Recent developments in PROFIBUS and PROFINET technology and applications

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PROFIBUS • PROFINET

Outline of presentation

- Requirements in the automation industry
  - General requirements and problems
  - Specific application requirements
- PROFINET
  - Characteristics and adoption
- Recent developments for hazardous environments
  - DART
  - High power bus techniques
- Safety and high availability systems
- Test tools, diagnostics and rapid fault finding
- Device standardisation through profiles
- Education and training

Control system architecture

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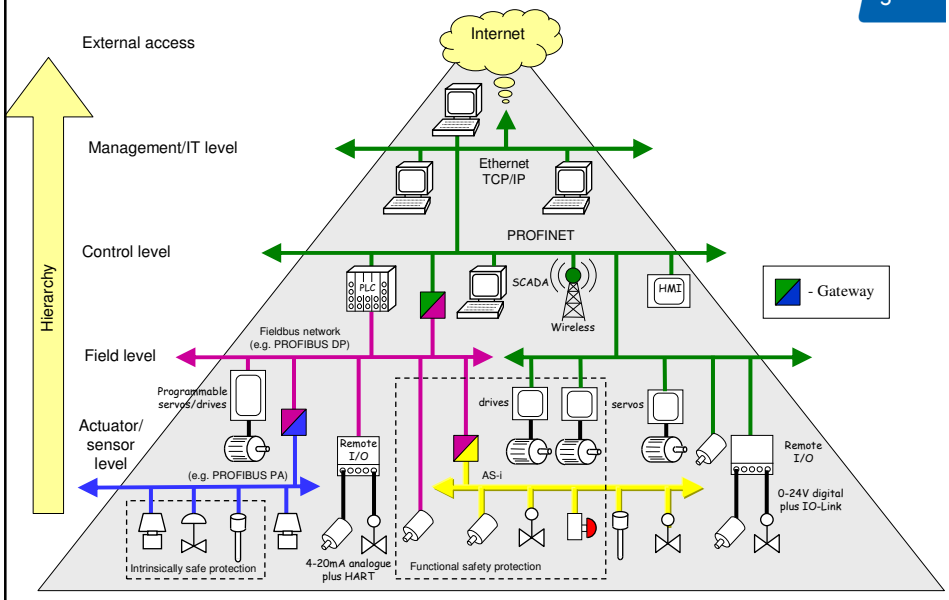

General Requirements and Problems

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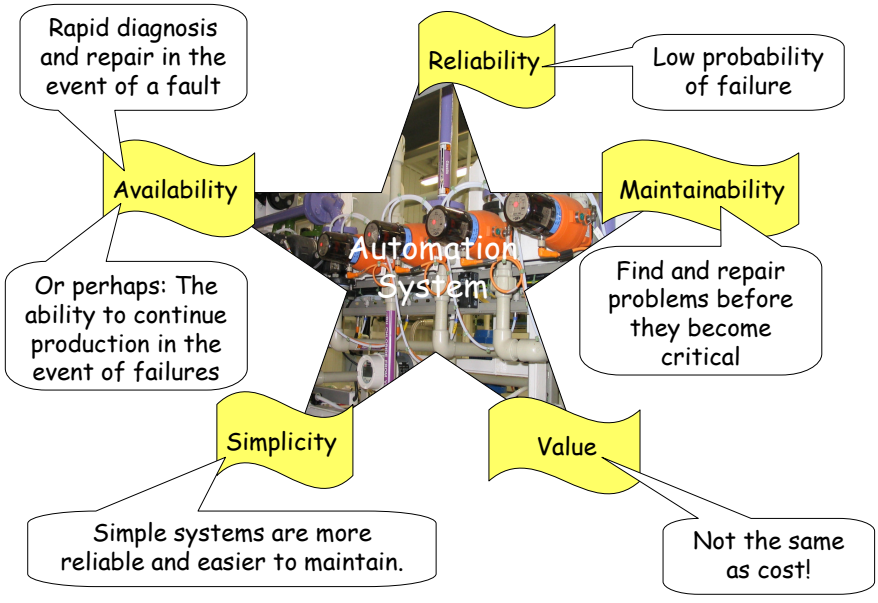


Application specific Requirements

- Operation in explosive environments
  - Gas and oil, waste treatment, mining, chemical industries.
- Functional safety requirements
  - High integrity fail-safety for use in factory automation and process control.
- High speed requirements
  - Positional control systems, servos, robotics
  - Fast, deterministic control loop cycle times
- High availability requirements
  - Not the same as safety. Achieved thorough high reliability devices and redundancy.
- Large system capability
  - Extensive system operation and management.

