GE
Intelligent Platforms

A Revolutionary Approach: Quad Redundancy Control

Ensuring the Highest Level of Availability With Smart Redundancy and Predictive Intelligence

Introduction

According to Electric Power Research Institute, companies in some industries can lose as much as $6.45 million per hour of downtime, and a research report from Oracle states that for large companies, a gain of just one percentage point of availability is worth $7.358 million per year. Even at an average size company, one hour of downtime can cost $10,000, which translates to a loss of $3.679 million per year with a 5% power availability loss.

The business impact of an unplanned outage can range from lost productivity to lost customers, depending on the business model and application, but it is clearly costly and disruptive. In addition, because many companies host critical data and services that impact other stakeholders, any loss is usually multiplied—leading to even higher total costs—both financial and operational.

As costs of a system disruption continue to soar, companies in some industries—particularly those that are web-based, customer support-focused, or security-focused—simply cannot afford downtime. Consequently, they increasingly share the same demand: to ensure the highest level of system reliability and availability at the control layer, which is the heart of any backup power solution.

GE Intelligent Platforms is at the forefront of this emerging need in the redundant controller technology space. Revolutionizing the traditional redundancy system, it offers a unique approach with an innovative "quad" redundancy control solution that virtually eliminates downtime risk—enabling companies to protect against lost productivity, profitability and customer satisfaction.

This white paper introduces GE Intelligent Platforms' quad redundancy control concept, discusses its unprecedented technical capabilities and benefits, and highlights key considerations to help companies determine whether a quad-based control solution should be part of their system design requirements to minimize financial and operational risks.

Quad redundancy control—What is it?

To ensure continuous operation, a traditional redundancy control system is based on the doubling of individual system components and the passing over of control from the active to the backup system at the moment failure occurs. The system controls a single process using two real-time synchronized CPUs. The active CPU provides process control and simultaneous synchronization of the backup CPU; if a failure of the active CPU is detected, the backup CPU is switched into the active mode, which takes control of the whole process. Essentially, the principle is to have one backup to ensure continuity of operations without disruption.

By contrast, a quad redundancy control system has four redundant controllers—a Master Controller and three synchronized backup controllers. It leverages Ethernet-based I/O that can seamlessly arbitrate its I/O control from one of the four controllers. If the Master Controller or any of the system components fail, the system identifies the best backup controller to take over and provide the system with the most capability to withstand the next sequence of multiple or cascaded system failures.

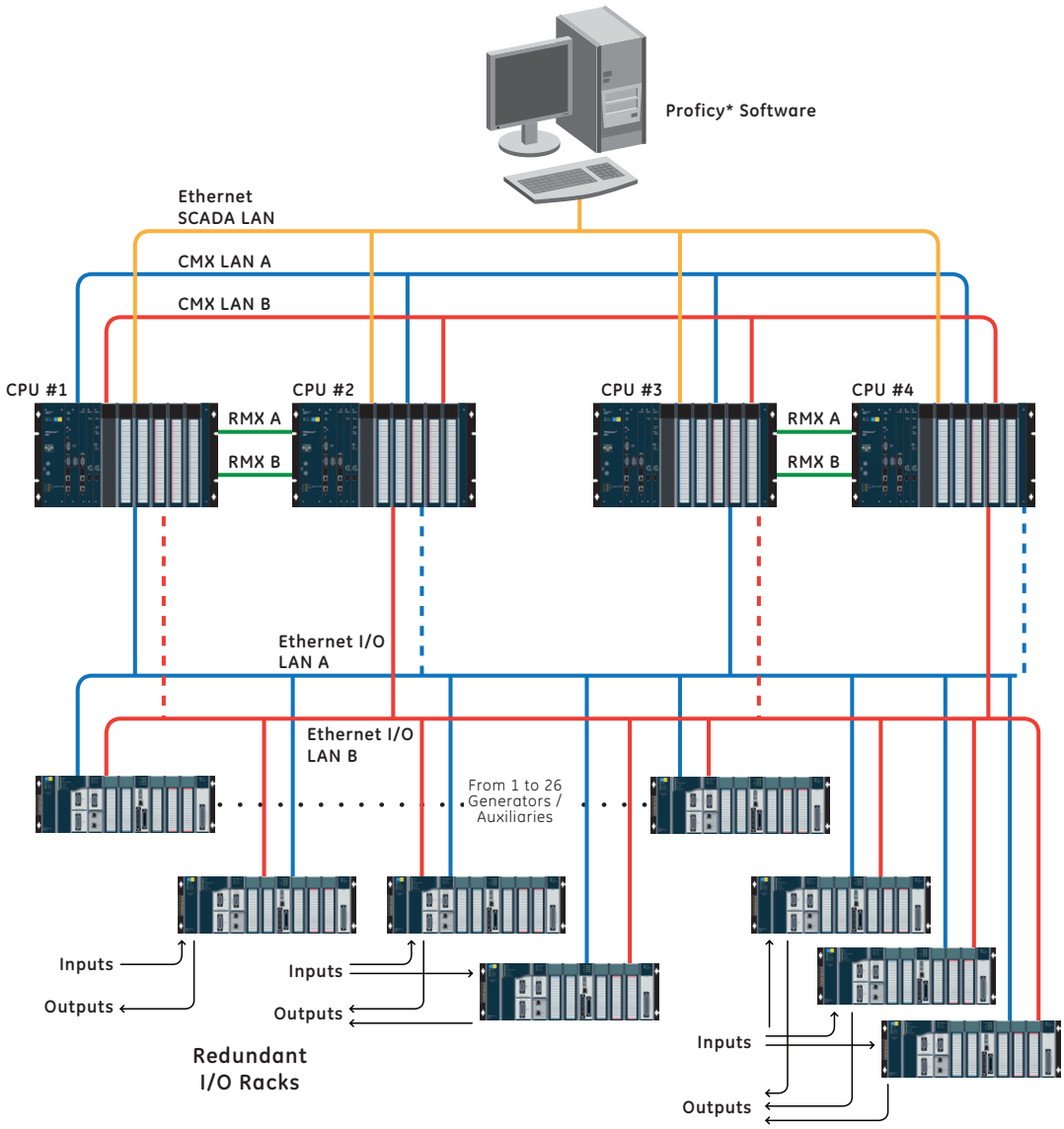
A quad redundancy control system addresses the increased demand for more redundancy with higher speeds, real-time communications and deterministic data transfers. It can provide maximum availability in applications, including but not limited to emergency power for hospitals, data centers and critical processes where downtime is not an option.

