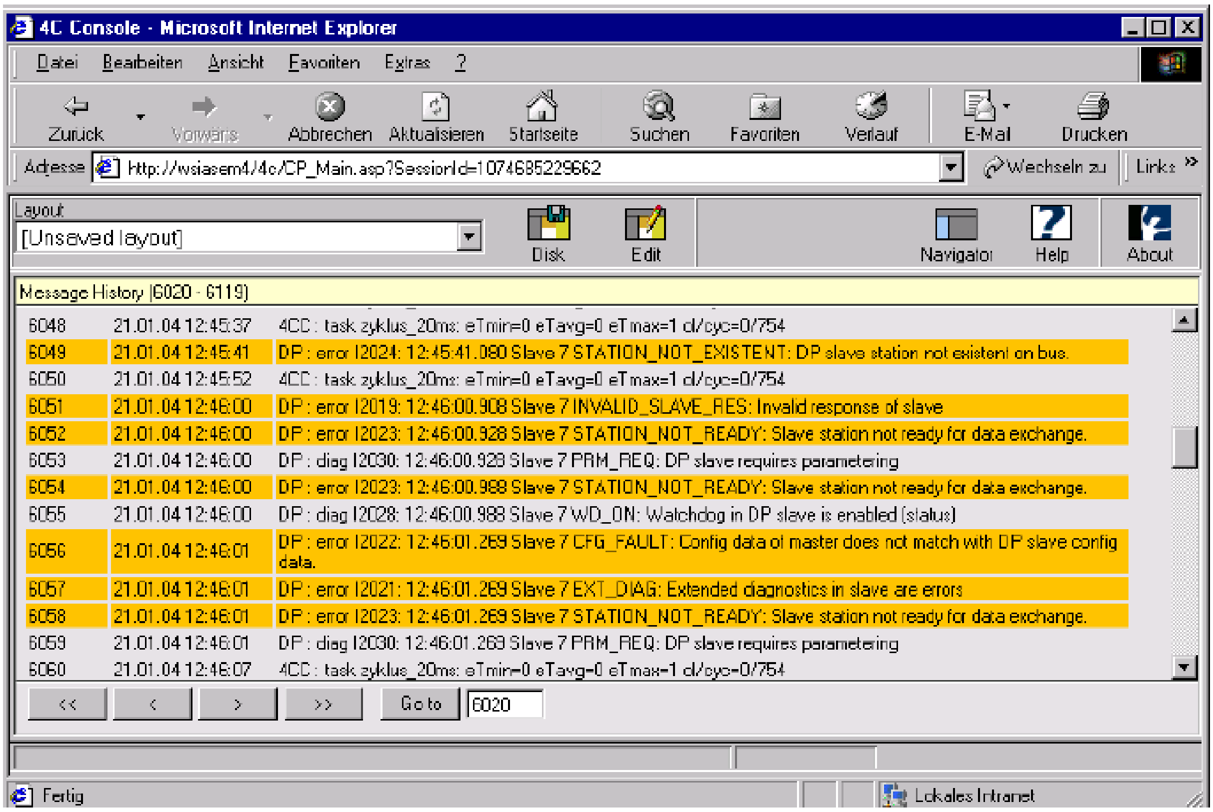
Annoyance with Profibus?

You might think that a guideline on troubleshooting in Profibus networks could simply be organized according to the different types of errors possible. But this might not be what the affected individuals actually need. When faced with a Profibus problem, you first need to know where to begin your analysis. All too often, the only information available initially is something along the lines of "the measurements in silo 5 are dropping out sporadically" – and then the finger of blame is pointed prematurely at the bus technology. Part 1 of the guideline for Profibus diagnosis provides tips on the right approach to problems and the software to be used; part 2 will be published in the May issue of elektro Automation.