PROFINET

- PROFINET is an open Industrial Ethernet standard developed by the PROFIBUS Organisation.
  - Uses completely standard Ethernet.
  - Operates at 100Mbit/s over twisted-pair copper or fibre-optic cables,
  - Exclusively uses switches and full duplex operation to completely eliminate collisions,
  - Makes use of TCP/IP and other IT standards.
  - But, is "real-time" and deterministic,
- PROFINET is well thought out to incorporate all the requirements of automation and control systems.
- PROFINET is now mature and stable. It is growing in popularity – but not as fast as originally predicted.

PROFINET

- Many features that have been developed for PROFIBUS devices have been directly incorporated into PROFINET:
  - Standardised module and channel-related diagnostics,
  - Alarm and status information,
  - Identification and Maintenance (I&M) functions,
  - Time stamping,
  - Highly deterministic process cycle timing,
  - Device description file (GSD) with configuration data for the device and available modules – PROFINET uses XML.
- PROFINET is 100% compatible with PROFIBUS, and other fieldbusses (Foundation Fieldbus, Interbus-S, AS-i and others).

PROFINET

- New developments that are specific to PROFINET include:
  - "iPar" parameter server
    - Provides standardised parameter access over PROFINET
    - Save and restore of all device parameters.
    - Direct device replacement with automatic parameter download now possible. No tools required.
  - PROFINET for PA
    - Development progressing.
  - ProfiEnergy
    - This important profile is now appearing in PROFINET devices.
  - ProfiDrive
    - PROFINET drives now widely available.

PROFINET compared to PROFIBUS

- PROFIBUS:
  - Uses multi-drop segments with many devices on one cable.
  - Termination is in the hands of the user.
  - Spur lines are often used.
  - Incorrect termination and spurs are a major cause of problems.
- PROFINET
  - Multi-drop connection is not used; all cables connect just two devices together. "Switches" are used for branching to devices.
  - No more spur lines.
  - Termination is provided within every Ethernet device; no longer in the hands of the user.
  - No more red switches to play with!

PROFINET compared to PROFIBUS

- Will this be the end of wiring problems?
  - I doubt it. I predict that all the earthing/screening and moisture ingress problems will remain - and may even get worse.
- PROFINET runs at 100Mbit/s, PROFIBUS runs at 12Mbit/s. So is PROFINET faster than PROFIBUS?
  - No they are about the same.
    - Why?
  - Because the PROFINET telegrams are much bigger.
- PROFINET is significantly more complex than PROFIBUS because Many more different protocols are involved.
- Security is an issue with PROFINET because Ethernet systems are potentially open to hacking.
- So the case for PROFINET is not that clear-cut!

PROFINET

- The good news is that the PROFINET specification is very firm.
  - The GSD (XML) specification has been fixed for several years now.
  - The high speed Isochronous Real Time specification is stable.
- Users are adopting PROFINET in manufacturing and general automation.
  - 2.1 million nodes installed at the end of 2009
  - Predicted to grow to 3 million this year.
  - For every PROFINET device sold last year 6 PROFIBUS devices were sold.

