

7/2005

July

# atp

Automation Technology  
in Practice

---

Breakthrough in Fieldbus technology –  
High Power Trunk concepts

---

**Reprint**



Oldenbourg





# INSTALLATION TECHNOLOGY FOR FOUNDATION™ FIELDBUS H1 AND PROFIBUS PA



Fieldbus™  
Foundation



# Breakthrough in Fieldbus technology – High Power Trunk concepts

Do we see the breakthrough of fieldbus technology in process automation? The fieldbus experience reports presented at the 'Association of Users of Process Control Technology' NAMUR general assembly in 2004 seem to confirm that. Topology concepts with high power in the field for all explosion hazardous areas, sophisticated protection and diagnostic functionalities of modern Fieldbus Installation Systems as well as easy-to-use planning tools form the basis for the positive appraisal of several major operational process production plants with continuous fieldbus instrumentation. These experiences confirm the expectations specified in 2002 by the FuRIOS study.

## Introduction

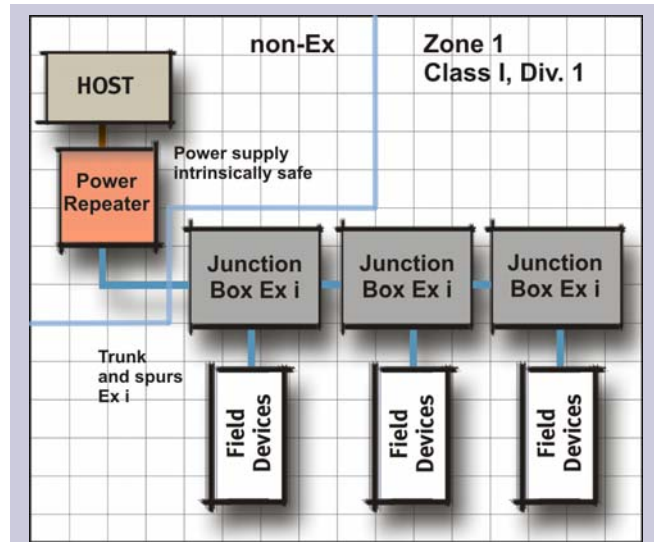
Nowadays, PROFIBUS and FOUNDATION Fieldbus are frequently discussed in the process automation industry. Whether at the NAMUR general assembly in November 2004, in the discussion forums at the German Interkama fair in April 2005 or in the many international brain trusts, plant instrumentation with digital communication seems to experience the breakthrough [1]. If approaching this topic as an outsider, this great interest seems astonishing at the first sight. The control of process plants by means of computer and PLC is a long established technology. PROFIBUS DP, HART or similar protocols communicate without problems with the instruments close to the processes.

At least, this seems to be the case. At a closer look, the decisive difference becomes apparent "in the last meters". In most cases, at some point between the digital controllers and the sensors and actuators

in the field, there are I/O interfaces which convert the digital signals of the control system into conventional 4-20mA signals. These may be I/O cards in the control room or Remote I/O systems somewhere in the plant. In any case, there are analogue/digital conversions during signal transmission, with all tolerances and risks of faults. The core of the current discussion is the term "continuous" digital communication, i.e. the direct data exchange between the process control system and the chipset in the field device, without interfaces and their tolerances. However, people want to keep the comfort of power supply and signal transmission via the same two-core cable, as known from conventional technology. Suddenly the choices are very limited. Many of the protocols used in automation technology, such as PROFIBUS DP, Modbus or Industrial Ethernet, are not designed for this purpose and require additional power connections.

