



Power Supply Reliability

TECHNICAL WHITE PAPER

Power supply systems are available with built-in redundancy and diagnostics, providing reliable power with minimal configuration and engineering effort required from end users.

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Title: Power Supply Reliability

Abstract:

Reliable power is a fundamental requirement for any automation system application, but some situations demand the very highest integrity level power supply. Petroleum refineries, safety systems, emergency systems, and many automated processes utilizing digital fieldbus networks are prime candidates for power supply redundancy backed by comprehensive diagnostics capabilities—which together provide maximum reliability.

Simple power supply redundancy using diodes to isolate multiple supplies has been a traditional solution. It is economical and has few drawbacks, but this configuration does not offer the highest level of performance, and users are left to develop their own methods of monitoring the equipment and power availability. This involves extra effort, risk, and cost.

A new class of redundant-capable power supply platforms is now available, offering not only high reliability, but also extended diagnostic features such as power quality monitoring and hardware monitoring. Designers can choose from a standardized assortment of best-of-class power supplies, and combine them with a dedicated diagnostic feedback system to guarantee system functionality. These proven power supply hardware configurations are field tested over many years of service.

To be truly useful, a diagnostic device must offer useful standard functionality, with the capability for advanced users to delve into the detailed settings and fine tune behaviors to their needs. Furthermore, the diagnostic device must be able to communicate warnings and alarms to a higher level automation, asset management, and/or other system so that users can fully realize the value and take advantage of the additional information.

This white paper will investigate the benefits of power supply redundancy and diagnostics for the most critical applications, detailing how the power system components work together to provide maximum reliability.



Diagnostic Benefits

Power supply diagnostics offer many benefits, some of them direct and obvious, others less so. Table 1 summarizes these benefits, many of which are needed to configure the type of reliable power platform needed for critical processes and systems (Figure 1).

Critical applications demand maximum uptime, and if a problem occurs then the downtime for repair and restoration must be minimized. Uptime is maximized through the use of reliable, resilient, and redundant components. Downtime is minimized by a system that actively monitors itself and alarms when there are problems, so that users can quickly diagnose and replace faulty components.

NASA's extensive recovery and redundancy plans for the International Space Station (ISS) are a great example of how to prepare for trouble. As eWeek.com points out regarding a recent crisis on the ISS, without the "ability to deal with certain types of equipment failure, the ISS would not be the success it is today and lives would be at risk" (Reference 1).

When it comes to DC power supplies here on Earth, the primary method of achieving near

100% uptime is through the use of redundancy. Any consideration of power supply diagnostics is therefore almost always associated with redundant power supplies. Diagnostic capability is the supervisory feature that monitors the hardware and effectively tells the user when there is a problem and what needs to be addressed, and it further increases the reliability of both redundant and standard power supply systems.

For any system or project where reliable power is required, the term "reliable" applies not only to availability of the power, but also to the quality of the power. A high quality power supply is designed for low noise emissions on the output to best protect the operation of downstream equipment. Furthermore, an advanced power supply system must be capable of tracking the quality of incoming AC power as well as outgoing DC power, as degradation or excessive variations in the AC power input can presage problems.

Primary (incoming) electrical characteristics are a consequence of the quality of the input power to the power supply system. Secondary (outgoing) characteristics indicate how well the power supply system functions. Other important considerations are on-board power supply system parameters such as temperatures, as well as overall diagnostic information including ambient

Table 1: Benefits of Power Supply Diagnostics	
1.	Increased uptime
2.	Improves the reliability of N+1, N+N, and other redundancy schemes
3.	Tracks power quality
4.	Monitors power supply system hardware status
5.	Gives local and remote indication of status
6.	Can easily integrate into automation, plant asset management, and other systems
7.	Factory-set but fully configurable



Figure 1

temperatures and power supply redundancy status.

The capability of diagnostically monitoring an extensive array of data points such as these is what elevates the highest performing power supply platforms above basic mainstream power supplies. Unacceptable input or output power conditions announce to the user so that the situation can be handled before any equipment is adversely affected.

Furthermore, on-board diagnostics can be used to alert users when any system component has failed and needs replacement. In fact, warnings can be issued if any pre-failure conditions are sensed, allowing users to preemptively repair the system in a proactive manner. The most effective diagnostics offer some level of local indication, with more comprehensive data available remotely over a networked connection.

