# TRUNKGUARD® Solution Optimizes Fieldbus Installation At Greenfield Ethanol Plant

**By Tim Wilson and Jeff Marsh**

Like other process industry operations, bio-fuel production plants seek state-of-the-art automation technology in order to reduce raw material costs, increase yields, comply with regulatory standards and maximize revenues. However, plant managers must ensure control systems provide reliable operation and a low cost of ownership over the life of installed assets.

Although modern, fieldbus-based process control systems offer many operational benefits, ethanol producers need effective measures protecting the fieldbus physical layer against short circuits, improper termination and other problems that can adversely affect system performance and reliability. They also need solutions enabling a quick ramp-up from installation to operation of the control system in order to improve their time to market.

## Background

Industrialized nations dependent on other countries for fossil fuels have been severely impacted by declining oil reserves, coupled with an uncertain worldwide economic and political outlook. As a result, the U.S. government, along with leading energy producers, is ramping up support for alternative energy sources.

Despite the rising demand for bio-fuels, the profitability equation for the ethanol industry is negatively impacted by inefficiencies in production processes. An individual ethanol producer has little influence on the market price it receives for the product it ships, and little control over the price of feedstock and natural gas. What ethanol producers can do – must do – is tightly control their own plant operations, and thereby produce consistently high yield, while minimizing the consumption of energy and raw materials (See Fig. 1).

**Figure 1.** Achieving consistent profitability can be a tough challenge for bio-fuel producers. To ensure business success, ethanol plants must tightly control their production processes.

## Greenfield Plant Project

In February 2007, Abengoa Bioenergy Corporation commissioned a Greenfield ethanol production plant in Ravenna, Nebraska. Construction took place on the site where Abengoa built its original pilot plant in 2004. The Ravenna facility has an ethanol production capacity of 88 million gallons per year (MGY) and is one of the largest dry mill ethanol plants in the U.S.

Abengoa Bioenergy has more than 340 MGY of total installed capacity worldwide. In addition to the Ravenna site, the company operates ethanol facilities in Colwich, Kansas; York, Nebraska; and Portales, New Mexico. Its parent corporation, Abengoa Bioenergy, S.A. is one of the world's leading bio-fuels manufacturers and the largest ethanol producer in Europe.

In Abengoa's dry mill process, corn starch is hydrolyzed into sugar and then fermented into alcohol. The major steps in the dry mill operation are: milling, liquefaction, saccharification, fermentation, distillation, dehydration and denaturing (See Fig. 2).

***Figure 2.** Abengoa Bioenergy Corporation's Greenfield production plant in Ravenna, Nebraska, utilizes a dry mill process to produce ethanol from corn starch.*

When launching its ethanol plant project in late 2006, Abengoa Bioenergy enlisted Fru-Con, a large industrial engineering firm, to handle plant design, project planning, procurement and construction. FeedForward, Inc., a control systems integrator serving the processing industries, was awarded the contract for control system design and installation.

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Abengoa challenged its project team to achieve the lowest total cost of plant ownership through automation and integration from an operational and maintenance standpoint. Plant optimization required a state-of-the-art automation architecture connecting "smart" field instrumentation into a Distributed Control System (DCS) using digital networks with a high degree of diagnostics and troubleshooting information.

With the right automation technology, Abengoa could reduce the number of people involved in controlling and maintaining the ethanol plant, while at the same time, optimizing production by minimizing downtime and maximizing margins.

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## Control System Technology

After considering alternative solutions for plant enterprise automation, Abengoa decided upon Yokogawa's CENTUM CS3000 DCS. This system enables true distributed control throughout the ethanol plant. It distributes control strategies to field instruments, enables flexible device networking, and allows free access to the process and devices by system software.

