System diagnostics with PROFIBUS and SIMATIC
System diagnostics with PROFIBUS
Avoidance of faults using FastConnect

The necessity for achieving increasing productivity means it is essential to increase the degree of automation. The control systems used are increasingly based on distributed I/Os in conjunction with a fieldbus system, e.g. PROFIBUS.

To achieve productive and economical use of a plant, operators must be able to rapidly recognize and eliminate causes of faults in order to minimize production stoppages. This is only possible with powerful diagnostics systems.

A differentiation is made between two types of diagnostics:

- **Process diagnostics:** Detection and elimination of faults in the production process, i.e. outside the control system
- **System diagnostics:** Localizing and elimination of faults in the control system (incl. bus and visualization systems)

System diagnostics is of particular significance because it is always required.

In addition to the diagnostics of control components (modules, sensors, actuators etc.) and visualization systems (e.g. with WinCC® Scope), increasing importance is being attached to diagnostics of the fieldbus system.

SIMATIC®, in this case SIMATIC S7, provides a powerful, multi-level concept for PROFIBUS system diagnostics. This permits simplification of plant installation, commissioning and operation as well as a contribution to an increase in production over the entire lifetime of the plant.

The multi-level diagnostics concept provides various methods and tools for each phase of plant operation:

**Installation**
- Avoidance of faults using FastConnect

**Commissioning**
- Checking of physical bus design using the BT 200 bus tester including acceptance reports

**Startup, operation**
- System diagnostics with STEP® 7
- Visualization using "Signal system faults" or diagnostics package
- Online line diagnostics with diagnostics repeater

Diagnostics of the PROFIBUS is thus possible in every plant phase.

Avoidance of faults using FastConnect

The correct physical design of the bus system is a basic prerequisite for trouble-free operation of the plant. Plugs which are assembled poorly are frequently the reason for plant stoppages, and it is therefore essential to work particularly carefully during installation.

The FastConnect system for PROFIBUS supports and significantly accelerates this work. Tools, bus cables and plugs which are simple to handle permit fault-free assembly within minutes:

- FastConnect Stripping Tool (6GK1 905-6AA...)
- FastConnect standard bus cable (6XV1 830-0E...)
- FastConnect bus plug with insulation displacement system (6ES7 972-0B 50-...., 6GK1 500-0FC...)

Assembly of FastConnect bus cables
BT 200 bus tester
Installation assistance for PROFIBUS

The physical bus design of the PROFIBUS network is checked at the end of the installation phase. Physical faults of the fieldbus can thus be largely excluded during subsequent commissioning.

BT 200 bus tester
The BT 200 bus tester is used to check electrical PROFIBUS networks. It is an invaluable assistance when installing distributed automation solutions with PROFIBUS. It can check the correct functioning of bus segments in offline mode, i.e. without a connected master.

Features
- Easy to operate even without special PROFIBUS knowledge
- Finds installation errors within seconds
- Makes error search easier
- Reduces commissioning and service times
- Increases plant availability
- Produces acceptance reports

Functions
Bus line diagnostics (offline)
Checking for:
- Wire break

Logging kit for acceptance and documentation

BT 200 bus tester

Technical specifications BT 200

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface to PROFIBUS</td>
<td>9 pin sub D socket</td>
</tr>
<tr>
<td>Transfer speed</td>
<td>9.6 kbit/s to 12 Mbit/s</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>using built-in NiCd rechargeable battery; charger available as accessory</td>
</tr>
<tr>
<td>Languages</td>
<td>German, English, French, Spanish, Italian (can be set)</td>
</tr>
<tr>
<td>Permissible environmental conditions</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>+5 °C to +45 °C</td>
</tr>
<tr>
<td>Storage and transport temperature</td>
<td>-20 °C to +60 °C</td>
</tr>
<tr>
<td>Relative humidity, max.</td>
<td>95% to +24 °C</td>
</tr>
<tr>
<td>Construction design</td>
<td></td>
</tr>
<tr>
<td>Dimensions (W x H x D) in mm</td>
<td>210 x 100 x 55</td>
</tr>
<tr>
<td>Weight, approx.</td>
<td>350 g</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>IP 20</td>
</tr>
<tr>
<td>Order No. group</td>
<td></td>
</tr>
<tr>
<td>• BT 200 bus tester: 6ES7 181-0...</td>
<td></td>
</tr>
<tr>
<td>• Protocol kit: 6ES7 193-8...</td>
<td></td>
</tr>
</tbody>
</table>

Determination of the used cables is additionally possible, e.g. for documentation purposes.

