

Modular architecture for high power UPS systems



Abstract

Today, more than ever before, energy efficiency and cost-savings are among the top priorities for customers of 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 in order to be able to achieve, not only the necessary energy and cost-savings, but also the uninterrupted support that they are expected to provide to their commercially critical applications. In turn, UPS systems are required to deliver optimum power quality at minimal cost whilst delivering 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 to the design of high performance UPS solutions. Furthermore modular solutions are in line with the European Union Code of Conduct on Data Center 'Best Practices' which specifically highlights the advantages to be gained from the use of modular concepts in energy efficient UPS systems.

Introduction

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

As a recognized leader in the UPS industry, Chloride UPS have long been known for anticipating market needs and developing benchmark solutions particularly in terms of technology.

To this extent Emerson Network Power's Chloride business has developed Chloride Trinergy®; an intelligent modular solution designed to meet the highest standards of performance, serviceability, flexibility and scalability, while also incorporating maximum energy saving features. Furthermore, Chloride Trinergy® meets all of the requirements set out in the European Union Code of Conduct on Data Center 'Best Practices' mentioned with reference to modular concepts.

Chloride 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 the Chloride Trinergy® modular architecture later in this paper, but first we need to understand exactly what modularity is and how the concept forms the basis of the latest milestone in UPS innovation.

EU Code of Conduct on Data Centers: Energy Efficiency Best Practices

" The provisioning of excess power..... in the data center drives substantial fixed losses and is unnecessary. Planning a data center for modular (scalable) expansion and then building out this capacity in a rolling program of deployments is more efficient."

The European Code of Conduct recommends

"modular (scalable) UPS systems across a broad range of power delivery capabilities. Physical installation, transformers and cabling are prepared to meet the design electrical load of the facility but the '....UPS....' are installed, as required, in modular units. This substantially reduces both the capital costs and the fixed overhead losses of these 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 be able to allow it to work together with other modules as a larger, more powerful system. Depending on the modular approach taken by the manufacturer, UPS modules can be arranged as a combination of power and/or battery modules housed within the same cabinet. 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.

The basic concept of modularity has been used in our 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 cabinet. This improves the flexibility and serviceability of the UPS and thus reduces the time needed for service, repair (MTTR - mean time to repair minimized) and maintenance.



Vertical modularity: Internal view of UPS with sub-assemblies

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 as and when their future business needs change.



Horizontal modularity: Conventional horizontal modularity: UPS in parallel

Chloride Trinergy®

Chloride Trinergy® is designed to monitor the operating environment in which it works and intelligently select the most efficient functioning mode for resolving disturbance while maintaining top performance of the load.

One of the elements that makes Chloride 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**.

Chloride 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.



Chloride Trinergy® has three dimensions of modularity; Vertical, Horizontal & Orthogonal, all incorporated to make it the best scalable solution available in the market.

So how do Chloride Trinergy®'s three dimensions of modularity work?

Vertical modularity for serviceability

As seen earlier, Vertical modularity essentially refers to the stacked drawers inside each cabinet module which can be individually extracted for ease of service and maintenance.

Key characteristics of Chloride Trinergy®'s vertical modularity:

- **Construction** - Each individual UPS power module 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** - Chloride Trinergy®'s 200 kW modules are based on easily withdrawable units, allowing maintenance on individual components to be greatly simplified.
- **Installation** - Chloride Trinergy®'s modular design facilitates installation by allowing the UPS to be assembled on-site, module-by-module, making it ideal even for sites with difficult accessibility. The maximum dimensions of any single Chloride Trinergy® 200 kW unit are: W.1070 x D.850 x Ht.1780 mm.

Horizontal modularity for power upgrades

Chloride Trinerity® can scale up to 1.2 MW of power by adding complete 200 kW cabinet modules to an existing modular infrastructure.

Key characteristics of Chloride Trinerity®'s horizontal modularity include:

- **Parallel Modules** - A single Chloride Trinerity® UPS system 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** - Chloride Trinerity®'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.
- **In field upgradability: grows with load needs** - A Chloride Trinerity® 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** - Chloride Trinerity® 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** - Chloride Trinerity® is designed to allow individual power modules to be isolated for safe maintenance whilst 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. Chloride Trinerity® 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 Chloride Trinerity®'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 Chloride Trinerity® system** has been achieved by basing the system on the well proven transformer-free free technology currently used for 200 kVA Chloride UPS.
- **Maintainability (MTTR)** - The modular arrangement of Chloride Trinerity®'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 extends also to batteries. Whilst it is possible to use a common battery for the whole Chloride Trinerity® system, reliability can be further enhanced by using distributed batteries i.e. a separate battery bank for each 200 kW UPS module. The I/O Box used for connecting the batteries provides the DC electrical connection facility to enable either one single battery or distributed batteries to be used.