**Table 1: Basic fieldbus parameters according to IEC 61158-2**

Parameters	Specification according to IEC 61185-2
Data transmission rate	31.25 kbps
Total length of all cables (cable type A)	1,900 m
Max. spur length	120 m
Max. number of nodes per segment	32
Signal coding	Manchester II
Min. operating voltage per device	9 V
Min. current consumption per device	10 mA
Signal transmission	± 9 mA

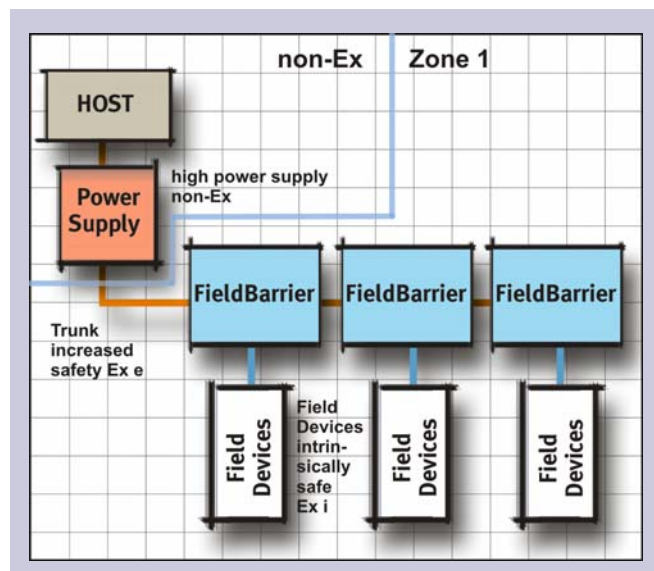


**Fig. 1: Fieldbus segment, completely in explosion protection "Intrinsically Safe"**

## Fieldbuses for process automation and explosion protection concepts

In fact, the discussed fieldbuses are the PROFIBUS PA and the FOUNDATION Fieldbus H1, which both are based on IEC 61158-2 and allow the combination of supply current (direct current) and digital signal (alternating current) on the same two-wire cable. This standard

defines some general conditions for the structure of a fieldbus network. Table 1 summarizes the most decisive of these conditions. Furthermore, there are four cable types specified (table 2). Type A is used as reference cable and is especially recommended for fieldbus installations. Type C and D should only be used for modifying existing plants and for heavily reduced networks [2]. More-



**Fig. 2: Fieldbus segment according to the High Power Trunk concept with fieldbus barriers**

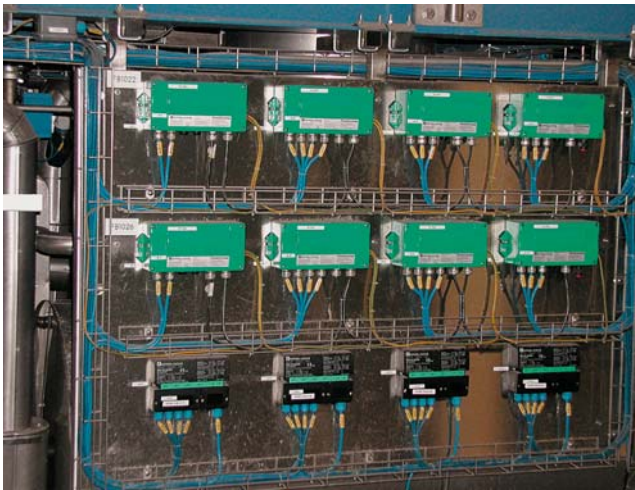


Fig. 3: Fieldbus barriers in the Rubyred plant of Clariant

over, the practical layout of a fieldbus network depends on the actual current consumption of the used field devices, the desired reserves as well as the ambient conditions. Since the specification in the standard refers to a temperature of 25°C, the influences of deviating climatic conditions must be taken into consideration. These considerations show that the design of a fieldbus network is a very complex task, even in the safe area. Additionally, there are the safety evaluations when looking into explosion hazardous areas. For Zone 1, usually the protection method "intrinsic safety" Ex i is required because it is the only method that allows live maintenance and service during operation without

