Application Report

Fieldbus or Remote I/O – which is the best solution?

A comparison of the two technologies and an attempt to answer this question

by André Fritsch

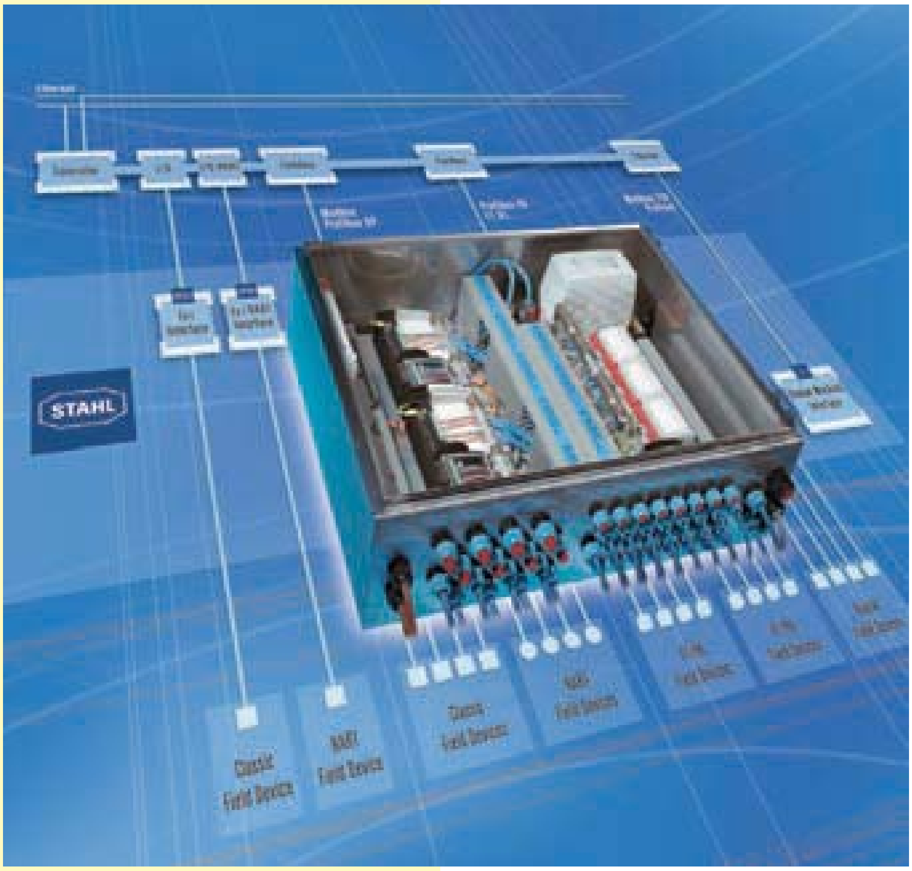


Figure 1: Fieldbus and Remote I/O in actual process world

If we follow discussions in the technical press or at events, we quickly get the impression that Fieldbus technology will replace Remote I/O sooner or later. By contrast, opponents of this theory consider Fieldbus technology to be simply a passing fad that will disappear again someday. If we assess the differing arguments and compare the advantages and disadvantages of the two technologies, a clear result will not be reached. So the question of ›Fieldbus or Remote I/O – which is the best solution?‹ still applies.

Review – **How it all began**

The first solutions incorporating explosion-protected design were marketed around 20 years ago, superseding traditional point-to-point cabling in hazardous areas and establishing digital data transmission in this sector as well. One of the first commercially successful systems of this type was produced by the R. STAHL Schaltgeräte GmbH company. Interestingly, the Remote I/O System ICS MUX was, at the time, marketed under the name of ›Fieldbus System ICS MUX‹ (Figure 2). The system was designed for installation in Zone 1 hazardous areas and allowed users, for the first time, to link their conventional and HART-compatible field devices [2] universally via digital communication to their control systems [6]. Due to a lack of standardised bus protocols, R. STAHL had to develop and use its own Fieldbus protocol. When, a few years later, Profibus DP became established on the market, it was possible to use it as an intrinsically safe version designed by R. STAHL. The system encountered major interest in certain sectors of industry. The offshore industry in particular was able to utilise the advantages of digital data transmission profitably.

Despite the advantages and the resultant saving potentials, it took over 10 years for the market to accept Remote I/O technology. Nowadays, there are a number of different Remote I/O systems from various suppliers on the market. R. STAHL unveiled the second generation of its system in 2001: The I/O system IS1, the generation following the ICS MUX consequently used all ideas of the previous version and rapidly climbed to the top of the market based on this previous experience [7]. Interestingly, most of the modern, explosion protected Remote I/O systems still continue to use an intrinsically safe version of Profibus DP, the system having originally been designed by R. STAHL and standardised by the PNO (Profibus User Organisation) a few years ago with slight modifications [3]. Work on standardisation of it is currently underway at the IEC.