Businesses increasingly face the criticality of uptime—driving facility owners and operators to adopt and invest in the latest technologies that provide continuous control of their backup systems.

GE Intelligent Platforms believes a quad redundancy control system provides superior reliability and availability for the most demanding industrial and commercial applications—ensuring the most seamless redundant control switchover. Its revolutionary Quad PAC system ensures business continuity by providing uninterrupted control of applications and processes in the event of individual system component failures. The next section explains the technical details of GE Intelligent Platforms' Quad PAC system.

The Quad PAC solution architecture

The Quad PAC application consists of two redundant pairs of GE Intelligent Platforms' PACSystems* RX7i controllers working in unison, for a total of four RX7i controllers and their associated items (racks, power supplies, etc). The controllers in the pairs are connected via redundant high-speed fiber optic modules, which provide synchronized logic solving and data transfer between the controllers. Similar technology is used via network hubs to tie all four controllers into a cohesive quad-redundant solution.



GE Intelligent Platforms' unique Quad PAC redundant control system provides two mirror-imaged pairs of redundant controllers, whereby one of the four controllers can back up any of the other controllers in the system.

A Revolutionary Approach: Quad Redundancy Control

As almost all paralleled switchgear in critical power delivery applications involve a mirror-imaged mechanical backup architecture with generators, GE Intelligent Platforms' Quad PAC redundant control system provides two mirror-imaged pairs of redundant controllers, with the unique capability that any one of the four controllers can back up any of the other controllers in the system.

Consequently, there are always three complete levels of backup, which is different than what most offerings refer to as "redundant redundant," whereby the solution does not synchronize the two pairs. Instead, the two pairs operate independently and are only capable of controlling their side of the mirror image; they do not back each other up and are not synchronized.

In contrast, the Quad PAC can provide full control of either side or both sides of the paralleled switchgear, even with a redundant pair completely out of service. Furthermore, whereas traditional redundancy systems pose a risk for system designers with only a single backup when one of the controllers is down for maintenance, the Quad PAC architecture allows maintenance shutdowns of one side of the mirror, including the controls—providing multiple backups.

The Quad PAC I/O system

The Quad PAC I/O system involves GE Intelligent Platforms' PACSystems RX3i Remote I/O and redundant Ethernet LANs. Each remote I/O rack supports redundant network interfaces and provides all four controllers with the system inputs and outputs in a fully arbitrated format.

The remote I/O racks may be grouped into either a single (one I/O rack), redundant (two I/O racks), or triple redundant (three I/O racks) rack configuration, in which each I/O rack communicates independently with all four controllers, and each controller shares the same input and output point addresses from each I/O rack.

Functional operation of the Quad PAC solution

The Quad PAC solution works in harmony to deliver a "Smart Redundancy" approach for all mission-critical power applications. It consists of three critical elements:

- The PAC Virtual Master control algorithm
- The PAC Virtual Master LINK
- The PAC ENIU redundant I/O networking infrastructure

Smart redundancy for predictive intelligence

The **PAC Virtual Master** algorithm that resides in each of the four controllers and operates virtually between all is the most important feature of the Quad PAC solution. Each controller runs in parallel, solving the process logic based on its own input data. Only one controller, the "Master" Controller, can control the outputs at any time and share its solution (outputs and process data) with the other three controllers, so they are ready to take control if there is a failure in the control system.

