

## ARC WHITE PAPER

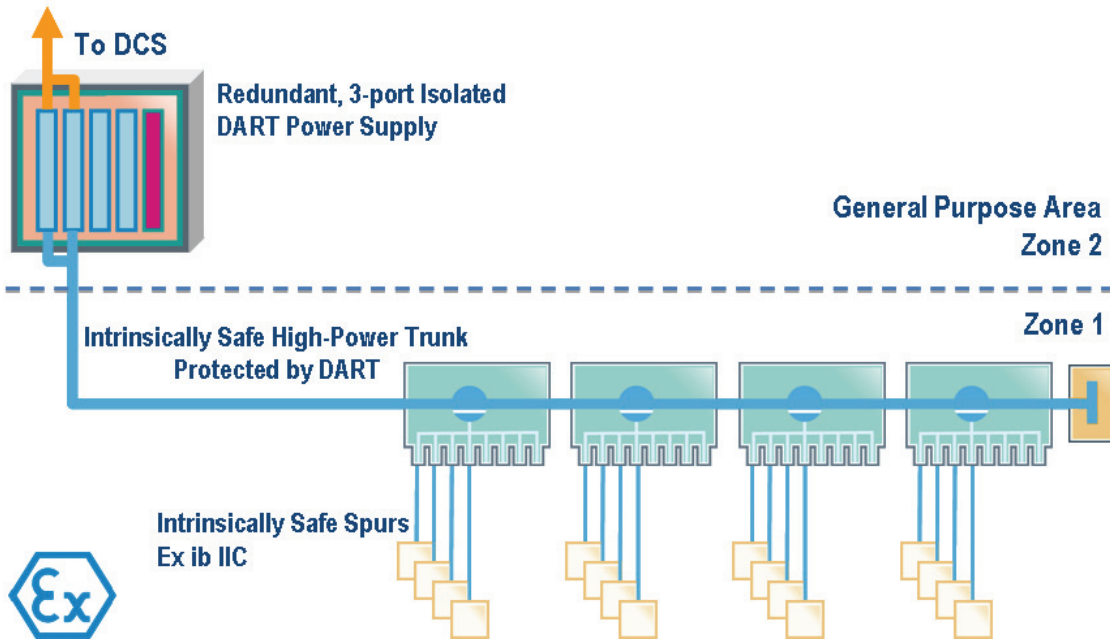
By ARC Advisory Group

FEBRUARY 2011

### **DART Ushers in the Next Generation of Intrinsic Safety**

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**The DART Concept Allows Much Higher Power Levels and Device Counts in Hazardous Areas Compared to FISCO**

	<b>FISCO</b>	<b>DART</b>	<b>HPTC</b>
<b>Hazardous Area</b>	Zone 0...1/ Div. 1	Zone 1	Zone 0...1/ Div. 1...2
<b>Gas Group</b>	IIC	IIC	IIC
<b>Output Power</b>	1.26 Watts	8 Watts	14 Watts
<b>Output Values</b>	12.6 V / 100 mA	22.4 V / 360 mA	28 V / 500 mA
<b>Cable Length</b>	Short	Medium	Long
<b>Device Count</b>	Small	Medium	Large

**Intrinsically Safe Fieldbus Evolution:  
Comparing Parameters**

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## Executive Overview

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Investments in process equipment typically have the longest lifecycles of any industrial assets. When the payback period is over, process systems can be operated for many years at a high profit if they are maintained well. In the process industries, fieldbus technologies have helped many process users to manage their assets intelligently based on the wealth of information that smart field devices can deliver. However, fieldbus in hazardous areas requires particular attention with regards to

The primary benefit of intrinsic safety is to allow the operation of automation equipment in hazardous environments with hot work permitted during operation.

explosion protection. Here, power restrictions on equipment that limit the network device-count can make some installations cumbersome or difficult to realize.

Since the advent of intrinsic safety (and later fieldbus), several concepts have addressed this problem with incremental success. Now, a new concept -- Dynamic Arc Recognition and Termination (DART) -- has eliminated the power problem while maintaining intrinsically safe energy levels of power supply, installation components down to the device with a new approach to energy limitation. The concept allows for considerably higher direct power, while ensuring intrinsically safe energy requirements via rapid disconnection.

