

Pepperl+Fuchs GmbH – Koenigsberger Allee 87 – 68307 Mannheim - Germany

Please quote the following contact information when publishing:

Tel.: +49 621 776-2222, Fax: +49 621 776-27-2222, www.pepperl-fuchs.com, pa-info@de.pepperl-fuchs.com

Editorial contact: Christa Blas (Tel.: -1420, Fax: -1108), cblas@de.pepperl-fuchs.com

Safer by a distance!

Functional Safety and GAMP-aligned Automation with Remote I/O

Profibus Remote I/O systems have become established on new plants and plant extensions in the process industries, thanks to the higher data transfer rates and improved accuracy compared to conventional technology. Also considering the GAMP requirements of the pharmaceutical industry and the SIL concept, the system reduces the cost of plant automation.

The Profibus covers all the important issues to be found in the data transfer involved in a modern installation. Although Profinet offers communication at higher speed via Ethernet, Profibus DP/DPV1 and Profibus PA are already regarded as proven technology for process instrumentation in the chemical, petrochemical and pharmaceutical industries. These plants have undergone dramatic changes. Interfacing sensors and actuators in the field with the control system, previously accomplished via point-to-point connections, now requires new concepts when using Profibus. Explosion protection in these types of plants has always necessitated the use of safety barriers. Traditionally, these barriers are either galvanically isolated, like DIN rail-mounted devices, or require equipotential bonding when they are not galvanically isolated. Figure 1 shows how conventional assemblies are replaced by Remote I/O stations.

Distribution boxes and marshalling racks are concentrated in the Remote I/O stations in Zone 1. This also applies to the signal conditioning assemblies and the I/O cards of the control system itself. Therefore Remote I/Os are also often referred to as intelligent distribution boxes. With Profibus or Modbus, Remote I/Os significant savings can be achieved compared with conventional instrumentation while a traditional installation for one hundred loops needs 1,600 terminals on the way to the control system, a Remote I/O requires only 404 for the same task.

Through the combination of different explosion protection methods within the Remote I/O station a plug-in system has emerged, which simplifies engineering and at the same time is

as easy to handle as conventional, galvanically isolated Ex-i signal conditioners. In a running system input and output modules can be replaced without a hot-work permit (hot-swap) and without plant standstill.

Another important aspect is the extension of the system to include new measuring stations during actual operation. This procedure, known widely as HCiR or CiR (Hot Configuration In Run) is state of the art for Remote I/O and in the case of several manufacturers this can be undertaken irrespective of the support of this function by the control system. This is a significant advantage, since down times in plants are costly. Without this feature, it is quite likely that whole plant sections would have to be brought to a standstill, even if just one simple temperature measuring point or mass flow meter needs to be added.

Speed and expansion

Profibus transfers 240 bytes of information per cycle or 80 analogue values with adequate space for diagnostic data. Several manufacturers use an intrinsically safe Profibus for hazardous areas and limit the number of analogue channels to 40. Only one manufacturer uses the combination of different explosion protection types in order to fully exploit the 80 possible analogue circuits or 40 high energy valve circuits.

At 1.5 megabits per second, the Profibus can bridge 200 meters without a repeater. If 1,000 meters have to be bridged, then this is possible at 187.5 kb/s. If the full speed must be utilized, connections with optical links are an option. These are also immune to electromagnetic fields and require no repeater.

The non-intrinsically safe Profibus does not need additional assemblies and can support up to 125 stations with maximum interference immunity. This provides the planning engineer with the freedom to arbitrarily distribute large and small Remote I/O stations around the plant according to the requirements of the process. Stations close to the location of measurement and the field devices are fully in accord with the original Remote I/O concept.

The modular arrangement also offers the possibility of taking care of many other control and instrumentation tasks side-by-side with the I/O assemblies within a Remote I/O station. RIO brings all types of signals to the Profibus, not just the traditional intrinsically safe signals. It is only then that the Profibus makes full use of its capabilities and those of the Remote I/O. For this reason Remote I/O assemblies were developed – to process intrinsically safe and non-intrinsically safe signals on one and the same backplane. Increased safety and intrinsic safety bring signals of a most varied type to the Profibus, from 1-2 mW up to AC 230 V at 1 A. This way the conventional single loop wiring is completely replaced. Even safety-relevant circuits can be served by RIO in certain areas, as will be explained later.

