Modular architecture for high power UPS systems

Abstract

Today, more than ever before, energy efficiency and cost savings are top priorities for customers in all applications. The efficient use of energy, however, is an issue that is particularly critical for the data center sector, both from an environmental and financial perspective. As a consequence, data center operators seek solutions that incorporate optimum performance and reliability to achieve not only energy and cost savings, but also the uninterrupted support that they are expected to provide to their commercially critical applications. In turn, UPS systems must deliver optimum power quality at minimal cost while maintaining levels of redundancy that ensure seamless operation and savings.

In order to meet the demanding performance and efficiency requirements of today’s ever-growing data centers, it is becoming more and more common to adopt a modular approach for the design of high performance UPS solutions. Additionally, modular architecture coupled with advanced control systems provide the data center operator with an unprecedented level of flexibility to respond to rapid variations in load demand without sacrificing efficiency.

Introduction

The modular approach to UPS architecture provides a number of advantages for the end user by broadening the scope of energy and cost savings, system flexibility, adaptability, redundancy, and fault tolerance.

As a recognized leader in the UPS industry, Chloride has long been known for anticipating market needs and developing benchmark technology solutions. Continuing this trend, Chloride has developed Trinergy; an intelligent modular solution designed to provide the highest standards of performance, serviceability, flexibility, and scalability, while also incorporating maximum energy saving features.

Trinergy is like no other modular solution ever before seen in the market. We will take a closer look at the specific design features of Trinergy’s modular architecture later in this paper, but first we need to understand exactly what modularity is and how the concept forms the basis of Chloride’s latest milestone in innovation.

Advantages of modular architecture

Conventional UPS systems consist of large-capacity blocks which are inefficient if loaded below optimal levels. The operator also incurs substantial capital costs and efficiency penalties to provide redundancy and capacity for rapid growth.

Modular, scalable UPS systems permit the customer to make capital investments only as needed while remaining nimble for expansion. Modular systems also simplify service and facilitate concurrent maintainability. And, new control technologies enable some to deliver the highest levels of efficiency at loads as low as 20% of capacity.
Modular architecture for high power UPS systems

What is modularity?

The modular design of a UPS consists of separating the system components into smaller parts (modules) that work together as a whole system. Each individual power module is built with the necessary hardware to allow it to work together with other modules as a larger, more powerful system. In terms of UPS, the configuration of a group of modules working together as a complete system helps eliminate the possibility of a single point of failure thus minimizing downtime.

Modularity has been used in Chloride UPS in certain forms for some time. Existing modular arrangements already incorporated in Chloride UPS are the concepts of Vertical and Horizontal modularity.

**Vertical modularity:** refers to the internal architecture of the UPS in which the component parts are configured as extractable sub-assemblies inside the UPS “core” cabinet. This improves the flexibility and serviceability of the UPS and thus reduces time needed for service, repair (MTTR - Mean Time to Repair) and maintenance.

**Horizontal modularity:** refers to the option of increasing the overall system power by adding additional UPS modules to an existing modular infrastructure in order to increase power and/or redundancy. Horizontal modularity allows the end user to make an initial investment in line with their immediate (short-term) power protection needs and subsequently increase the power of the system when their future business needs change.
Modular architecture for high power UPS systems

Trinergy modularity

Trinergy is designed to monitor the operating environment in which it works and intelligently select the most efficient functioning mode for resolving disturbances maintain top performance of the load. As we will see later, modularity plays a key role in maintaining peak efficiency.

One of the elements that makes Trinergy a unique UPS is the combination of Vertical and Horizontal modularity together with the addition of a new third dimension referred to as Orthogonal modularity.

Trinergy’s three dimensions of modularity, allow the user to add power modules to a central I/O Box at anytime during the lifecycle of the UPS, allowing it to reach the highest active power rating available to date in a single UPS system: 9.6 MW.

Vertical modularity for serviceability

As seen earlier, Vertical modularity refers to the sub-assemblies inside each “core” or power module which can be individually extracted for ease of service and maintenance.

Key characteristics of Trinergy’s vertical modularity:

- **Construction** - Each individual UPS power module core cabinet houses standard sub-assemblies for the rectifier, inverter and static bypass which together make up the component parts of a single 200 kW UPS.
- **Accessibility** - Modules are easily accessible from the front of the cabinets, allowing for simplified service and maintenance to be carried out. Front accessibility has the added benefit of space saving by eliminating the need for free space in the rear of the unit.
- **Maintenance** - Trinergy’s 200 kW modules are based on easily withdrawable units, allowing maintenance on individual components to be greatly simplified.
Trinergy can scale up to 1.2 MW of power in a single row by adding complete 200 kW cabinet modules to an existing modular infrastructure.

Key characteristics of Trinergy’s horizontal modularity include:

- **Parallel modules** - A single Trinergy UPS array can consist of up to six 200 kW UPS cabinet modules. The number of UPS modules that can be connected depends on the initial choice of the central I/O Box which is available for two, four or a maximum of six 200 kW modules. Once the dedicated I/O Box has been installed, it can be configured to the power rating required by adding or removing modules to meet the installation power requirements.

- **Distributed control** - Trinergy’s parallel control is distributed evenly between UPS modules so that there is no master/slave architecture, hence eliminating the possibility of a single point failure. The essence of this concept is that the overall multi-module system is controlled and monitored automatically by the integral controls within each individual UPS module. A closed loop data bus system enables data to be shared between modules and is configured such that a first fault in the data string will not affect operation or load support.

- **Ease of installation** - Trinergy’s modular design facilitates installation by allowing the UPS to be assembled on-site, making it ideal even for sites with difficult accessibility. The maximum dimensions of any single Trinergy 200 kW unit are: W.42 x D.33.5 x Ht.70 inches.