Operation in Explosive Environments

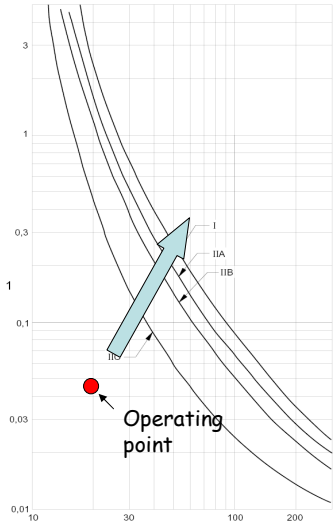
- Intrinsic safety, Ex i
  - Fieldbus Intrinsically Safe Concept (FISCO)
  - Very simple implementation on Manchester Bus Powered segments using certified devices
  - Certification of the installation is not required
  - Suitable for all zones
- Non-incendive, Ex n
  - Fieldbus Non-Incendive Concept (FINCO)
  - Designed to provide more power
  - Approximately twice the number of devices
  - Only for zone 2, not zone 0 or 1
- Increased safety, Ex e
  - Based on good design
  - Only for zones 1 & 2, not zone 0

DART

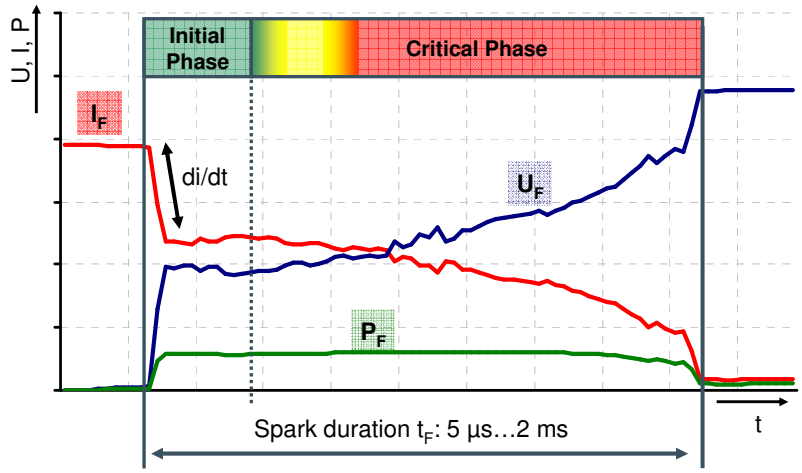
- Dynamic Arc Recognition and Termination.
  - A new approach to hazardous area safety theoretically giving full power into a hazardous area.
  - Uses a new technology to sense a spark or arc.
  - Kills the power supply within 10 µs before an explosive situation arises.
  - This is not a new idea but the technology has now caught up with the concept.
  - Can be used in Zones 1 & 2 only.

DART

- The Intrinsic safety (Ex e) approach limits the power to below the ignition curve for the gas or dust.
- DART does not limit power, instead it dynamically detects any rapid change in current caused by cable break or short and quickly kills the power supply.
- Disconnection and switching is very fast so the spark has no time to become incendive!

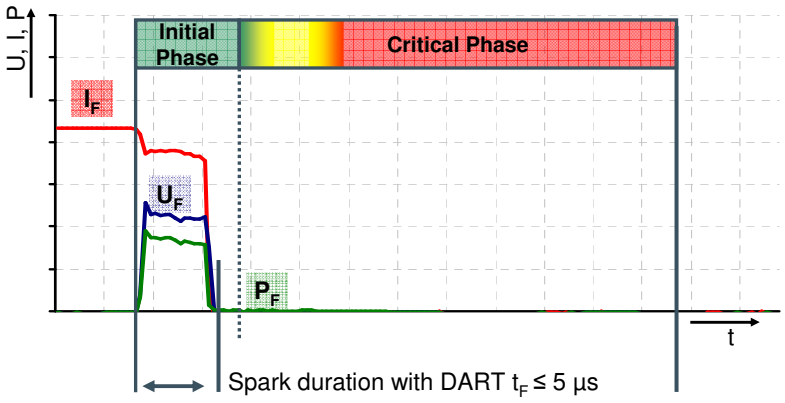


DART



Without protection the spark duration may be long enough to cause ignition

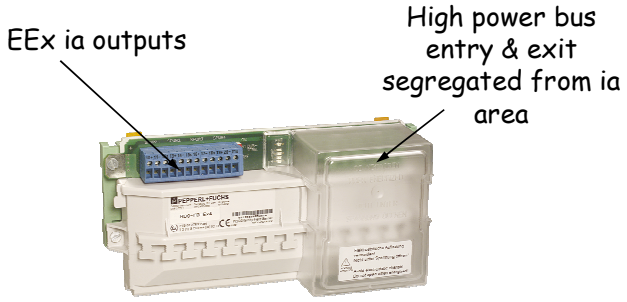
DART



With DART the spark energy is cut to zero before ignition occurs.