Different users have varying levels of technical capability. For many applications, it is advantageous for diagnostic power supplies to be factory set right out of the box to provide the most commonly needed functionality. On the other hand, many advanced facilities have specific site conditions or monitoring needs, and therefore need a fully configurable diagnostic system to meet their requirements. Today's power supply systems meet both needs with factory settings to handle standard applications combined with the ability to customize diagnostics as needed.

While power supply diagnostics are a key feature for effective equipment protection and optimized process production, they also play an important role for any critical safety or emergency system where personnel protection is at stake. Coupled with redundancy, diagnostics provide a reliable power supply, as detailed in the following sections.

Redundancy Rules

Since redundancy almost always forms the foundation of any reliable power solution, it is important to understand some related terminology and methods. A common redundancy scheme is called “N+1”, which means that if the application requires “N” power supplies to operate normally then there is at least “1” more independent backup power supply available in the event that one of the original units fails. Many times this is achieved with a simple pair of power supplies, each sized to carry the entire load. However, the logic is extendable to installations where “N” is 2, 3 or more.

An enhanced redundancy scheme is called “2N” or “N+N” and means that for a normal configuration of “N” power supplies (where N is greater than or equal to 1), there is an entire complement of identical backup hardware available in case any of the original hardware fails. “N+N” aims to reduce the number of single point-of-failure conditions.

Diagnostics capabilities associated with a power supply system should include functionality for the user to easily configure the desired redundancy

type, as well as to continuously monitor the status of constituent components. The flexibility to easily configure advanced configurations such as multiple redundancy groups greatly simplifies implementation, and is a feature found in advanced power supply systems.

Whenever multiple power supplies are arranged in a redundant fashion, it is desirable to operate them in an active load-sharing manner. This levels the load among the available equipment in order to prevent running some of the components at their upper limit. This improves reliability, and also shortens recovery response if there is a failure.

Redundancy itself would not be very valuable if each component had to be de-energized for repair or replacement, so many redundant power supply systems are configured in racks or chassis such that replacement parts are “hot swappable” without interrupting the output (Figure 2). To minimize downtime, the “hot-swappable” concept should extend to additional components, such as the diagnostic module itself.

Of course, good design practices include feeding redundant power supplies from multiple different power sources where possible, and configuring



Figure 2

the source circuits in such a way as to make the DC power supplies serviceable. An excellent feature of flexible power supplies is the ability to accept a wide range of either AC or DC voltages, and to generate an adjustable DC voltage output range. This reduces the number of device models that must be stocked, greatly increasing the chance that the proper power supply will be on hand when needed.

If care isn't taken, "homemade" redundancy assembled from various components may result in lower reliability than a purchased redundant power supply system configured to meet user needs. Control Design relates how one facility implemented a homegrown diode-based redundancy scheme that handled an overvoltage output at one power supply by simply routing the possibly damaging voltage to other equipment (Reference 2). A better option would have been to purchase a redundant power supply system up front, and to solicit configuration input from the supplier as needed.