Figur 1: Web access to the Profibus master diagnoses of the 4Control control system from Softing

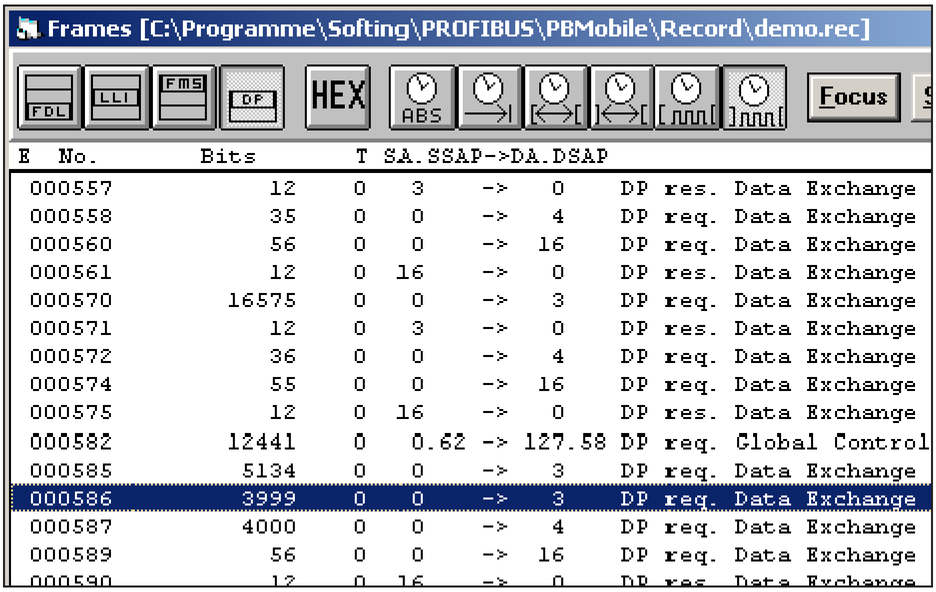
The standardized Profibus diagnostic features offered by nearly every Profibus-enabled PLC provide a starting point for Profibus troubleshooting. Traditional PLCs supply this information in the form of function blocks. From there, the information can be sent to the control system. The process is simpler with PC-based control systems ("soft PLCs") which store Profibus diagnoses directly in corresponding log files. Preference should be given to systems which use the standard names for Profibus errors and very little manufacturer-specific jargon. This makes it easier for everyone involved to interpret the results. In this way, you can quickly establish whether you're dealing with a real or alleged Profibus problem. Without a great deal of effort, you can detect real Profibus problems such as parameterization errors, configuration or module selection errors, and the sporadic failure ("non-existence") of slaves. However, it is also possible to detect exceeded threshold values or cable breaks on the field side – issues which will show up in an expanded Profibus diagnosis even though they do not indicate an error in the Profibus itself. A protocol analysis tool can be used for verification purposes or in cases where the Profibus master diagnoses cannot be easily accessed. Such a tool silently records telegram traffic on the Profibus network and can be triggered by slave failures to chronicle the prelude to and aftermath of such failures. The various commercially available Profibus masters will react differently to slave failures, so it is important to ensure that your protocol analysis tool can deal with this. The tool must feature a generally applicable slave failure trigger. Softing AG provides the necessary filters and triggers with its PBMobil tool. It is also important to choose a tool which correctly displays the intervals between telegrams in bit times. Otherwise it will not be possible to compare bus parameter values such as the slot time, max Tsdr and Idle1.

The most important practical tips from the first part of the guideline are summarized here:

