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## **FOUNDATION Fieldbus offers Safety Functions and true Control in the Field**

**The Oil & Gas industry turns out to be one of the biggest user of FOUNDATION Fieldbus technology when comparing the market segments of the plant automation industry. According to recent surveys this is mainly due to the inherent diagnostic and plant asset management capabilities of fieldbus technology. Now the Fieldbus Foundation has given its technology one more mighty push with new functionalities. Safety systems running on fieldbus protocol are close to market introduction. And a decided focus on truly decentralized plant control unveils the benefits of the FOUNDATION Fieldbus-inherent Control in the Field feature.**

### **Truly decentralized plant control – Control in the Field (CIF)**

In an automated process plant the control system is collecting the measurement data from all sensors in the field, calculating the appropriate course of action and sending the actuating variables back to the field, to the valves and actuators. In modern installations the signals are transferred digitally via a fieldbus network, thus saving significant cost compared to conventional analog point-to-point connections. Hardly recognized, however, is an inherent feature of FOUNDATION Fieldbus technology, the ability to do real 'Control in the Field'. Many FOUNDATION field devices have control functionalities embedded which would allow control loops on device level, without bothering the higher-level control system. For instance, a PID function block in a valve positioner allows close control of the fluid flow rate without the need to interact with the overall control system. In such a case there is no single point of failure above the field level, even a malfunction of HMI and a loss of visibility into the process would not affect the operation of the plant. The communication in a FOUNDATION Fieldbus segment is managed by the Link Active Scheduler (LAS), an arbitrator that decides which device will have access to the network and when. Since the LAS is embedded in many field devices the communication in the segment will always continue without the need of a higher-

level 'bus master'. For maximum availability a second LAS, residing in another field device, can be configured as Backup-LAS (BLAS). The BLAS constantly monitors the communication on the network and will take over shock-free in case of malfunctions.

Recently ARC Advisory Group has published a white paper outlining 'The Business Value Proposition of Control in the Field' [1]. This paper is based on an extensive study conducted by Industrial Systems and Control Ltd. (ISC), a highly specialized automation engineering consultancy with close relationships to the renowned Industrial Control Centre at the University of Strathclyde, Scotland. ISC examined the differences in timing and sequencing between a fieldbus system using Control in the Field (CIF) versus a fieldbus system employing control in the host (DCS) to establish typical latencies and sample rates that limit control performance. The test cases included:

- Ideal Control in the Field (CIF)
- Fast control in the DCS synchronous with the fieldbus macrocycle
- Fast control in the DCS asynchronous with the fieldbus macrocycle

The test simulation scenarios covered different process dynamics, from a 'very fast', ideal liquid flow process through a 'fast' process representing a typical flow or pressure process to 'slow' process with deadtime of greater than 5 seconds. Quantified were the step response and disturbance rejection times under these various conditions. Based on these simulations ISC concluded that Control in the Field can provide improved performance in typical fast process applications. Improvements in response time of 10-30% were recorded, improvements in disturbance rejection reached up to 20%. However, due to the complex interactions of control loops in process plants even the performance of slower loops could benefit from the improvement of flow and pressure control.

Shell Global Solutions International (SGSI) has performed extensive evaluation of Control in the Field. A statement by SGSI indicated: "Control in the field using FOUNDATION fieldbus technology is recommended by SGSI for simple and cascading loops, not for complex loops. Major benefits identified by SGSI are reduced process controller loading, reduced network traffic enabling more loops per segment, as well as very fast loop response." [1]

These findings are in line with ISC who concluded that Control in the Field offers users of FOUNDATION technology a number of key performance benefits such as:

- improved control loop performance
- improved reliability and availability
- improved loop integrity
- reduced loading on DCS/PLC and data network

- lower CAPEX and installation costs
- reduced OPEX

On top of that, Control in the Field enables greater flexibility in plant automation strategies. Due to the reduced load higher-level controllers gain free capacity to handle more significant tasks such as advanced control and optimization.

ICS has identified several areas of application where Control in the Field could offer very high benefits. For instance in power generation plants CIF-control of the fuel gas supply for a pair of gas turbines could prevent tripping both turbines simultaneously. Or in compressor control CIF could allow to run compressors close to the surge line and thus operate them more efficiently without the danger of damage.

The ARC White Paper is available as free download on [www.fieldbus.org](http://www.fieldbus.org).