Relatively early after the introduction of Remote I/O technology, the idea occurred to leave out the analogue to digital conversion of signals step and implement data transmission entirely digitally. The power supply was to be supplied via the same bus as that being used for data transmission. However, this approach, a genial one in itself, took an amazingly long time to become reality. One of the main problems related to joint stipulation of a uniform, worldwide Fieldbus Standard. Consequently, it was only a few years ago that two solu-

Figure 2: ICS MUX - Remote I/O, dating from 1990

Figure 3: Modern Remote I/O System IS1 in the year 2006

tions were able to gain ground on the market; two solutions that were, admittedly, conceived on the basis of a common physical aspect, the ›Physical Layer‹ in accordance with EN 61158-2 [4] but that otherwise function entirely differently. The Profibus PA was particularly successful in Germany and Europe, but also for instance in China, while the American system, the Foundation Fieldbus H1, became widespread in the USA, Asia and the Middle East.

Fieldbus technology quickly became an important factor on the market, also driven by the marketing measures taken by the organisations backing the systems, Profibus International [8] and Fieldbus Foundation [9].

Fieldbus in the real world

If we discuss the topic with members of one of the two major Fieldbus organisations, we quickly get the impression that there are only two possible solutions for process automation in the world: Profibus PA and Foundation Fieldbus H1.

Unfortunately – or perhaps fortunately? – the real world is substantially more complex. In reality, a mix of what is now three generations of field devices are being used. Classic 4 – 20 mA technology, HART field devices and Fieldbus devices peacefully coexist. Even pneumatics is still used in many installations.

4 – 20 mA field devices installed in hazardous areas were and are connected via conventional isolators in a traditional point-to-point connection to input/output cards of the control system. Even new installations are frequently equipped with this technology. If, for instance, there is a demand for single-channel technology, electrical isolation or the use of circuits of functional safety in accordance with EN 61508 [10], [14], a solution using conventional isolators remains the best and most cost-effective solution. In addition, the very simple wiring and diagnosis procedure for such installations is an important argument for many users. ➔

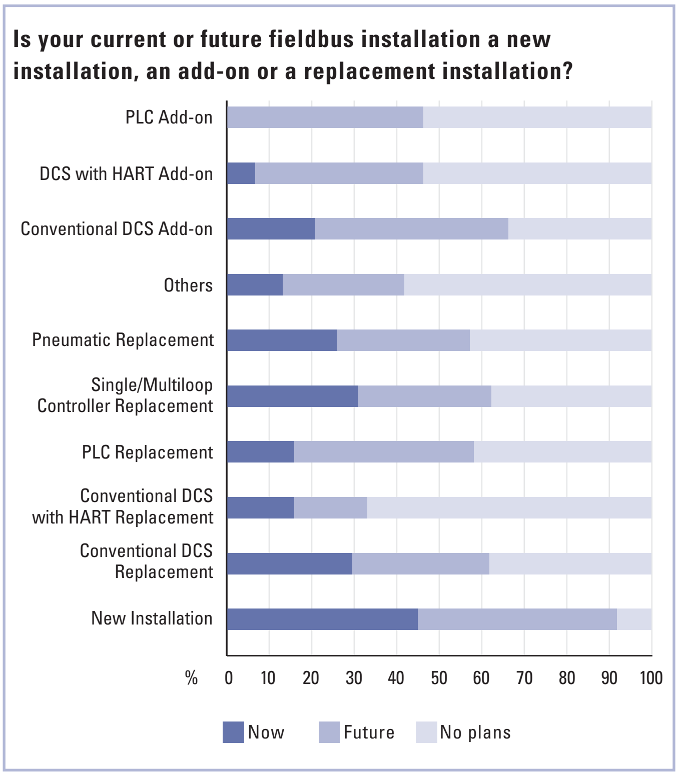


Figure 4: ARC inquire on the subject of Fieldbus installation (survey from ARC INSIGHT)

Many years ago, the HART protocol was able to gain ground as the de-facto standard in digital communication on the basis of the 4 – 20 mA signal over other solutions [2]. The HART field devices installed since then number approx. 12 Mio. and no real decline in sales figures can currently be seen. In addition, far more HART field devices than devices with Fieldbus interface are sold. Many diagnostic and maintenance tasks can be performed with this very simple protocol so that users see little need for replacing this technology. The HART field devices in hazardous areas are also connected with conventional isolators, whereby the HART signal itself is frequently decoupled from the analogue signal with HART multiplexers and transferred to special HART management systems. These systems are then used for configuration, diagnosis or logging, detached from the control system.