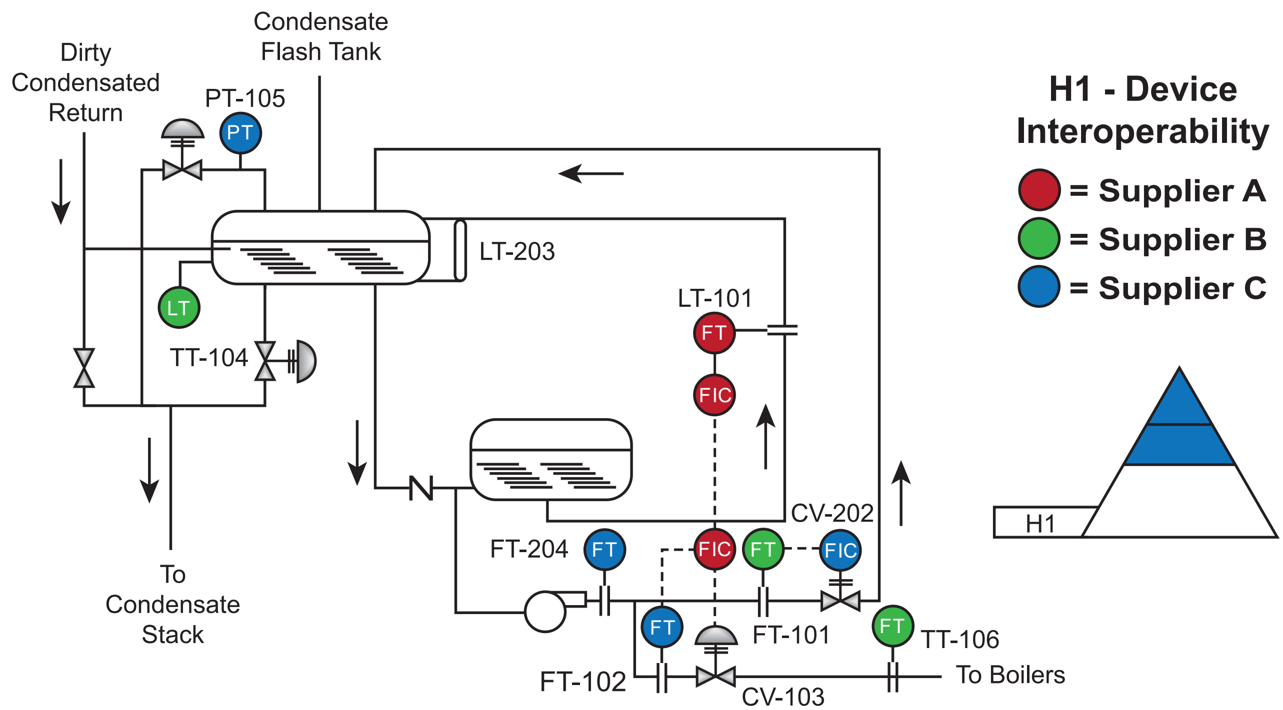
The Yokogawa DCS takes full advantage of open, digital network standards to provide a secure control platform for the future. The system employs the FOUNDATION fieldbus H1 protocol for use with analog devices, and AS-i bus with a Profibus-DP gateway for all motor control centers (MCCs). The major advantage of fieldbus technology, and the one most attractive to end users, is its reduction of capital expenses (CAPEX) and operating expenses (OPEX) through reduced wiring and greater information availability from field instruments. Remote configuration and asset management are two further benefits of fieldbus installations in process plants.

FOUNDATION fieldbus is an all-digital, two-way communications system interconnecting interoperable field equipment from different suppliers, such as sensors, actuators and controllers, on a single network. The fieldbus system infrastructure reduces the amount and complexity of wiring throughout a plant (See Fig. 3).

FOUNDATION fieldbus also transmits multiple variables, enabling a reduction in process variability as well as device identification information. The technology allows collection and transmission of robust instrument diagnostics, thus reducing unnecessary shutdowns and improving safety and regulatory compliance.

For motor control centers, Profibus-DP offers simplified control, increased diagnostics and reduced cabling. The Profibus network allows centralized control to be connected to widely distributed I/O as part of the MCC. Profibus cabling functions as a replacement for the bundles of hardwiring typically interconnecting operating units. Functionally, each MCC device connected to the system becomes a node on the network.

**Figure 3.** FOUNDATION fieldbus is an all-digital, two-way communications system interconnecting plant field equipment.



## Fieldbus Design Considerations

Many process plants are embarking on real fieldbus applications for the first time. Fieldbus is a truly enabling technology, but its installation involves some additional considerations over and above traditional 4-20 mA systems. Upfront engineering is key to the success of any fieldbus project, and end-users must be mindful of physical layer requirements such as power conditioning, segment termination, etc.

Without correct connection of wiring and field devices, any anticipated ROI from fieldbus technology can be wiped out as technical complications can delay setting up a plant and take a long time to recoup in operational savings.

It has been estimated that wiring malfunctions are responsible for about 90 percent of the challenges on fieldbus projects; the biggest causes of performance and reliability problems are bad termination, short-circuits, interference and inadequate earthing. Under/over termination, in particular, can be a significant issue during plant startup and commissioning. Simply put, technicians sometimes set segment terminators incorrectly for a given installation.

All fieldbus segments need proper termination to prevent communication errors through uncontrolled signal reflections. In some cases, multiple terminators are placed on an individual segment—creating major complications on large installations. Physical inspection of junction boxes and field enclosures is often the only way to locate and correct the terminator position, which is a significant delay to the commissioning process.