DART systems supply enough power to support nearly as many devices as are typically applied in non-hazardous areas. In addition, DART can also power field instruments that previously needed more power than intrinsically safe solutions could offer. Thanks to DART, process users can now take full advantage of the many benefits of fieldbus technology, such as ensuring system availability and, ultimately, lowering total cost of ownership.

## Business Goals Drive Improvements in Intrinsically Safe Fieldbus

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The recent global economic downturn leaves the manufacturing industries with a host of challenges to overcome. As recovery sets in, global competition intensifies, forcing companies to continue managing costs through operational excellence while justifying capital investments. In the process industries, this means deploying technologies that maximize the availability of mission-critical systems.

Oil & gas, chemicals, and other process industries often deploy automation equipment in hazardous areas where equipment operates in the

presence of explosive gases or dust. To ensure safe operation in hazardous areas, automation systems are typically designed to be intrinsically safe. Intrinsic safety (IS) is usually achieved by limiting the available power to keep electrical energy below a level that can cause ignition by sparking or heating effects. This can be validated with an assessment of the safety parameters of the power source, the supplied devices, and the connecting cable. IS is the safest method of explosion protection, but its downside is the inherent limit in power (typically less than two watts).

#### Pro

- Technology enhancements
- Predictive maintenance strategies
- Remote configuration
- Optimized asset effectiveness
- Legacy system replacement

#### Con

- Risk aversion of end-users
- Lack of single fieldbus standard
- Unrealized initial savings
- Training issues
- OpEx vs. CapEx savings
- Limited value to EPCs

#### Arguments For and Against Fieldbus

with more power supplied to the fieldbus segment while maintaining IS at the device connection. HPTC initiated the break-through of fieldbus in process automation. These concepts are described in detail in the next section.

#### Entity

Introduced in the 1980s, the Entity concept defined intrinsic safety requirements for fieldbus, typically by limiting power of all components in the loop, for example, to 1.2 watts for gas group IIC applications. While this conservative calculation satisfied IS requirements, the allowed current of 70 to 100 mA limited its practical use as only two to three devices per segment could be connected. The result was that few products were developed and Entity never became popular with end users.

In addition to these limitations, validating intrinsic safety with Entity burdens the end user with tedious calculations. Another limiting factor was the high initial cost of this technology, including double or triple redundant circuits for current limitation and constant voltage together with galvanic isolations.

#### The Evolution of IS Fieldbus

Early solutions for intrinsic safety, such as the Entity concept and FISCO, provided the first methods for connecting multiple devices to a single power supply or fieldbus segment. The low power available limits the number of devices per segment and reachable cable distance, forcing users to design complex bus topologies with many branches and making fieldbus more difficult to cost-justify.

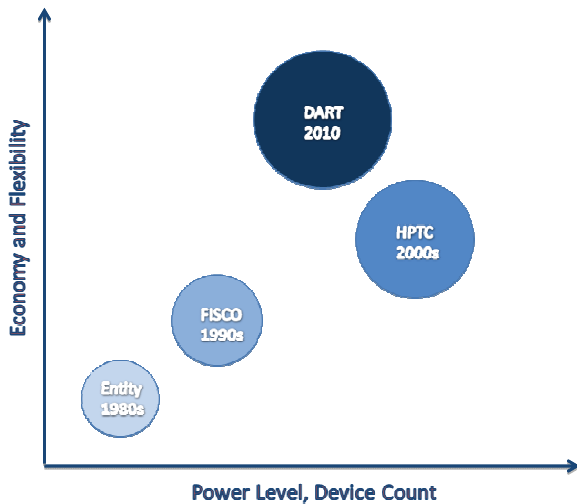
Later, the High-Power Trunk Concept (HPTC) provided safe installation in explosive environments for junction boxes and a trunk line

## FISCO

As fieldbus became more popular in process applications in the 1990s, the Fieldbus Intrinsically Safe Concept (FISCO) and the related FNICO<sup>1</sup> sought to enhance the Entity concept by simplifying system calculations and allowing more power, and therefore more devices, on the wire.

With FISCO, only one power supply is permitted per fieldbus segment. All other devices are considered to be power drains and equipped with measures to prevent unintentional power feedback to the cable. FISCO places restrictions on cables and devices relative to parasitic capacity and inductance. While field devices require certification from an approval body, manufacturers can document cable compliance with a simple declaration.