- **In field upgradability**: grow with load demands - A Trinergy system can initially be configured to meet the immediate load requirements without oversizing the system to cater to foreseeable future load requirements. Additional modules can easily be added at a later date as and when the load power requirements change. This helps minimize the initial capital investment and has the added advantage of ensuring that the UPS system operates at a significantly higher percentage load for optimum efficiency.

- **Internal redundancy** - Trinergy can be configured to provide different levels of system redundancy. A system is defined as redundant if the number of power modules installed is at least N+1, where N equals the number of power modules necessary to power the load and 1 is the redundancy coefficient. This essentially means that even in the rare case that a single power module fails, it will automatically be disconnected from the system and the remaining modules will continue to support the critical load.

- **Concurrent maintainability** - Trinergy is designed to allow individual power modules to be isolated for safe maintenance while the remaining modules continue to provide conditioned power to the load.

- **Availability** - Availability of power from a user’s perspective is fundamental to the entire installation. It is essential that the user has the confidence and knowledge that the UPS is always in service, supplying conditioned and secure power to the critical load without interruption. The availability of power for the critical load is directly linked with reliability and maintainability. This means that the Mean Time Between Failure (MTBF) of the equipment must be high and the Mean Time To Repair (MTTR) should be as short as possible in order to achieve a high system availability factor. Trinergy addresses both of these functions by using well proven 200 kW power modules for high MTBF and standard modular UPS sub-assemblies to ensure minimum MTTR for each UPS.

- **Reliability (MTBF)** - It is essential that the Mean Time Between Failure (MTBF) of a UPS system is as high as possible, especially to satisfy the demands of critical computer applications such as data centers. The concept of redundancy is a key element in designing highly reliable power supply systems with high MTBF. The advantage of Trinergy’s modular system is the ease with which additional modules can be added in order to achieve the level of redundancy required by the system.

- **The high MTBF of the Trinergy system** has been achieved by basing the system on Chloride’s well proven transformer free technology currently used for its existing 200 kVA UPS.

- **Maintainability (MTTR)** - The modular arrangement of Trinergy’s internal sub-assemblies ensures a short Mean Time to Repair (MTTR) for individual UPS modules. If spares are held on site, the MTTR can be further reduced.

- **Batteries** - The concept of modularity can be extended to batteries as well. The Trinergy can be equipped with multiple strings of batteries, each with its own disconnect/breaker. Thus, any one battery string or cabinet does not represent a single point of failure.
Orthogonal modularity of parallelability

Orthogonal modularity is the ability of Trinergy to work with up to eight complete UPS systems in parallel—up to a total of 9.6 MW. Key characteristics of Trinergy’s orthogonal modularity:

- **System power capability** - Orthogonal modularity refers to the ability of Trinergy to connect up to eight 1.2 MW UPS arrays, each with six 200 kW UPS modules, to achieve a total system power capability of 9.6 MW.

- **System power flexibility** - Trinergy can also be configured to match existing site switchgear power requirements. For example, a 2 MW system can be configured as two systems of five 200 kW modules or it could equally be configured as five systems of two 200 kW in order to match existing electrical switchgear.

- **System power redundancy** - Redundancy can be built into the system at any point. For example, a 1 MW load may be supported by five 200 kW modules with an extra module added to achieve the redundancy required for the given load. Similarly, if eight groups of six 200 kW (N+1) systems were to be operated in parallel then the effective overall level of redundancy for this as an 8 MW system would be (N+8). In this way an exceptionally high level of security and availability of power protection can be configured to meet specific load requirements. If however, a lower level of redundancy is required (N+1) it is possible to achieve a higher power configuration of 9.4 MW while at the same time maintaining redundancy.

- **Circular redundancy (how modularity can improve efficiency)** - When using a redundant system it is quite common that UPS operate at light loads which in turn lower its efficiency. Trinergy however, has a built in circular redundancy capability which allows the system to automatically switch OFF excess UPS power capacity not required to meet immediate load requirements. This allows Trinergy to operate with extremely high efficiency—even at very light loads, while maintaining a very high level of reliability of the system, activating only the required number of power modules. The use of automatic circular redundancy means that the overall system is able to run at optimum efficiency at all times while maintaining a very high level of load protection. The circular redundancy system ensures that the “rested” (excess) UPS modules are rotated so as to allow all modules to be operated for an equal amount of time.

I/O Box

Trinergy’s three levels of modularity are built around the I/O Box that is the major interface for connectivity and power connections.

Traditional multi-module UPS systems require an input supply protection device for each UPS in the system. Trinergy simplifies this with the central I/O Box which serves as a connect point for all connectivity and power connections for each group of up to six 200 kW power modules. The central I/O Box also houses a 12.1 inch LCD touch screen display which allows for easy monitoring of both the system and the individual modules. The touch screen provides access to operational parameters and to the service history log in order to fast track maintenance.

The main power isolators are located on the front of the I/O Box, including the rectifier and static bypass input breakers and battery breaker. The central I/O Box is available in three different ratings: 400 kW, 800 kW and 1200 kW. In its largest format, up to six 200 kW power modules can be connected to the I/O Box. The central I/O Box is configured to allow either top or bottom cable entry as required. This I/O interface for both power and communication, greatly simplifies installation.
Conclusion

From the characteristics outlined in this paper it is evident that the modular architecture used in the design of Trinergy allows for unprecedented flexibility and efficiency. Its modular architecture offers attractive benefits for end users in terms of significant capital cost savings and operating costs reduction.

Trinergy’s modular architecture is designed to give users the flexibility of expanding the system in small or large increments to cater for changes in the business power protection requirements. This naturally provides cost savings for end users as they are able to make an investment based on their immediate power protection requirements with peace of mind knowing that in the future they can easily build on their existing infrastructure.