DART – THE FUTURE OF EXPLOSION PROTECTION TECHNOLOGY

T. Klatt
Pepperl-Fuchs, Mannheim, Germany

In the process industry, it is possible for potentially explosive gases to escape in the event of a fault, which can be ignited through electrical sparks e.g. from instrumentation and control operating equipment. Because these explosions can have catastrophic consequences, the ATEX 137 European Directive prescribes an appropriate risk analysis and suitable measures for explosion protection.

A method for explosion protection called intrinsic safety was developed in England and Germany. In this method a fail safe circuit limits the electrical power going out into the field so that potentially ignitable sparks cannot occur. Intrinsic safety protection is considered to be the best solution because of its safety against failure, complete accessibility to the equipment during operation, and reduced deterioration of the explosion protection components.

However, instrumentation and control equipment with power requirements greater than 2 W cannot be intrinsically safe, and the alternative explosion protection techniques required for this type of equipment are expensive, take up space, and significantly limit the handling of the equipment. Wearing parts and possible installation errors also frequently reduce the desired protection objectives.

DART (Dynamic Arc Recognition and Termination) enables the power in intrinsically safe power circuits to be raised significantly (up to 50 W) while maintaining all the advantages of an intrinsically-safe installation.

MOTIVATION: INTRINSIC SAFETY WITH SIGNIFICANTLY MORE POWER

The explosion protection method Intrinsic Safety (Ex i) prevents the possibility of ignitable sparks so the installation technology for intrinsic safety in hazardous areas is identical as that used for safe areas. This also means that while a plant is operating the handling and maintenance of intrinsically safe electrical circuits and apparatus within a hazardous area can be carried out without the need of a hot work permit and is the same as if working in a safe area. The validation of this form of explosion protection is very easy and, when using fieldbus, does not require any calculation.

Up to now the explosion protection method intrinsic safety uses power limitation, and very seldom provides more than 2 W to the field, as a result the use of intrinsic safety is typically limited to measurement and control technology.

Significantly higher effective power can be provided by DART®-Technology (DART: Dynamic Arc Recognition and Termination) without losing the positive features of intrinsic safety. DART can easily be implemented into existing or new technologies and it enables the builder and user of a plant to simplify an existing application. Complex and expensive explosion protection methods like increased safety or flame proof enclosure can very often be replaced by intrinsic safety. This will allow the use of intrinsic safety in new applications, especially when live maintenance is advantageous.

With DART significantly more real power can be provided to the field, this then allows the use of intrinsic safety in a lot more relevant applications within the process industry such as: Weighing machines, illuminating systems, mass flow meters, positioners and fieldbus applications like FOUNDATION Fieldbus H1 or PROFIBUS PA.

THE DART-BASIC CONCEPT

The explosion protection technology intrinsic safety "i" is an explosion protection method which is based on limiting electrical energy inside of apparatus and connecting cables within potentially explosive atmospheres down to a level which is not capable to ignite the surrounding atmosphere neither through sparks nor through heating. With this document only the creation of sparks will be observed.

DART is a fast shut down system, that detects an unintentional status or a failure of the system at the moment it arises. DART converts this dangerous status immediately to a safe one. by shutting down the electrical circuit within microseconds, thereby avoiding the appearance of the ignitable energy stored in the spark (and this at significantly higher electrical values than actually allowed in accordance with the respective IEC/EN standards).

A DART protected electrical circuit consist of a source, one or more loads and the associated cabling. The source contains comparators to detect quick current changes and overload conditions (see Figure 1). The internal resistor R_{Start}, when switched into the circuit under fault conditions, realises the classical intrinsically safe status by restricting the current to below ignition levels.

The characteristic curves in Figure 2 show the turn on and turn off procedure. When the source is off switch S1 (see Figure 1) is open. When the source is turned on (Point 1) the voltage drop across the internal resistor R_{Start} increases and the operating point moves from point 2 along the curve to point 3. When the threshold voltage is reached switch S1 closes and this causes the other resistor curve to become valid and the source will provide full power to the field. When the comparators detect an error condition, switch S1 will be opened in less than 2 μs which then switches the source back to the safe status.

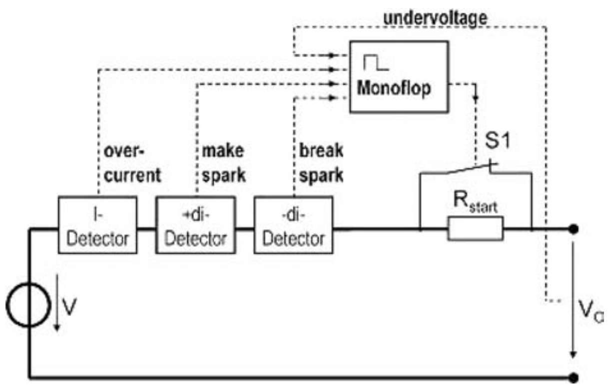

Figure 1. Block diagram of a DART-source

SAFETY RELATED REQUIREMENTS

PHYSICAL BASICS OF AN IGNITION

Generally there must be a differentiation between a "make spark" and "break spark". A "make spark" occurs when there is a short between leads and a "break spark" occurs when there is a lead breakage. Both types of failures can occur anywhere in an electrical circuit. (see Figure 3).