Both solutions have two things in common: the complexity and the susceptibility of the individual wiring to faults. With Remote I/O technology, analogue field devices can be integrated very elegantly in control systems via a digital bus protocol. A large number of input/output cards of a control system are replaced by only a few communication modules. Consequently, both space and money are saved while still allowing the existing field devices to be used either with or without HART communication, which is a clear cost advantage in view of service lives of over 15 years. Even the HART signal can be transmitted either via the Profibus DP to the control system or via a separate Servicebus to the autarkic HART management system.

In the case of simple digital signals from contacts, proximity switches or solenoid valves and indicators in particular, Remote I/O technology is and will remain the most cost-effective solution. Remote I/O technology is still the best method of implementation if there is a demand for maximum availability and redundancy solutions. Certain interesting advantages of both a technical and a commercial nature were introduced to the automation platform with Fieldbus technology. New functions, such as ›Control in the Field‹ of the FF H1 Fieldbus are able to substantially optimise applications. Many computer-bound operations, such as a PID control algorithm or limit-value monitoring functions and actions, can be performed locally and system-independently in the field devices. This relieves the load on the control system and ensures availability of process control even without system intervention.

Planning, installation and maintenance of Fieldbus networks can be performed efficiently and in a cost-saving manner. The very extensive diagnostic options and diagnostic signals open up the field of preventive maintenance, also known under the keywords of ›predictive maintenance‹, an aspect already long familiar in the field of mechanical engineering and machine construction, and to process automation as well. In turn, this results in a savings potential relating to the lifecycle costs of an installation.

However, according to a survey conducted by the ARC Advisory Group [11] in 2003 the advantages of Fieldbus technology are primarily utilised in new installations. Only a few users see there to be an acute need to act and, even in the near future, see a need to convert to Fieldbus technology (Figure 5) for existing installations with conventional field devices with or without HART.

Different opinions – different solutions

Of course, we will hear differing opinions if we ask the question that we asked at the start: ›Which is the best solution?‹. Many users still prefer conventional wiring with explosion protected isolators for applications in hazardous areas. The signal can be measured with simple ammeters, no specially trained staff are required and modifications can frequently be made simply by reconnecting a few wires. The advocates of Remote I/O technology argue on the basis of their good experience over the last few years. In addition, use of Remote I/O technology does not necessitate exchange of the field devices, which would represent a substantial cost factor.

Fieldbus users emphasise in particular the new functions such as ›Control in the Field‹ or the extended diagnostic options, along with the simpler wiring since no power supply is necessary in the field.

Many users already look to the future and consider existing Fieldbus technology to be a transitional solution that will be followed by new solutions that really can be used universally. New transmission technologies such as Industrial Ethernet or even Wireless for instance, would then play a role.

Many publications in periodicals, reports and market analyses have discussed the advantages and disadvantages of Fieldbus technology in comparison with Remote I/O and conventional technology. The results, however much as they may differ, are certainly all correct. We must simply occasionally read between the lines.

A field report of the NAMUR Working Group AK 2.6 ›Fieldbus Technology‹, dated November 2004 [12], shows the share of Fieldbus field devices in comparison with conventional devices on the basis of certain example projects (Figure 5). The result: only 20 % of all field devices used featured a Fieldbus interface. On the one hand, this does not sound particularly positive for this technology but it does, of course, apply only to the projects analysed and should not be assessed as a fact applicable worldwide. In other projects, up to 95 % of all field devices featured Fieldbus. This depends greatly on the end user, the manufacturer of the control system and the application

The FuRIOS [13] study is a well-known one. It attempted to compare costs of Fieldbus wiring with the costs of Remote I/O on the basis of a real project with all parameters. For instance, it included the costs of planning, wiring, field devices, calibration and commissioning. The result of the analysis was that Fieldbus wiring is approx. 4 % cheaper than comparable Remote I/O technology, which is an absolutely correct value subject to the boundary conditions investigated for this project. Investigations in relation to other projects subject to other boundary conditions, however, may possibly produce entirely different results. We should also mention that the project investigated was ultimately implemented in an entirely different way.

The evaluation of sales figures from field device manufacturers in relation to the share of Fieldbus field devices actually sold in comparison with conventional or HART-compatible devices also provides an interesting picture. Off the record, one major manufacturer reports that currently only 2 % of all devices sold feature a Fieldbus interface. The reason in this case has nothing to do with the price. The market prices of devices with or without Fieldbus interface are now virtually identical although list prices still differ. The list price of fieldbus devices is approx. 30 % higher than conventional devices. By contrast, if we consider the percentage growth rates in the statistics over recent years, we can see a very clear trend towards the Fieldbus. Consequently, the manufacturer's conclusion is clear: the Fieldbus market is only just developing.

