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BUS PHYSICAL LAYER DIAGNOSTIC

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Abstract: Article deals with elimination of transmission problems using Fieldbus Tester for physical layer of PROFIBUS DP. For experiment was used Softing's diagnostic tool PB-T3 and Profibus network with 16 stations. The special device, conection and method were prepared for simulation of transmission troubles. Results and experiences of this diagnostic method can be used for training of diagnostic experts.

Keywords: Communication diagnostics, electrical drive, error detection, physical layer, PROFIBUS tester, RS 485

1 INTRODUCTION AND PRELIMINARIES

PROFIBUS is worldwide fieldbus with dominant impact in Europe. Profibus has own rules of application for multivendor communication between devices of many producers.

Tested or certificated devices and recommended cables, conectors, repeaters and terminators can be used in line topology. All this bus components succumb of ambient impact like vibration, accidental deformation or particular damage, temperature cycles, ageing, EMI, etc. There are sources of failures in hardware, including conections. Detection type of the fault and localisation of an error is task for diagnostic expert and good diagnostic methods and tools.

PROFIBUS provides different versions of the physical layer. All versions are based on international standards and assigned to PROFIBUS in both IEC 61158 and IEC 61784. Four types of the interfaces are used in PROFIBUS (PNO, 2002). The diagnostic tool works only with PROFIBUS DP protocol on RS485 interface.

2 PROFIBUS DP ON RS485 INTERFACE

RS485 is the most commonly used transmission technology. It uses a shielded twisted pair cable and enables transmission rates from 9,6 Kbit/sec to 12 Mbit/sec. Up to 32 stations can be connected in a single segment with a bus structure (see Fig.1). The maximum permissible line length depends on the transmission rate. The beginning and end of each segment is fitted with an active bus terminator (Fig.1). Both bus terminators have a permanent power supply to ensure error free operation. The bus terminator is usually switched in the devices or in the connectors. The cable shield should be grounded on both sides where possible.

If more than 32 stations are implemented or there is the need to expand the network area, repeaters must be used to link the individual bus segments. Maximum 9 repeaters can be used.

The use of cable type A is recommended in PROFIBUS installations with RS485 interface. The data of the cable type A are in Table 1.