Figure 4 is an example of the real time behaviour of a lead breakage ("break spark") – current and – power.

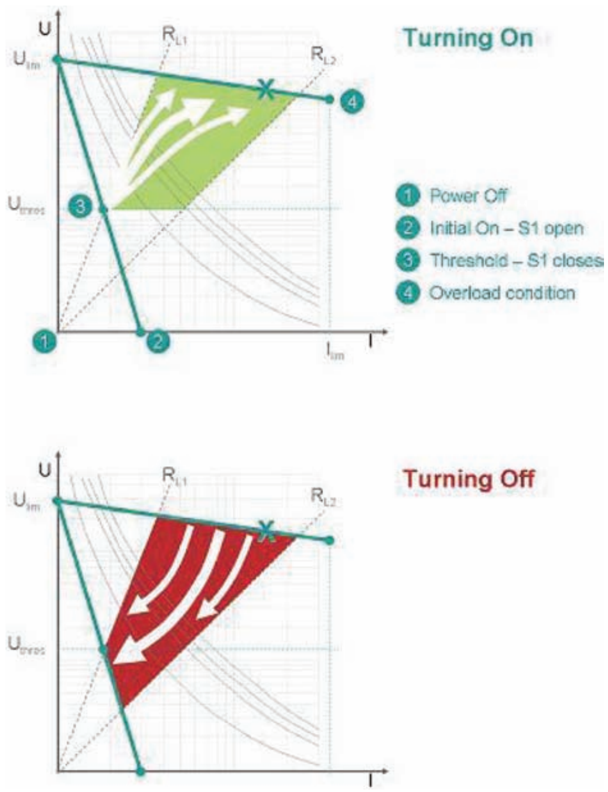

Figure 2. Switch operation of a DART-source

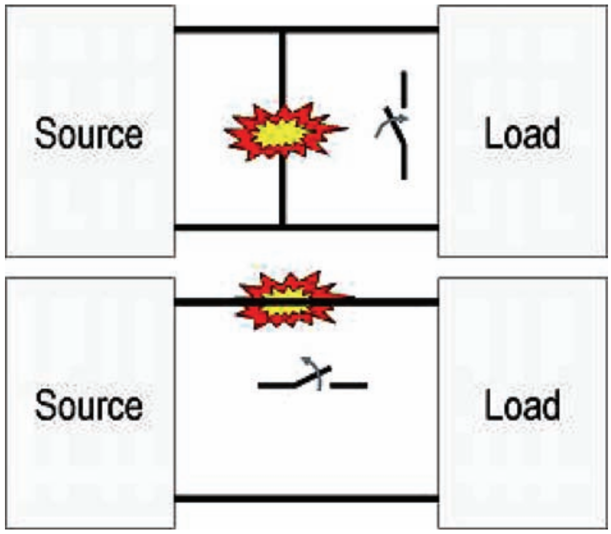

Figure 3. Make and break spark

The safety system must react immediately when such critical dynamical characteristics of current and voltage occur, whilst comparable characteristics, created by the load due to the functionality or load changes, are not detected by the safety system. For example loads have to be modified in a way, that such behaviour will not be transmitted to the source where the safety system is integrated.

THE SAFETY CONCEPT

The safety concept is based on the fact that each spark starts with a "current jump". In case of "make spark" this jump is positive in case of "break spark" it is negative. The dynamics for a secure detection of failures was analysed by the German PTB (Physikalisch Technische Bundesanstalt) and is the basis for the DART safety concept.

To ignite a potential incendive atmosphere spark energy is required. Energy is, when referring to Figure 4

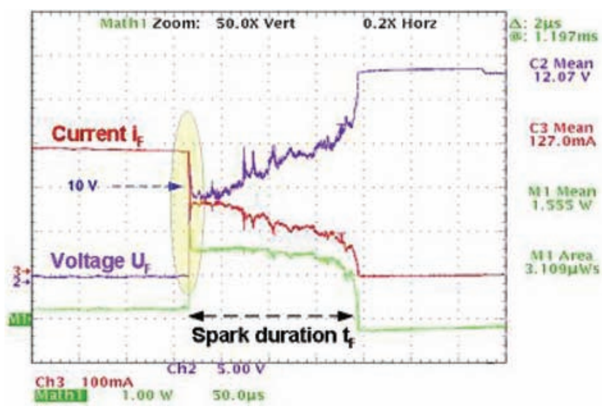

Figure 4. Oscillogram of a resistive break spark behaviour (24 VDC/280 mA)