### **Fieldbus Safety Instrumented Functions (FF-SIF)**

A long-standing request of end users is the integration of safety-related functions into the fieldbus functionalities. Today, end users operating plants with fieldbus technology have to install two data networks in parallel, one bus network for the plant control signals and one conventional network for the SIL instrumentation of the safety system. As far back as in 2003 the NAMUR 'User Association of Process Control Technology in Chemical and Pharmaceutical Industries' published their recommendation NE 97 with the title 'fieldbus for safety-related uses' [2]. This paper discussed the options on how to integrate standard signals and safety-related signals into one digital fieldbus network. The main target was to get rid of the conventional network for the safety system and run all kinds of signals throughout the plant over one single physical layer infrastructure. Based on this recommendation both major fieldbus associations, PROFIBUS and Fieldbus Foundation, enhanced their bus protocols with features to allow transmission of highly sensible safety signals. The final specifications of FOUNDATION Fieldbus Safety Instrumented Functions (FF-SIF) were released in January 2009. Prior to that the Fieldbus Foundation conducted an extensive testing and demonstration project including test installations at Saudi Aramco in Dharan, Shell Global Solutions in Amsterdam, Chevron in Houston, TX, and BP Gelsenkirchen in Germany (Fig. 1). As a result training guidelines, installation best practices and interoperability test kits are already available, even if the first SIL-rated fieldbus field devices are expected to appear on the market not before 2010 [3].

Looking at data integrity, today many users of software tools still have their doubts on the safety and reliability of the data transmission. On the other hand, online-banking and conducting of sensible business processes over Internet are on the upswing. Clever software

security algorithms make sure a data signal reaches its destination without disturbance. Or, in case the data is damaged, the recipient realizes it immediately and initiates appropriate safety measures. These algorithms have been written into a dedicated safety protocol stack which is added to the application layer 7 of the fieldbus protocol. That safety protocol stack is according to IEC 61508, covers Safety Integrity Level (SIL) 3 and had been approved by the German TUV in 2006. Fieldbus devices with integrated safety stack can now communicate with the safety-DCS without fear of data errors, thus allowing a fully digital fieldbus safety system up to SIL 3. And the beauty of it – the signals run over the same data network as the standard process control signals, thus omitting the need for a safety wiring system in parallel. The transmission of the process control signals has no influence on the safety functions. Even more, the Fieldbus Foundation added some specific diagnostic function blocks to their safety stack which can be used to detect critical situations in the process and react accordingly without human interference.

SIL assessment for a conventional analog safety system covers the complete loop including one field device, control system and corresponding electrical equipment such as intrinsically safety barriers. For a fieldbus segment connecting several field instruments, some of them process control, some of them safety-related, this would be a rather complex process. Luckily the passive physical layer components, such as cables, wiring blocks and fieldbus power supplies, do not need to be included in a SIL calculation. Similar to a conventional system in which a cable fault is securely detected due to the 4...20mA or quiescent current principle, a fault in the passive physical layer is securely detected by the safety protocol. As such the passive fieldbus infrastructure is perceived as 'black channel' (Fig. 2). The safety-related field devices, however, do require SIL ratings. To certify all necessary devices in both fieldbus variants PROFIBUS PA and FOUNDATION Fieldbus H1 would be a very costly process for both manufacturers and users. To minimize this expenditure NE 97 proposes to virtually split a device in three functional units. The sensors and actuators are identical to existing 4...20mA or HART devices which are either SIL-rated or proven-in-use. The safety protocol stack which ensures a secure communication is certified according to IEC 61508. So it remains in the responsibility of the device manufacturer to implement a secure bus connection. NAMUR takes it one step further and proposes to have a secure switch in the device to activate the safety protocol. Thus the identical type of device could be used for safety-related and non-safety-related systems. The prototype devices used in the FOUNDATION Fieldbus demo project followed these recommendations, the first beta-version devices are appearing on the market today.