Asset-Management functions – thanks to HART

Field devices have been equipped with HART communication capabilities for many years. It is only now that their full potential can be used. In the past HART field devices had to be parameterized with the aid of handheld devices, or via a HART multiplexer. However, the intelligent field devices contain much more information than the standard 20 mA signal normally reveals. Although the hand-operated devices have been used in the past principally for setting parameters and measuring ranges, HART via Profibus offers additional Asset-Management functions such as, for example, information on preventive maintenance. Modern Remote I/O for process control systems support HART communication via the Profibus.

There are two ways of combining the HART communication in the Profibus protocol: Either with the FDT concept (Field Device Tool) or with the EDDL tool (Electronic Device Description Language). Both methods are equally efficient and are therefore supported by most Remote I/O. Depending on the Profibus master, one or the other methods are preferred for HART communication. Since the asynchronous HART protocols are transferred when the cyclic data do not load the bus, this method is also referred to as Nested Communication or Boxed Communication. The type of nesting is determined by one of the known methods - FDT or EDDL.

A number of system houses have opted for FDT. The FDT specifications define the language, with which the various devices can communicate with each other on the bus. There is a master, which contains the FDT container. This is comparable with an operating system, in whose environment all other applications operate. Devices, which are to be usable in the system, must have a DTM (Device Type Manager) device description. HART field devices have an HART DTM. All DTMs are installed on the master console, in order to incorporate them in the FDT Container. In this way an open system arises, which provides the various manufacturers with the possibility of coexisting in the Microsoft environment through standardized description languages.

Several system manufacturers prefer the established Device Description Language (DDL), which works in a very similar fashion to the FDT concept. Here, DDs (device descriptions) secure the incorporation in the framework application of the master, so that this can use the special characteristics of the field devices. Thus the functionality of the HART field devices is accessible to the Profibus through FDT or EDDL.

Class 1 and Class 2 Masters

As described above, the HART communication on the Profibus uses the nested communication and asynchronous data traffic, which is only supported by Profibus DPV1. Several control systems offer the Profibus DPV1 master and can therefore utilize HART from the system environment via Profibus. These are able to fully exploit the special

characteristics of the field devices and the Remote I/O and undertake parameter changes and measuring range settings via the bus. Also service information on run time intervals can be called up. This provides, for example, information on maintenance work that will become due on valves, whose motions have been recorded in the intelligent field device itself.

Since a number of systems houses have opted for Profibus DP instead of Profibus DPV1, it became necessary to make the asynchronous data accessible using a class 2 master. As opposed to the primary master, the class 2 master provides a bypass to the DP master and is therefore completely independent of the class 1 master. Whilst the latter provides the normal control and instrumentation functions for the trouble-free operation of the plant, the class 2 master is concerned exclusively with the asynchronous communication. This takes place only as required.

In class 2 applications the Remote I/O functions as a HART modem and receives HART messages from a workstation or a class 2 master via the Profibus. The modulation of the 20 mA signal for the connected transmitter supply device and output isolator is derived from this. By contrast, the field devices send their response via the Profibus using the nested communication.

The Remote I/O stations can be installed in Zone 1, so that the field wiring is considerably simplified. The process control system addresses the Profibus Remote I/O with the connected field devices via the components in the field mounted substations. A combination with other non-HART signals is possible in the same Remote I/O station.

Instrumentation suitable for GAMP

In accordance with current automation practices in the pharmaceutical industry which are also being adopted by the water and petrochemical industries, instrumentation based on Remote I/O is now spreading. The required validation procedures are available – and, at the same time, costs are reduced. The principles are based on internationally accepted rules and the devices are fully compatible with the Atex Directives 94/9/EC [1] and 99/92/EC [2].