special precautions. The original approach to fieldbus Ex i was a simple transfer of the methodology used in conventional technology by introducing special Fieldbus Power Supplies which meet the requirements of intrinsic safety. This subjects the complete fieldbus segment to the energy limitation, as shown in fig. 1. The analogous adoption of the confirmation of intrinsic safety, the so-called Entity concept, did not only cause a considerable workload in terms of calculation and documentation, it also led to the result that only 4-5 instruments could be operated per segment. A different approach, the "Fieldbus Intrinsically Safe Concept" FISCO [3], specified in IEC 60079-27, al-

lows the use of up to eight field devices per segment and considerably reduces the efforts for confirmation of intrinsic safety. On the other hand, FISCO specifies certain cable parameter restrictions which lead to cable type A as the best choice for Ex ia IIC, increases the technical requirements on the field devices and significantly reduces the flexibility of the network. Especially the reduction of the spur length to a maximum of 60m and the entire cable length to 1,000m is quite a setback. For Zone 2, the "Fieldbus Non-Incendive Concept" FNICO was developed and ultimately included in the new edition of IEC 60079-27. It considers the lower safety requirements in Zone 2 and thus allows a higher power supply. In all other aspects it corresponds to FISCO with all obvious restrictions. Against this background, it is comprehensible that the acceptance of fieldbus technology in process automation was rather restrained for many years. In particular, since the investment costs did not bear comparison with the established conventional technology due to the low number of fieldbus devices per segment.

### Breakthrough in connection technology – Fieldbus Barriers

The FuRIOS study [4], presented at the NAMUR general as-

sembly in November 2002, marked the turning point. This study was carried out by Aventis Pharma Germany, now Sanofi Aventis, and Infraseriv Höchst Technik with the support of renowned manufacturers of process automation equipment. The basis was the newly developed fieldbus barrier technology, which separates the two functions "fieldbus power supply" and "protection by intrinsic safety". This was preceded by the consideration that interventions during live operation are only necessary at the field devices and their connecting leads (spurs), whereas the passive wiring between the control room and the distributors in the field is subject to minimum stress only and thus is hardly affected by faults. Moreover, the communication in the segment would be interrupted anyway during works on a fieldbus trunk. Thus, it would hardly be possible to safely continue the production process with several instruments out of operation. The result of these considerations is the use of two different explosion protection methods, as shown in fig. 2. The trunk between the safe area and the fieldbus distributors close to the process is installed using the explosion protection method "increased safety" Ex e and thus allows a significantly higher supply energy compared to Ex i as well as the use of cost-effective non-Ex power supplies. Fieldbus barriers such as the FieldConnex® FieldBarrier by Pepperl+Fuchs, which allow the intrinsically safe connection of up to four field devices, are used as distributors in Zone 1. Devices according to Entity or FISCO can be combined at will since the confirmation of intrinsic safety is only required for the loop between the device and the output of the FieldBarrier. By daisy-chaining multiple fieldbus barriers it is possible now to connect the maximum number of 32 devices as specified in the standard, even in 1 applications. Further advantages of the FieldBarrier include the individual short-circuit current limi-