Looking at the physical layer topology the best option would be to run independent segments in redundancy, closely following the installation guidelines for fieldbus networks [4] and

safety systems (Fig. 3). However, even if the physical layer as 'black channel' cannot lead to dangerous situations a bad fieldbus infrastructure can seriously impair the operation of the plant. Irradiation of external noise due to bad shielding, faulty installation and even deteriorations over the live span of the plant can alter signals to such an extent that the safety stack might recognize a dangerous fault and shut down the production process. Consequently an appropriate fieldbus installation has to provide all possible means, such as isolation, diagnostic and redundancy options, to secure a highly reliable signal transmission. Comprehensive fieldbus infrastructure systems such as FieldConnex<sup>®</sup> by Pepperl+Fuchs offer these options and, even more, provide 'advanced diagnostics' for real-time and online monitoring of the wiring network. Quality loss of the digital signals, noise irradiation and cabling faults can be located exactly and immediately, integrated oscilloscope functions allow analysis of individual fieldbus signals. By means of triggers and trend analysis even minute ageing influences can be detected in time to allow preventive measures. For maximum convenience of the plant operator these alarms can be integrated in some of the major DCS systems [5]. Thus modern fieldbus infrastructure systems optimize the 'black channel' to ensure maximum availability and reliability of the safety-related fieldbus.

In order to combine these requirements for safety systems with the power supply of field devices in explosion hazardous areas the so-called High-Power Trunk concept is strongly recommended [6]. This concept follows the trunk-and-spur topology and is based on a combination of two explosion protection methods. The field devices in the hazardous area Zone 1 / Class I, Div. 1 are connected intrinsically safe Ex ia to the junction boxes, thus allowing maintenance and repair work without hot work permit. The trunk connecting the several junction boxes, however, is according to the protection type 'Increased Safety' Ex e, and allows to lead a high supply current into the hazardous area in order to supply the multitude of field devices on one segment. The conversion from Ex e to Ex ia is executed by specific junction boxes, commonly called fieldbus barriers [4]. Some variants, such as the FieldBarrier of the FieldConnex system, offer additionally short-circuit protection for each spur and allow for capacitive grounding. For Zone 2 / Class I, Div. 2 Segment Protectors offer similar features, the field devices are connected according to protection type Ex ic, formerly Ex nL [7]. The increased safety trunk runs to the Fieldbus Power Supplies which combine the digital fieldbus signal of the DCS with the DC supply power from the bulk power supplies. Here so-called Power Hubs offer a huge flexibility in terms of redundancy, isolation options, diagnostics and number of fieldbus segments (Fig. 4).

## **Conclusion**

With the introduction of FF-Safety Instrumented Functions and the new focus on FF-Control in the Field operators and planners of automated process plants have powerful tools to

further increase plant efficiency and reduce CAPEX and OPEX. FOUNDATION Fieldbus offers benefits in the three key areas Process Integrity, Business Intelligence and Open, Scalable Integration, thus enabling the end users of process automation technology to increase their revenues and profits.

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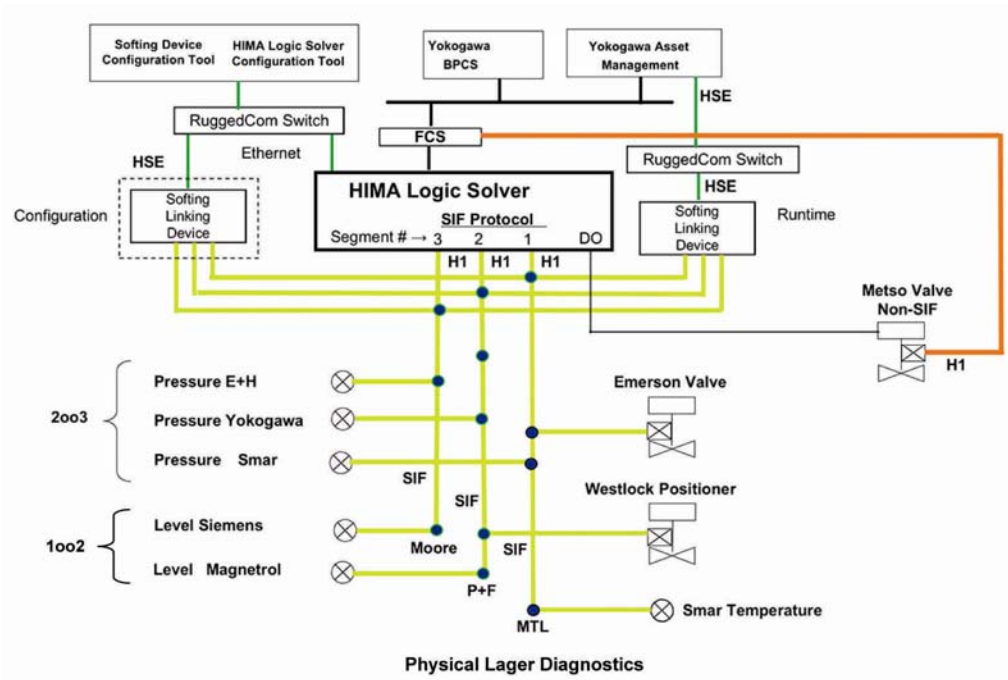


