THIRD-GENERATION FIELDBUS POWER SUPPLIES DELIVER KEY BENEFITS

Simon Marsh

MTL Incorporated

Abstract: The paper will begin by tracing the development of power supplies for FOUNDATION fieldbus™ systems, explaining how practical problems have been overcome by successive product enhancements. The key technical requirements of fieldbus power supplies for reliable, long-term operation will be explained, showing how such products may be integrated into third-party control systems. The latest developments in power supply technology will also be introduced, including third-generation, high-density systems that are ideal for control system integration in large fieldbus projects. Benefits in terms of cabinet space savings, bulk power supply ratings and engineering effort will be discussed.

Keywords: Power supply; power conditioner; availability; redundancy

1. Introduction.

The quest for ever higher levels of reliability for FOUNDATION fieldbus™ systems in the process industries has led to a steady evolution in the design of fieldbus power supplies. Discerning end-users have asked manufacturers for improvements in overall performance, and experience from operating installations has contributed to a base of knowledge about what works well 'in the field' and what does not. The control system manufacturers have also looked for ways to simplify the integration of power supplies into their systems, and some have imposed rigorous testing regimes. Meanwhile, the Fieldbus Foundation has responded to calls from the industry for the introduction of a standard against which the quality of power supplies could be measured, and in mid-2004 it introduced the FF-831 qualification test.

2. Continuous evolution

Today's fieldbus power supplies have therefore matured in all respects from their early beginnings, and this paper sets out to describe how the latest generation of products achieve the very highest levels of availability - with associated benefits in terms of cost, ease of installation, and overall cabinet space savings. The attendant merits of fieldbus 'physical layer' diagnostics will also be discussed.

2.1 Early beginnings

The earliest fieldbus power supplies were designed to conform to the fieldbus standard, IEC 61158-2, in terms of the output voltage and the conditioning components required to put power onto the two-wire bus without interfering with the digital communications. Such supplies worked satisfactorily in the development environment, but the first real site installations drew attention to failings in the event of faults to earth in the field wiring. Such problems were not evident in the laboratory, but the absence of isolation between the bulk power supply and the individual fieldbus segments meant that combinations of earth faults could result in cross-talk between segments or even the complete loss of one or more segment. See Figure 1.

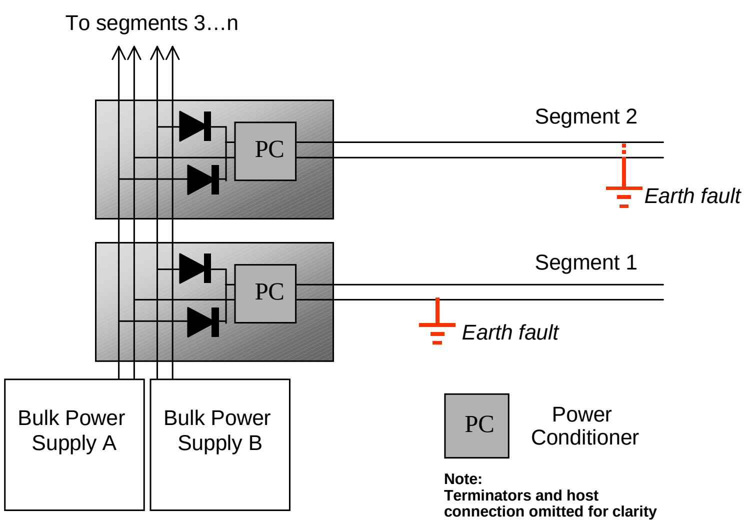

Figure 1: Faults in non-isolated scheme

2.2 Second-generation enhancements

Second-generation products rectified these problems by introducing isolation between the bulk power supply and the bus in each power conditioning module, as illustrated in Figure 2. Combinations of faults no longer threatened the complete network. Redundant power modules operating in a load-sharing mode, together with the ability to replace a failed module while under power, provided high levels of system availability. This redundant, isolated scheme quickly established itself as the industry's preferred architecture for high reliability fieldbus systems, and an estimated 10,000 fieldbus segments are currently powered in this way.