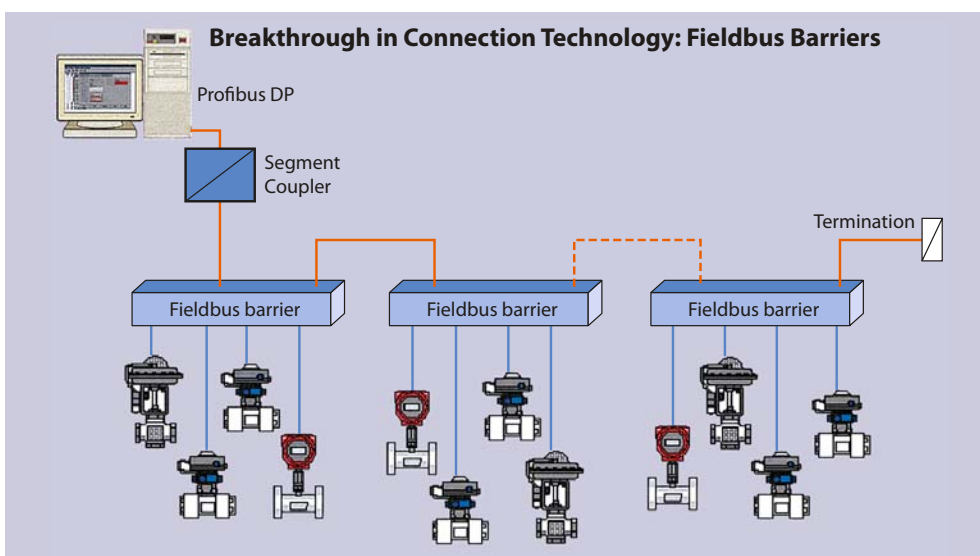


Fig. 4: Conclusion of the fieldbus experience reports at the NAMUR general assembly 2004

**Table 2: Cable types for fieldbus networks**

	Type A (reference)	Type B	Type C (*)	Type D (*)
Cable description	Twisted pair, shielded	One or more twisted pairs, total shielding	Several twisted pairs, not shielded	Several non-twisted pairs, not shielded
Nominal conductor cross-section	0.8 mm <sup>2</sup> (AWG 18)	0.32 mm <sup>2</sup> (AWG 22)	0.13 mm <sup>2</sup> (AWG 26)	1.25 mm <sup>2</sup> (AWG 16)
Max. DC loop resistance	44 Ohm/km	112 Ohm/km	264 Ohm/km	40 Ohm/km
Characteristic impedance at 31.25 kHz	100 Ohm + 20 %	100 Ohm + 30 %	**	**
Max. attenuation at 39 kHz	3 dB/km	5 dB/km	8 dB/km	8 dB/km
Max. capacitive unbalance	2 nF/km	2 nF/km	**	**
Group delay distortion (7.9 ... 39 kHz)	1.7 mysec/km	**	**	**
Surface covered by shield	90%	**	n.a.	n.a.
Recommended extend of network (incl. spur cables)	1,900 m	1,200 m	400 m	200 m

All data based on an ambient temperature of 25°C  
 (\*) only to be used for retrofit applications and substantially reduced networks  
 (\*\*) not specified

tation of each output, thus protecting the trunk against negative feedback of device faults, as well as the option of capacitive grounding (see [2] and [8]), which leads to significant savings with regard to the earthing concept.

Due to the high power supply via the Ex e protected trunk, the fieldbus barrier concept is often called "High Power Trunk concept". The FuRIOS study was based on a virtual fieldbus network according to this concept and compared it with a real pharmaceutical chemical plant already in operation. The study's target was to evaluate the cost/benefit aspects of the real batch plant realized with Remote I/O systems and to compare them to the plant planned with fieldbus, under consideration of the complete life cycle. The theoretical results were very promising. So Aventis decided to realize the fieldbus solution: In May 2004 the new plant for producing the antibiotic Ketek was commissioned, in which 1,600 PROFIBUS PA devices communicate fully digital via 470 fieldbus barriers [5]. At the same time, further plants based on the FuRIOS recommendations were put into operation, such as at DSM, Novartis and Clariant [6]. The latter's extensive use of the FieldBarrier is documented in fig. 3. Accordingly, the experience reports on five fieldbus plants producing at full speed, which were pre-

sented at the NAMUR general assembly in November 2004, ended with the conclusion shown in fig. 4: Breakthrough in connection technology – fieldbus barriers [7].

### Fieldbus power supplies and safety

An essential component of any fieldbus segment are the power supplies, which carry out the impedance matching for coupling the DC supply current with the AC amplitude of the digital fieldbus communication. In addition to a stable, error-free signal transmission, a high operational safety is required because all field devices connected to the segment would fail simultaneously in case of a power supply failure. For this reason, modern systems like the modular FieldConnex® Power Hub offer a number of protection mechanisms.

Passive impedance matching: For current/signal coupling, passive components are used. Their high efficiency of up to 91% induces only minimum thermal strains on the environment and the modules themselves. The operational safety is proven by high MTBF numbers.