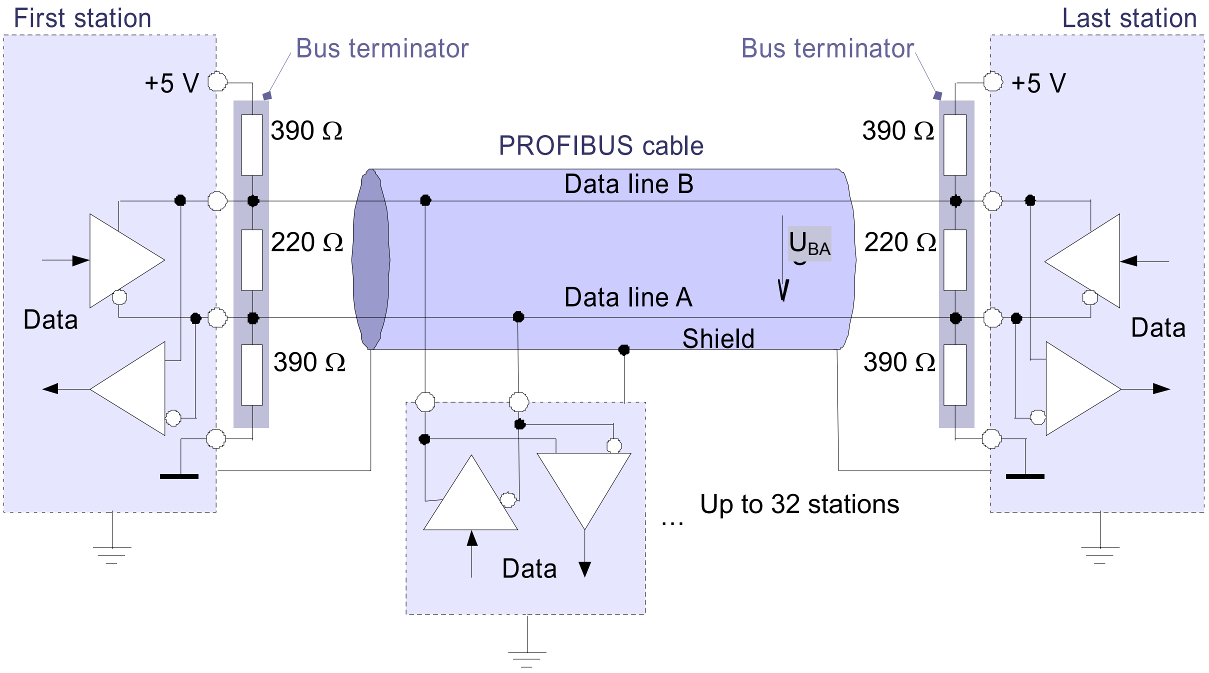

Figure 1: Interconnection of the stations on PROFIBUS DP segment

Table 1: Basic data of the cable type A

Impedance	135 – 165 Ω
Capacity	≤ 30 pF/m
Loop resistance	≤ 110 Ω/km
Wire diameter	> 0,64 mm
Core cross-section	> 0,34 mm^2

3 PROBLEM STATEMENT

The detectable common problems on Profibus cable: signal line is broken, terminator power is insufficient, a termination is missing at the end station, an extra terminator at a station, high line resistance between two stations, high capacity between bus lines, PROFIBUS drivers output low voltage, baudrate too high for installed cable length, too many stations.

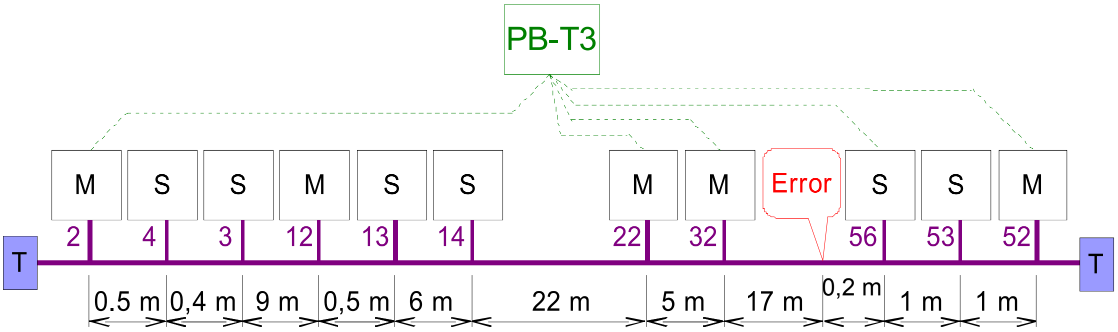

Figure 2: The testing PROFIBUS DP network

A testing communication network is shown in Fig.2. The network consists of five PROFIBUS DP Masters Class I (the „M“ stations – five programmable logic controllers), five PROFIBUS DP Slaves (the „S“ stations – one DP/PA link, two remote I/O systems ET 200M, two electrical drives) and hardware error generator (Error). The measurements were accomplished in five measuring points (see the stations with PROFIBUS addresses 2, 22, 32, 52 and 56 in Fig.2).

The PB-T3 tester provides an overview of the signal conditions on the bus – it detects the signal quality of each device on the bus. PB-T3 does not influence the signal levels neither the bus traffic. The quality evaluation is based on several parameters of the signal. 1. A level of the differential voltage (i.e. between A nad B lines). 2. The edge steepness. 3. The overshoots and undershoots. 4. Level dips. All these features are summarized in the quality level value. The results of the quality measurement are displayed on bar graphs, which we can see in Fig.3. The first bar graph from the left shows the signal quality of all stations measured at the station with PROFIBUS address 2 (see Fig.2). The second bar graph is measured at the station no. 22 and third one is measured at the station no. 52. The quality is stated in the range 0 – 5000, while the accepted signal quality is represented by range 2500 – 5000.