Testing the PROFIBUS interfaces of master/slaves
Checking of:
- RS 485 driver
- Internal 5-V supply
- RTS signal

Checking for established slaves
All slaves which have been established on a PROFIBUS link are listed in a life list. Individual slaves can also be specifically addressed to check their communications capability.

Logging functions
Using the additional logging kit, all test results can be transmitted to a PC where they can be viewed and saved as a clear test report. This permits e.g. fast, simple generation of acceptance reports or documentation.
Bus cables are also subject to external influences during plant operation which could lead to damage. It is particularly recommendable to permanently check the cables if additional stress factors exist, e.g. with trailing cables or strong vibrations, in order to reduce failures to a minimum.

**Diagnostics repeater**

**Online diagnostics of bus cable**

The diagnostics repeater is available for line diagnostics during plant operation. It is integrated as an RS 485 repeater into the PROFIBUS network and additionally contains powerful functions for line diagnostics.

The diagnostic repeater recognizes the following cable errors:

- A or B cablebreak
- Short-circuit of the signal cables to screen
- Missing or superfluous bus terminators

The diagnostic repeater is configured as a norm slave in STEP 7, COM PROFIBUS or with GSD data.

**Design**

- Three segments can be connected, two of which can be diagnosed
- Up to 62 stations (31 per segment which can be diagnosed)
- Cascading of up to 9 diagnostics repeaters

**Technical specifications diagnostics repeater**

<table>
<thead>
<tr>
<th><strong>Transmission rate</strong></th>
<th>9.6 kbit/s to 12 Mbit/s</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bus protocol</strong></td>
<td>PROFIBUS DP, also with ProfiSafe and isochronism</td>
</tr>
<tr>
<td><strong>Stations per segment</strong></td>
<td>max. 31, max. 62 per diagnostic repeater</td>
</tr>
<tr>
<td><strong>Interfaces</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Bus segment connection</strong></td>
<td>FastConnect insulation displacement method</td>
</tr>
<tr>
<td><strong>Power supply connection</strong></td>
<td>Terminal block</td>
</tr>
<tr>
<td><strong>Power supply</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Rated voltage</strong></td>
<td>24 V DC (20.4 to 28.8 V)</td>
</tr>
<tr>
<td><strong>Permissible ambient conditions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Operating temperature</strong></td>
<td>0 to +60 °C</td>
</tr>
<tr>
<td><strong>Transport/storage temperature</strong></td>
<td>-40 to +70 °C</td>
</tr>
<tr>
<td><strong>Relative humidity, max.</strong></td>
<td>95% at +25 °C</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Dimensions (W x H x D) in mm</strong></td>
<td>80 x 125 x 67.5</td>
</tr>
<tr>
<td><strong>Approx. weight</strong></td>
<td>300 g</td>
</tr>
<tr>
<td><strong>Degree of protection</strong></td>
<td>IP 20</td>
</tr>
<tr>
<td><strong>Order No. group</strong></td>
<td>6ES7 972-0AB01-0...</td>
</tr>
</tbody>
</table>
Diagnostics repeater

Mode of operation

Repeater functionality
The diagnostic repeater is integrated as a normal RS 485 repeater in the bus system. However, it contains its own PROFIBUS address. It has repeater functionality:

- Number of stations can be expanded (max. 127) and extended into the bus system
- Regeneration of signals in amplitude and time (“re-timing”)
- Galvanic isolation of segments which are connected

Diagnostics functionality
The diagnostics functionality repeater, initiated by STEP 7 or COM PROFIBUS, determines the topology of the bus system. Using S7-400 CPUs from FW level V3.1, determining of the topology can also be initiated from the user program. The topology can be displayed in STEP 7, V5.2 and higher. The quality of the bus system can also be visualized in statistical form in STEP 7.

When an error occurs, the repeater, as a PROFIBUS slave, transfers a norm diagnostics message automatically to the master. The message contains information regarding:

- The bus segment affected
- The error location (for example, between stations X and Y), i.e. the distance of the error location from the stations in meters
- The possible cause of error, e.g. short-circuit of signal cable A to the screen

Hence, sporadic cable errors are recognized and reported as diagnostics.

The error messages are completely incorporated into the system diagnostics of STEP 7 and COM PROFIBUS. They are graphically displayed in the individual diagnostics of the diagnostics repeater.