Redundancy of the Power Modules: The power supplies' availability can be further increased by means of an optional parallel configuration of the electronic components with

load sharing and automatic switchover in case of fault.

Redundancy of the power sources: Two bulk power supplies can be connected in parallel by means of appropriate, integrated decoupling diodes.

Redundancy of the fieldbus communication: Two redundant host interfaces can be used per segment. Here a special short-circuit current limitation of the host connections protects the fieldbus segment against negative feedbacks, too.

Protection against resonances and crosstalk: For this purpose, the innovative "Crosstalk and Resonance Suppression Technology" CREST was developed, which ensures a high stability of the fieldbus signal.

Monitoring and error message: Diagnostic modules mo-

nitor the fieldbus installation and indicate error states via LED, separate relay outputs as well as a special diagnostic bus.

The Power Hub is designed to be used in High Power Trunk concepts in safe and all explosion hazardous areas. A choice of different motherboards and power modules allows to meet any requirement, from a simple segment without any special protection needs up to four parallel segments with redundant host connections, advanced diagnostic functionality and redundant power modules with galvanic isolation. Fig. 5 shows the Power Hub in its maximum configuration. Motherboards with specific system connectors or slots for linking devices are available for many types of control systems.



**Fig. 5: FieldConnex® Power Hub for Foundation Fieldbus H1, 4 segments in redundant configuration**

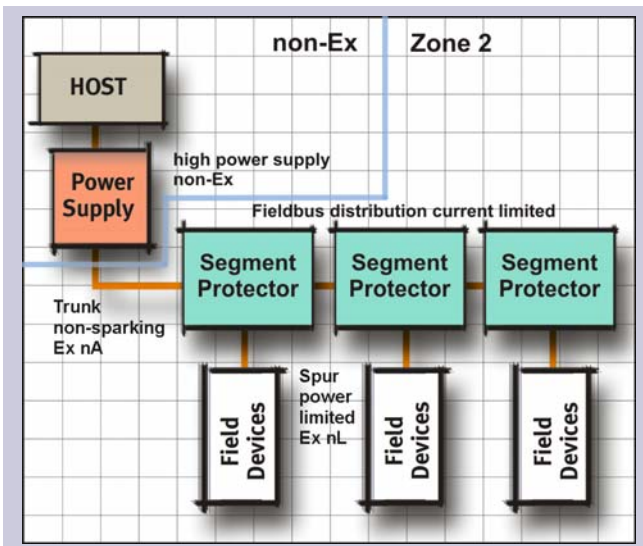


Fig. 6: High Power Trunk concept for Zone 2

### High Power Trunk concepts for Zone 2

Due to the necessity to save costs, the reduction of Zone 1 in favour of Zone 2 is increasingly considered. Consequently it is reasonable to introduce High Power Trunk concepts that are adapted to the reduced safety requirements of Zone 2 applications.

Instead of the fieldbus barrier, Segment Protectors of the FieldConnex® system can be

used (see fig. 6). For the trunk the explosion protection method "non-sparking" Ex nA applies and allows to lead high currents into Zone 2. The Segment Protectors are certified according to EEx nA[L] and can be mounted in Zone 2. Every output is energy limited according to EEx nL IIC, the output current is max. 40mA, the output voltage max. 31V. In addition, each output is individually short-circuit current limited to

45mA. Field devices with a respective certification for Zone 2 or according to EEx i can be connected. The safety parameters are calculated according to the Entity concept. Due to the individual consideration of each spur, this calculation is significantly simplified. For the supply of the currently common intrinsically safe field devices, the FieldConnex® Power Hub system offers power modules with a voltage limitation to max. 23V. By using power modules with a limitation to 17.5V, segments can be installed according to the FNICO concept as described above. However, there are currently only a few field devices certified according to FNICO on the market. Moreover, the possible maximum cable lengths and device numbers are reduced due to the voltage limitation.