Certain large-scale projects in recent years, such as the SCIP (Shanghai Chemical Industry Park) Project in China, seem to emphasise the advantages and the acceptance of the Fieldbus. Over 23,000 signals, a truly impressive number, were implemented in this project with devices using the Fieldbus Foundation H1 protocol. However, if we take a look at the digital signals, of which there are typically at least just as many, we can see that they were wired with conventional isolators. One of the main end users responsible for this project reports, in an interview, on his considerations regarding the use of Fieldbuses for this. One very important requirement on his part was the use of the most state-of-the-art technology available on the market. Of course, he then clearly opted for Fieldbus technology.

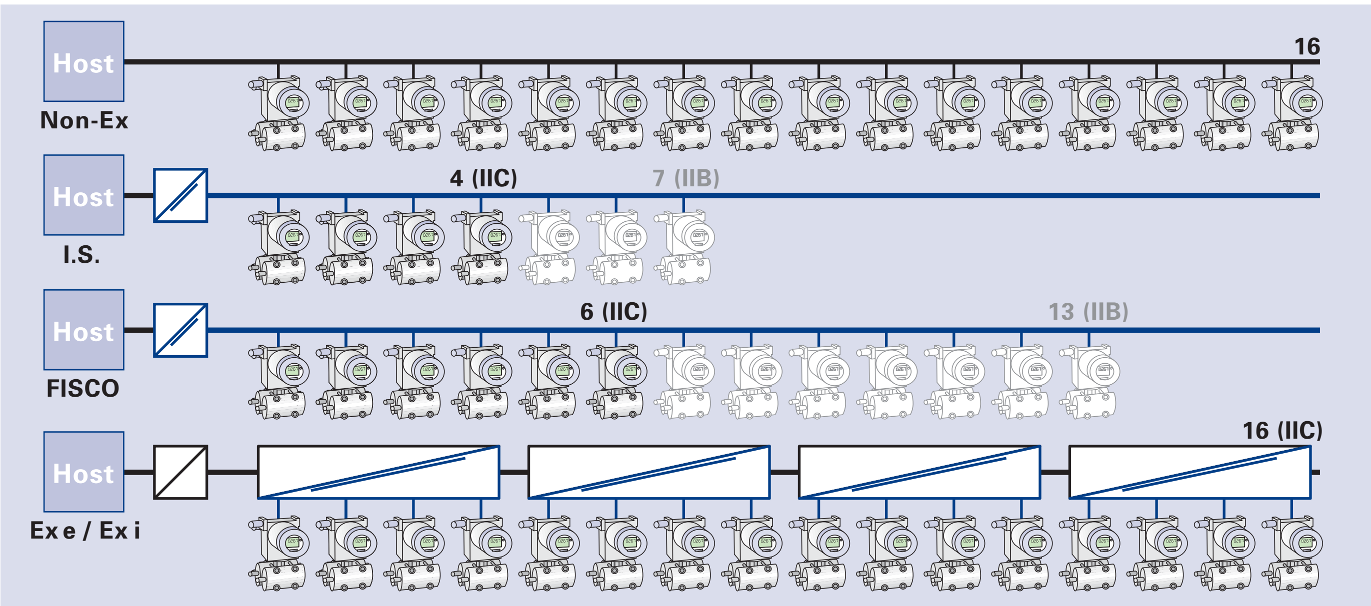
Project	Total Number	Field devices with Fieldbus	Fieldbus
VITEX B 350/CH DSM	4500	790	PROFI BUS
WSH2084/CH NOVARTIS	1500	260	Fieldbus Foundation
B150/UK NOVARTIS	4600	950	Fieldbus Foundation

Figure 5: The quantity of conventional devices compared with that of Fieldbus devices used in diverse projects

Attempt at a technical and neutral comparison

One of the major stumbling blocks to the success of the Fieldbus and a major disadvantage by comparison with Remote I/O for instance in the past was the small number of Field devices that could be connected to one bus segment (Figure 6). While the number of →

Figure 6: Number of field devices connectable to one bus segment



field devices per bus line typically is around 16 in the case of non-explosion protected versions, the number drops dramatically in hazardous areas. The first approach to designing an intrinsically safe bus on the basis of the classic concept of verification of intrinsic safety resulted in a maximum number of approx. four field devices, at least in accordance with the requirement for Explosion Group IIC. This is an understandable but, of course, unacceptable result owing to the required energy limitation, the complex verification procedure in the case of several bus users and corresponding line parameters. Thereupon, the PTB in Germany investigated the actual behaviour of field devices connected to an intrinsically safe Fieldbus and also used tests with the spark test apparatus along with experimental verification for this. The results, published at the time in PTB Report W-53 (1), were very interesting and opened up a far better range of possible applications. Aside from certain boundary conditions, to the effect that, for instance, only one power feed into the bus is permitted and that all bus users must feature a passive behaviour, it was also the case that real lines and line models were used. One of the most astounding results was that the bus most likely to ignite has a line length of zero metres. This model has now been adopted in international standardisation as well, under the name of FISCO (Fieldbus Intrinsically Safe Concept), and was incorporated in IEC 60079-27 [5] together with a similar concept for Zone 2 under the name of FNICO (Fieldbus Non Incendive Concept).