Short-circuits are another common problem in fieldbus installations. Maintenance technicians can jostle cables, corrosion can weaken connections, and vibration from pumps and motors can loosen cables and connectors. Plant operators must be concerned about what might happen to an entire fieldbus segment if any single instrument shorts out.

Engineers designing fieldbus systems are faced with incorporating some form of spur short-circuit protection, which may be either active or passive in design. A “current limiting” approach, employed by many conventional fieldbus device couplers, restricts the amount of power short-circuits can draw to between 40 and 90 mA. However, it also holds the fault on the segment continuously. The additional current draw can deprive other instruments on the segment of power, overload the segment power supply, and cause an entire segment to have a catastrophic failure.

For example, a segment may have 10 measuring devices plus two valves connected via 1000 m of 50 Ohm nominal cable. In this case, the trunk voltage drop equals 12.5 V, which allows 12.5 V at the farthest device. However, if a short occurs at a spur and an additional 60 mA load is “locked in” to the segment, this takes away enough power so that devices receive less than 9 V, and some will drop off the segment. If two shorts occur, all the devices could drop off, and an entire process unit might go down.

## Physical Layer Solution

Industrial plants can avoid many fieldbus physical layer problems from the beginning, simply by specifying the latest generation of device couplers with automatic segment terminators and short-circuit protection. These devices simplify fieldbus installation and significantly reduce the time required to install and troubleshoot devices in the field.

The new breed of fieldbus device couplers greatly assist in segment commissioning by eliminating errors associated with manual termination, including failures resulting from over/under termination. They also address the problem of excess current on a fieldbus spur; rather than limiting the fault current to a fixed (and always higher) level, the spur current is switched to a nominal trickle-level. With removal of the short, the spur is automatically reconnected to the fieldbus segment.

On Abengoa’s Greenfield plant project, FeedForward, acting as control system designer, installed the MooreHawke TRUNKGUARD system—the first FOUNDATION fieldbus and Profibus physical layer solution providing fully automatic fieldbus segment termination. The control system architecture incorporated 72 individual fieldbus segments with over 650 nodes. The device segments were installed utilizing MooreHawke field device couplers, redundant fieldbus power supplies and segment power conditioners (See Fig. 4).

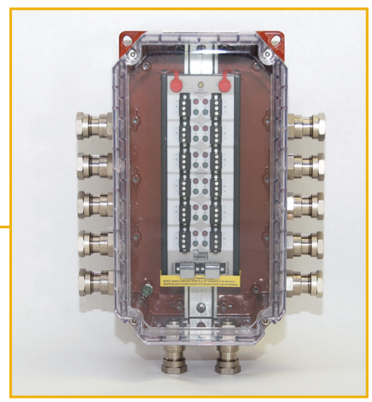
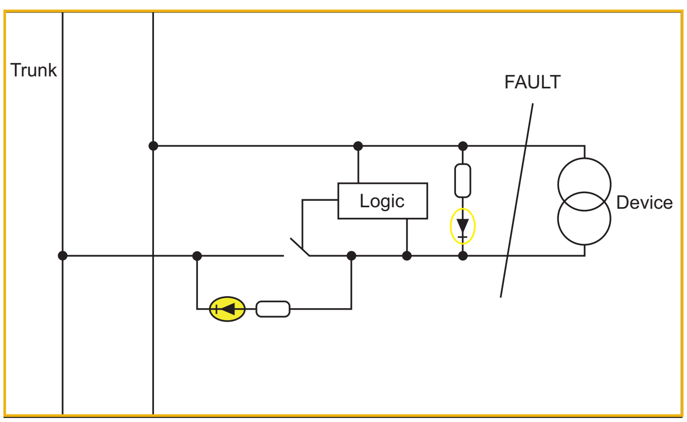


**Figure 4.** On Abengoa’s Greenfield plant project, TRUNKGUARD device couplers provided fully automatic fieldbus segment termination.

Unlike the older current limiting technique, TRUNKGUARD's short-circuit protection method prevents segment failure caused by single device faults. Its unique "fold-back" technique automatically removes the faulted device from the segment, and does not permit any current flow to the device until the fault is corrected. The fold-back technique employs a logic circuit on each spur, which detects a short in an instrument, disconnects that spur from the segment, and illuminates an LED visible to maintenance personnel.

The auto-termination capability assures local parts of a segment will continue to function even if remote parts of the segment are accidentally disconnected, preventing costly downtime and hazardous situations—a matter of critical concern in both process and discrete manufacturing. Segment termination automatically activates when the device coupler determines it is the last fieldbus junction device in the segment; if it is, it terminates the segment at the proper coupler. If it is not the last device, it does not terminate the segment, since the downstream device coupler will assume that responsibility. No action—such as setting DIP switches—is necessary to terminate a segment properly.

