PROFIBUS and Integrated Safety architectures in Ex areas

Since 1989, PROFIBUS has developed into a worldwide leading fieldbus system used in machine and process plant automation. The main reason why PROFIBUS stands out from other fieldbus systems is because it offers such an extraordinary breadth of applications. Application specific requirements have been integrated into application profiles, and these applications have been combined as a whole to create a standardized and open communication system. The use of open standards instead of proprietary solutions ensures long-term compatibility and expandability, which forms the basis for implementing comprehensive investment protection for users and manufacturers.

SIEMENS plays an active role in the PROFIBUS and PROFINET International organization, providing products and solutions according to the standards that can be easily integrated with other vendors. The constant development of new products and features now provide enhanced solutions for the Process Industry, especially in regards to Hazardous area installations and Integrated Safety systems.

The Basics of PROFIBUS

PROFIBUS is part of the IEC 61158 standard and describes the method of functioning of the Fieldbus.

This technology is used to link controllers to sensors and actuators on the field level using digital communication, and allowing simultaneous constant data exchange for control purpose as well as on-demand data transmission for parameterization and commissioning for example. Figure 1 shows an example of a basic PROFIBUS Network with master controller and slave devices using RS485 communication.

PROFIBUS provides two main technologies, PROFIBUS DP and PROFIBUS PA. The communication technology (protocol) is the same, only the transmission technology differs to answer the various needs of the automation market. PROFIBUS DP mainly uses RS485 or Fiber optic, where PROFIBUS PA is based on MBP technology. Figure 2 shows the various layers and market name related to them.
The easy-to-use and cost-effective RS485 transmission technology is preferred for use with tasks which require a high transmission speed (Up to 12Mbps), but which do not require explosion protection (intrinsic safety). A variant, (RS485 IS) is available for intrinsically safe areas and is described in the next section. It is widely used in the production industry and is also found in parts of the process industry. A twisted, shielded copper cable with a pair of wires is used. The bus structure enables nonreactive coupling and decoupling of stations and incremental commissioning of the system. Subsequent system expansions do not affect stations already in operation within certain specified limits.

MBP (Manchester Coded, Bus Powered) transmission technology implements the simultaneous supply of power to the connected field devices and communication of the data over a single cable, i.e. directly via the bus medium. It also provides wiring topology flexibility; longer segment length (up to 1900m) with a fix baudrates of 31.25 Kbps. This enables wiring overhead to be significantly reduced, meets requirements for much simpler and safer installation and boasts all the benefits of digital transmission down to the field device. MBP was specifically developed to meet the demands of process automation and is standardized in IEC 61158-2.

PROFIBUS in Hazardous area

In compliance with hazardous area requirements, such as low power and intrinsic safety, the use of the RS485 interface with its high transmission rates is also possible in and Ex zone. This intrinsically safe bus is obtained by using an RS485 IS Coupler. The SIEMENS Fieldbus isolating transformer provides this functionality, requires no programming, and has a repeater to amplify the signal data on the bus line. RS485 IS devices, such as the ET200isp can be connected to the intrinsically safe bus and directly integrated in Ex ib Zone 1. Figure 3 shows the various topologies possible with RS485 IS network.
In the MBP-IS version, this transmission technology is especially suitable for use in hazardous areas in Process Automation, and is therefore widely used in applications of the chemical, oil and gas industries. Explosion protection is implemented via limiting power in the incoming bus supply or more frequently in the installation components in the field. Working on field devices during active operation is made possible, for example, by means of intrinsically safe ignition protection.

Linear and tree structures and combinations of both are thus possible. In practice, the “trunk & spur topology” (see Figure 4) has established itself as the de-facto standard, as it is especially clear and well-laid-out.
PROFIBUS PA also offers ring topology to provide redundancy mechanism on the MBP bus. The combination of redundant couplers and field devices with active field distributors implements ring redundancy and creates expanded media redundancy. Subsegments which have become effective due to a short circuit or wire break are automatically and seamlessly operated further via a coupler each in a line structure (Figure 5).

Figure 5 summarizes the different transmission technologies and limitations of devices per segments. For RS485, an extra care should be taken in regards to cable length as the Baudrate defines the maximum allowed. Please refer to the PROFIBUS standard for more information.