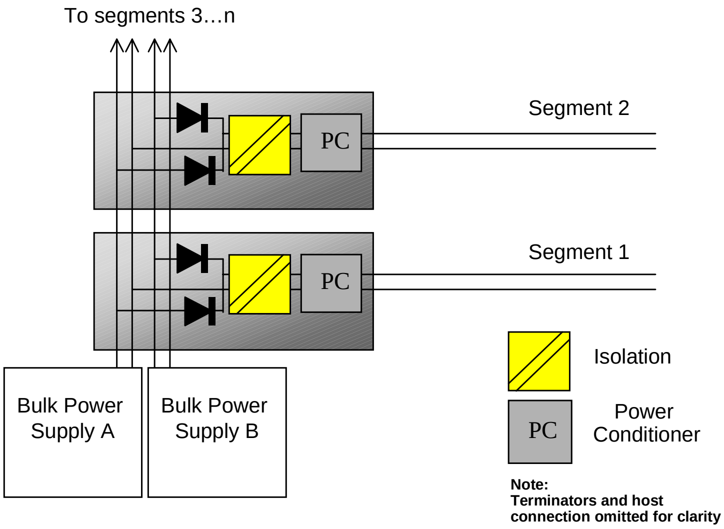

Figure 2: Isolated scheme prevents cross-talk between segments

With this arrangement, a module carrier provides the mechanical and electrical platform for the redundant modules, and includes the components required for segment termination, bulk power steering and fault indication. It also has connections for the field wiring, host control system and optionally-redundant bulk power supplies. This format lends itself well to the design of multi-segment 'backplanes' for integration into fieldbus control system cabinets. Such backplanes typically support two or four pairs of redundant power modules, and are fitted with system connectors that plug directly into the fieldbus module by means of a prefabricated cable. Figure 3 illustrates some examples of integrated fieldbus power supply backplanes for the major system vendors.

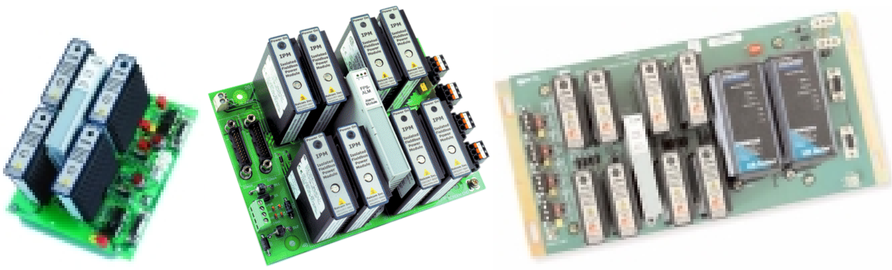

Figure 3: Integrated fieldbus power supply systems

3. Reliability considerations

The overall availability and mean time to failure (MTTF) of redundant, carrier-mounted power supplies is derived from a combination of the probability of coincident failure of the power modules and the probability of failure of the carrier. Some components on the carrier represent single points of failure, so it is important to ensure that the integrity of the redundant scheme is not diminished.

Alternative architectures have also been introduced into the market; among these is the use of a non-redundant power conditioning circuit, with redundant power feeds. The avoidance of redundancy is argued on the basis that the conditioning components are passive and have an acceptably long time between failures. The electrical and mechanical platform required to support the conditioners (principally inductors and capacitors) is complex, however, and additional multi-pin connectors are required. Techniques have also been introduced to simulate the isolation barrier between the bulk power supply and fieldbus segments in order to minimise the effects of multiple earth-faults.

4. Further maturity

The continued drive towards more compact and power-efficient fieldbus systems, together with scrutiny of failure modes in non-redundant system components, has led to a further evolution in power supply design. As the size of fieldbus projects continues to increase, and installations with thousands of fieldbus segments are no longer exceptional, there has been increasing pressure to reduce the footprint of the fieldbus hardware, with a promised reduction in the number of equipment cabinets required. The control system vendors have themselves followed a similar pattern by increasing the channel density of their fieldbus cards. Higher density systems require a corresponding reduction in current consumption and heat dissipation. This, coupled with the desire to aim for ever-higher levels of reliability, has resulted in a new generation of fieldbus power supply.