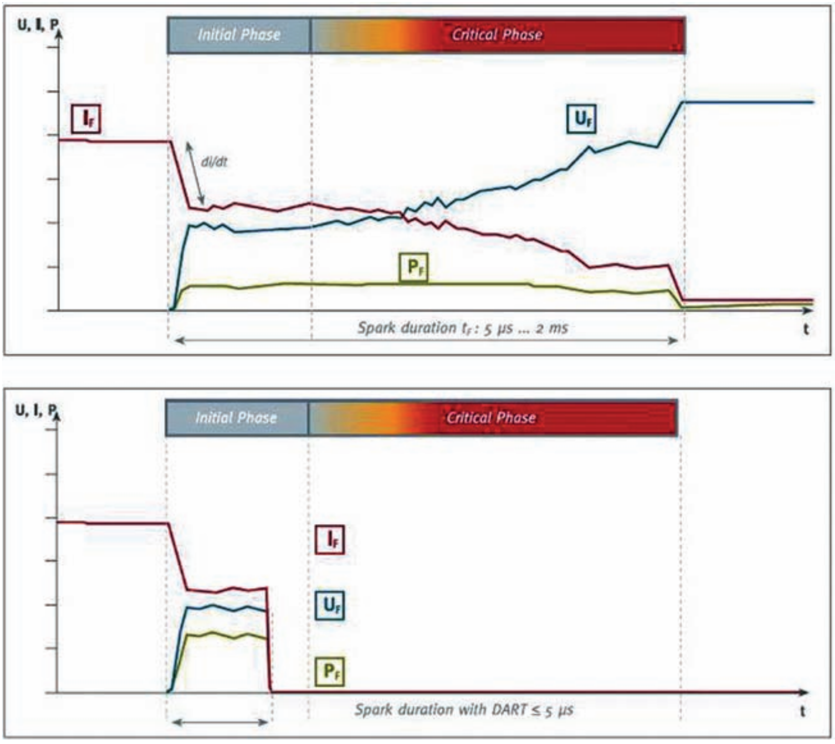

Figure 5. Current, voltage power of a spark with and without DART

the area beneath the (green) power curve. The energy stored in a spark increases over time, and the consequence of this is that the time behaviour of a spark starts with an initial phase where the spark is not dangerous and not capable to ignite an incendive atmosphere, then after a certain time the energy stored in the spark becomes critical (upper diagram Figure 5).

The DART circuit will switch the system into the safe status before the spark becomes critical. A typical time frame for the initial phase is 5 μs, however the travel time of the error signal has to be considered. The information about a current change (di/dt) and the corresponding "turn off" from the power supply travels as a guided wave along the cable from the fault location to the power supply and back at approx. 160,000 km/sec. This is why the length of the cable is an important aspect of safety considerations (see Table 1).

Table 1. DART-power values compared to classical IS components (grey colour)

	U_{out}	P_{out}	Cable length
DART Power	50 VDC	Approx. 50 W	100 m
	24 VDC	Approx. 22 W	100 m
	50 VDC	Approx. 8 W	1000 m
IS barrier	16 VDC	Approx. 320 W	1000 m
DART Fieldbus	24 VDC	Approx. 8 W	1000 m
FISCO Fieldbus	12,8 VDC	Approx. 1,4 W	1000 m

APPLICATION OF THE DART- SYSTEMS

Valve clusters and magnet operated valves require an increased start up current and a reduced holding current. With DART savings can be realised via the explosion protection method (today Ex d or Ex p) and installation technology (today Ex e).

Flow Measurement: With more power devices with higher accuracy and a better resistance against cavitation.

Illumination systems and optical warnings: First experiences with modern LED technology could show that at least the connection technology and perhaps the lamp itself could be realised in intrinsic safety. The maintenance intervals would be increased and the exchange of a lamp would be much easier.

Analyser: DART protected connectors will allow "plug and play" in the hazardous area. This would be advantageous for example in a biochemical application with moveable containers because measurements could be done directly in the medium and not like today in bypass pipes.

