

## An ear to PROFIBUS

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*Diagnosis is becoming increasingly important for improving the availability of fieldbus systems and lowering maintenance costs. The spectrum of diagnostic tools ranges from handheld testers for cabling to asset monitoring systems. The innovative protocol analyzer from Softing shows that bus monitors can make a significant contribution in this context*

The decentralization of intelligence in automation installations and the digital transmission of information pose major challenges for system start-up and maintenance personnel. Functions which were previously provided by mechanical, electromechanical or pneumatic means are now being taken over by software-based mechatronic systems. And information which was once transmitted as an analog electrical signal – and was thus easy to check – is now transported as digital telegrams over fast data networks.

The decentralization of intelligence also makes the engineering, commissioning and maintenance of installations more difficult. The cost of this work has now surpassed the pure hardware costs many times over. Effective diagnostic concepts offer great potential for saving money here. In order for complex automation processes to be carried out efficiently, it is critical to check that fieldbus-based automation installations are functioning properly and to detect potential component failures early on.

### *It starts with an orientation on the protocol*

The first diagnostic tools were bus monitors for logging and then reviewing bus traffic. When fieldbuses first began to be used, the primary diagnostic goals were protocol verification, troubleshooting during the development of fieldbus-capable devices, and checking the interoperability of devices from different manufacturers. This is why classic bus monitors are protocol-oriented and demand detailed knowledge of the communication protocol on the part of users.

As fieldbus technology has matured and become more widespread, a need has arisen for tools to assist with the commissioning and maintenance of fieldbuses. The staff carrying out this work usually have no special knowledge of the communication protocol and therefore expect to be able to analyze communication processes in a problem- or solution-oriented way.

Softing released its first PROFIBUS protocol analyzer in 1990. The company also offers the PB-T3, a tool for analyzing the quality of the electrical signals in PROFIBUS networks. Its most recent diagnostic tool is the bus✓check protocol analyzer, which features a diagnostic mode that provides a clear overview of the state of all PROFIBUS stations. This means that even users without detailed knowledge of the protocol can see at a glance whether PROFIBUS is running smoothly or whether there are problems.

## Continual online diagnosis

The basis of this diagnostic mode is a state observer which continually analyzes all PROFIBUS telegrams and draws conclusions regarding the communication state of the stations. The tool always analyzes a complete DP cycle. This makes it possible to indicate the operational state of the stations (e.g., the exchange of useful data) and to automatically analyze errors in protocol sequences, such as invalid response telegrams.

The protocol analyzer displays the operational state of the bus stations on three levels: the bus segment, the master devices active in this segment, and the slaves assigned to each master. A status indicator classifies the functional state of each bus station: green indicates correct operation ("data exchange" state on the slave), yellow indicates exceptional situations such as diagnoses or reparameterization, and red means that the station has failed (no activity). Clicking on the bus segment or a bus station displays additional information in a separate window.

Identification	Value
Station Type	"Slave"
Station Address	7
Vendor	SIEMENS
Model	ET 200M
GSD File	Siem801e.gsd
Expected Ident Number	801E
Real Ident Number	801E

State	Value
State	Data Exchange
Related Master	1
Last Bus Cycle	1321
Last Poll Cycle	1325

Station Delay	Value
Last Station Delay Time	16 bit times
Station Delay Time	16.29 bit times

Date and Time	Message
12.03.2007 13:30:55.082868	Slave 7 receiving parameters
12.03.2007 13:30:55.086206	Slave 7 receiving check configuration
12.03.2007 13:30:55.089280	Slave 7 reporting diagnosis
12.03.2007 13:30:55.096090	Slave 7 in data exchange
12.03.2007 13:30:55.237988	Slave 7 reporting diagnosis
12.03.2007 13:30:55.769088	Slave 7 in data exchange
12.03.2007 13:30:56.606242	Slave 7 receiving parameters
12.03.2007 13:30:56.609414	Slave 7 receiving check configuration
12.03.2007 13:30:56.612490	Slave 7 reporting diagnosis
12.03.2007 13:30:56.613298	Slave 7 in data exchange

*Clear presentation: In diagnostic mode, the operational state of all bus stations is displayed in a tree structure on the left-hand side of the screen.*

The segment level shows the information relevant to the entire bus segment, such as the baud rate, the number and length of token rotations, and faulty telegrams which cannot be allocated to individual stations. A matrix with all 126 possible station addresses presents the selectable statistical values for every single station. Information such as the communication state (stop, clear, operate) and the length of the polling cycle (cyclic polling of assigned slaves) is visualized for each master.