Operation in Explosive Environments

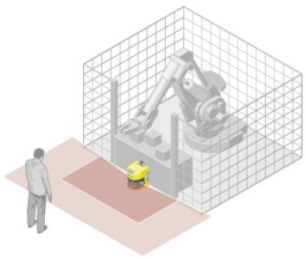
- High power bus concept
  - Uses increased safety (Ex e), Nin-incendive (Ex n) or DART technology to provide high power into a zone 1 or 2 area
  - Then Ex i barriers are used to connect to devices in zone 0 areas



Field barrier mounted in hazardous area (zone 1 or 2)

Functional Safety Systems

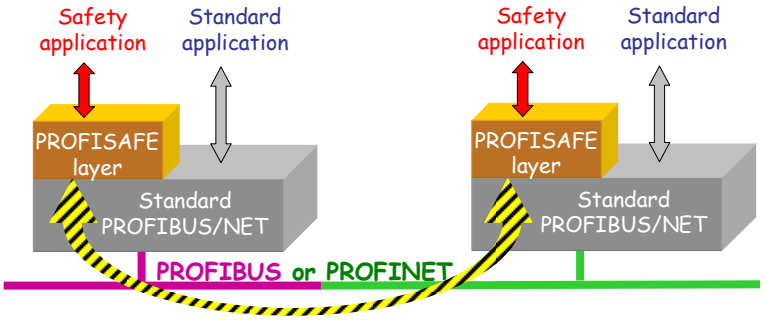
- Functional safety protection systems are an important part of control and automation.
- These systems are concerned with the protection of people and livelihood, i.e. accident avoidance.



- Traditionally, functional safety systems were implemented as hard-wired systems, completely separate from the control system. The reason for this was the relatively poor reliability of control systems and avoidance of common cause failures.

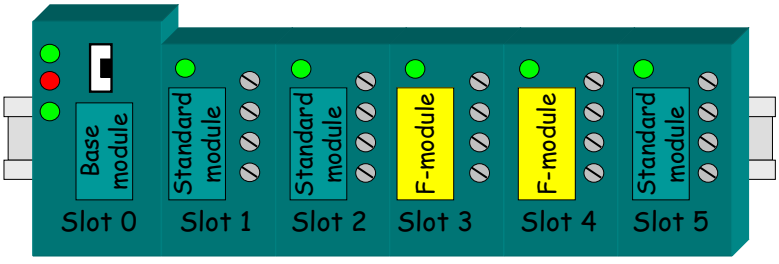
PROFISAFE

- Modern standards allow us to implement functional safety over fieldbus.
- The safety integrity of such systems is often better than the old hard-wired systems.
- PROFISAFE is a safety-related profile that applies to PROFIBUS and PROFINET



PROFISAFE

- The PROFISAFE error detection mechanisms are totally independent from the underlying protocol.
- The safety data is placed in a standard PROFIBUS or PROFINET telegram frame together with standard, non-safety-related process data.
- This means that safety and non-safety can be mixed in one device



PROFISAFE

- PROFISAFE
  - Caters for requirements up to Safety Integrity Level three (SIL3).
  - Operates transparently over PROFIBUS or PROFINET.
  - Can be combined with AS-i safety devices.
  - Allows free mixing of non-safety and safety-related equipment and data.
- But
  - PROFISAFE systems must be properly designed, implemented and tested.
  - Reliable bus operation is essential – we must ensure that the installation is good and check the quality of communications.