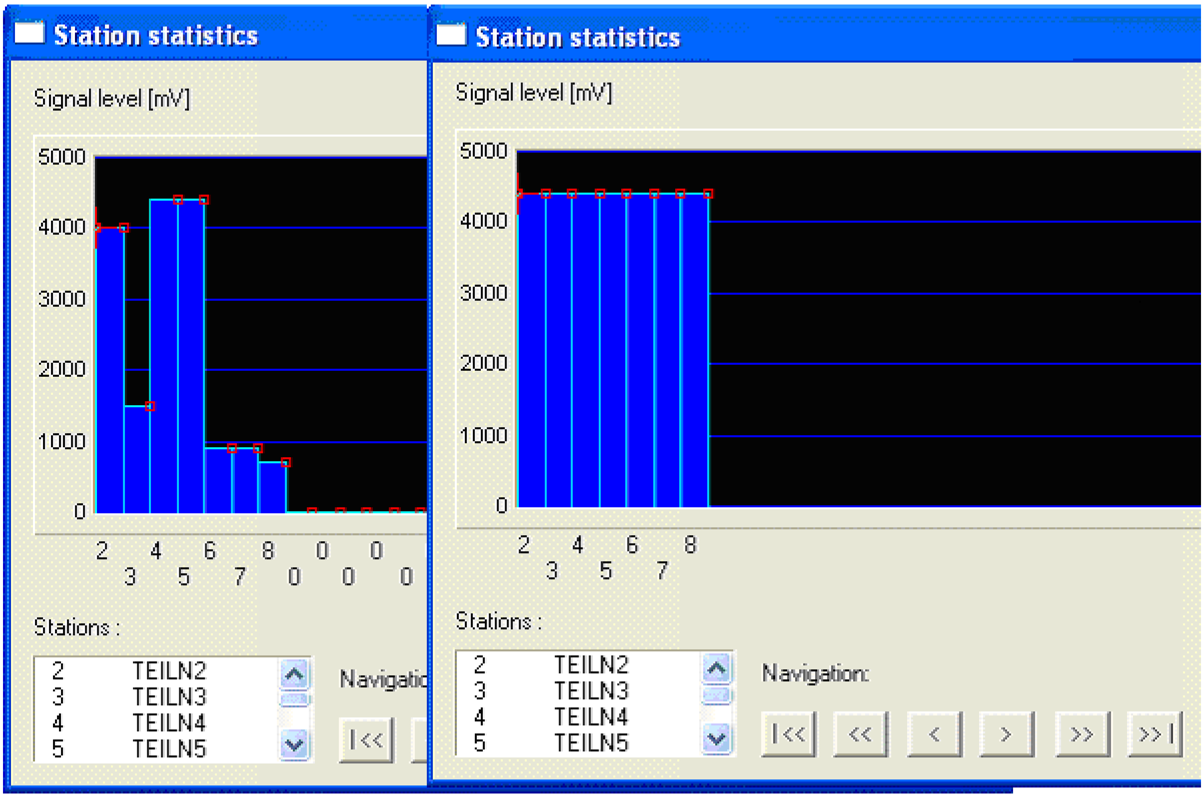
- The Profibus diagnostic features integrated in modern industrial control systems provide a good starting point for efficient troubleshooting.
- More detailed information can be obtained from a protocol analysis tool working as a "silent listener" – however, such a tool should feature a generally applicable slave failure trigger.
- The bar chart above provides an overview of the quality of the telegrams in terms of voltage; however, station problems are only really indicated by values which are too low at several measuring points.
- Levels which vary from measuring point to measuring point may indicate missing or surplus termination resistors or high resistance.
- EMC disruptions can be reduced by using compensating cables parallel to Profibus, for example, although because of the skin effect which occurs at high frequencies, these cables should be finely stranded and have a wide cross-section.

Is there really a weak node?