In the future these voltage limitations will be required less often because more and more field devices with certifications according to EEx nL with  $U_i > 32V$  become available. Thus, the voltage limitation of the Segment Protector takes effect, the Power Hub's standard high-power modules can be used and ultimately the advantages of

the High Power Trunk concept can be realized to the full extent.

### Support tools for planning a fieldbus network

A support tool that was used in designing several of the fieldbus plants presented at the NAMUR general assembly 2004 was the fieldbus design software tool "Segment Checker". This planning tool allows a quick and easy layout of fieldbus segments by simple "drag and drop" from a device catalogue, which includes all modules necessary for fieldbus installation as well as a selection of field devices (fig. 7). Once the network dimensions and environmental parameters have been entered, the energy calculation as well as the evaluation of fault conditions and system integrity are performed automatically. The results are provided as a text file including a bill of materials and form a good basis for plant detail planning. Segment Checker can be used flexibly as it is possible to add individual field devices as well as to integrate additional field device catalogues. This software tool is available for download at [www.segmentchecker.com](http://www.segmentchecker.com).

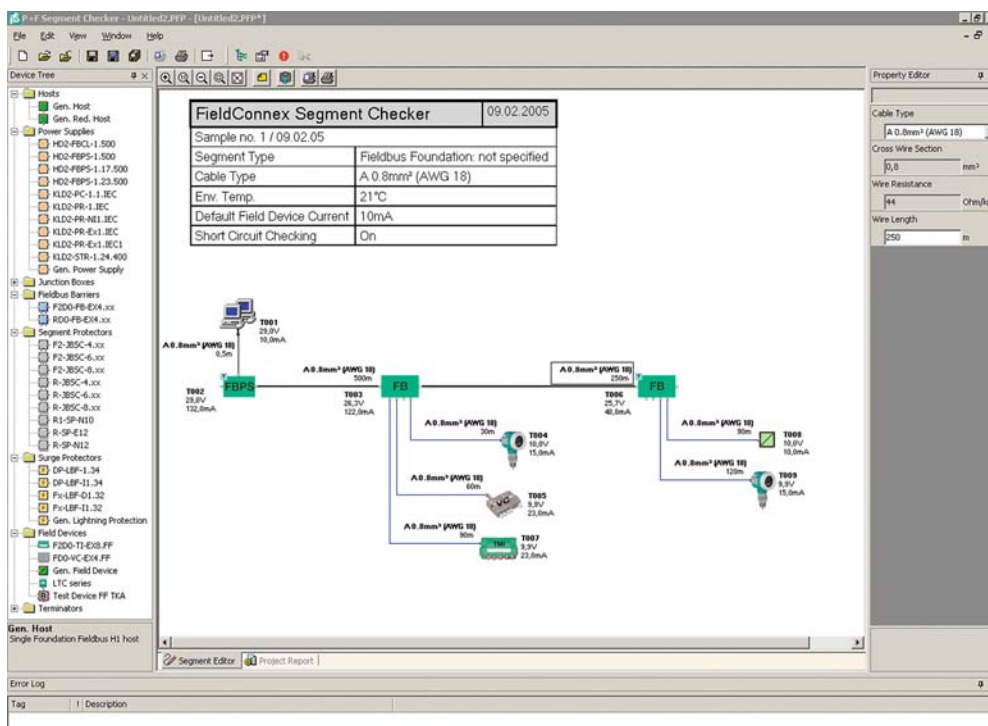


Fig. 7: Fieldbus design tool "Segment Checker"

### Perspective

The first practical experiences with extensive fieldbus applications in large-scale industry projects are encouraging. The presentations at the NAMUR general assembly concluded with the statement that fieldbus is the right path to the future. Nevertheless some requests were proposed to manufacturers and fieldbus organizations, which they are happy to take up. For example, the fieldbus barrier concept is now explicitly explained in the official Application Guide of the Fieldbus Foundation [8]. The continuing development of the High Power Trunk concepts, especially for Zone 2, as well as advanced protection and diagnostic functionalities will contribute to the growing acceptance of fieldbus technology.