The screenshot shows the PROFIBUS Protocol Analyzer interface. On the left, a tree view shows 'Segment\_500000' containing 'Master(1)', 'Slave(2)', 'Slave(7)', and 'Slave(19)'. The main window displays a 'Total Retries' matrix for station addresses 0 to 120. The matrix has columns for retries 0-9 and rows for addresses 0-120. Some cells are highlighted: 'M' at (0,1), '0' at (0,2), '4' at (0,7), and '7' at (10,9). Below the matrix is a log window for 'Segment 500000' showing messages with timestamps and descriptions, such as 'Slave 7 reporting diagnosis' and 'Slave 7 in data exchange'.

Overview: Statistical values for all 126 possible station addresses can be found in a matrix on the segment level.

### Comprehensive information policy

More than 50 different pieces of information are available for each slave, including the communication state, the address of the assigned master, the identification number, and the parameterization, configuration and input/output data. The tool also provides statistical information such as the number of I/O cycles, parameterization attempts, diagnostic messages and repeat telegrams, as well as error counters and the real measured station delay time.

A log window shows the primary state changes for each slave, such as parameterization, the commencement of the exchange of data, and diagnostic messages with time stamps. The first diagnosis and the last 20 diagnoses are also saved and displayed for each slave.

The diagnostic mode therefore provides a comprehensive snapshot of the current state and the history of a PROFIBUS DP network. This information is usually sufficient to gain an overview of the functional state of the PROFIBUS network. The information needed to optimize the network is also available. By comparing the length of the master's polling cycle with the total token rotation time, it is easy to determine whether the DP cycle can be shortened further or whether there is still room for a second master. The measurement of the real station delay time shows whether the slot time is too long. And finally, the error counters and counters for repeat telegrams can indicate the presence of latent errors long before these can impact the functionality of the installation.

## Detailed traffic analysis

If the extensive information provided in diagnostic mode is not sufficient for tracking down an error in the PROFIBUS network, then an expert who is familiar with the PROFIBUS protocol can log the telegram traffic in order to analyze it later. This so-called trace mode, which can run parallel to the diagnostic mode, offers the functions of a classic bus monitor.

The screenshot displays the PROFIBUS Protocol Analyzer software interface. The main window shows a table of captured telegrams with columns for Frame No., Time Stamp, Address Information, Protocol, Primitive, Service, and Data. The table lists various frames, including FDL requests for FDL\_STATUS and TOKEN, and DP responses for DATA\_EXCHANGE. A detailed view of a selected frame (Frame No. 394) is shown below the table, displaying the PROFIBUS Frame structure: Time (0:00:00:00.403190), Frame Type (SD1), Source address (1), Destination address (67), FDL Service (FDL\_STATUS), and Primitive (Request). The interface also includes a Buffer usage indicator, a Stop button, and a Project/Record File path at the bottom.