Due to the fact that DART will work with higher safety parameters than current intrinsic safety levels, technology vendors of field instrumentation have to be included in discussions regarding this new technology. These discussions have shown that a voltage of 24 V with a provided power of 12 W is suitable for all above mentioned

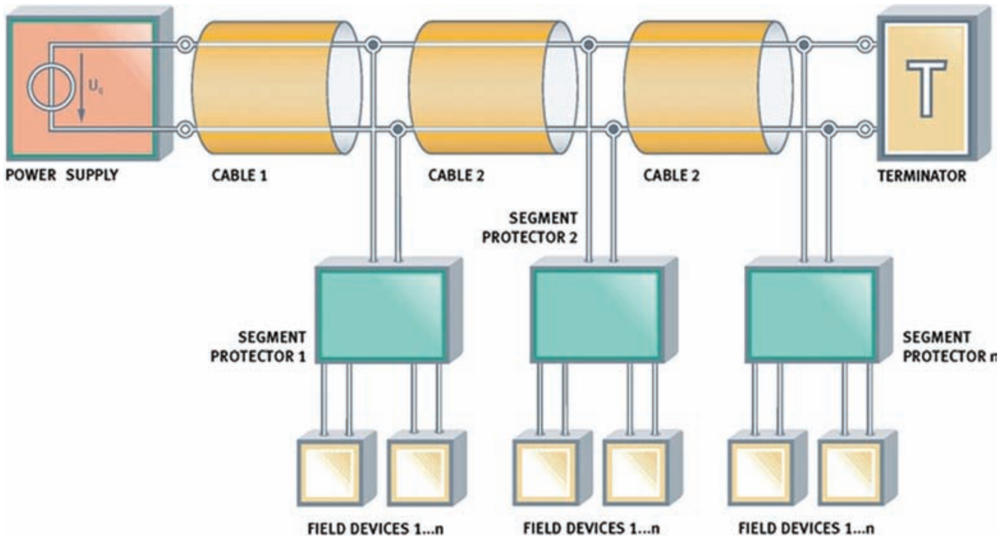

Figure 6. DART fieldbus application

application. This is the first step into the direction of interoperability between DART source and DART load.

All the above mentioned applications could also be achieved by data transmission. Special agreements regarding data transmission will follow. For the first application it is, from the point of view of field instrument vendors, acceptable to provide a fully intrinsically safe 4 wire technology. So the DART power supply will work in parallel to the data transmission for example fieldbus or classical 4 ... 20 mA technology. Later on, when the data transmission protocol is agreed the 4-wire devices will become 2-wire devices.

The first DART application which will be available by end of 2010 will be a DART fieldbus application (see Figure 6).

Today fieldbus applications very often are using a High Power Trunk concept. When using this concept it is required to protect the trunk cable against mechanical damage, corrosion, effects of heat and chemical effects. With DART it is possible to have high power on the trunk under intrinsic safety conditions. This will keep the trunk wiring easier and cheaper. In this kind of application the DART fieldbus power supply will provide the DART power and the DART segment protector decouples the DART trunk from the spur. This enables standard fieldbus instruments which are certified in accordance with the Entity or FISCO model to be connected to the spur.

STATUS OF STANDARDISATION

Today all the safety limit values for spark ignition given in the basic standard on "Intrinsic safety" IEC/EN 60079-11 are based on the spark test apparatus defined there. This apparatus generates both break sparks and make sparks under prescribed constraints. With none of the listed evaluation methods is it possible to carry out an objective safety assessment of DART components because the achievable ignition limit values with this new concept are way above the values in the standards. The intrinsic safety of these sources can only be ascertained by means of their dynamic principle of operation, i.e. their immediate reaction to fault conditions.

In order to assess the advantages in using dynamically acting sources, and to be able to apply this internationally, it is necessary that a supplement be prepared to cater for the use of other methods in IEC 60079-11. In discussion with the DKE working group 241.0.14 "Intrinsic safety" the German delegation of the sub-committee SC 31G "Intrinsically Safe Apparatus" (MT 60079-11) has reached the following conclusion during the IEC session in November 2007:

In the 6th edition of IEC 60079-11, due for publication around 2010, section 10.1.2 will be supplemented. In cases, in which the spark test apparatus cannot be used – such as in the case of dynamically acting sources – alternative test methods will be permissible. The test methods to be used will be incorporated into the standard at a later stage, when further assured knowledge of these is available.

Thus the 6th edition will open up the way for the international application of the DART technology.

CONCLUSION

Due to new approaches in conjunction with new electronic circuit solutions it has succeeded to increase the desirability and capability of the explosion protection method intrinsic safety. With the dynamic working DART concept up to 50 W of effective power can be realised using this protection method.

The German PTB (Physikalisch Technische Bundesanstalt) will take care that dynamically acting sources like DART will be integrated into the IEC/EN 60079-11. The new edition of this standard is expected for 2010. The first DART application is expected to be available by end of 2010 a short time after the IEC/EN 60079-11 has been published.

LITERATURE

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3. Udo Gerlach, Thomas Uehlken, Ulrich Johannsmeyer, Physikalisch-Technische Bundesanstalt PTB, Andreas Hennecke, Martin Junker, Pepperl + Fuchs, Significantly more Power in intrinsic safety through innovative technologies, VDI Verlag.