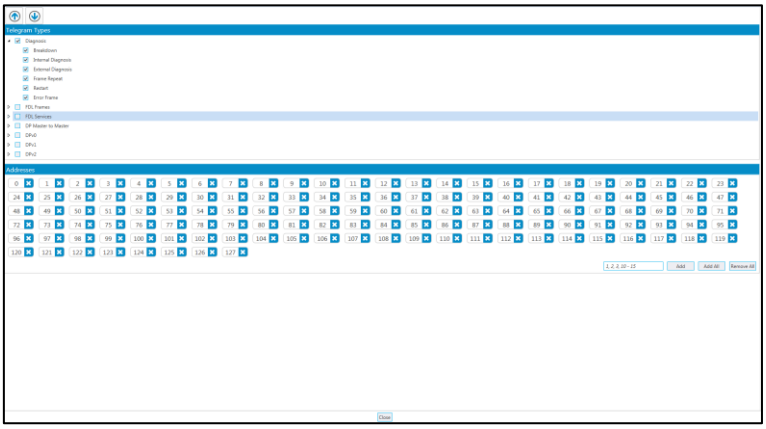


Figure 20: Search filter

Once these are defined, the found entries are shown via the up/down function in the telegram overview (Figure 21).

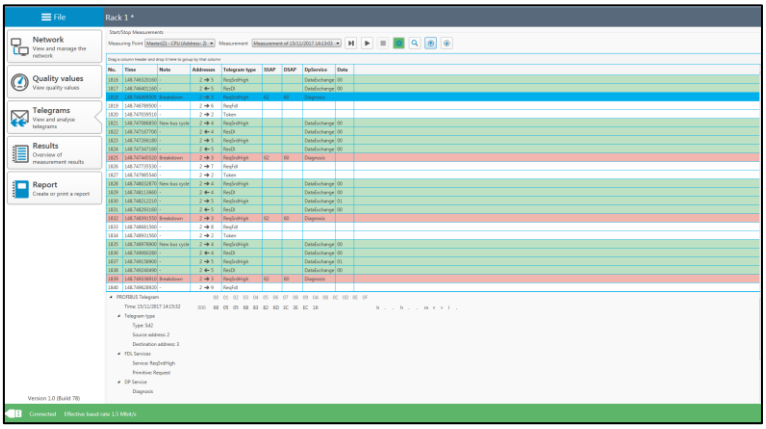


Figure 21: Telegram evaluation

6 Results

6.1 Network overview

After the measurements have been completed, all available recordings can be accessed in order of measuring point and time under the “Results” sub-item. In the network overview, a total evaluation is performed for the selected data record with regard to bus physics and bus communications and presented according to the defined criteria. If all values are within the specifications, then this is indicated by a green icon (Figure 22).

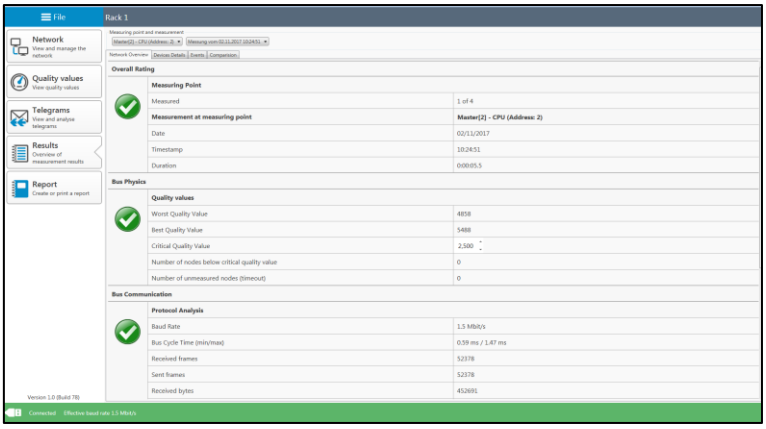


Figure 22: Network overview

Evaluation criteria:

No fault: Communication is functioning without any problems.