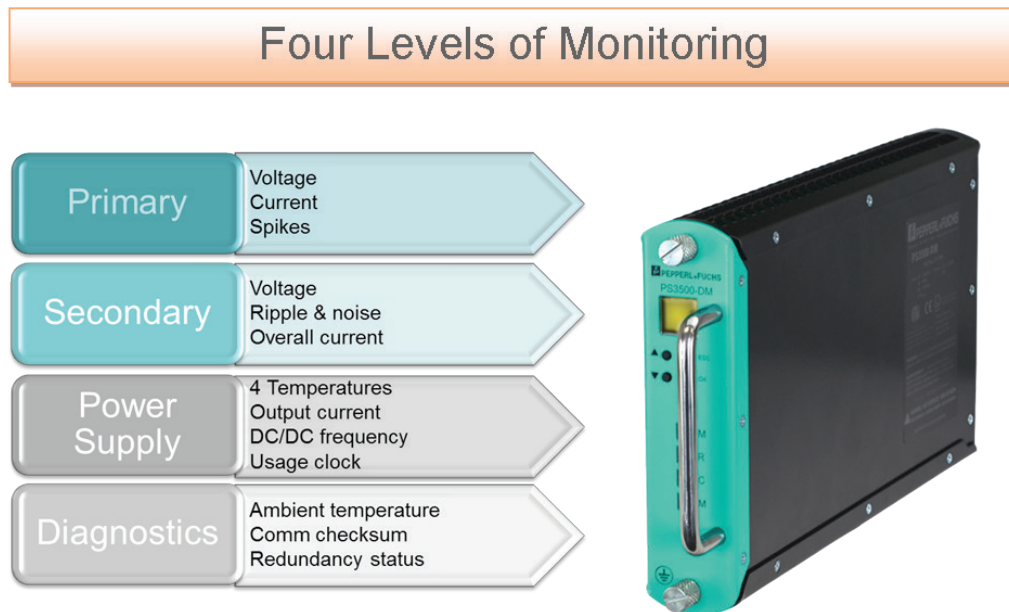
Diagnostic Details

In-depth, real-time diagnostics should encompass four major categories in order to fully represent power supply system performance (Figure 3):

- Primary: Incoming voltage, current and spikes
- Secondary: Outgoing voltage, ripple, noise and current
- Power Supply: Internal temperatures, currents, DC/DC frequency, clock
- Diagnostics: Ambient temperature, communications, redundancy status

Primary and secondary abnormalities are identified with warnings and alarms. In addition, transient input aberrations such as spikes can be filtered out and counted to support upstream power quality troubleshooting. On the output, ripple and noise can be tracked to ensure they are within acceptable limits for the equipment being served. Power supply and general diagnostics provide preemptive warnings of impending problems, such as a control panel overheating.

Figure 3



Devices of all types in today's automation landscape are becoming "smarter," and device integration capabilities are gaining importance as a method to improve operations. When examining the lifecycle costs of system integration, Control Engineering has found "the tighter you wish to control a process, the more you need to measure it" (Reference 3). The more you measure, the more it will cost, but a balance point must be determined since "there is a fiscal context to both under-controlling and over-monitoring a process or production line."

For diagnostic power supply systems, the quantity and quality of data available effectively elevates these systems to the level of smart field devices. Instead of power supplies simply being a low-level utility, they can be integrated into the automation system as an active part of the control strategy. Default settings cover a useful majority of applications, while warning/alarm thresholds are fully configurable in order to address the needs of any specific application.

Networks Deliver Information

Networking a digital diagnostic power supply into a plant's automation, asset management, or other system is achieved in the most cost-effective and straightforward manner when standard open communication protocols are used. There are several common protocols that can enable two-way interaction between the diagnostic system and the supervisory control system.

Field Device Tools is a standardized interface between host systems and digital devices, used to communicate with and configure the devices. As part of Field Device Tools, each device must offer a Device Type Manager which fully defines the communication functionality of the device. An alternate technology for describing what information is accessible in a digital device is called Electronic Device Description Language, which requires Electronic Device Descriptions for each device.

Some upper-level control platforms that are commonly used to monitor diagnostic power supply system information are programmable logic controllers (PLCs), programmable automation controllers (PACs), and distributed control systems (DCSs). The human machine interfaces (HMIs) and operator interface terminals (OITs) associated with these control platforms provide a powerful method of elevating alarm information to the operators in the control room and in the field.

Today's PLC, PAC, and DCS control platforms are also very likely to incorporate instruments and devices on a variety of digital bus systems such as DeviceNet, Ethernet, FOUNDATION fieldbus, PROFIBUS, HART and more. While smart bus-capable devices are far more powerful than their "classic" 4 mA to 20 mA predecessors, they are also more sensitive to power quality. A reliable

diagnostic power supply system is therefore a natural fit for bus-enabled automation and process control applications.

Asset management software is yet another class of upper-level system capable of harnessing the informational power offered by redundant power supply diagnostics. When these two technologies are integrated, users can implement condition-based maintenance (CbM) strategies. CbM is a method of continuously monitoring equipment health in order to predict upcoming maintenance needs before a failure adversely affects the facility. The result is improvement in overall reliability, reduction in maintenance costs, and improved safety.