FISCO offers cost-savings over earlier validation methods. A FISCO-compliant fieldbus system consists of a power supply and a number of transmitters with a special type of cable and termination devices. Up to ten devices can be connected per segment, but this limits the cable length. If the devices meet the FISCO requirements and the output parameters of the power supply, no further calculations are necessary. Validating intrinsic safety only requires that end users document the FISCO compliance of the hardware used, thus saving them time and money.



**The Evolution of Intrinsically Safe Fieldbus Technology**

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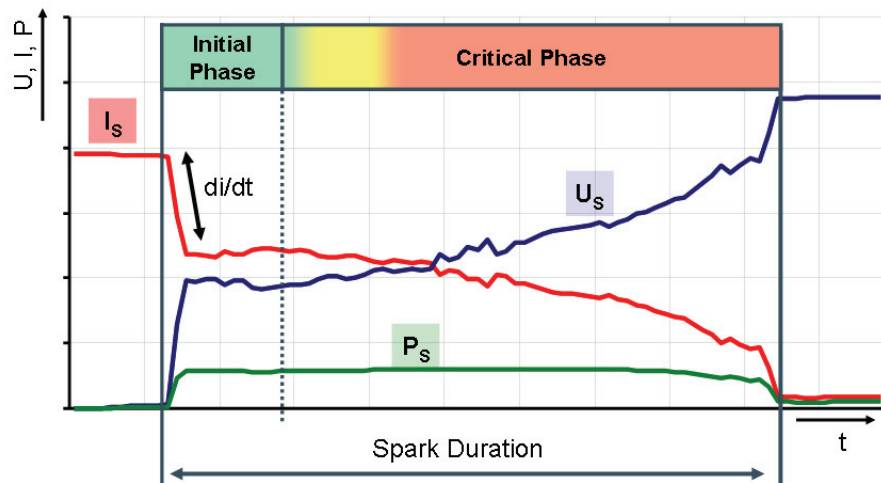
## The High-Power Trunk Concept

The High-Power Trunk Concept provides more power to the segment, therefore requiring “protected installation” for the trunk cable (e.g. armored cable or duct) due to the high level of power. Devices are connected to the trunk-line via IS barriers located in the field that reduce the power to intrinsically safe levels. However, this requires that a fieldbus be installed with two different explosion protection methods – something not all customers are willing to accept. Nonetheless, this clever combination of methods for explosion protection paved the way for the break-through of fieldbus in hazardous areas.

<sup>1</sup> Fieldbus Non-Incendive Concept for Class 1, Zone 2 or Class 1, Div 2

## DART: A Dynamic Approach to Intrinsic Safety

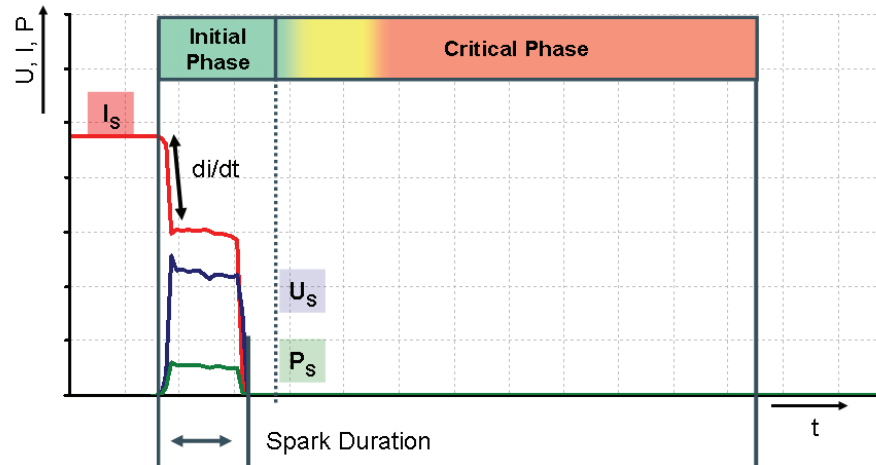
The next revolutionary step, Dynamic Arc Recognition and Termination (DART), eliminates the *power* problem of intrinsic safety with a completely new approach to *energy* limitation. The concept allows for considerably higher direct power, while maintaining limitations on intrinsically safe energy via rapid disconnection.