Warning: A quality value is below specification, or a communication error has occurred on the network, but without causing system failure. The sources of this event should be localised and resolved.

Fault: A critical fault has appeared in the network, or originated from a device, and this fault leads to system failure. Urgent action is required to resolve the fault.

If error events occurred during the recording period, or if quality values were found to be below threshold, then this is indicated by a yellow icon (warning, not yet a failure) or a red icon (fault) (Figure 23).

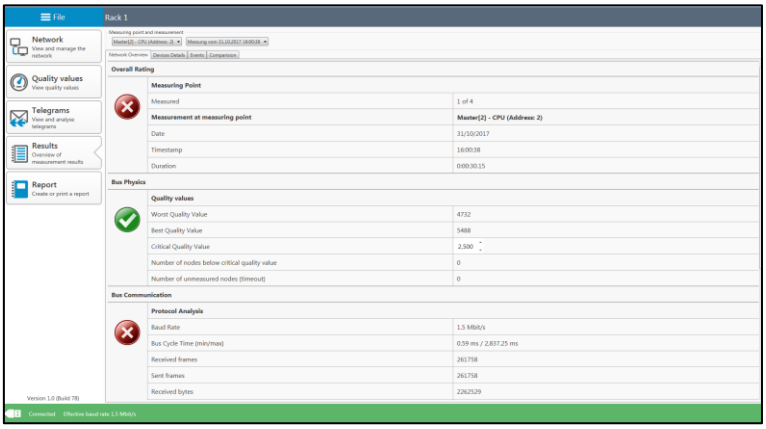


Figure 23: Bus communication fault

6.2 Device details

The address-based device overview under the sub-item “Device details” helps with a more detailed localisation of errors. Unlike in the overall evaluation, all detected Profibus devices are listed in ascending order of address and colour-coded to show their status. The individual results of the physical and logical evaluation are shown by selecting the relevant address.

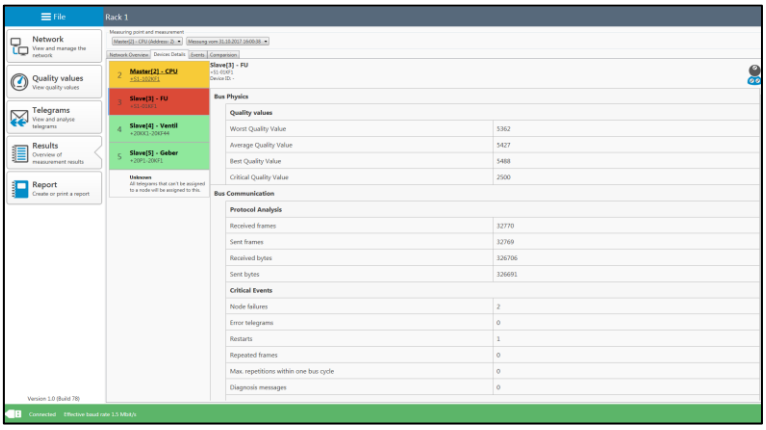


Figure 24: Fault, slave addr. 3

6.3 Event list

The event list shows the recorded fault entries. The table illustrates when and how often certain telegram errors occur. The events are shown based on their address and can be grouped with a sorting function.