## Literature

- [1] Litz, L.: The breakthrough of Fieldbus in Process Automation – do we see it now? in: FuRIOS 2 Compendium, Pepperl+Fuchs GmbH, March 2005
- [2] PROFIBUS PA User and Installation Guideline, PROFIBUS Nutzerorganisation e.V., 2003 AG-140 Rev. 1.0, Foundation Fieldbus Application Guide 31.25 kbit/s Wiring and Installation, Fieldbus Foundation, 1996
- [3] Johannsmeyer, U.: Investigations into the Intrinsic Safety of fieldbus systems, PTB report W-53e, Pysikalisch-Technische Bundesanstalt, Braunschweig 1994
- [4] Tauchnitz, T., Schmieder, W., Seintsch, S.: FuRIOS: Fieldbus and Remote I/O – a system comparison, in: atp Automatisierungstechnische Praxis 44 (2002), Edition 12
- [5] Eckert, C.: The fieldbus is finding its wings, in: MessTec & Automation 12/2004
- [6] Eichhorn, T., Pelz, M.: Fit for the future – fieldbus technology at Clariant, in: CHEManager 07/05
- [7] Schwibach, M., Meier-Künzig, T., Seintsch, S., Zobel, J.: Fieldbus Experience Reports, Presentation at the 'Association of Users of Process Control Technology' NAMUR general assembly Nov. 4th, 2004, published in: FuRIOS 2 Compendium, Pepperl+Fuchs GmbH, March 2005
- [8] AG-163 Rev. 2.0, Foundation Fieldbus Application Guide 31.25 kbit/s Intrinsically Safe Systems, Fieldbus Foundation, 2003

Thomas Kasten and  
Bernd Schüssler



Dipl.-Wirtsch.-Ing. Thomas Kasten is responsible for the product group FieldConnex® in the Marketing Department of Pepperl+Fuchs GmbH. Prior to that he held several positions outside of Germany, covering technical marketing and service. He is a member of the Marketing Working Group of the PROFIBUS User Organisation and of the European Marketing Council of the Fieldbus Foundation.

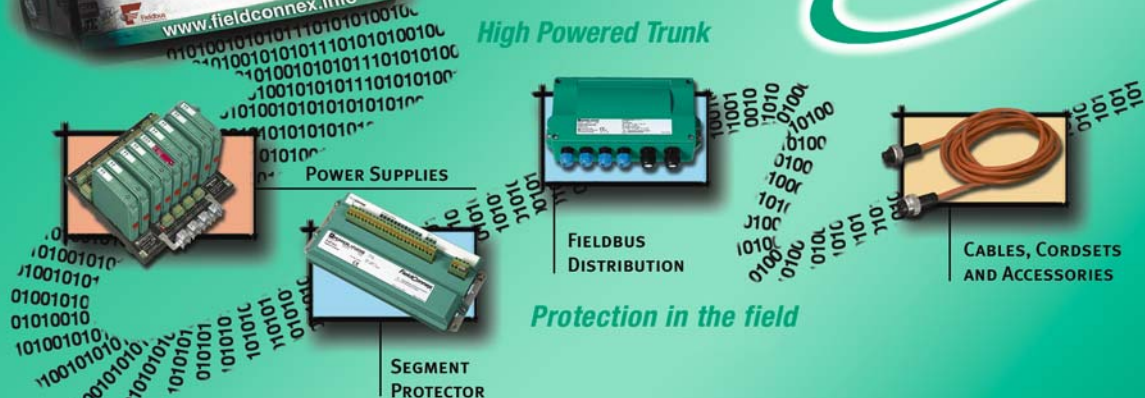
Address: Pepperl+Fuchs GmbH, Division Process Automation, Königsberger Allee 87, 68307 Mannheim, Germany, Phone: +49 (0)621 776-1415, E-mail: tkasten@de.pepperl-fuchs.com, www.fieldconnex.info



Dipl. Ing. Bernd Schüssler is Business Development Manager for the product lines Remote I/O, HART and Fieldbus at the North American headquarters of Pepperl+Fuchs in Twinsburg, Ohio. Before, he held the position of Product Manager for the product group Fieldbus components at Pepperl+Fuchs, Inc. He is an active member of the North American Marketing Council of the Fieldbus Foundation.