Frame No.	Time Stamp	Address Information	Protocol	Primitive	Service	Data
378	13:30:50.403190	1 -> 67	FDL	Request	FDL_STATUS	
379	13:30:50.403734	1 -> 1	FDL	Request	TOKEN	
380	13:30:50.403880	1 -> 2	DP	Response	DATA_EXCHANGE	07 00 00 00 00 53 00 00 00 00 0...
381	13:30:50.404452	1 -> 2	DP	Response	DATA_EXCHANGE	87 00 00 00 00 00 00 00 00 00 0...
382	13:30:50.405082	1 -> 7	DP	Request	DATA_EXCHANGE	00
383	13:30:50.405334	1 -> 7	DP	Response	DATA_EXCHANGE	35
384	13:30:50.405636	1 -> 19	DP	Request	DATA_EXCHANGE	18
385	13:30:50.405878	1 -> 19	DP	Response	DATA_EXCHANGE	00
386	13:30:50.406180	1 -> 68	FDL	Request	FDL_STATUS	
387	13:30:50.406724	1 -> 1	FDL	Request	TOKEN	
388	13:30:50.406870	1 -> 2	DP	Request	DATA_EXCHANGE	07 00 00 00 00 53 00 00 00 00 0...
389	13:30:50.407442	1 -> 2	DP	Response	DATA_EXCHANGE	87 00 00 00 00 00 00 00 00 00 0...
390	13:30:50.408070	1 -> 7	DP	Request	DATA_EXCHANGE	00
391	13:30:50.408324	1 -> 7	DP	Response	DATA_EXCHANGE	35
392	13:30:50.408624	1 -> 19	DP	Request	DATA_EXCHANGE	18
393	13:30:50.408868	1 -> 19	DP	Response	DATA_EXCHANGE	00
394	13:30:50.409168	1 -> 69	FDL	Request	FDL_STATUS	
395	13:30:50.409712	1 -> 1	FDL	Request	TOKEN	
396	13:30:50.409858	1 -> 2	DP	Request	DATA_EXCHANGE	07 00 00 00 00 53 00 00 00 00 0...
397	13:30:50.410432	1 -> 2	DP	Response	DATA_EXCHANGE	87 00 00 00 00 00 00 00 00 00 0...
398	13:30:50.411060	1 -> 7	DP	Request	DATA_EXCHANGE	00
399	13:30:50.411314	1 -> 7	DP	Response	DATA_EXCHANGE	35
400	13:30:50.411614	1 -> 19	DP	Request	DATA_EXCHANGE	18
401	13:30:50.411858	1 -> 19	DP	Response	DATA_EXCHANGE	00
402	13:30:50.412158	1.62 -> 127.58	DP	Request	GLOBAL_CONTROL	00 00
403	13:30:50.412650	1 -> 70	FDL	Request	FDL_STATUS	
404	13:30:50.413194	1 -> 1	FDL	Request	TOKEN	

**Complete telegram logging:** In trace mode, telegrams are displayed as an overview (one telegram per line), as well as in completely decoded form.

There are two modes of operation here as well: with "immediate logging", the logged telegrams are managed in the memory as a buffer or circular buffer, making rapid interaction with them possible. Once the relevant telegram sequence has been "captured", it can be stored as a file. With "long-term logging", the telegrams are continually stored in files for later analysis. This data can be filtered during logging and monitoring; criterias for this filtering are address and services/functions. Address and service criteria can also be triggered by starting or stopping the logging (trigger function). Telegrams are displayed in the usual way as an overview (one telegram per line), as well as in completely decoded form. The time stamps have an accuracy of 1  $\mu$ s, and differential times can also be displayed in bit times.

## Mobile use

Since the protocol analyzer can be connected to the PROFIBUS network via a USB interface, it is also suitable for mobile use with a laptop. No separate power supply unit is necessary, because power is also supplied via USB. The maximum power consumption of 200 mA allows longer measurements to be made when the laptop is running on battery power. Instead of using a conventional PROFIBUS ASIC for

receiving telegrams, the protocol analyzer employs a specially designed receiver circuit which delivers more precise results and more detailed error information. For direct connections to PROFIBUS PA networks, a second interface is available for the MBP bus physics used in PA. This means that bus traffic can be recorded and compared on both sides of a PA segment coupler.



*Bus analysis via USB: A USB interface is used to connect the protocol analyzer to the PROFIBUS network and to supply power.*

### *Compact*

Softing's bus✓check protocol analyzer for PROFIBUS is a diagnostic tool which helps system start-up and maintenance personnel with troubleshooting, preventive maintenance and network optimization. The analyzer also offers interesting features for PROFIBUS experts in development departments, such as the immediate and long-term logging of telegrams. The modularity of the software and hardware makes the system flexible and extensible.