End users throughout the Fieldbus world are demanding more power to connect more instruments to their Fieldbus segments in Class I, Division 1, and Class I, Division 2, hazardous location applications. Some are pointing them to FISCO (Fieldbus Intrinsically Safe COncept) and FNICO (Fieldbus NonIncendive COncept) as the answers to the quest for more power on the Fieldbus. There is a superior alternative to both that gives engineers all the power they need to fully load a Fieldbus segment, even in a hazardous location.

This article will introduce the High Power Trunk concept and its advantages over FISCO and FNICO. It will defuse many of the myths about FISCO and FNICO and will demonstrate how modern Fieldbus installations can be altogether free from power restrictions.

**FISCO, FNICO Background**
Over the past several years, Fieldbus technology has been rapidly adopted in many process industries. However, end users have been unsatisfied with the traditional solutions for Fieldbus applications in hazardous location applications because they could not enjoy the same benefits in terms of power, cable length and number of devices/segment in hazardous location applications compared to general-purpose applications due to energy limitation on the trunk.

At the introduction of Fieldbus technology, the Entity concept with cabinet mounted barriers and power supplies was used as the standard solution for hazardous area applications. This type of solution barely supplied enough power for 3 or 4 instruments per segment and it was very cumbersome to match entity parameters of the devices and the power source. End users voiced their concerns and manufacturers responded with another solution for IS (Intrinsically Safe) segments. The result was FISCO (Fieldbus Intrinsically Safe COncept).
FISCO was developed by the Physikalisch-Technische Bundesanstalt (PTB) in Germany and is based on experiments performed by the PTB in order to find a solution to provide more power over a Fieldbus into a hazardous location. In 2002 the IEC 60079-27 standard was published, which describes the FISCO model.

FISCO is based on the following conditions:

- The Fieldbus must be based on the “Manchester Bus Powered” physical layer in accordance with IEC 61158-2 (i.e. Foundation Fieldbus or Profinet PA)
- Only one active source (i.e. power conditioner) is permitted per segment. All other components act as passive current sinks (instruments)
- The basic current consumption of a field device is at least 10mA
- The following must be ensured for each device:

<table>
<thead>
<tr>
<th>Power Supply</th>
<th>Field Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{oc} \leq 17.5\text{V}$</td>
<td>$V_{max} \geq 17.5\text{V}$</td>
</tr>
<tr>
<td>$I_{sc} \leq 380\text{mA}$ (in acc. with ignition curves)</td>
<td>$I_{max} \geq 380\text{mA}$ (in acc. with ignition curves)</td>
</tr>
<tr>
<td>$P_a \leq 5.32\text{W}$</td>
<td>$P_i \geq 5.32\text{W}$</td>
</tr>
<tr>
<td>-</td>
<td>$C_i \leq 5\text{nF}$</td>
</tr>
<tr>
<td>-</td>
<td>$L_i \leq 10\mu\text{H}$</td>
</tr>
</tbody>
</table>

*Table 1: FISCO model energy limitations*

- Total cable length is limited to 1000m (trunk plus all spurs)
- Maximum spur length is 60m
- The Fieldbus cable must conform with the following parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance</td>
<td>$15\Omega/\text{km to } 150\Omega/\text{km}$</td>
</tr>
<tr>
<td>Inductance</td>
<td>$0.4\text{mH/\text{km to } 1\text{mH/\text{km}}}$</td>
</tr>
<tr>
<td>Capacitance</td>
<td>$45\text{nF/\text{km to } 200\text{nF/\text{km}}}$</td>
</tr>
</tbody>
</table>

*Table 2: Cable parameters acc. to FISCO*

Typical FISCO power conditioners available today supply 12.8 V and 100mA for Class I, Div.1, groups A-D. In a real world application this can result in 4 to 8 devices per segment. This is still far below the capabilities of a general purpose Fieldbus installation where users can connect up to 16 instruments per segment.
If in a given application all devices are certified in accordance with FISCO and the above-mentioned conditions are fulfilled the proof for intrinsic safety is reduced to comparing the following parameters:

<table>
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<td>$V_{oc}$</td>
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<td>$P_{a}$</td>
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</table>

*Table 3: Proof of intrinsic safety with FISCO*

FNICO (Fieldbus NonIncendive COncept) is very similar to FISCO but for Class I, Division 2 applications. As for the FISCO model, the same basic rules and conditions apply for FNICO. The only major difference is that FISCO uses a higher safety factor for its electrical values versus FNICO. Due to the lower safety factor for FNICO, it is possible to supply more current into a Class I, Div.2 hazardous location. Typical values for FNICO are 12.3V at 215mA.

**FISCO, FNICO Limitations**

Although FISCO/FNICO offers some additional power compared to the entity concept, users still cannot enjoy the same benefits they get when using Fieldbus in a general purpose configuration. The overall cable length is theoretically limited to 1000m, spurs are limited to 60m and the current and voltage levels are still very low, which results in significantly shorter cable runs than the theoretical maximums.