Except of the signal quality measurement, the tester records a characteristic section of the signal waveform of a relevant frame and displays it on the oscilloscope of the application software. Based on the signal waveform, various cable problems can be revealed.

The PB-T3 determines also the edge steepness for rising and falling edges. The rise and fall times are determined with a resolution of 1/16th of the baud rate used and displayed as a value between 0/16th and 16/16th. This value specifies the slovest rising and falling edge of the relevant frames.

The evaluation of the measurements, performed in at least two measuring points, allows a disclosure of the most PROFIBUS physical layer errors.

Too many terminators

This error represents situation when an additional (usually forgotten) termination resistor is connected to the bus. The results of the measurements are in Fig.3. The measurements were performed in three measuring points – on the stations with PROFIBUS addresses 2, 22 and 52.

The bargraphs of the signal quality do not give exact information as to localisation or the type of the error. Therefore the oscilloscope display evaluation is needful. Theese measurements were performed from measuring point of the master with PROFIBUS address 52, while the signals of the stations 32 and 56 were evaluated. The first thing that the oscilloscopic waferoms show is reduced bus idle level. This situation can have two reasons. The first one is an additional termination resistor connected to some station somewhere on the bus. The second reason is an unsupplied terminator at one end of the bus. The error is possible to localise through edge steepness of the signals. Because the rise and falling times of the signals from the station 32 are much longer as it is with the station 56, we can assume that the error occurs on the station 56, or nearby.