The FISCO concept then allowed approx. 6 – 7 bus users for Explosion Group IIC to be connected to one Fieldbus. This resulted in a rise in acceptance, and the use of Fieldbus solutions increased substantially. Even today, the FISCO concept is used as the basis in many Fieldbus applications.

In comparison with the Fieldbus of non-explosion protected design, the result was however still well below the theoretical maximum number of 16. It was only the concept of Fieldbus barriers [18] that brought the breakthrough. This involves dispensing with an intrinsically safe bus in favour of a higher power infeed. However, a barrier

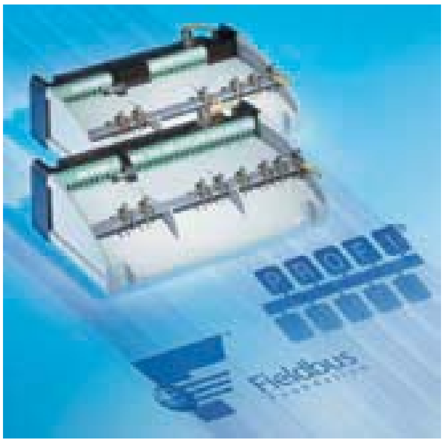


Figure 7: Field device-coupler for an Ex e Fieldbus

is connected in-between, splitting the non-intrinsically safe bustrunk into several isolated intrinsically safe bus spurs, a technology based on the example of classic Ex-i isolation with electrical isolators, in order to be able to use the advantage of type of protection intrinsic safety to exchange field devices during operation in Zone 1. This elegant solution means that the 16 field devices from the non-explosion protected approach can also be achieved for use in hazardous areas. It means that up to 16 field devices in accordance with FISCO specification can be operated on one bus (Figure 7) with modern Fieldbus barriers, such as the field device couplers from the new ISbus Series (15) from R. STAHL. In addition, features integrated include short circuit protection of the spurs, diagnostic elements and various screening concepts.

In order to find the best solution, we will compare the solution options for the Fieldbus with a Remote I/O on the basis of a signal volume of 120 devices below.

Assuming that only analogue signals are used, we obtain a clear picture (Figure 8). In the case of the pure ›e‹ FISCO approach,

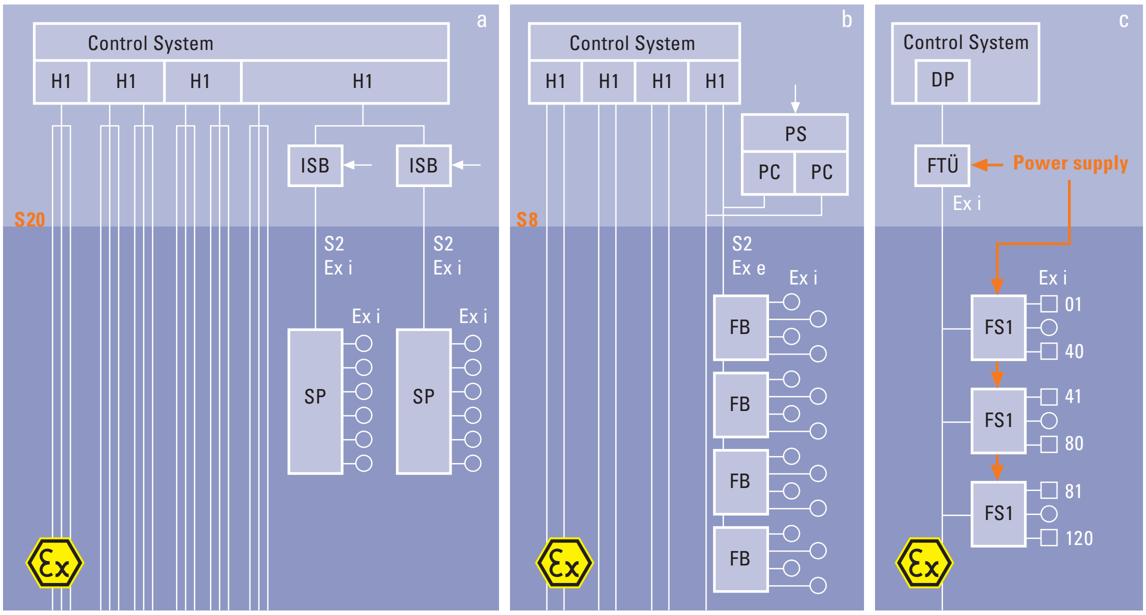


Figure 8: Diagram showing three approaches to solving the problems

a) FISCO Fieldbus with spur protection (SP)