For most applications, the energy limitation on the trunk is not really needed due to the fact that fieldbus users do not perform live maintenance on the trunk cable because of the high risk of losing an entire segment due to a single short.

In addition to the low power restraints and contrary to some general purpose power conditioners, FISCO and FNICO power conditioners do not offer redundancy nor do they offer any online physical layer diagnostics.

End-users also end up with more hardware in their control room cabinets because several FISCO/FNICO power conditioners might have to be connected together to maximize the number of instruments on a single segment. This represents additional wiring cost and installation time and ultimately adds to the overall project cost. Having to install additional hardware in a centralized control room also goes against a distributed Fieldbus architecture. One of the benefits of using Fieldbus technology is that
it allows for the distribution of equipment into the field and away from the control room, thus saving expensive control room real estate.

The availability of FISCO/FNICO devices on the market is also limited. Although FISCO devices are more frequently available, FNICO instruments have not been introduced to the market and may never make it due to some new innovations such as the “High Power Trunk” concept.

The High Power Trunk Concept
A new approach to solving hazardous area Fieldbus applications is based on the “High Power Trunk” concept. In contrast to the FISCO/FNICO concepts, the High Power Trunk concept does not limit the energy on the Fieldbus trunk cable to intrinsically safe or nonincendive levels, rather the energy on the spur connections is limited to the instruments. This allows end users to get the maximum number of devices on a segment while also being able to achieve maximum cable lengths. Depending on the application, the protection (energy limitation) is done in the field, inside the junction box.
As described earlier, Fieldbus users do not normally perform live maintenance on a Fieldbus trunk cable because of the high risk of losing an entire segment due to a single short on the trunk cable. By not limiting the energy on the trunk, the High Power Trunk concept offers the same advantages seen in general-purpose applications in hazardous location applications. Typical values for a High Power Trunk solution are 30V at 500mA. And products such as fieldbus barriers and fieldbus segment protectors make it easy to apply the High Power Trunk Concept even in the most hazardous environments.

A fieldbus barrier, for example, can be used in Class I, Division 1 applications. It provides intrinsically safe, short circuit protected spur connections for either entity or FISCO based instruments. The High Power Trunk connections of the fieldbus barrier are galvanically isolated from the IS spur connections.

Fieldbus segment protectors can be used in general purpose as well as Class I, Division 2 applications. They provide short circuit, energy limited (nonincendive) outputs. When used in a Division 2/nonincendive application they can connect to either a nonincendive field wiring apparatus or intrinsically safe rated devices, which enables the end user to connect/disconnect instruments under power.

Both fieldbus barriers and segment protectors are typically mounted in a Division 2 area where the high power trunk connections can be made following Division 2 wiring method. Division 2 wiring methods include open cable tray with PLTC/ITC (Power Limited Tray Cable/Instrument Tray Cable) such as a standard type A Fieldbus cable, armored cable or conduit. Many end-users are moving away from using conduit in Division 2 Fieldbus installations due to cost and are adopting open cable tray in combination with PLTC/ITC cable.
Fieldbus barriers and segment protectors move the energy limitation out of the control room cabinet and into the field by combining the features of short circuit protected junction boxes with a built-in barrier. This enables users to fully distribute their Fieldbus equipment around the plant, taking full advantage of Fieldbus technology. Another benefit of the High Power Trunk concept is that it gives the end-user the freedom to choose any type of instrument entity, FISCO or FINCO.
In addition to fieldbus barriers and segment protectors, a new generation of Fieldbus power conditioners with built-in redundancy and online physical layer diagnostics capabilities is coming available. These “intelligent” power conditioners were requested by some of the early Fieldbus adopters who realized the importance of gaining access to the physical layer of the bus. For example, with these new features end-users will be able to online monitor and detect:

- Noise levels on a segment
- Voltage and current levels
- Ground faults

This will give users a much better picture of what is actually happening on a given segment, 24/7. Physical layer diagnostic information can also be very useful during start up, commissioning and troubleshooting. Users will know if the Fieldbus physical layer conditions are changing over time and can take action before a segment fails.
Conclusion
The High Power Trunk concept allows Fieldbus technology users to design their segments free of any power restriction. In fact, the only limitations are the control system or the Fieldbus specification itself. Finally, engineers can enjoy the same benefits in terms of power, cable length and number of devices per segment in hazardous location applications as they do in general purpose applications.

From a technical as well as a commercial standpoint, the High Power Trunk concept offers significant advantages over the previous methods. Not only does it offer significantly more power, but it also provides more options to the engineers to implement redundancy and online physical layer diagnostics. Plus, FNICO will not be properly implemented until a wide range of FNICO instruments are available. FISCO on the other hand will only be used for those rare applications that require an intrinsically safe trunk but do not require redundancy or any physical layer diagnostics.

The High Power Trunk concept works for all Fieldbus applications. It simplifies segment design, minimizes the amount of hardware used, supports a distributed architecture, allows for live maintenance and offers state-of-the-art power redundancy and online physical layer diagnostics.