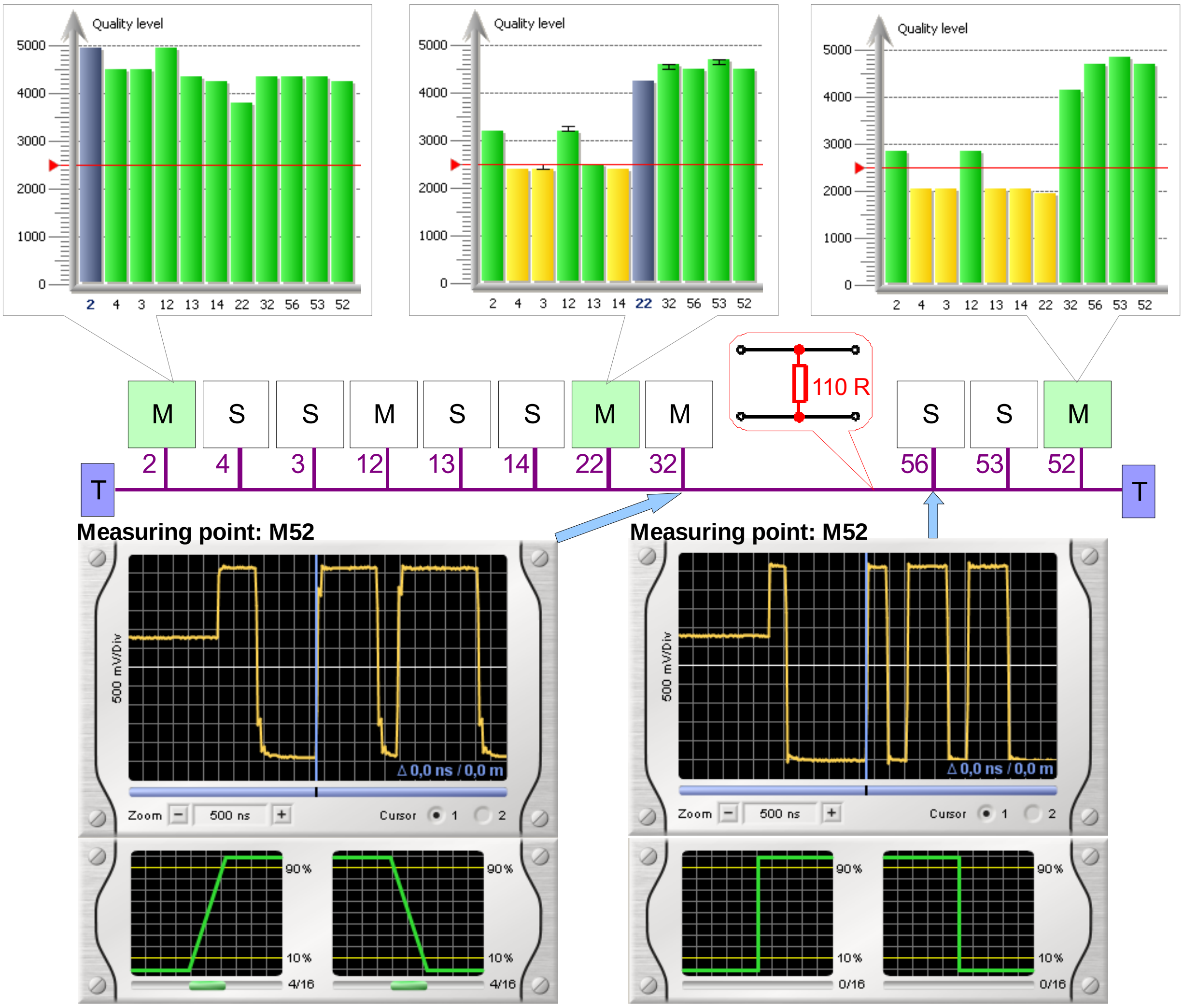

Figure 3: Bar graph of the signal quality for all stations and the oscilloscope displays of the station 52

Wrong cable type

This error is simulated via additional capacitor between the data lines. The results of the measurements are in Fig.4. The measurements were performed in three measuring points – on the stations with PROFIBUS addresses 2, 22 and 52.

The bargraphs of the signal quality give estimative information as to localisation of the error. It is localised close to the right end of the bus (the right end of the bus is represented by station 52). This assumption is confirmed via oscilloscope display of the station two signal, measured on station 2 (see the left oscillogram in Fig.4). The reflections with 520,8 ns delay are visible on the oscillogram. This implies that the point of the reflections is located about 60 m from the station 2[1]. The reflections of the signal measured on station 52 are greater in magnitude and their time delay is very short (see the right oscillogram in Fig.4). The reason of the error is possible to disclose from the shape of the reflections, that leed to increased capacitance.

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[1] The distance is calculated for the signal propagation speed 230.10^{6} m/s.