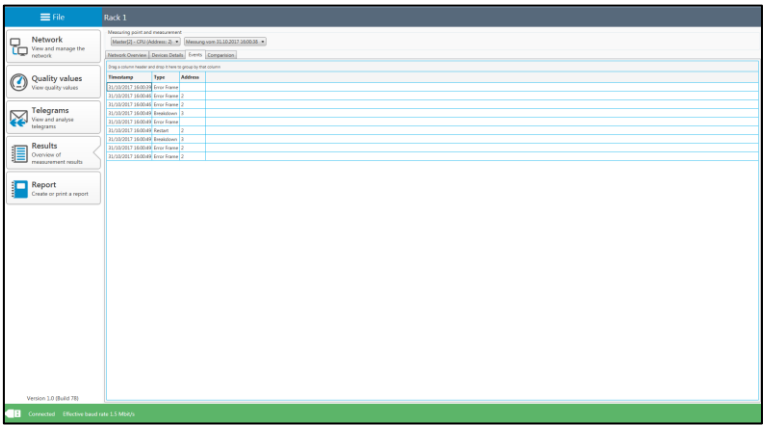


Figure 25: Event list

6.4 Comparison

Stable physical conditions are the foundation of fault-free Profibus communication. When commissioning a new system or modifying an existing system, we therefore recommend performing an evaluation of the quality values to document the status quo and as a reference for future measurements. In order to detect changes in the physical condition early on, and for before/after comparisons in the event of a fault, the ***PB-Q^{ONE}*** has a compare function. In a first step, load the stored measurement file and select the relevant measuring point. Next, perform a current measurement at this point. Using the “Compare with” drop-down menu, load the values from the initial measurement for comparison. The two measurement series are juxtaposed, and potential deviations for each address become detectable.

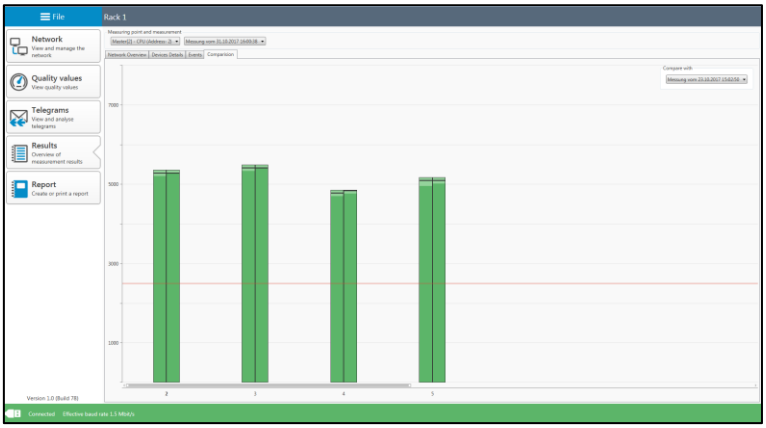


Figure 26: Compare function

7 Report

This function is used to document the recorded measurement results. On one hand, this enables the storing of a measurement record with customer and inspector information, as well as the topology plan (see example in the appendix). Clicking on the branding entries enables changing logos and header colours for customisation.

The report is stored in the MS Word format to enable adding the results of other analyses (cable test, permanent network monitoring, EMC analysis), as well as comments and additional information.

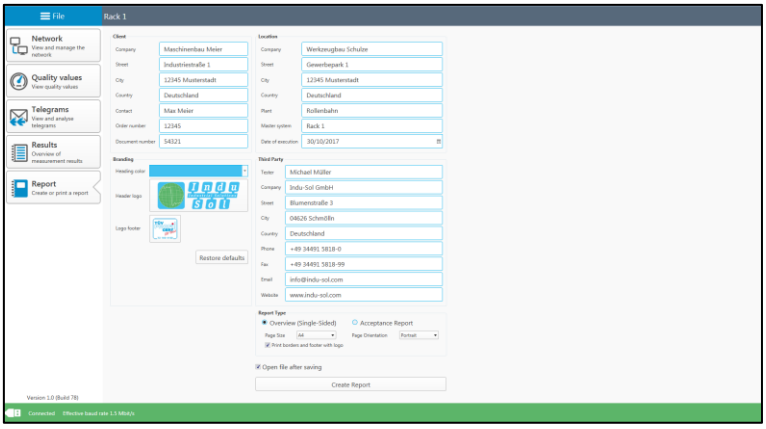


Figure 27

8 Technical data

- Power supply: via USB
- Tolerance: ±10%
- Current draw: max. 500 mA
- Start-up current: max. 150 mA
- Dimensions (W x H x D): 60 x 35 x 118 (in mm)
- Weight: 200 g
- Protection rating: IP20
- Operating temperature: +5 °C to +55 °C
- Storage temperature: -20 °C to +70 °C
- Relative air humidity: 10%…90%