b) Fieldbus with Fieldbus barrier (FB)

c) Remote I/O with field-station in Zone 1 (FS1) the 120 field devices must be split over a total of 20 Fieldbuses. This results in a cabling complexity that is already greatly reminiscent of conventional point-to-point wiring. If Fieldbus barriers are used, the number of Fieldbuses is still only reduced to eight. Since a Remote I/O system typically can be used to connect up to 64 analogue field devices in Zone 1 and since Profibus DP allows up to 31 such stations, only one single bus is required for this. On the other hand, a Remote I/O requires an additional power supply and does not offer the diversity of functions and diagnostic options of the devices for the Fieldbus.

Table 1 compares the functional and technical aspects of the two solutions, Fieldbus and Remote I/O, and assesses them. An assessment system similar to school class grades is intended to provide a neutral, technical comparison. ›++‹ = problem solved very well, grade 1, ›+‹ = problem solved well, grade 2, ›o‹ = can be solved with restrictions, grade 3 and ›–‹ = cannot be solved adequately, grade 4.

However, the requirement in the application also influences the technology that can be used in this comparison. If, for instance, line redundancy is required through to the field level, only Remote I/O can be a practical solution, whereas Fieldbus must be selected for the ›Control in the Field‹ function.

However, the overall result in this comparison also does not really help us to answer the question ›Which is the best solution?‹.

Function	**Remote I/O**	**Fieldbus**
Transfer rate	+	0
Diagnostic, alarms and events	+	++
Control in the Field	–	++
Number of bus lines	+	0
Space required	0	+
Large distances	+	0
Redundancy	+	0
Available field devices	++	0..+
Integration of conventional field devices	+	0
Mixing Ex – Non-Ex	+	0
Simple digital signals (contacts, ...)	++	+
One line for energy and data	–	++
Integration of operator interface	+	0
Summarised (note)	**2.2**	**2.3**

Table 1: Functional comparison between Remote I/O and Fieldbus

The best solution

Since what has been said above and the examples have not been able to help us much in answering the question, we consequently only have two approaches left. Both parties withdraw to their camps, gather further arguments for ›their‹ technology and condemn the advocates of the other party. It is doubtful to what extent this would lead to a practical and, above all, helpful solution for the user.

Alternatively, we should consider to what extent the strengths and weaknesses of both technologies can be combined. After all, the aim of every manufacturer must be to design and offer the best and most effective solution for their customers. Depending on application, boundary conditions or also personal preferences, the →