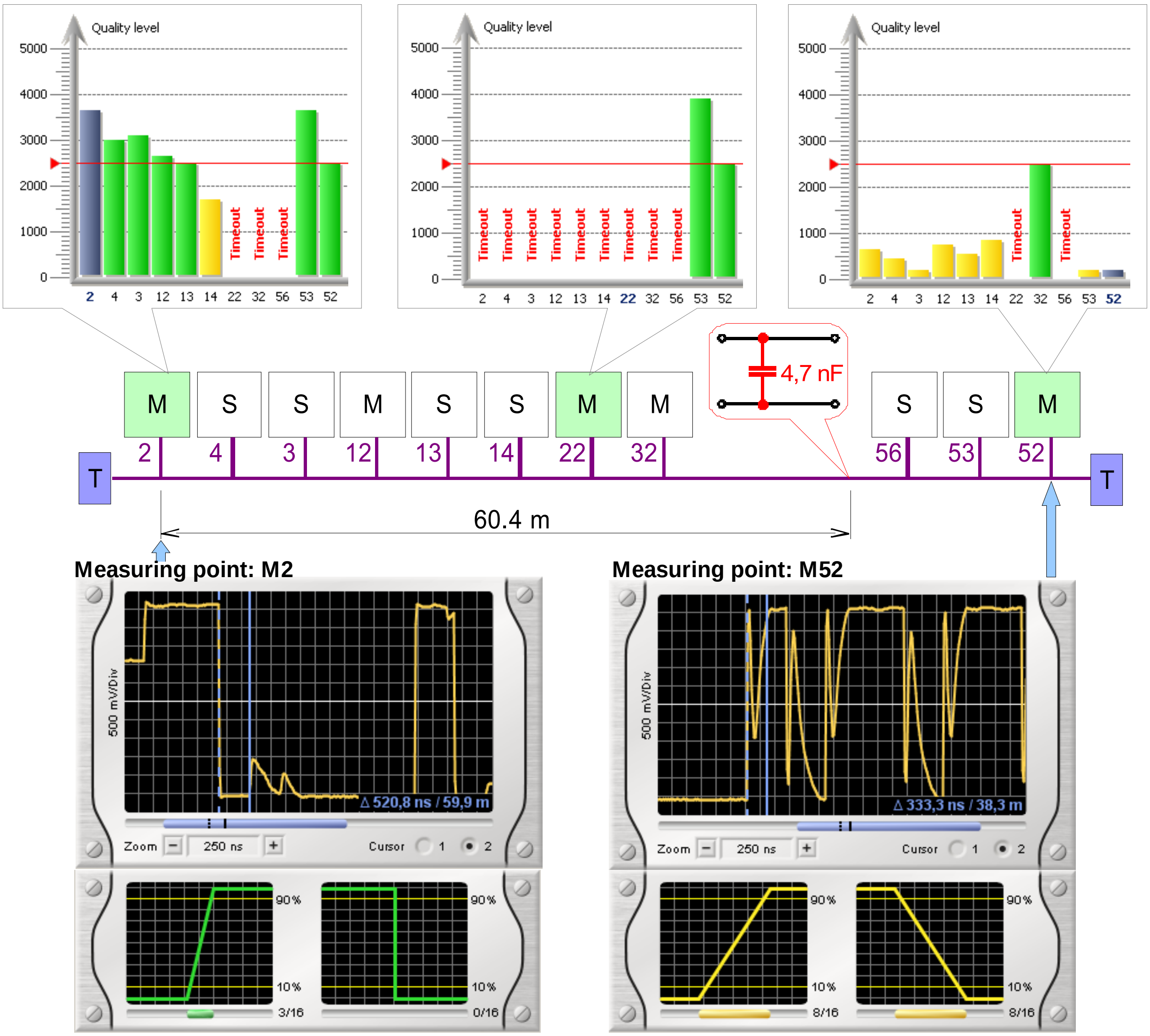

Figure 4: Bargraph of the signal quality for all stations and the oscilloscope displays of the stations 2 and 52

Line break

The bus wires A, B were opened nearby station 56. The results of the measurements are in Fig.5. The measurements were performed in three measuring points – on the stations with PROFIBUS addresses 2, 32 and 56.

The bargraphs of the signal quality give estimative information as to localisation of the error. It is localised between the stations 32 and 56. The reason for this assumption is following. The station 32 reads the data of the stations 2-32, but the station 56 reads the data of the stations 53-52. The character of the error is disclosed from the oscillogram of the second station's signal, measured on station 32 (see the left oscillogram in Fig.5). The oscillogram signals the opened line. The station 56th oscillogram shows almost no distortion of the signal and it means the error is located close to the station 56.