The PAC Virtual Master continuously calculates in real time the relative system availability for all four of the CPUs. The system's patent-pending Virtual Master algorithm performs a set of system analytics on the key process input variables (KPIVs) to clearly predict and identify the controller most capable of "withstanding a sequence of multiple or cascaded system failures" while maintaining maximum system availability. Based on the calculated results of that algorithm, it assigns the Master Controller; the three other controllers are then synchronized to that particular Master Controller as backups.

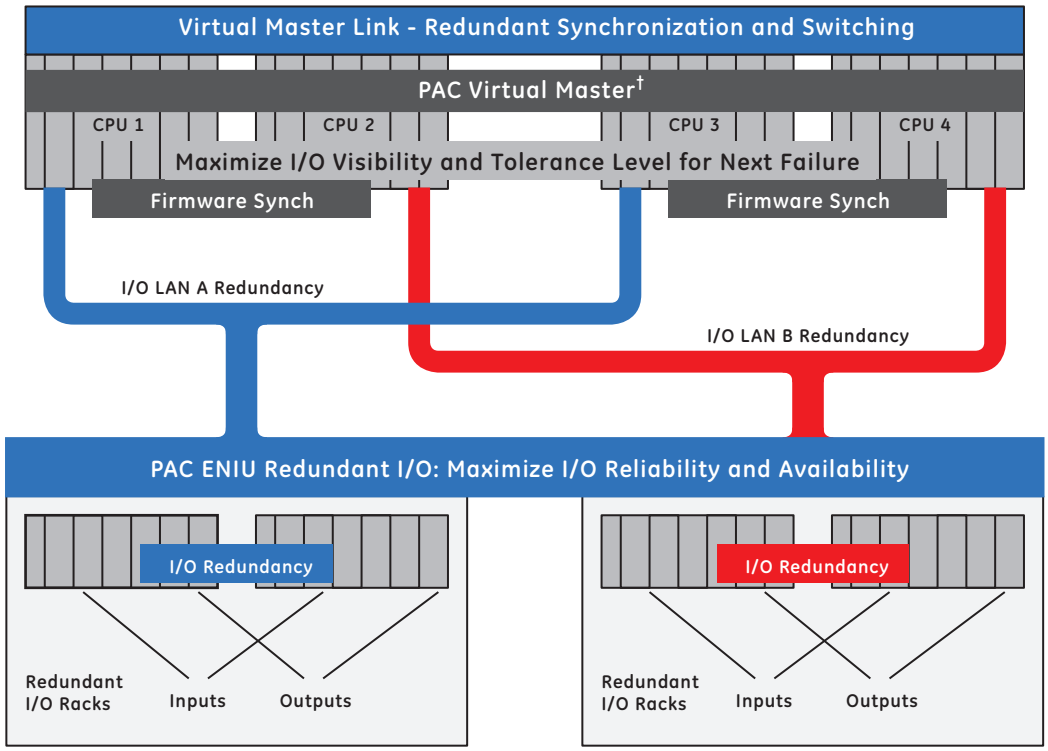
If the master or an external component fails, the PAC Virtual Master will then select the next master based on the outcome of "new" real-time system analytics, which results from the system components that remain functional and the projected level of availability to keep the system operational. A system can fail from four (operational) CPUs down to one without losing control of the I/O—delivering a truly "Smart Redundancy" system.

The Quad PAC system addresses the increased demand for "near-zero downtime" in mission-critical applications for hospitals, data centers and critical processes. It uses a unique and revolutionary "predictive intelligence" schema available in the market for the first time.

The redundant fiber-optic **PAC Virtual Master LINK** provides both high-speed process data synchronization and role switching of the Quad Master Controller. The instantaneous sharing of process and I/O data to each of the controllers allows any one of the controllers to take on mastership of the process at any time.

The **PAC ENIU redundant I/O networking infrastructure** links all the Quad PAC controllers, generators and/or auxiliary PACSystems RX3i controllers, and all remote I/O drops. The unique, multi-path application of the Ethernet networking infrastructure provides the Quad PAC controllers with both constant and maximum visibility of the field I/O data, thereby maximizing overall system reliability and availability.

The network infrastructure provides scalability with industrially hardened, standards-based Ethernet network components, enabling the infrastructure to leverage newer or higher performing technologies as Ethernet standards advance. For example, users can factor in considerations such as migrating to future 10 Gbit fiber-based Ethernet backbones or using media redundancy with "Ring" topologies.