Acting as a central repository of device information, the asset management system is useful for more than just troubleshooting and maintenance purposes, according to ISA InTech (Reference 4). In fact, skilled personnel can leverage this information to make improvements, as careful examination of data can often reveal areas for improvement. For example, abnormally high failure rates of a particular power supply can be analyzed to find the root cause by looking at all of the data associated with the power supply's operation.

Standards and Efficiency

Any power supply considered for high integrity service should meet or exceed all applicable standards and certifications. Depending on where the equipment will be installed, European Conformity (CE) markings or Underwriters Laboratories (UL) listing should be considered mandatory. Additionally, equipment should operate in accordance with electromagnetic compatibility (EMC) standards for both preventing unwanted emissions and immunity to other emissions. Finally, if the equipment will be used in hazardous locations, then it must be rated as suitable for such areas.

High-efficiency hardware almost always makes technical sense, and certainly reduces energy losses and therefore operating costs over the lifetime of the equipment. However, there are secondary benefits. When less energy is lost as heat, it is often possible for the power supply system to be passively cooled with no active fans required, and this often translates into acceptable operation at higher ambient temperatures. Simply removing the requirement for fans eliminates an extremely vulnerable failure point, and can greatly increase overall system reliability.

It is clear that there are many benefits to integrating power supply diagnostics, as illustrated in the following application examples.



Reliability Brings Benefits

Consider a producer of corn-based petroleum products and related goods. Such a facility would be a heavy user of PLC, PAC, and/or DCS digital automation systems for discrete manufacturing, process automation, and safety systems. These control platforms would report back to HMIs in a main control room, as well as to OITs installed more locally to the equipment.

A refiner of this type would have many continuous processes which take significant time to start up and achieve efficient operation. Many of these facilities can identify the exact profit per hour when the plant is running properly, and therefore the lost opportunity cost when not running.

Any power loss to equipment or automation systems for such a process would represent an expensive disruption. Some product would be lost, there would be a wasteful time of restarting the process, and there would be a period of inefficiency until the process was back in balance. It is possible that additional costs associated with specifying diagnostic and redundant power supply systems can be saved if even one failure event is avoided.

In a modern production process plant such as this one, it is also very likely that industrial fieldbuses such as FOUNDATION fieldbus or PROFIBUS would be in service. The high volume of data transmitted through these digital systems can make them susceptible to electrical disturbances on the power supply system. Providing a high-quality redundant power supply capable of proactively monitoring power quality is the premier method of keeping fieldbus systems online.

Petrochemical and other plants also typically have safety and emergency shutdown systems. These systems are designed to prevent unwanted

product releases, to prevent fires or explosions, to protect equipment, and most importantly to protect personnel. It is obvious that these systems should be supplied with the highest reliability power.

Refineries often operate asset management systems for tracking instrumentation, motor drives, and other equipment. A diagnostic power supply is a natural fit to be integrated into such a system, and to become an active and integral part of the plant maintenance strategy.

In all of these examples, diagnostic capabilities coupled with a redundant power system provide the best-of-class solution for reliable power supply.

Conclusion

Designing a world-class automated process operation does not begin and end with just the selection of the automation platform. Instead, the endeavor involves a range of considerations as the entire system must be analyzed from an overall perspective including the automation products, process sensors and instrumentation, controlled devices, communications methods, installation means, and the power supply methodology.

Reliable power is desirable for any application and has a direct impact on most aspects of an automation system and the equipment it controls. Methods of achieving reliable power come at an additional cost and effort that is particularly justified for critical process control systems, safety and emergency systems, and any configuration using digital field busses. Reliability encompasses many characteristics such as providing a high quality output, offering maximum availability through redundancy, and advanced diagnostic capabilities.

Diagnostic capabilities are a very significant differentiator elevating the best power supply systems above basic products. Power supply diagnostic functions allow the equipment to monitor itself and alert the user if there are any abnormalities with power quality or problems with the hardware. Such a system provides the highest possible uptime, minimizes downtime by providing comprehensive feedback if there is a failure, and directs technicians to preemptively repair equipment before it fails.

Diagnostic power supply systems are more advanced than standard systems, but they are relatively simply to apply as they are available preconfigured with preferred features and settings. These systems also can be custom

configured to meet the needs of the most demanding applications.

Providing unreliable power to a critical process automation system is akin to filling a high-performance car or airplane with questionable fuel. Are you willing to take such a risk?

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