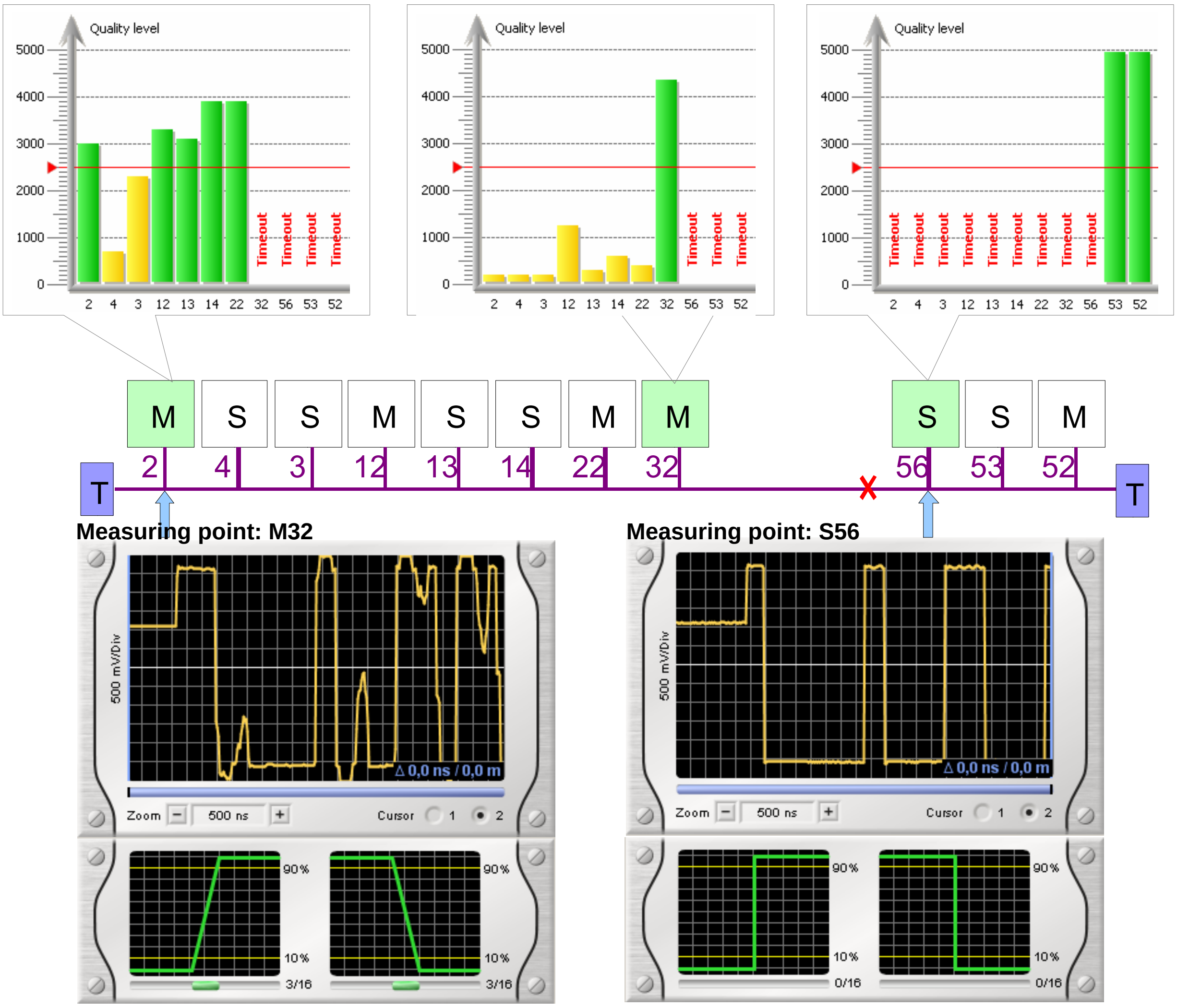

Figure 5: Bargraph of the signal quality for all stations and the oscilloscope displays of the stations 32 and 56

High transition resistance

High transition resistance error is simulated via additional resistor connected to the bus. The results of the measurements are in Fig.6. The measurements were performed in three measuring points – on the stations with PROFIBUS addresses 2, 22 and 52.

The bargraphs of the signal quality give exact information as to localisation of the error. It is localised between the stations 32 and 56. The reason for this assumption is following. The station 2 receives the high signal quality of the stations 2-32, and bad signal quality of the stations 53-52. The station 52 receives the high signal quality of the stations 53-52, and bad signal quality of the stations 2-32. The character of the error determinates symptomes from the oscillograms. High quality of the edge steepness for rising and falling edges indicate no problem with capacitance. The reflections and damping of the signal show the changes of line parameters. The reason of the error in summary leeds to increased line resistance.