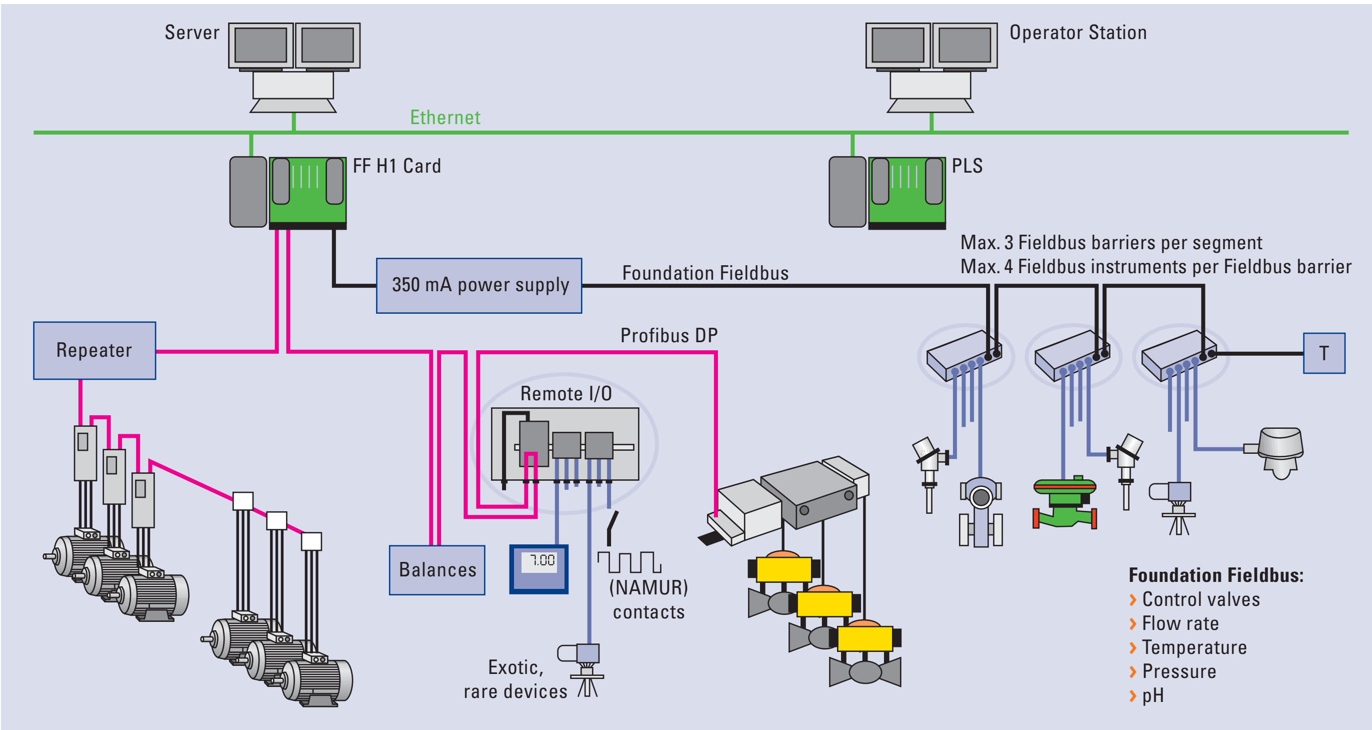


Figure 9: Combination of different techniques used in a project by Novartis

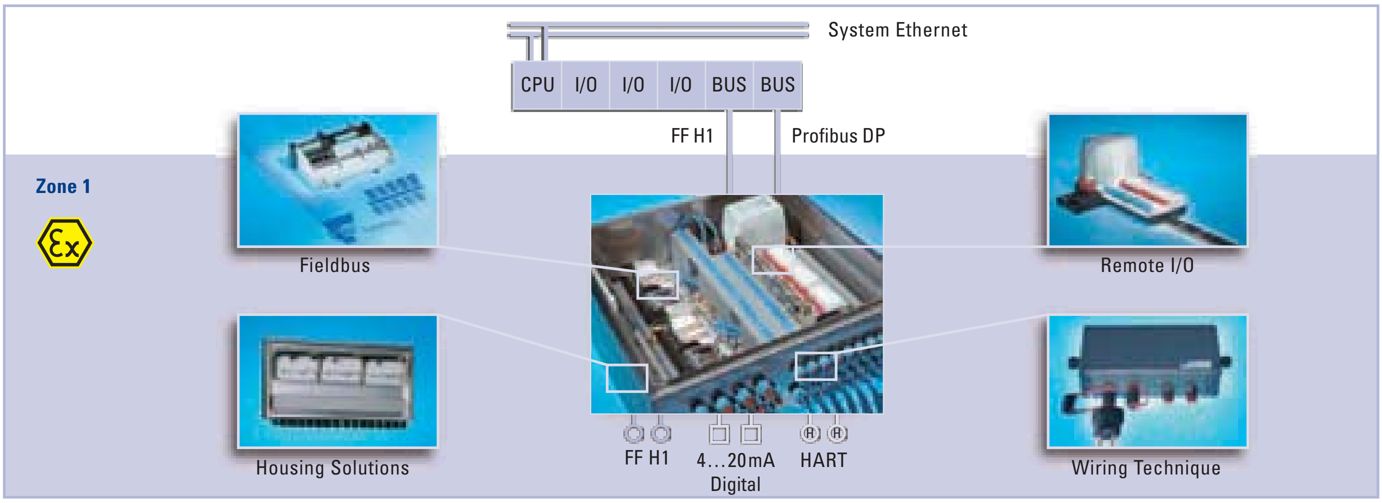


Figure 10: Fieldbus and Remote I/O harmonious together in a Field-station in Zone 1

user must have the option of choosing from conventional isolators, Remote I/O or Fieldbus and, of course, also combining these individual solutions to form an overall solution.

This approach to solving the problem is not simply theory. If we take a look at existing project solutions, we will frequently find just this combination. Along with Fieldbuses, electrical isolators were also used in the above-mentioned SCIP Project in China. The Swiss company Novartis used either Fieldbus with Fieldbus barriers or Remote I/O in its WSH2084/B150 Project, depending on application. For instance, the more complex transmitters or positioners with Fieldbus connection were used so as to utilise all advantages of the large scope of functions. By contrast, a far less costly solution with the Remote I/O System IS1 on the Profibus DP was used for simple digital signals (Figure 9).