<table>
<thead>
<tr>
<th></th>
<th>RS485</th>
<th>RS485-IS</th>
<th>MBP</th>
<th>MBP-IS</th>
<th>Fiber Optic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data transmission</strong></td>
<td>Digital; differential signals acc. to RS485; NRZ (no return to zero)</td>
<td>Digital; differential signals acc. to RS485; NRZ</td>
<td>Digital; bit-synchronous, Manchester coding</td>
<td>Digital; bit-synchronous, Manchester coding</td>
<td>Optical, digital, NRZ</td>
</tr>
<tr>
<td><strong>Transmission rate</strong></td>
<td>9.6 to 12000 Kbit/s</td>
<td>9.6 to 15000 Kbit/s</td>
<td>31.25 Kbit/s</td>
<td>31.25 Kbit/s</td>
<td>9.6 to 12000 Kbit/s</td>
</tr>
<tr>
<td><strong>Data security</strong></td>
<td>HD=4; parity bit; start/stop delimiter</td>
<td>HD=4; parity bit; start/stop delimiter</td>
<td>Preamble; fail-safe start/stop delimiter</td>
<td>Preamble; fail-safe start/stop delimiter</td>
<td>HD=4; parity bit; start/stop delimiter</td>
</tr>
<tr>
<td><strong>Cable</strong></td>
<td>Twisted, shielded two-wire cable, cable type A</td>
<td>Twisted, shielded four-wire cable, cable type A</td>
<td>Twisted, shielded two-wire cable, cable type A</td>
<td>Twisted, shielded two-wire cable, cable type A</td>
<td>Multi- and single mode glass fiber; PCF, plastic fiber</td>
</tr>
<tr>
<td><strong>Remote power supply</strong></td>
<td>Possible using additional cores</td>
<td>Possible using additional cores</td>
<td>Optional using signal cores</td>
<td>Optional using signal cores</td>
<td>Possible using hybrid cable</td>
</tr>
<tr>
<td><strong>Ignition protection types</strong></td>
<td>None</td>
<td>Intrinsic safety Ex ib</td>
<td>None</td>
<td>Intrinsic safety Ex ia ib</td>
<td>None</td>
</tr>
<tr>
<td><strong>Topology</strong></td>
<td>Line topology with termination</td>
<td>Line topology with termination</td>
<td>Line topology with termination</td>
<td>Line and tree topology with termination; also combined</td>
<td>Star and ring topology; typical, line topology possible</td>
</tr>
<tr>
<td><strong>Number of nodes</strong></td>
<td>Up to 32 nodes per segment. Max total 126 per network</td>
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<td>Up to 32 nodes per segment. Max total 126 per network</td>
<td>Up to 126 nodes per network</td>
</tr>
<tr>
<td><strong>Number of repeaters</strong></td>
<td>Max. 9 with signal refreshing</td>
<td>Max. 9 with signal refreshing</td>
<td>Max. 4 with signal refreshing</td>
<td>Max. 4 with signal refreshing</td>
<td>Unlimited with signal refreshing; note signal propagation delay</td>
</tr>
</tbody>
</table>

Figure 3
**Integrated Safety in Ex Areas**

The risk of human injury, damage to production systems and environmental harm is inherent in many industrial processes. This realization resulted in "safety-related automation technology" becoming of great importance, as its safety requirements are far above and beyond those of standard automation technology. This demand must also be satisfied by the fieldbus technology, and the PROFIsafe communication profile serves this purpose for PROFiBUS.

To be able to extend PROFiBUS PA into Ex zone 1 hazardous area, physical adaptation (employing RS 485-IS coupler isolating transformer and RS 485-IS transmission technology) is vital. Use of components certified to Fieldbus Intrincically safe concept (FISCO) model by an authorized approving authority (eg PTB, UL) is recommended.

PROFIsafe is a profile that implements safety-related data transmission between

- the safety-associated devices placed in the field and
- safety applications executed in the automation system

PROFIsafe was the first communication standard in compliance with IEC 61508, which permits standard and safety-related communications on one-and-the-same bus. With SIL 3 (Safety Integrity Level), it fulfills the highest requirements in the process industries.

PROFIsafe utilizes the standard services of the lower-level bus system to implement safe communication. Standard and safety related data are transmitted over the same bus. Collusion-free communication is possible using a bus system with media-independent network components.
Additional software layer within the device and automation system is employed without modifying the standard PROFIBUS communication mechanisms. This allows the use of standard communication modules, connectors or cables for PROFIsafe communication.

When transmitting messages, PROFIsafe comes up with four measures against any possible faults or errors, such as corrupted addresses, loss, or delay:

- PROFIsafe is consecutively numbered
- The time is monitored (watchdog)
- Authenticity is monitored using "passwords"
- An optimized CRC (Cyclic Redundancy Check) detects corrupted data bits in a message frame

PROFIsafe uses existing standard communication components such as cables, ASICs and standard software packages.

Benefits with the PROFIsafe profile are:

- Increased flexibility
  Safety and standard automation can be separated into two different PROFIBUS cables

- Flexible Modular Redundancy
  Ultimate flexibility to choose the redundancy levels to fit the Safety Instrumented Function

- Reduced inventory thanks to savings on components
  Just one PROFIBUS cable for standard and safety-related communication is possible

- Faster system setup and commissioning
  Use of existing PROFIBUS cable for fail-safe communication too