Error location, type of error and corresponding corrective measures are displayed in addition to status info about each segment.
Function "Hardware diagnostics"

In addition to the cable diagnostics with BT 200 and the diagnostic repeater, the master and slave modules connected can also be diagnosed during commissioning and operation. Powerful STEP 7 functions are available for this purpose.

**Overview diagnostics in HW-Config**

The topology of the automation system is graphically displayed in a window in the STEP 7 tool HW-Config (overview diagnostics). The diagnostics symbols clearly point to existing diagnostics information of the monitored devices (e.g. PROFIBUS slave faulty/failed).

If more detailed information is required, a detailed window can be called directly from the overview, and contains detailed fault information in alphanumerical text on the individual modules (module status).

With DP stations, the depth of information of the DP slave diagnostics extends down to channel-specific indication of a fault on a distributed I/O device, with specification of the module slot, channel number and cause of the fault in alphanumerical text.

The degree of detail of the error message also depends on the used hardware. A comprehensive range is available for the ET 200® distributed I/O stations, ranging from low-cost components up to high-feature modules with comprehensive diagnostics information.

The modules themselves also contain LEDs which provide information on the module status, even specific to the channel if required.

**Diagnostics buffer of the CPUs**

The module status of the CPUs in HW-Config also indicates the contents of the CPU diagnostics buffer. All system and application-defined events are entered here with a time stamp. This provides an additional global overview of the complete control system (see figure at the left).
Function "Signal system faults"

During plant operation, monitoring is carried out by the operating personnel using HMI® systems. Any faults which occur are immediately displayed to permit elimination as rapidly as possible.

It is particularly advantageous if system faults are signalled in addition to process messages.

Simple message configuring

The STEP 7 function "Signal system faults" (STEP 7 V5.1 and later, WinCC V5.1) means that message configuring is possible without extensive programming requirements:

The contents and design of a fault message can be set as required using a parameter input form. The fault texts are extracted from HW-Config or the GSD file.

STEP 7 then automatically generates all required blocks (fault OBs, diagnostics FB, invocation OBs) and when they are called in the S7 application program. It is only necessary for the user to load the generated blocks with the S7 project into the CPU.

The effort required for visualization is equally small. Fault texts and all relevant diagnostics data are automatically imported during generation of the HMI data as a result of the common database of STEP 7 and ProTool®, the central HMI configuring software. It is only necessary to load the ProTool project onto the HMI platform following data generation.

The following are appropriate for operation and monitoring:

- OP/TP170B, MP270®, MP370®, MP370-Touch, OP/TP 270 as well as PCs with SIMATIC ProTool/Pro® Runtime

Automatic message display

If a system fault occurs which is signalled e.g. by a PROFIBUS slave, the CPU processes the fault blocks, and sends the corresponding message via PROFIBUS or MPI to the HMI system.

With HMI diagnostic information is displayed as plaintext with time stamp and can be acknowledged by the user (see figure at the left).
Visualization of system diagnostics

A "Diagnostics package" is offered for plants which have been programmed using older STEP 7 versions (< V5.1, SP2), or for existing plants which are to be expanded by visualization of PROFIBUS diagnostics.

This package comprises a project with function block FB 125 and data block DB 125 together with prepared diagnostics displays for SIMATIC HMI units.

The FB and DB are integrated into the PLC program, the diagnostics displays with variables, symbol lists and graphics into the visualization project (ProTool/Pro or WinCC). The displays can be matched to the plant configuration.

During operation, the display variables in the HMI systems access the data block in the controller, and display the corresponding information.

Faulty/failed slaves are identified in color in the "Overview diagnostics" generated in this manner. It is possible to revert from the overview diagnostics to the detail diagnostics.

The detail view shows type of device, slave address, slot number and type as well as error text and cause of error. Cable-noise interference, which is recognized by the diagnostic repeater, is also displayed in the diagnostic package.

The diagnostics package can be used with:

- SIMATIC S7-300/-400 with CPU 31x-2 DP, CPU 31xC-2 DP, CPU 41x-2 DP, CP 443-5 or IM 467 and SINUMERIK 840D/840 DI

For HMI tasks, the SIMATIC Panels (OP/TP/MP) and PCs with SIMATIC WinCC or ProTool/Pro Runtime can be used.

The diagnostics package is available for downloading free-of-charge at:

http://www4.ad.siemens.de/view/cs/en/5362473
http://www4.ad.siemens.de/view/cs/en/6095050