High Availability systems

- PROFIBUS and PROFINET are very reliable technologies that have inbuilt mechanisms to make them robust against failure.
- Further, the extensive standardised diagnostics provide rapid diagnosis of problems.
- However devices, cabling, power supplies, sensors and actuators can fail.
- Redundant systems can help keep production running in the event of failures.
- Redundant designs provide two or more devices to carry out the same function. Should device one fail or be out of service, then the other(s) can continue to provide the function whilst the failed device is out of service.

High Availability systems

- The proper design of redundant systems is not simple.
- PROFIBUS and PROFINET support standardised redundancy systems for:
  - Controllers
  - Media (i.e. copper and fibre-optic cables)
  - IO devices, sensors and actuators
- Multiple masters with automatic duty-standby switching are available from a number of suppliers.
- These can drive different networks to provide redundancy down to the field level. However, separate power supply is advisable to minimise common-cause failures.
- Redundant media when used should always be routed separately to avoid common-cause failures.
- Redundant IO devices can be used in the field driving the final actuator or sensors.

High Availability systems

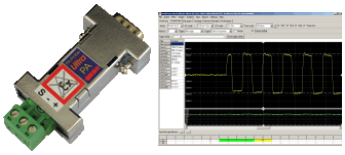
- It is important to understand that the redundancy only applies to duplicated equipment. Common mode failures, like power supply failure, interference pickup etc can disrupt both or all channels or communication.
- Further, redundancy can never provide 100% operation, because the system is no longer redundant after a failure has occurred.
- Also we must understand that redundancy and safety are totally separate.
  - A redundant system can improve availability, but has no influence on functional safety.
  - A functional safety system without redundancy will give worse availability than a standard control system.
- Rapid diagnosis and repair are essential.

Test and health checking tools

- Network analysers have improved in capability over the past ten years by including waveform visualisation and PA capability.

Procentec ProfiTrace

Softing Analyser



Procentec PA Probe

P+F diagnostic module

Test and health checking tools

- These tools continue to increase in functionality.
- For example the ProfiTrace analyser from Procentec boasts the following features:
  - High-speed analyser for both DP and PA.
  - PA probe for PA connection.
  - Decoding of all telegrams.
  - Built-in high-speed oscilloscope DP and PA.
  - Rapid overview of network health
  - live list and bar chart
  - Health-checking and performance statistics.
  - Report generation for documentation.
  - OPC server for connection to SCADA systems.

Profiles

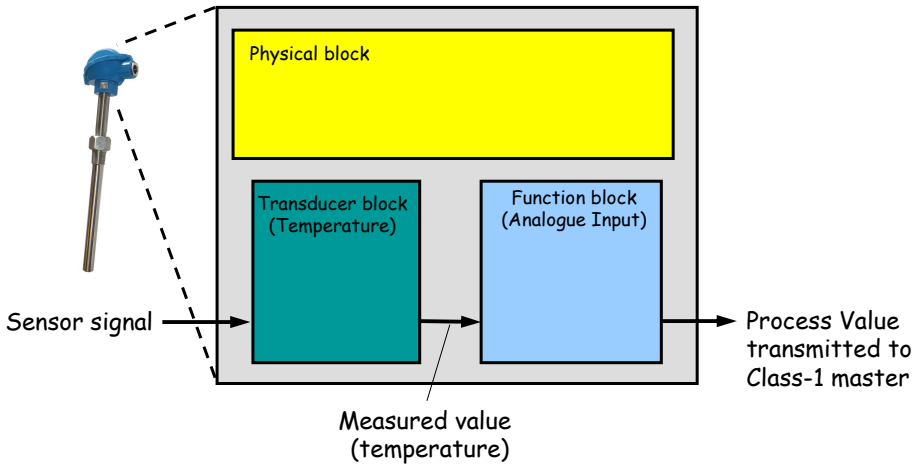
- The PROFIBUS and PROFINET standards specify what is required to ensure communication between devices, however it does not specify what the data represents, nor how it is organised!
- A profile is a clear description of a particular type of device in terms of its I/O data, operation and functions.
- Profiles have been developed by PI for a wide range of devices:
  - Drives, encoders, servos, NC machines
  - Process instrumentation, controllers and actuators.
  - Etc.
- A profile is manufacturer independent, so it provides a generic device with which to communicate.