8.1 Technical drawing

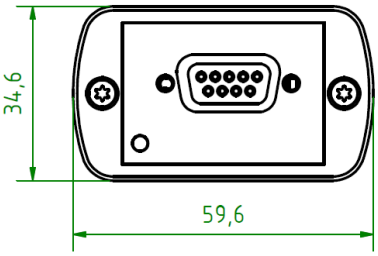


Figure 28: Front view

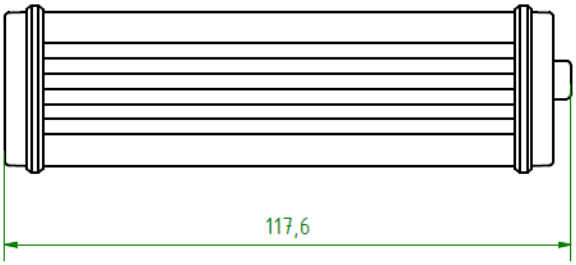
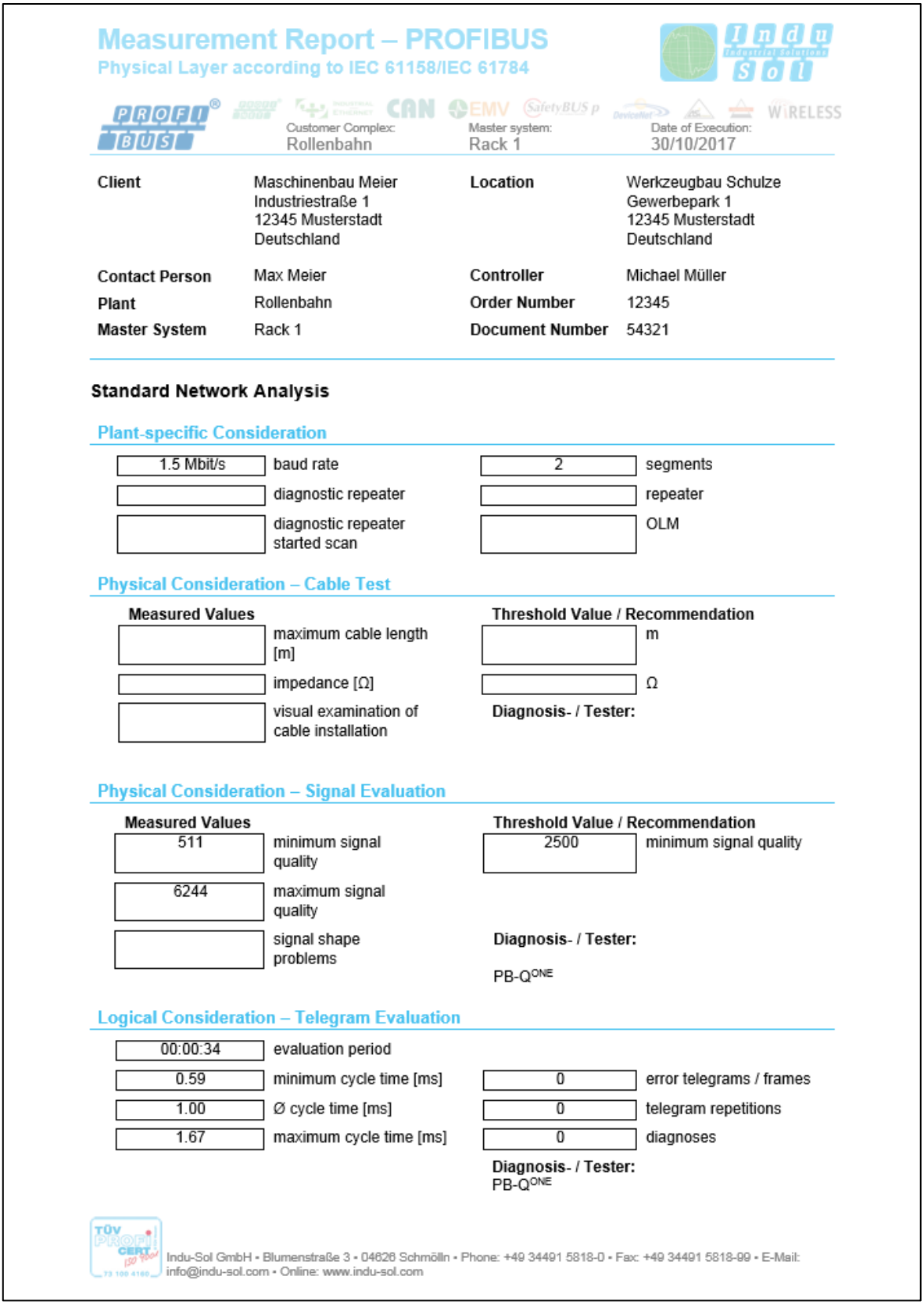