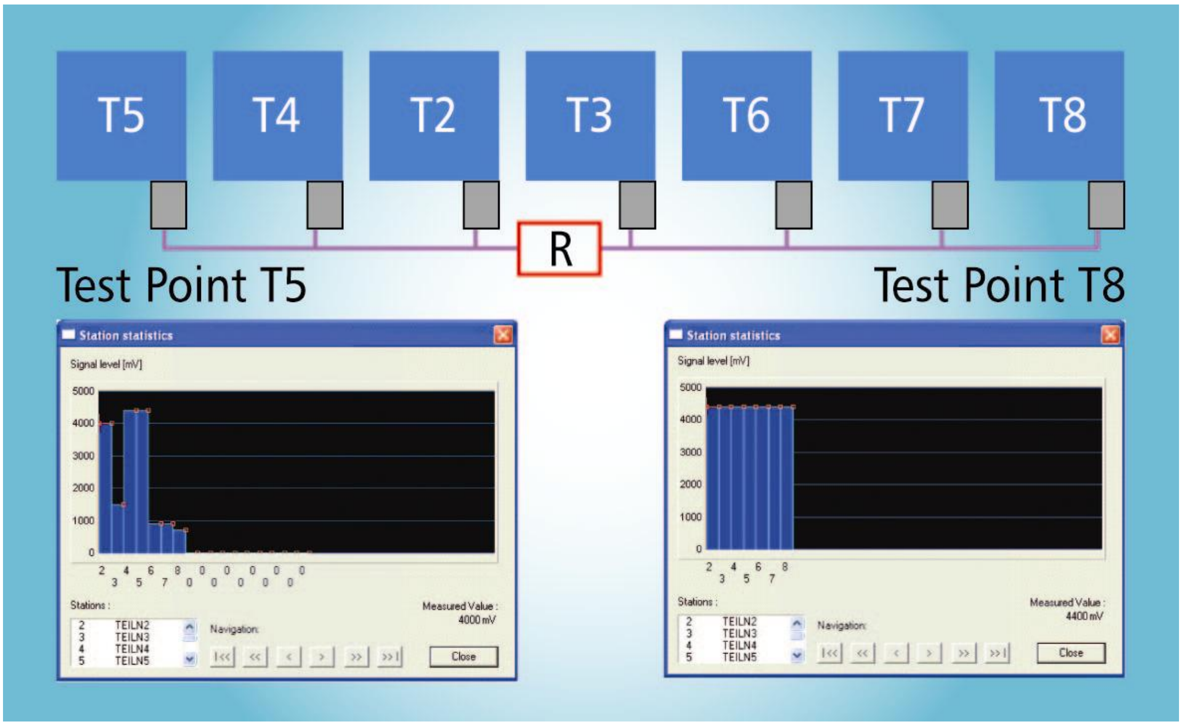
The bar chart of the Profibus tester provides an initial overview of the quality of the telegrams as regards voltage. One advantage of this tool is that it can be used to carry out measurements nearly non-reactively on an operational installation. The tool displays the voltage of the telegrams from each station (sender) when they arrive at the measuring point. It would be premature to assume that stations with a lower voltage are experiencing problems.



Figur 2: Slave 3 is no longer sending input data – despite correct and repeated requests from the master



Figur 3: Bar chart of the Profibus tester: Station 5 is missing its termination resistor



Figur 4: Mirror-image measurement results when there is a single instance of high contact resistance between slave 2 and slave 3.

This conclusion is only true if the same low voltage is measured for this station at all measuring points. In this case, you're dealing with a weak node which is sending telegrams with a low voltage.

Does the level depend on the measuring point?