The PA Profile

- The current PA Profile (V3.02) defines standard models for a wide range of process instruments and actuators. E.g.:
  - Temperature, Pressure, Level, Flow … transmitters
  - Process switches for all types of variable
  - Valve actuators and positioners
  - On-off valves
  - Etc.
- The PA profile provides standardised instruments, sensors and actuators, which are identical across manufacturers.
- Using the profile model of a PA device has distinct advantages over manufacturer-specific models.

The PA Profile

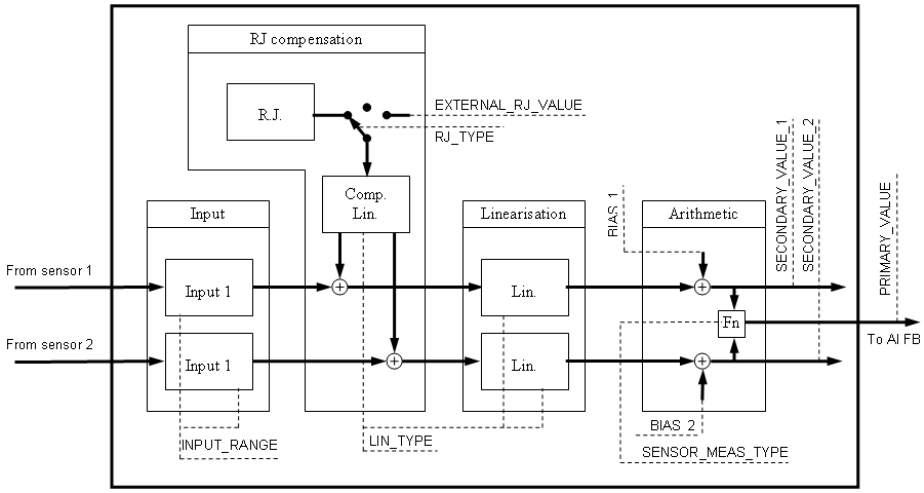
- As an example, consider a simple temperature transmitter:



The PA Profile

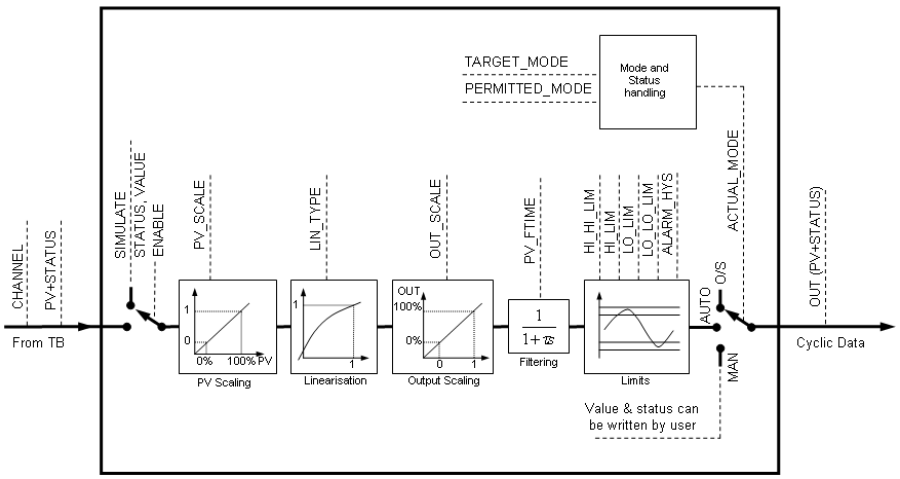
- The Physical Block
  - contains information on the device that is independent of the measurement or actuation. This ensures that the function and transducer blocks are independent of the device hardware.
- The Transducer block
  - Transducer blocks separate the sensor or actuator and the function block, process the signal and provide a device independent interface.
  - Transducer blocks reflect the measurement or actuation that is taking place.
- The Function block
  - Provides common signal manipulation functions that are independent of the transducer.