Address: Pepperl+Fuchs, Inc., 1600 Enterprise Parkway, Twinsburg, OH 44087, USA, Phone: +1 330-486-0002, Fax: +1 330-425-4607, E-mail: bschuessler@us.pepperl-fuchs.com

# FIELDCONNEX – CONNECTING FIELDBUS POWER AND KNOWLEDGE



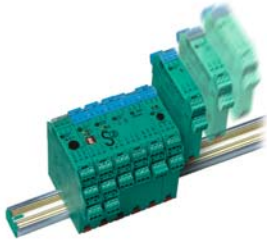
www.fieldconnex.info

**PEPPERL+FUCHS**

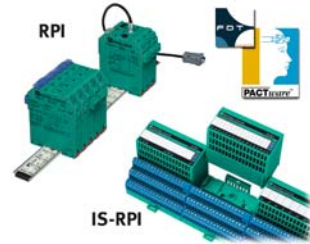
# Comprehensive Interface Technology – including sensors for level measurement



Point-to-point – single standard signal lines transmit field signals conventionally to the control system. Two systems are available for conventional instrumentation. The K-System for mounting on the support rail and the motherboard solution with plug-in modules on the system circuit board.



Point-to-bus – conventional point-to-point connections for the process and bus connections for the control system. For applications in explosion protection zone 2 the remote I/O RPI System is used, whilst for direct installation in zone 1 IS-RPI is the first choice – inclusive of HART transfer. Configuration can be carried out using the FDT-compatible **PACTware™** software with the appropriate DTMs.



Installing – connecting – protecting fieldbus systems with Bus-to-Bus technology. Fully compatible components specially developed for the demands of process technology allow you to speedily plan and commission your fieldbus system and to operate your plant safely and efficiently. FieldConnex®, the fieldbus installation technology from Pepperl+Fuchs – for PROFIBUS and Foundation Fieldbus.



Practical sensors to measure levels in liquids and solids. Sensors from Pepperl+Fuchs are widely used in the chemical and petrochemical industries, in bulk materials and waste water applications. Your application can benefit from our extensive product range.



Just mark the product groups of interest to you. We will make sure you get the information by return.

Please give me a call

**Just copy and fax it to us today!**

Please send the request material to the following address:

Company																					
Name																					
Position																					
Road/Street																					
Post Code											City										
Telephone																					
E-Mail																					

[www.pepperl-fuchs.com](http://www.pepperl-fuchs.com)

## Worldwide Headquarters

Pepperl+Fuchs GmbH · Königsberger Allee 87  
68307 Mannheim · Germany  
Tel. +49 621 776-0 · Fax +49 621 776-1000  
e-mail: [pa-info@de.pepperl-fuchs.com](mailto:pa-info@de.pepperl-fuchs.com)

## USA Headquarters

Pepperl+Fuchs Inc. · 1600 Enterprise Parkway  
Twinsburg, Ohio 44087 · Cleveland-USA  
Tel. +1 330 4253555 · Fax +1 330 4 25 46 07  
e-mail: [sales@us.pepperl-fuchs.com](mailto:sales@us.pepperl-fuchs.com)

## Asia Pacific Headquarters

Pepperl+Fuchs Pte Ltd. · P+F Building  
18 Ayer Rajah Crescent · Singapore 139942  
Tel. +65 67799091 · Fax +65 68731637  
e-mail: [sales@sg.pepperl-fuchs.com](mailto:sales@sg.pepperl-fuchs.com)



**PEPPERL+FUCHS**