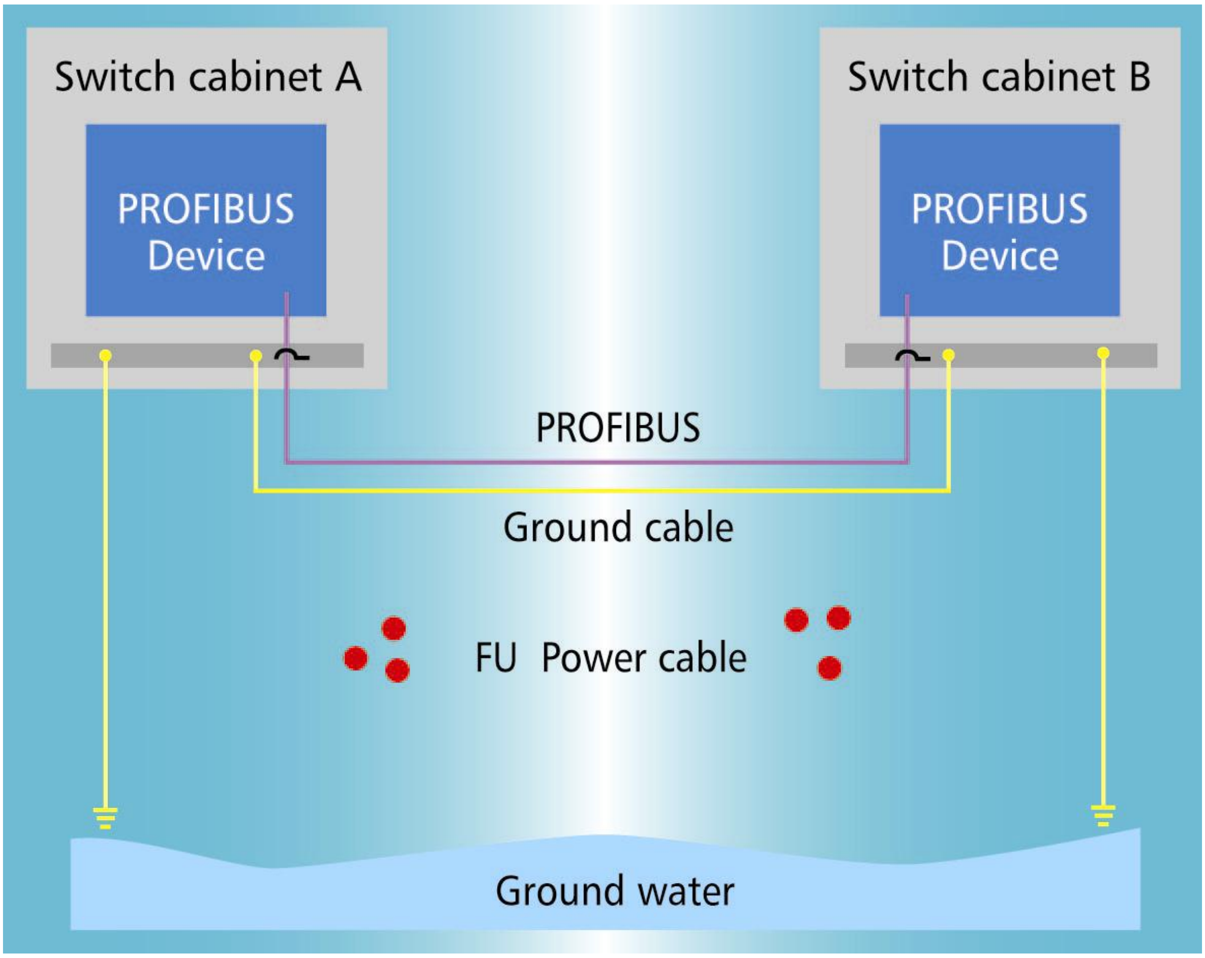
If the measured voltage of a station changes from one measuring point to another, the problem is not a low output voltage from the station. Instead, this usually indicates missing or surplus termination resistors, high-impedance short circuits or other wiring problems which are degrading the signal quality. The problem can generally be found wherever the voltage drops are the greatest. Interestingly, the transmission voltage of the station near the problem is often least affected. This logic also applies to missing or surplus termination resistors and high-impedance short circuits.

Contact resistance and long lines

Another typical measurement pattern arises when there is high line resistance. This manifests itself in that stations which show a good level at one end of a line will have a bad level at the other end and vice-versa. The level of the "closer" stations will be good, while that of the stations which are "further away" will be bad. When such mirror-image measurement results are achieved, a distinction must be made between individual instances of high contact resistance and bus lines which are too long overall. In the former case, the location of the problem can be easily identified because there will be two clear groups of stations: those with good voltage on this side of the error, and those with bad voltage on the other side of the error. If the situation is not so clear, however – that is, if the voltage has gradually declined – you can assume that the resistance per unit length is too high overall. This could be caused by a bus line which is too long. This problem can be corrected using logically transparent repeaters which physically separate the network into two independent segments.

EMC disruptions due to loop antenna effects

Another major source of EMC disruptions are ground loops which arise from "by-the-book" grounding. In this case, the shield of the Profibus cable, which is grounded at both ends, along with the local ground rods and the groundwater act as a loop antenna for the high-frequency electromagnetic fields which emanate particularly from the power cables for controlled drives. Because of these induced voltages, individual bits in a telegram may be corrupted, a checksum failure may arise on the telegram level, or the slave which has been invoked may not accept or respond to the master telegram. These ground loops are almost impossible to avoid. The only way to alleviate their symptoms is by laying compensating cables parallel to the communication cable. These cables give the induced current a different path to take besides the shield of the Profibus cable. However, the skin effect may occur with high frequencies. If the compensating cables is not finely stranded, a large proportion of the high-frequency currents may flow over the shield of the Profibus cable despite the generous cross-section of the ground wire.