Furthermore, Remote I/O and Fieldbus need not only be combined at application level. Even a mechanically integrated approach in one and the same field housing is conceivable. The example of a Zone 1 field station demonstrates how both solutions can be ›packaged‹ elegantly in one housing (Figure 10).

This means: regardless of the type of field devices in the installation, conventional 4 – 20 mA devices, HART signals, digital signals or Fieldbus devices, the connection is made at one field station. On the one hand, the field device couplers are installed for FF H1 devices, for instance, in the station and connected via the Fieldbus to the control system. On the other hand, the Remote I/O System IS1 is used to gather the remaining signals from conventional or HART field devices and also transmit them via the Profibus DP to the control system. Of course, depending on requirements, different types of field housings with further components or other built-in components may be used, or Fieldbus and Remote I/O components can be installed separately. The broad range of housing and wiring system products from R. STAHL complements these examples in an ideal way in this case and offers the user a broad selection for every application.

Even better in future?

Mind you this solution is not entirely perfect. Two different bus systems are used, meaning that users must also avail of know-how in relation to both these buses. While the obstacles are not very difficult for combination of Profibus DP and Profibus PA, there is a world of differences between Profibus and Foundation Fieldbus H1. In this case, different wiring techniques, different cables and lines, different communication modules, and differing engineering necessitate a certain complexity that is, admittedly, manageable but that is not negligible.

A very interesting approach to solving the problem will become available in the future. Industrial Ethernet technology is, slowly but surely, making its arrival in the process automation scene [16]. While initial solutions are already in use in practice in the sector of production automation, such as PROFINET [17], process engineering has had more of a ›wait and see‹ stance. Certain critical details, such as fast switching to redundancy, have not yet been adequately solved. How will Industrial Ethernet be able to be used practically in hazardous areas? In addition, the wide variety of Ethernet protocols, such as Modbus TCP/IP, Profinet IO, Vnet/IP or FF HSE, are more confusing than helpful.

Approaches to solving the problem are, however, already on the horizon and Industrial Ethernet is consequently opening up a real integration process for Remote I/O and Fieldbus that will be available in the not too distant future.

New technologies open up new capabilities and practical changes. But, as we can learn from the past, an abrupt change from one technology to another occurs only very rarely. The safety barrier, a component that has already so frequently been written off, is still used in the case of intrinsically safe signals. Admittedly, modern electrical isolators have now achieved broad acceptance but, to date, they have not been able to entirely oust the safety barrier. Neither has Remote I/O with all its advantages led to a collapse of the isolator market. By contrast, the market is still characterised by slight growth at a very high level. So even the Fieldbus will not oust its ancestors in the foreseeable future but, rather, will complement them practically. When thinking about new technologies and solutions, we should never lose sight of the actual objective: best possible benefit for the user.

An intelligent combination of the strengths of Remote I/O technology and Fieldbus technology, depending on the nature and scope of the installations, provides the best and most effective solution, even now, and will do so even more in the future.

www.fieldbus-solutions.info

R. STAHL cooperation in the Marketing Committees of the Fieldbus organisations

Along with many years' cooperation in various national and international standardisation committees in the sector of explosion protection of electrical apparatus, the R. STAHL company has recently also been actively involved in the marketing committees of the two Fieldbus organisations Profibus and Foundation Fieldbus.

Aside from organising presentations at trade fairs and shows, brochures and Internet information, these Marketing Departments also regularly organise events for end users and engineering companies so as to help end users and planners to understand Fieldbus technology better, and allow them to exchange opinions and experience.

Dr. Peter Völker, Managing Director and Chairman of the Board of the R. STAHL AG company has been a member of one of the highest Committee of the Fieldbus Foundation in Europe, the EMEA EAC (European Middle East African – Executive Advisory Council) since last year. The EAC's scope of decision-making covers budget decisions and decisions on release and financing of marketing events. The EMEA Steering Committee that coordinates the national Marketing Committees, plans and holds European events such as the so-called End User Councils and EPC events, and is in direct contact with industry organisations such as NAMUR and with the FF Headquarters in Austin, Texas USA, which is subordinate to this Committee. The R. STAHL company is represented on this Committee by André Fritsch, Product Manager, Control and Instrumentation Systems, who is also an active member of the corresponding national committee, the German Marketing Committee. He is also a member of the comparable Profibus organisation, the Profibus PA Marketing Group. The R. STAHL company is also represented in certain other marketing groups of the FF. For instance, staff from the local subsidiaries are active, working members in the USA, the Middle East and in Eastern Europe.

By this cooperation, the R. STAHL company ensures optimum exchange of information for its customers in relation to Fieldbus technology.

Further information available at www.fieldbus.org and www.profibus.com.

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