**Figure 5.** *Device couplers utilizing "fold-back" active spur protection automatically remove the faulted device from the segment, and do not permit any current flow to the device until the fault is corrected.*




Tests by Evaluation International, an independent instrumentation testing and evaluation service, confirm the advantages of the fold-back technique: When a spur is short-circuited, segment voltage actually increases, because the device coupler removes the shorted device from the segment. This means multiple short circuits on a segment cannot deprive other instruments of power and cause a complete segment failure, as with conventional device couplers (See Fig. 5).

With fold-back device couplers, users are also free to place more devices on fieldbus segments. A large industrial process operation may have hundreds if not thousands of devices. If the "safety margin" approach is implemented, where the entire capability of fieldbus is not used, the cost of all the extra fieldbus segments can become substantial.

## End User Benefits

For Abengoa Bioenergy, the fieldbus-based DCS employing TRUNKGUARD technology will deliver long-term competitive benefits. Fieldbus provided a "leaner" automation architecture containing less wiring and hardware than a traditional control system. Loop and wiring diagrams, panel drawings and cable schedules were greatly simplified. Plus, installation was easier than with a traditional system since several devices could be multi-dropped on a single pair of wires.

The flexibility of the fieldbus architecture also allows the Ravenna plant to reconfigure its process automation scheme to meet product and sales demands without major reinvestments. It reduces I/O subsystem requirements and makes the plant control system very scalable. The system can be expanded or modified loop-by-loop as needed.

Thanks to the fold-back device couplers, which do not allow any excess current per spur under fault conditions, FeedForward's control system designers were free to configure fieldbus segments at their maximum capacity. Unlike the current limiting approach, which places additional load on the fieldbus segment upon detecting a short, the fold-back technique removes the failed device from the segment and utilizes a "trickle current" to determine when the short is eliminated. This, in turn, enables voltage on the segment to actually increase—minimizing the possibility of other devices dropping off the network.

The TRUNKGUARD solution also expedited unit startup at the Abengoa facility by providing increased fieldbus status information. Green and red LEDs on device couplers helped technicians determine if there was proper voltage on the fieldbus spurs. The indicator lights also showed whether terminators had been applied at specific device couplers.

## Lessons Learned

Abengoa's Greenfield ethanol plant project provided valuable insights for process industry end users installing their first fieldbus control systems. Engineers face new challenges when designing fieldbus segments, which potentially can be brought down by a single short. For most process plants, this is unacceptable; they cannot afford an unexpected shutdown that would immediately affect their bottom line (See Fig. 6).

**Figure 6.** *Abengoa's Greenfield ethanol plant project provided valuable insights for process industry end users installing their first fieldbus control systems.*

Specific "lessons learned" from the Abengoa project include:

1. Don't become confused by the choice of fieldbus technologies. Rather, choose a solution that provides a satisfactory and functional control system for your particular application. In continuous operation process plants, FOUNDATION fieldbus and Profibus-PA are the dominant fieldbus protocols. Most installations will use multiple fieldbusses to accomplish the many tasks required.

2. FOUNDATION fieldbus and Profibus systems carry both DC power and the digital communications signal on the same wire pair. Thus, the segment power supply requires low pass "conditioning" to filter out that signal. This conditioning may be "active" (notch filters, etc.) or "passive" (series inductance).

3. Terminators are required at each end of the segment cable to prevent line reflection, which may otherwise result from open-ended cables, and also to source/sink the communications current. Careful number of terminators is essential, or the issue can be completely avoided by using device couplers that automatically provide correct signal termination.

4. Short-circuit faults on individual spurs will drag down the entire fieldbus segment. Hence, device couplers need to incorporate some form of spur short-circuit protection, which again may be active or passive in design. The best approach is auto-setting fold-back overcurrent protection, where any faulty spur is switched off and that load completely removed from the segment. This approach also allows system designers to use the maximum available power supply capacity without worrying about "headroom."

5. Do not ground the shield in the field. This can result in unnecessary complications and noise issues. Instead of grounding in multiple locations using a capacitive technique, installers should ground the bus one time only at the power conditioner level.

## Conclusion

Thanks to a well-engineered fieldbus automation solution, Abengoa's Ravenna, Nebraska, ethanol production facility has achieved optimal process operating conditions that increase yields, while also cutting the amount of energy needed per gallon of ethanol produced.

Abengoa ensured the fieldbus installation was simple, practical and reliable by utilizing the TRUNKGUARD physical layer solution. On its Greenfield plant project, these innovative fieldbus device couplers spelled the difference between quick up-time and low maintenance, versus delayed start-up and frequent downtime.

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