**The Electrical Characteristics of a Spark.**

Explosions of hazardous gases can be triggered by sparking in the wiring of automation systems operating in hazardous areas. Sparks typically occur when a contact is made or broken, which ordinarily happens during maintenance work. If enough energy is present in the wiring, an explosion occurs. Rather than taking the traditional approach of limiting this energy by limiting available power, the DART concept detects a fault condition by its characteristic rate of change of current and disconnects power before sparking can start.

In normal operation, a DART-compliant power supply feeds the full nominal power of 8 to 50 watts. This is many times greater than the normally permissible level of about two watts for intrinsic safety. Should a fault occur, for example due to a wire break or disconnect, the potential spark 'slowly' heats up, but remains non-incendive during the initial phase.



**DART Monitors the Characteristic Current Drop ( $di/dt$ ) and Switches Off Power Before the Critical Phase is Reached.**

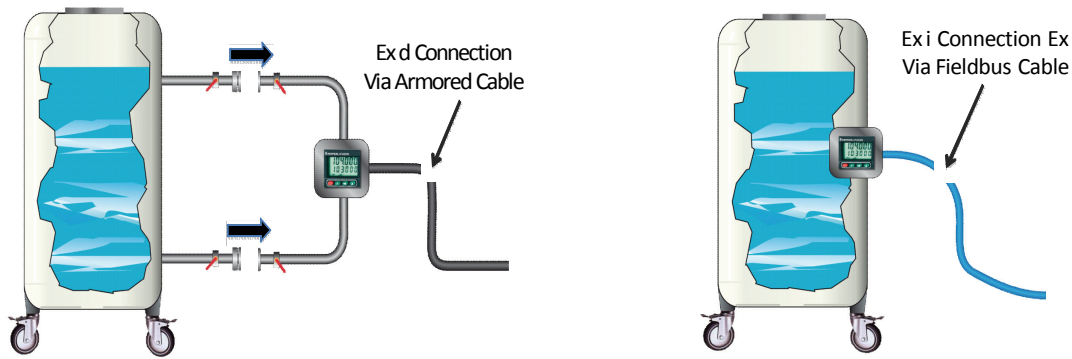
DART detects the resulting change in current  $di/dt$  and immediately switches off the power supply. Within only a few microseconds, the energy from the electrical system is reduced to a safe level, robbing a spark of the energy needed to ignite hazardous gasses. Fortunately, the change in current  $di/dt$  is highly characteristic, so monitoring this makes such faults easily detectable.

### DART Application Example

The following example illustrates how DART technology can be used to deliver power to a device in a potentially hazardous area despite intrinsic safety limitations. In this example, a measuring device attached to a bypass pipe monitors product parameters of a liquid in a tank such as the pH value. To take a measurement, the tank is connected temporarily to the bypass to allow a sample of the liquid to pass through the measuring device. After the measurement, the bypass is removed and then cleaned before the next use.

To power the device within the hazardous environment requires a “protected installation”, meaning that the power cable must be protected against influences that could cause a fault leading to a spark. These influences include mechanical or chemical damage, corrosion, or high temperatures.

While this method ensures compliance with explosion protection requirements ‘flameproof enclosure’, the use of the bypass pipe may lead to other problems such as leaks or the introduction of contaminants that may distort the process. Additionally it causes significant costs of cleaning or hygiene.



**A Protected Installation Using An Armored Cable To Ensure Explosion Protection.**

**The Same Installation Using a DART-Compliant Power Supply And an Intrinsically Safe Cable.**

With DART technology, the measuring device can be placed inside the tank -- “inline” with the process. In place of a mechanically robust cable, an intrinsically safe cable connects the device to a DART-compliant power supply. Should a wire fault occur, the power supply recognizes the situation and cuts off power to the device long before the spark can ignite. This solution eliminates the need for the bypass pipe and the armored cable, helping to reduce upfront capital costs and to lower operating costs.

## Technical Advantages of DART Applied: DART Fieldbus

As the above example shows the DART concept offers many technical advantages over its predecessors, but the largest benefit is economic.

Intrinsically safe protection of entire segment, including trunkline

Power supply redundancy

Support for existing intrinsically safe devices

Continuous advanced physical layer diagnostics

cable lengths to 1000m - long enough for most applications

Simple verification of IS during planning of each segment

### DART Fieldbus Advantages

DART applied to fieldbus provides a much higher intrinsically safe power allowance to the trunk so that the segment can support up to about 32 devices per segment – the maximum permitted per segment. This reduces capital costs by eliminating excessive fieldbus infrastructure. Moreover, cable lengths as long as 1000 meters are possible, opening up many application areas to fieldbus technology while maintaining intrinsic safety requirements for all devices and cables, including the trunk line.