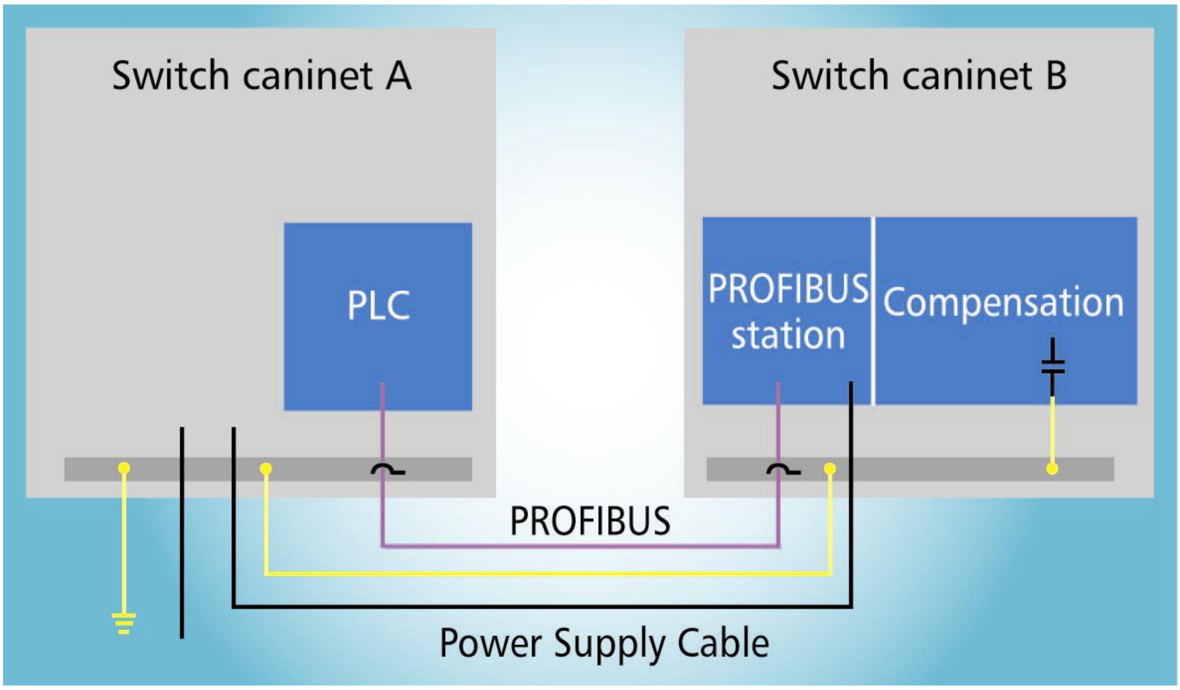


Figur 5: A compensating cable reduces EMC disruptions due to ground loops

EMC disruptions due to neutral grounding

EMC disruptions may also arise if switch cabinets are fed by frequency converters from neighboring switch cabinets which also contain Profibus stations. In this case, a high-grade reactive power and harmonic compensation system keeps the power network clean, but it makes life more difficult for the Profibus. The compensation of the drive or frequency converter causes any high-frequency peaks to be bypassed to

ground. This gives rise to mass currents in switch cabinet "B", which in turn must flow over the available paths (ground cable and Profibus shield) in the direction of switch cabinet "A". Such currents can reach a magnitude which is not only disruptive to Profibus traffic, but which also surpasses the thermal capacity of the Profibus cable. A clamp-on ammeter – a device for measuring leakage current – should be used to check shield currents and thus the success of the grounding measures. In order to determine the extent to which the shield currents are negatively affecting the Profibus, it's best to use a protocol analysis tool such as PBMobil, which provides statistics on the number of damaged telegrams.
For a Profibus which is stable despite the occasional corruption of telegrams through EMC disruptions, the "retry limit" bus parameter should be increased in the master. However, it should be noted that this can cause the bus cycle and reaction times of the system to increase.



Figur 6: Feed-in including grounding from neighboring switch cabinet