5. Third-generation systems

The most significant differentiators of third-generation systems are the use of multi-segment power supply modules, and the elimination of all components (other than connectors) from the module carrier. A typical system has two eight-channel modules mounted on a common carrier, as shown in Figure 4. The segment outputs of each module operate in redundant, load sharing mode, and the proven isolation scheme from second-generation designs is carried forward.

Figure 4: High-density power system

The inclusion of eight fieldbus power supplies in a single module delivers immediate benefits in terms of component count and module footprint, with a corresponding reduction in manufacturing cost. It is not a mechanical re-packaging of an earlier design, but a new development, taking advantage of the latest advances in circuit design. The current consumption and heat dissipation per fieldbus segment are also significantly reduced, leading to larger numbers of channels per cabinet and savings in bulk power supply budget. In practical terms, as many as 10 sets (80 fieldbus segments) can be installed per cabinet side in a 2m x 800mm cabinet, as illustrated in Figure 5.

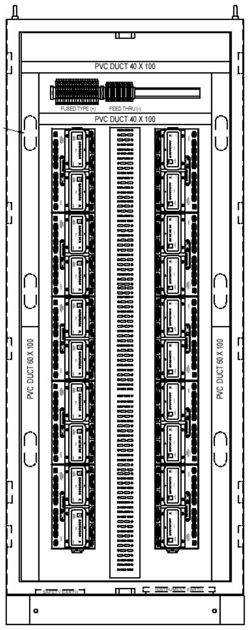

Figure 5: Typical cabinet layout

Fault detection can be included inside the power modules, such that any fault leading to the failure of one or more fieldbus segments is announced. A failed module may be removed and replaced while energised, without interrupting the fieldbus segments.

The module carrier may be either DIN-rail mounted, or designed for fitting into the control system vendor's mounting channel. It is completely component-free, having only connectors for the fieldbus wiring, host system, bulk power and alarm circuit. It therefore has an extremely long time to failure, and for all practical purposes does not contribute to the fault analysis.

The fieldbus terminator components are also eliminated from the backplane, being located inside the power modules. A 'smart' terminator design means that the correct terminating impedance is automatically presented to the bus, regardless of whether the systems is operating with one or two power modules.

Examples of high-density fieldbus power systems for direct integration into DCS cabinets are shown in Figure 6.

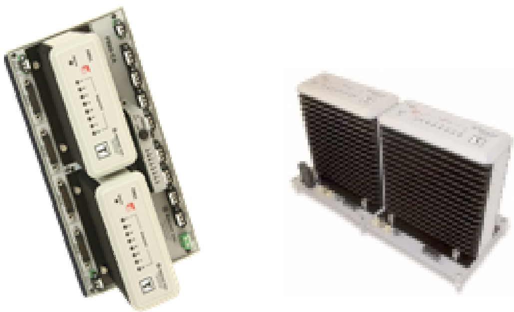

Figure 6: Integrated, high-density fieldbus power systems

6. Physical layer diagnostics

The extensive experience gained from diagnosing faults on FOUNDATION fieldbus™ networks using hand-held test equipment such as that shown in Figure 7 has led to the development of continuously-monitoring diagnostic hardware.

Figure 7: Hand-held fieldbus test equipment

The architecture of high-density power supplies lends itself to this technology, since the monitoring module can be shared across a number of segments, thereby reducing the overhead cost. The diagnostic module is able to measure parameters such as bulk power supply input voltage, segment voltages, signal levels of all devices, and average noise and peak noise in several bands. Additionally the monitor can be designed to check that the bus is properly terminated and for fieldbus-to-shield short circuits. If high levels of retransmissions are detected on the network, the measured physical layer parameters can be used to predict the corrective action required on the segment.

This can usually be carried out before poor network health leads to devices being removed from the live list, which could affect operation of the plant.

Alarm limits for each measured parameter can be made configurable to avoid nuisance alarms. The alarm may be reported direct to the control system using a relay contact or over a network to the diagnostic management software.