GAMP (Good Automated Manufacturing Practice) has become the de-facto standard for the validation of automation systems in the European pharmaceutical industry. It was originally created by British pharmaceutical interests as a guideline for the manufacturers and users of automation systems. It is now issued by the GAMP forum, under the auspices of the ISPE (International Society of Pharmaceutical Engineering) and is available in its fourth revision [3].

Validation is in fact a coercive requirement. National monitoring directives, such as FDA, ensure through their inspectors and procedures, that the necessary criteria are met.

Validation can therefore be perceived as documentary evidence that a particular process leads to the production of a product, which achieves the prescribed specifications and quality

claims. By maintaining the GAMP4 procedures a pharmaceutical company can evaluate (validate) a prescribed process. GAMP4 has therefore become an important document in this area and the manufacturers of automation components must prepare their documentation in accordance with GAMP4 and even be able to carry out GAMP4 works acceptance tests (FAT, SAT, IQ and OQ).

Meanwhile it has become the responsibility of the manufacturer of automation systems to present the standard GAMP documentation and acceptance certificate. A standard equally accepted by both user and manufacturer saves time and expense and at the same time helps to balance out the variety of interpretations and differences in the quality assurance systems in the industry. GAMP is not restrictive. It is a source document, which while observing a common aim permits a certain degree of flexibility. GAMP protects both users and manufacturers. In this context it is reflected in the saying “In God we can trust everything else we must view with suspicion“.

That compliance with this practice makes sense is recognized very quickly by manufacturers and users once they are acquainted with it. Both time and costs are saved. Even in branches of industry, which do not come under the FDA, it is found increasingly that GAMP is seen as a way to safeguard quality and avoid misunderstanding.

Remote I/O Systems and GAMP

When validating a system it is now possible to include the Remote I/O configuration and the works acceptance test as a part of the life cycle. Manufacturers have recognized this necessity and have made the corresponding investment in the training of employees and have set up the required procedures and documentation formats, in order to test the Remote I/O in accordance with GAMP4 standards. GAMP4 FATs (Factory Acceptance Tests) are offered ex-works and trained personnel are also available for GAMP4 SATs (Site Acceptance Tests). In this way it is possible to incorporate Remote I/O totally in the validation process and to prepare the necessary documented evidence.

Safety Integrity Level und Remote I/O

Safety systems play an important role in industry. In the past a second switch-off system has often been necessary in conjunction with Remote I/O. Modern Remote I/O have SIL2 classifications for all analogue and binary output stages and therefore to some extent render the installation of a separate shut-down device (ESD – Emergency Shut Down) superfluous. This is achieved by bypassing the non-safety relevant control system, the Profibus network and the Remote I/O gateway. The shut-down works directly on the output modules. It is purely a hardware solution, which does not have to take account of any software. Figure 4 shows an example of the function of the shut-down circuit for a valve driver. The output is switched off when the emergency switch is actuated. At the same time the status information

of the inputs for the control system can still be read. So that the switching status of the valves can likewise be transmitted, as can the fact that the emergency shut down has been activated. In this case opto couplers are used for the individual shut-down of the output line of the modules instead of interrupting the auxiliary power for the module. This way no unnecessary fault messages are transferred to the control system. A host of alarms could otherwise lead to the whole station being disabled due to the overflow of the message memory.

Summary: Remote I/O is suitable for many applications

Profibus Remote I/O has been developed very intensively over the years. It offers a very cost-effective way of transporting a large number of input/output signals via a single bus line and makes Asset-Management information accessible via HART. GAMP4 FATs ensure, that on the arrival of the remote I/O on site, all configuration work is already complete and tested by the user. Valuable commissioning time is saved and the Remote I/O is validated in preparation of the required documentation. In addition, thanks to the SIL-approved Remote I/O, the cost of conventional wired safety signals is reduced. These advantages illustrate that the Profibus represents one of the most cost-effective ways of providing modern process instrumentation.