† Patent pending as of December 2009

Functional Block Diagram

Predictive intelligence schema

In the Quad PAC architecture, if the Master Controller fails, the system continually provides a real-time calculation of the system at any point in time to identify the backup controller that has the best "look-ahead view" of the entire control and remote I/O system components to take over mastership of the system—ensuring maximized uptime.

Benefits of quad redundancy control

With quad redundancy control, companies can rely on the highest level of availability at all times for maximized uptime, reduced costs, and improved performance—all of which drive the bottom line as well as customer satisfaction.

Maximized uptime

Continuity of your operations is critical, and a quad redundancy control system ensures that any process can continue without interruption by having one of its three backup counterparts assume control if failure occurs. By having one Master Controller and three synchronized controllers with "Smart Redundancy," there is a greater level of reliability to virtually eliminate downtime. Additionally, the use of Ethernet technology enables open communications and interoperability with third-party devices and future technologies, and mitigates the risks of downtime.

Reduced costs

The high cost of stoppage is a key consideration for investing in a quad redundancy control system. As the economic impact of even a short period of downtime or momentary interruptions can result in huge financial and operational costs, a quad redundancy system can be a cost-effective solution to protect against potentially greater losses in the future if a failure occurs. In addition, this type of high availability system can also help reduce costs by enabling maintenance or exchange of individual system components without interruption.

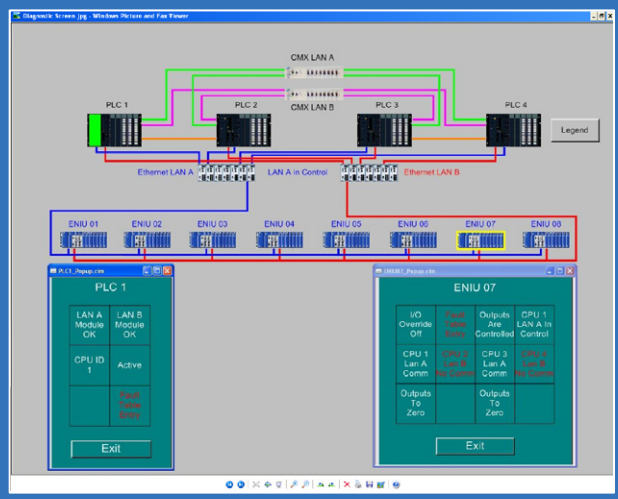
Improved performance

Mission-critical operations cannot afford a compromise in performance, which is another reason a quad redundancy control system can be beneficial. Leveraging the latest technologies, the system improves performance by enabling high-speed, low latency, data delivery and deterministic data transfers for demanding real-time communications. One can easily transfer significant amounts of data, operate in high-noise areas, or cover large distances in real time with seamless switchover control.

Reliability and maintainability: The heart of the Quad PAC control system

The Quad PAC comes with a diagnostic package, complete with HMI screens, that enables the user to visually determine which Quad PAC CPU is in control and quickly determine which control or network elements of the entire control system are fully or partially operational at any moment in time.

The software is available to run locally on a GE Intelligent Platforms Quickpanel* HMI for local maintenance activities. It is also available to run on the Proficy SCADA software as part of a larger server-based SCADA system, designed not only to operate and maintain the entire operation but also to continually monitor the health of the Quad PAC system and the connected I/O.



This figure presents a sample overview screen of the Quad PAC diagnostic package.

Key Considerations

Companies that are assessing the value of a quad redundancy control solution should consider the following questions:

- Does your project or your particular site involve "computer server farms" as the heart of your company's business model?
- Does your project utilize both primary and backup main utility power feeds with additional backup from local fuel-powered generator systems?
- Do you believe that even one minute of system downtime is unacceptable to your business model?
- Is your operation considered "mission critical" and is it imperative to be available 24/7/365?

Conclusion

As the business impact of system downtime can pose extremely prohibitive financial and operational risks, companies are increasingly seeking ways to ensure the highest level of system reliability and availability at all times through continuous control of their backup systems.

At the forefront of this emerging need is GE Intelligent Platforms' revolutionary quad redundancy control solution called the Quad PAC. Taking the traditional redundancy control system to a whole new level of availability, the Quad PAC solution provides two redundant pairs of controllers that offer a mirror-imaged approach and instantaneous synchronization to ensure maximized uptime.

The true power behind the Quad PAC solution is its "Smart Redundancy" capability. It has an algorithm that continually calculates the relative system availability in real time and delivers predictive analysis on key process input variables to clearly identify the next Master Controller most capable of surviving a system failure while maintaining maximum system availability.

A quad redundancy control solution such as GE Intelligent Platforms' Quad PAC is particularly ideal for companies that are web-based, customer support-focused, or security-focused and cannot afford any downtime. The unique and innovative approach virtually eliminates downtime risk—enabling companies to protect against lost productivity and profitability for a sustainable competitive advantage.

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