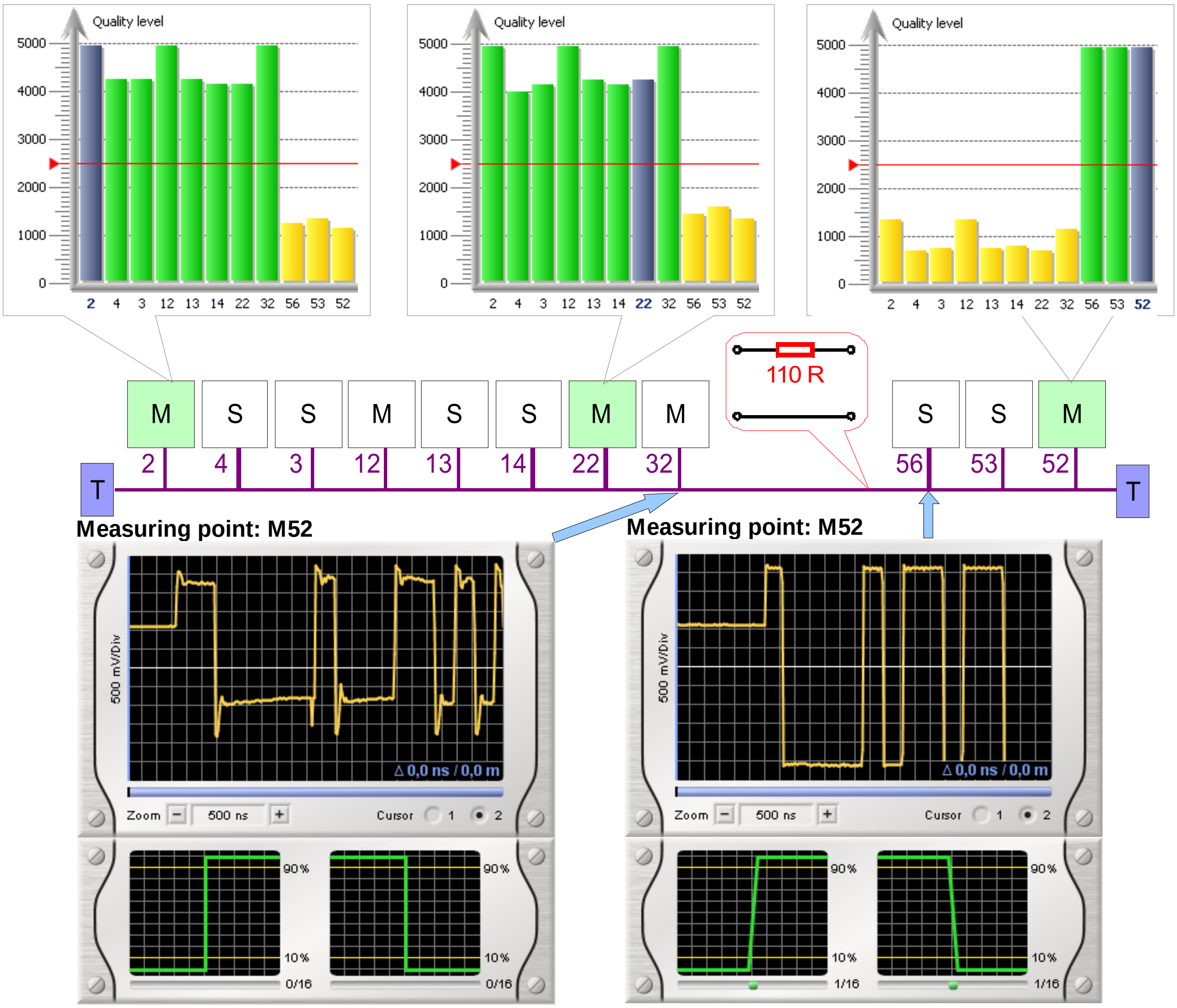

Figure 6: Bar graph of the signal quality for all stations and the oscilloscope displays of the stations 32 and 56

CONCLUSION

PROFIBUS is one of the standards for data communication in the industrial applications. Its reliability is one of the key factors determining the serviceability of a device or a plant. The correct function of the PROFIBUS sytems is determined by hardware factors and by configuration of the communication interfaces of the devices.

Diagnostic tool improves productivity by detection and localisation of errors and by preventive maintenance to avoid failures before they occur. The signal transmission quality evaluation is possible only through the specialized tools. But these tools have to be operated by qualified users, who are able to interprete the measured data correctly and to find out the source of the bus communication errors.

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