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Modular power protection in industrial applications – understanding the “ilities”

Modularity (1 of 5)

Modularity

Modular power protection and conversion technology has been used in commercial applications for many years and its benefits in this market sector are well understood and accepted. These benefits include, but are not limited to, availability (as opposed to reliability), scalability, flexibility and maintainability. It is because of these benefits that three-phase Modular UPS is the fastest-growing sector of the commercial UPS market.

Because modular power protection and conversion technology has proved so successful in commercial applications, the traditionally more "conservative" industrial engineers are now increasingly seeking ways to use such technology in industrial applications. The problem, however, is that the terminology associated with this technology can be misleading and marketing "spin" does little to help.

In this first of a series of five articles, we attempt to define and explain modularity from the electrical engineer's perspective and thereby better understand the benefits it can bring to industrial power system design.

Modular power protection and conversion technology, particularly in the form of UPSs, has long been used in commercial applications, but take-up in industrial areas has, to date, been relatively slow. Why is this so?

Whenever anyone describes the benefits of "Modular" power protection systems they invariably discuss topics like "Availability", "Reliability", "Scalability", "Flexibility" and "Maintainability", but what exactly does each of these "ilities" mean and why are they important?

This article is the first in a series of five in which David Bond, Managing Director at Benning Power Electronics (UK) Ltd, explains the terminology behind this increasingly important and popular technology.

Modularity in industrial power protection applications

3-phase UPSs that are widely regarded as being 'Truly Modular' have been around since 2001 in the commercial sector; however, despite many operational benefits this technology is only just beginning to be accepted in industrial markets. This is largely because of the differences between commercial and industrial users' priorities, pressures and the demands on their equipment.

A datacentre, for example, is a very dynamic environment that is forever changing and reacting to things like the need for ever higher power density and ever faster IT system performance. To maintain competitiveness a typical datacentre must upgrade its IT hardware every three to four years. By contrast, a power station is relatively stable and once the site control, management and telemetry systems are installed they are expected to have a useful working life of 20-25 years. These large differences in the requirements of commercial and industrial applications clearly require two very different approaches to the introduction of "new technology".

What is "Modularity"?

"Modularity" is "the state of being modular" and "Modular" is something "related to, or based upon, modules" so, the big question is, what is a module?

Whilst there isn't a universally accepted definition of "Module", most engineers would agree that a "Module" is "a self-contained device that performs a specific function" so this is the definition we shall use in this article.

Be aware, however, that manufacturers' Marketing departments often blur the lines between the various technologies and topologies so it is more important to understand what the technology/topology is rather than what it is called.

Modular topologies

Modular UPS topology has developed in three distinct stages: Advances in the design of electrical and electronic components, particularly surface mount devices, the introduction of Insulated Gate Bipolar Transistors (IGBTs), and the invention of the "Transformerless" UPSs allowed Modular UPS topology to develop from the traditional mono-block UPS of the 1980s through the modular-block architecture of the 1990s to the rack-mounted modular UPS that we see today.

Traditional mono-block

Most people think of a traditional mono-block when describing a UPS. This topology has been around for the past 50 years or more and the single floor standing UPS cabinet contains all of the system components necessary for the UPS to operate. The PCBs, switching components and reactive components are all separate, and individual PCBs and/or components need to be separately removed and replaced in situ to effect a repair. Such repairs are often time consuming, and whilst being repaired the entire UPS is offline and the load exposed to raw mains power.

Furthermore, if additional system capacity and/or redundancy is required after the UPS is installed then the system upgrade (scalability) will be expensive, assuming that sufficient floor space and electrical infrastructure is available to accommodate any additional UPS cabinets.

Clever marketing "spin" can argue that, despite their size and weight, each UPS cabinet is a module and therefore the UPS is modular. However, we will see below that mono-block UPSs are not really a true "modular" topology.

Fig. 1: A mono-block UPS with individually mounded PCBs and power switching components.

Modular-block architecture

Developing UPS technology allowed UPS construction methods to evolve, and "modular-block" systems began to appear. In this type of system each floor standing UPS cabinet still contains all of the UPS system components in a single cabinet BUT the major system components are grouped together into sub-assemblies that can be considered modules. For example, all UPSs have a rectifier, an inverter and a static switch. In the modular-block UPS the rectifier module(s), inverter module(s) and static switch module(s) are all self-contained and can be individually removed from and/or added to the UPS system.

The major benefits of modular-block topology are increased system availability and system maintainability because it is much quicker to replace, for example, a faulty rectifier module than it is to repair a faulty rectifier on site. Modular-block architecture systems, however, still suffer from the lack of "scalability" seen in the Mono-block systems.

Whilst Modular-block topology is a lot more “modular” than the traditional mono-block UPS discussed above, and whilst this is an excellent solution for some specialist applications, this is also not really a true “modular” solution.

Fig. 2: A modular-block UPS with individual rectifier and inverter power modules.

Rack-mounted Modular

In this topology, each UPS cabinet contains independent UPS modules that are paralleled to form the complete system. Each module is a complete and independent UPS functional unit, which can be removed from or added to the system without interrupting power availability to the critical load. The ability to very quickly remove and/or add modules into a fully functioning UPS system is often referred to as “hot swap” or “safe swap” and is one of the ways that this topology can be identified.

Because UPS modules can be very quickly and safely exchanged, added to or removed from a fully functioning UPS system this topology maximises system availability whilst enabling system scalability and flexibility. As we will see in the “Availability v. Reliability” article from this series it is the speed of repair of such UPS systems that maximises their availability whilst the “Scalability” and “Flexibility” articles will explain how such topology can reduce both the initial capital cost and the running costs of a properly configured system.

Fig. 3: A rack-mounted modular UPS with individual UPS modules

CPA or DPA?

There are two common forms of rack-mounted modular topology, known as Centralised Parallel Architecture (CPA) and Decentralised Parallel Architecture (DPA). If any of the modules in the system share common components (i.e. they all feed a single static switch or all use the same logic/control module) they are CPA. Each such shared component is a potential Single Point of Failure (SPOF). If all of the modules are capable of fully independent operation (i.e. they share no common components) they are DPA.

The difference between CPA and DPA is important to understand, because whilst CPA systems are lower cost, their single points of failure may not be acceptable for some applications.

Conclusion

The operational and commercial benefits of true modular UPS technology are too great to ignore and modular technology/topology will change industrial power protection in the same way it has changed commercial power protection.

It is necessary to properly understand what is meant by modularity/modular/module because not all “modules” are really “modular” and to have all the benefits of modularity calls for modular technology that has “hot swap” capability and Decentralised Parallel Architecture (DPA).

The next article in the “ilities” series will discuss the difference between “Availability” and “Reliability” and will consider the impact of true modular technology on “N+1” parallel redundancy and system repair times, and hence system availability.