The higher device count per segment eliminates the problem of having to design complex network topologies with many sub-segments, each requiring its own power supply, junction boxes, and barriers.



For fieldbus DART enables a complete intrinsically safe installation with cable lengths that are long enough for the vast majority of applications. The technology also offers advanced diagnostics to help users rectify problems quickly and ensure system availability. Verifying the intrinsic safety of an installation is easy and can be completed while planning each segment.

DART Fieldbus is designed as a fieldbus infrastructure for existing IS field devices and DCS systems, or for any installation in which an intrinsically safe fieldbus segment is required. For this reason, DART Fieldbus is suitable for both green- and brown field sites.

## DART Fieldbus Products

Pepperl+Fuchs offers FieldConnex DART Fieldbus products that have been tested and certified by Germany's *Physikalisch-Technische Bundesanstalt (PTB)*, a German metrology institute and federal certification body. These products include power supplies with redundant power modules and field distributors called Segment Protectors. While the FISCO standard allows for only one power source, DART Fieldbus provides power supply redundancy to ensure higher system availability. The power modules are not just

Pepperl+Fuchs offers the FieldConnex line of DART-compatible products for fieldbus infrastructure products that have been tested and certified by Germany's *Physikalisch-Technische Bundesanstalt*, a federal certification body.

simply wired in parallel over a diode – instead, they operate with load sharing, meaning that each module provides exactly half of the required power. This results in reduced losses and less generated heat, which translates to longer component life.

To connect conventional IS devices, the DART Segment Protector provides short-circuit protection for each device, increasing segment availability during 'hot' work, which is permitted at any time.

## DART Simplicity

DART Fieldbus is simple and straightforward to implement with no special demands on the user. Users experienced with fieldbus will typically require no additional training. In the planning phase, the user only has to consider a few parameters such as the maximum trunk length -- otherwise, the requirements match those of the IEC 61158-2 fieldbus standard. Documenting intrinsic safety compliance requires no complex calculations – just entering values in a simple table.

DART is simple to install and maintain. Users experienced with fieldbus will typically require no additional training.

Both trunk and spurs are installed in the same simple fashion and are maintenance free. Service technicians no longer need to distinguish between 'black' and 'blue' ca-

bles as is the practice with field barriers. Replacing devices and working on the trunk are permitted without a hot work permit. The DART Segment Protectors provide the necessary short circuit protection for 'live' work in case the supply is short-circuited when connecting or disconnecting the wires. Should a short circuit occur, power to the affected segment is limited by the Segment Protector. Finally, a plug-in monitor for the physical layer allows for easy and fast start-up and displays errors quickly and in plain text. Special fieldbus knowledge is not needed, so training costs are eliminated.

### **DART Certification**

DART Fieldbus is certified by the PTB according to the international standard IEC 60079-11 with an IEC-Ex certificate. This means that DART Fieldbus is certified according to the rules of international cooperation so that most regional institutes either recognize the certificate directly or issue a regional certificate without demanding new tests.

## **Last Word**

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Process manufacturers have benefitted from the use of fieldbus since the 1990s, but installations in explosive environments are subject to certain limitations to ensure intrinsic safety. Thanks to innovations such as the DART concept, fieldbus becomes yet another very economical alternative for installations requiring intrinsic safety.

Process users who employ fieldbuses in explosive environments can benefit greatly from DART technology. In ARC's opinion, DART's value proposition lies in its ability to deliver higher power levels to field instruments with a single fieldbus topology. In addition, DART is easy to install and offers advanced diagnostics for simplified maintenance. These benefits add up to both lower capital and lower operating costs for process equipment.

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**Acronym Reference:** For a complete list of industry acronyms, refer to our web page at [www.arcweb.com/Research/IndustryTerms/](http://www.arcweb.com/Research/IndustryTerms/)

**CapEx** Capital Expenditure  
**DART** Dynamic Arc Recognition and Termination  
**DCS** Distributed Control System  
**FISCO** Fieldbus Intrinsically Safe Concept  
**FNICO** Fieldbus Non-Incendive Concept  
**HPTC** High-Power Trunk Concept  
**IEC** International Electrotechnical Commission  
**IS** Intrinsic Safety  
**OpEx** Operational Expenditure

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