- The standard Temperature Transducer block



- The standard Temperature Transducer Block provides two channels of temperature measurement (the second is optional).
- The standard block can deal with all common types of transducer and has appropriate compensation and linearization provided.
- The block can process the two channels and provide:
  - two independent channels
  - The average of the two channels
  - The difference between the two channels
  - Average value except if one channel fails it provides just the other channel.

- The Analogue Input Function Block



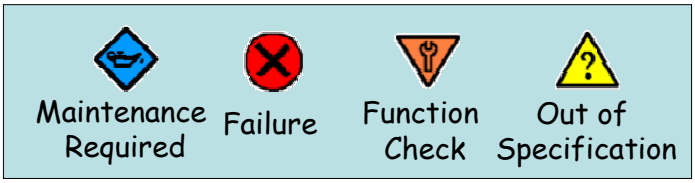
- The standard Analogue Input Function Block provides a number of optional functions including:
  - Simulation;
  - Linearization and scaling;
  - Signal filtering;
  - Process alarms (process value out of range);
  - Auto, Manual, Out of Service and failsafe modes of operation.

The Status Byte

- The process value in a PA transmitters and actuators is always transmitted as a scaled floating-point value (32-bit) together with a standard status byte (8-bit)
- The status byte provides information about the "quality" of the process value.
- These status bytes can be interpreted by PLC or SCADA software to provide a rapid and standardised health check on the process value.
- In addition the status can be used by the PLC logic to take appropriate safe action should the process value not be good.
- The same coding of status is provided for all instruments, actuators and discrete devices.

Condensed Status

- The latest version of the PA profile document provides a condensed status which is mandatory for all modern devices
- The condensed status provides a simple traffic light check on the state of the device:



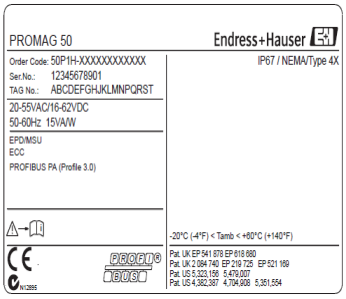
- The idea is to provide a simple standardised graphic on the Operator's screen showing the state of each measurement.

Automatic ID Number Adaption

- The Identification (ID) number of a device provides a quick and standardised check on the device type which is used during start-up.
- PA devices can use a manufacturer specific ID or a generic PA profile ID which is manufacturer specific.
- Users often adopt the manufacturer specific ID, often because this is the default value. However there are advantages in using the Profile ID:
  - The GSD file is manufacturer independent so different manufacturer's devices can be interchanged.
- V3.02 of the PA profile provides a mandatory mechanism for all modern PA devices in which the device will automatically adapt to the profile ID number should the device be configured as such
- This now means that a device that is configured in this way can always be exchanged with another manufacturer's device without any software or tools being required.

Identification & Maintenance functions

- I&M functions were introduced two years ago as a standardised "faceplate" for devices.
- I&M functions are now mandatory for all new PROFIBUS and PROFINET devices allowing simple and standardised access to device data.



- I&M functions include:
  - Manufacturer name
  - Device part number;
  - Device serial number;
  - Hardware and software revision;
  - Profile information (type, version ID number etc;
  - Tag number, installation date and description.

Education & training

- Significant changes have occurred over the last few years in education and training.
  - Certified PROFIBUS Installer has now become a standard requirement for many industries.
    - Not just for Installers, but for anyone working on PROFIBUS systems.
    - Basic and necessary foundation for anyone working on PROFIBUS systems.
  - Certified PROFINET Installer will have a similar important role in the near future.
  - The Certified PROFIBUS and PROFINET Engineer is a flagship qualification for people dealing in depth with these technologies
  - A number of colleges and Universities are now providing fieldbus training to their students
    - Some of which provide Certified status as part of a degree course in automation and control.