Figure 29: Side view

9 Appendix

9.1 Sample log



Measurement Report – PROFIBUS

Physical Layer according to IEC 61158/IEC 61784

Customer Complex:	Master system:	Date of Execution:
Rollenbahn	Rack 1	30/10/2017

Client	Maschinenbau Meier Industriestraße 1 12345 Musterstadt Deutschland	**Location**	Werkzeugbau Schulze Gewerbepark 1 12345 Musterstadt Deutschland
Contact Person	Max Meier	**Controller**	Michael Müller
Plant	Rollenbahn	**Order Number**	12345
Master System	Rack 1	**Document Number**	54321

Standard Network Analysis

Plant-specific Consideration

1.5 Mbit/s	baud rate	2	segments
	diagnostic repeater		repeater
	diagnostic repeater started scan		OLM

Physical Consideration – Cable Test

Measured Values		Threshold Value / Recommendation	
	maximum cable length [m]		m
	impedance [Ω]		Ω
	visual examination of cable installation	**Diagnosis- / Tester:**	

Physical Consideration – Signal Evaluation

Measured Values		Threshold Value / Recommendation	
511	minimum signal quality	2500	minimum signal quality
6244	maximum signal quality		
	signal shape problems	**Diagnosis- / Tester:** PB-Q^{ONE}	

Logical Consideration – Telegram Evaluation

00:00:34	evaluation period		
0.59	minimum cycle time [ms]	0	error telegrams / frames
1.00	Ø cycle time [ms]	0	telegram repetitions
1.67	maximum cycle time [ms]	0	diagnoses
		Diagnosis- / Tester: PB-Q^{ONE}	

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Measurement Report – PROFIBUS

Physical Layer according to IEC 61158/IEC 61784

Customer Complex:	Master system:	Date of Execution:
Rollenbahn	Rack 1	30/10/2017

Extended Network Analysis

Permanent Network Monitoring

	evaluation period	**Diagnosis- / Tester:**
	number of permanent established INspectors	PROFIBUS-INspektor NT (data collector) PROmanage NT (analysing software)

EMC Consideration

	number of performed measurements		
Determined Maximum Values		**Threshold Value / Recommendation**	
Consideration fieldbus shield			
	shield current [mA] (50/60 Hz)		
	shield current [mA] (40 - 1 kHz)		shield current [mA]
	impedance [Ω] bei 2,2 kHz		impedance [Ω] bei 2,2 kHz
Consideration bonding network (BN) / equipotential bonding			
	BN current (50/60Hz) [mA]		
	BN current (40 - 1kHz) [mA]		BN current [mA]
	impedance [Ω] bei 2,2 kHz		impedance [Ω] bei 2,2 kHz

Diagnosis- / Tester:
LSMZ I (leakage current measuring clamp)
MWMZ II (mesh resistance measuring clamp)
EMV-Inspector V2 (4-channel analysis device)