Orthogonal modularity for parallelability

Orthogonal modularity is the ability of Chloride Trinerger® to work with up to eight complete UPS systems in parallel equaling a total of up to 9.6 MW.

Key characteristics of Chloride Trinerger®'s orthogonal modularity:

- **System Power Capability** - Orthogonal modularity refers to the ability of Chloride Trinerger® to connect up to eight 1.2 MW UPS systems, each consisting of six 200 kW UPS modules, to achieve a total system power capability of 9.6 MW.
- **System Power Flexibility** - Chloride Trinerger® 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** - When using a redundant system it is quite common that UPS operate at light loads which in turn lower its efficiency. Chloride Trinerger® however, has an inbuilt circular redundancy capacity which allows the system to automatically switch OFF excess UPS power capacity not used in meeting immediate load requirements. This allows Chloride Trinerger® to operate with extremely high efficiency even at very light loads, while at the same time increasing the level of reliability of the system by 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 high level of load protection. The system of circular redundancy ensures that the "rested" (excess) UPS modules are rotated so as to allow them to be operated for an equal amount of time.

I/O Box

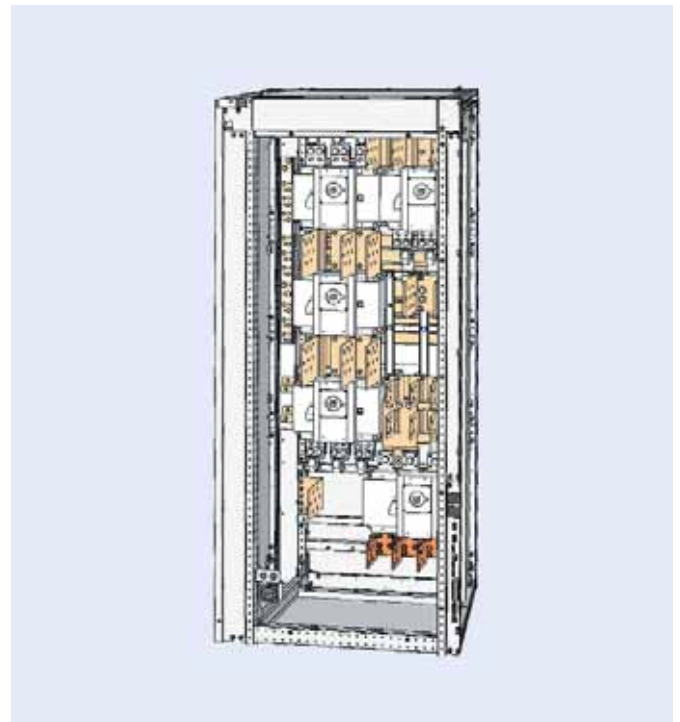
Chloride Trinerger's® three level of modularity are built around the I/O Box which is the major interface for connectivity and power connections.

Traditional multi-module UPS systems require an input supply protection device for each UPS in the system. Chloride Trinerger® simplifies this with the central I/O Box which serves as a central point for all connectivity and power connections of 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 the system and the individual modules.

The touch screen feature 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 switches, the system maintenance bypass switch, output switch and battery isolator. The arrangement enables any module to be isolated for maintenance purposes without disconnecting the load.

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 also contains the input and output terminals and is configured to allow either top or bottom cable entry as required. The I/O interface for both power and communication, greatly simplifies installation. Centralized and distributed battery configurations are also connected to the central I/O Box.



Internal view of I/O Box

Conclusion

From the characteristics outlined in this paper it is evident that the modular architecture used in the design of Chloride Trinerger® allows for never before seen flexibility and unprecedented efficiency. Not only is its modular architecture in line with European Union Code of Conduct on Best Practices, but it also offers attractive benefits for end users in terms of significant capital cost-savings and reduction in running costs.

Chloride Trinerger'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.

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