Fig. 1: Typical FF-SIF plant structure at the demo sites

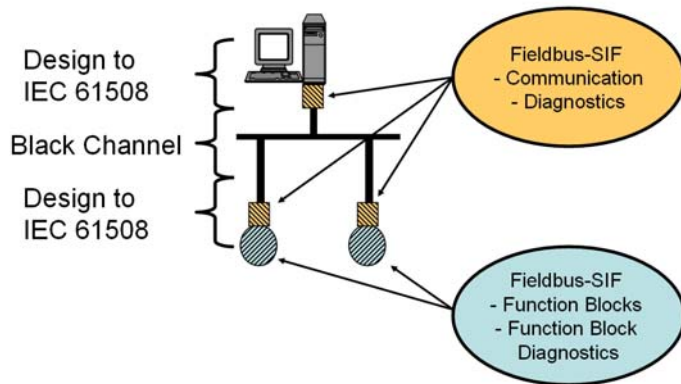


Fig. 2: FF-SIF protocol enhancements

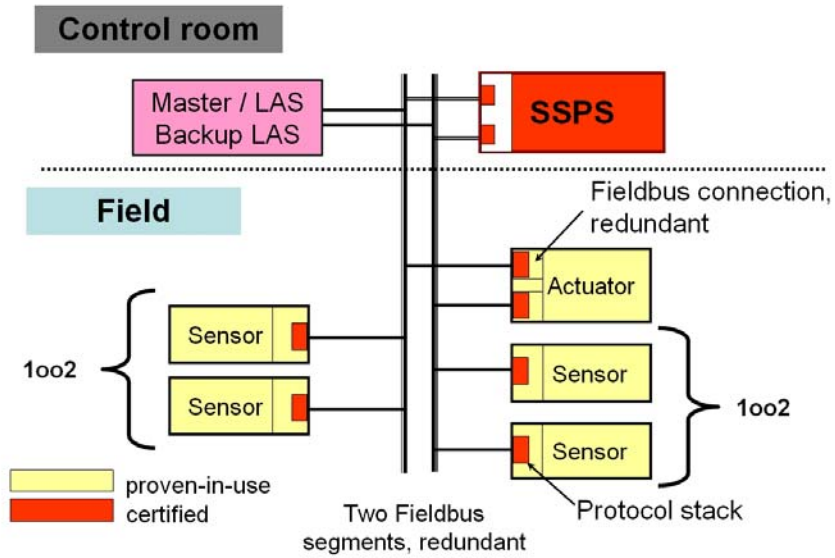


Fig. 3: Optimum physical layer topology for safety-related fieldbus

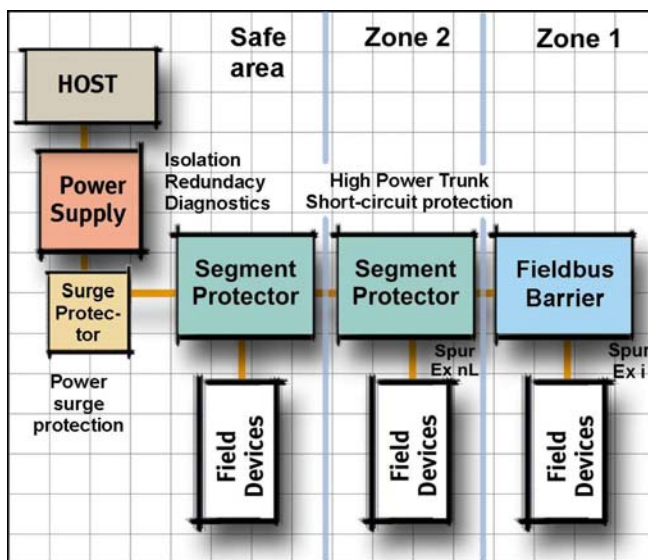


Fig. 4: High-Power Trunk topology with safety options