Measurement Report

Test Criterion

X	met		Recommendation
	partially met		
	not met		

Inspection Capability

X	given		Recommendation
	partially given		
	not given		

Date: 15/11/2017 **Issuer:** Michael Müller

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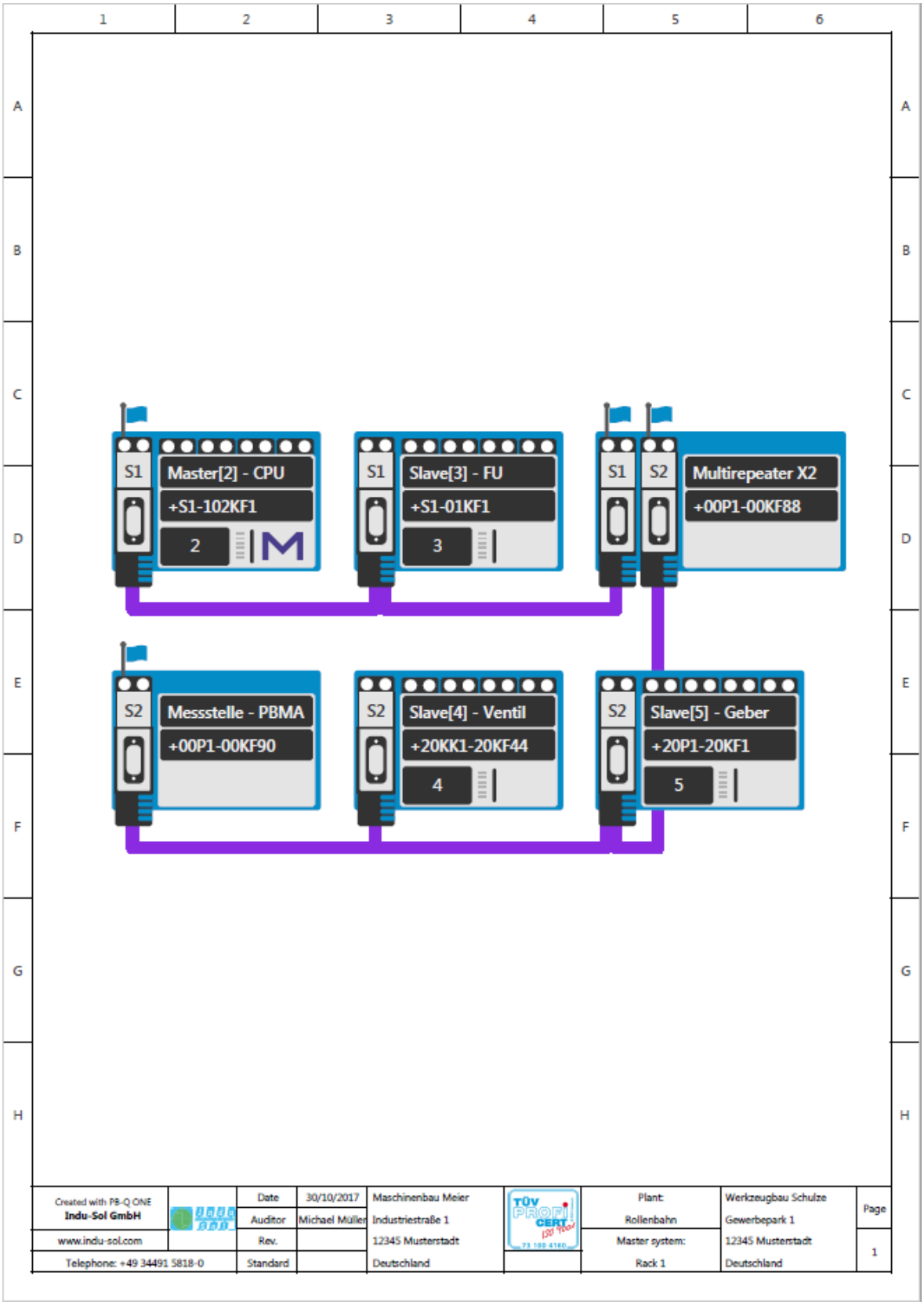
9.2 Sample plan



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