Literature and links

- [1] Directive 94/9/EG of the European Parliament and Council on the alignment of the statutory regulations for devices and protective systems for specified use in hazardous areas.
- [2] Directive 99/92/EG of the European Parliament and Council on the minimum level of regulation to improve the protection of the health of employees endangered by atmospheres capable of causing an explosion.
- [3] GAMP4 - GAMP Guide for Validation of Automated Systems published by the ISPE (International Society of Pharmaceutical Engineering), December 2001.
www.ispe.org

Author: Rainer Hillebrand, Dipl.-Ing. (TH), D.I.C.
Manager Remote I/O Product Group
Pepperl+Fuchs GmbH, Buehl Works
Tel.: (07223) 9909-117, Fax: -140
E-Mail: info-buehl@de.pepperl-fuchs.com

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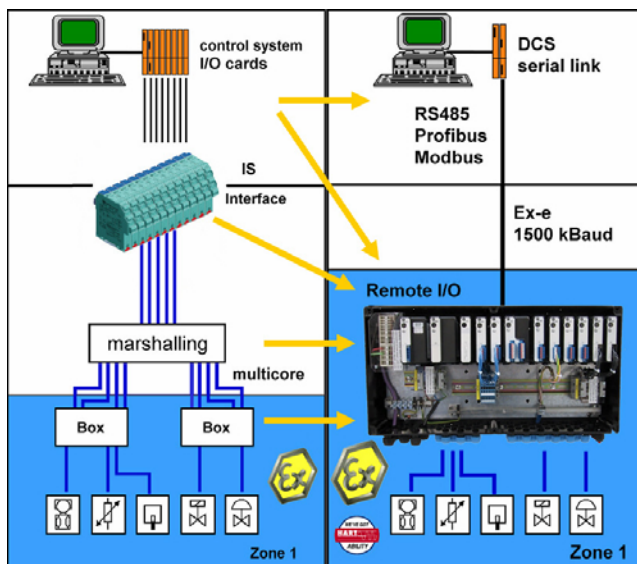


Figure1:
Conventional interfaces (left) compared with Profibus Remote I/O (right)

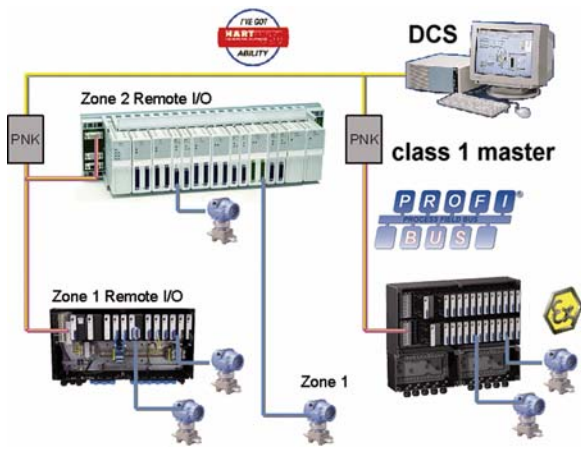


Figure 2:
 HART communication capability opens up Asset-Management functionalities, which were previously only accessed with difficulty.



Figure 3:
 Remote I/O systems can be installed in Zone 1.

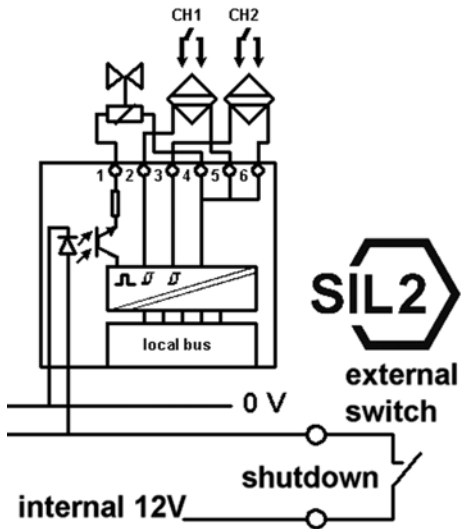


Figure 4:
 Valve drivers with bus-independent shut-down input: SIL 2