How Uninterruptible Power Supplies meet the needs of Defence Information Infrastructures

Military forces have always needed accurate and timely data to ensure operational success. Modern warfare trends towards widely dispersed activities mean that information must be delivered to a combat zone from points distributed across a large network. This network can include data centres 'back at base' as well as more local field units. Such data centres use power protection strategies including UPS systems to ensure mission-critical 24/7 availability. This article looks at how modern UPS technology allows operators to achieve the power security, flexibility and cost-effectiveness they must have.

Warfare trends

Throughout the history of warfare, military forces have always needed accurate, reliably communicated data to ensure success. Expected warfare trends will increase this demand for accurate data and the widely distributed ICT systems that deliver it. Military and strategic experts see future combat patterns tending away from large scale WW2 type territory battles and towards small-scale conflicts and insurgencies spread over wide areas. Efficient and successful response to such scenarios calls for network-centric warfare, where an entire army becomes a single entity with many parts that can shift and adapt to quickly-developing situations when and where they occur. Units must share real-time information, co-ordinate movement and react to battle conditions quickly and accurately. To be effective, this information must be complete, reliable and timely.

Much of the intelligence fed to personnel in the war zone will comprise data and updates from other combat areas. However there will always be a need to include information from "behind the scenes" back in the home country. From this comes the concept of a Defence Information Infrastructure that can handle military operations' entire needs on a global basis.

Moving to a network-centric environment will place new demands on the entire defence information infrastructure (DII) as well as on the battlefield systems. Such infrastructures must integrate vast amounts of data not only for operations intelligence, but also for related matters such as soldiers' pay and annual leave, and business transactions as well. This information must be available on a 24/7 demand basis to large numbers of users. New ICT capacity must be added quickly as units move to new theatres of war – and perhaps dismantled or redeployed as situations change.

Such capability is delivered from data centres in large central sites and smaller locations across Europe. These locations must be populated with high quality, secure ICT hardware, which can be configured to meet developing requirements as easily as possible. In the current economic climate, these installations must make sound business sense as well.

Quality and continuity of electrical mains power is an essential factor in ensuring the data centre's quality of service, security and cost-effectiveness. This can only be assured by employing an uninterruptible power supply system (UPS) capable of meeting the needs of the infrastructure. Configuring such a UPS can best be achieved using modern, modular UPS technology; this provides the level of availability the application demands, together with the equally important features of flexibility and low cost of ownership.

Modular UPS technology

An understanding of how modular UPS systems yield these benefits comes from looking at their key components and how they work together. Transformerless technology lies at their core; as we shall see, their key benefits ultimately derive from this. Originally, transformers were an essential part of on-line double conversion UPSs, stepping up the UPS inverter's output voltage to a level compatible with the original utility or generator mains supply. The transformers were not used for galvanic isolation as is sometimes believed.

More recently, advances in power semiconductor technology, and particularly the Insulated Gate Bipolar Transistor (IGBT) device, have made transformerless designs possible. In a typical implementation, the UPS's rectifier stage is followed by a DC boost converter which in turn feeds the UPS's output inverter. The inverter's boosted input allows it to supply AC voltage at mains level to the critical load with no need for an output transformer.

This transformerless design brings a number of advantages, of which the most significant is a dramatic reduction in the UPS's size and weight. For example a 120 kVA system that previously weighed 1200 Kg and occupied a 1.32 m^2 footprint can now be built with a weight of 370 Kg and a 0.53 m^2 footprint. These reductions have had a profound effect on UPS topology, because they allow a significant level of UPS power – currently from 10 to 50 kVA – to be delivered from a UPS module small enough to be mounted in a 19" rack rather than demanding standalone installation. This modular approach means that a single rack with capacity for 5 modules can be configured for any load from 10 to 250 KVA. Then as the load varies due to changing circumstances, modules can be added or removed to adjust the UPS's capacity accordingly.

This flexibility is particularly important in a fast-changing defence environment, where for example an entire communications and information system extension, with hundreds of terminals and associated servers, may require implementation in 9 months or less. In these circumstances the ability to deploy a compact and rapidly assembled modular system, or perhaps even use spare rack capacity within the existing installation, is very attractive. The UPS power is not limited to the rating of the rack, either. As much capacity as required can be added simply by paralleling racks to meet demand.

When a UPS supports a mission-critical component of a DII, the availability of the power it provides becomes of vital importance, considering the quite possibly life-and- death consequences of failure. Availability, which is the probability of a system being operational at a given time, can be calculated using the system's Mean Time To Repair (MTTR) and Mean Time Between Failures (MTBF) figures. Availability can be improved both by maximising MTBF and minimising MTTR. MTBF can be maximised either by increasing the reliability of every component in the system or by ensuring that the system is resilient to the failure of a single component. There is a finite limit to component reliability, even with increased cost. Power protection systems that rely only on component reliability achieve MTBFs of typically between 50,000 and 200,000 hours. However by adding resilience through redundancy, a three- to six-fold increase in power protection system MTBF can be achieved.

A system with redundancy is one that can survive the failure of single component. For example in a modular UPS system, a rack with three 10 KVA modules could be used to supply a 20 KVA load. If one module fails, the remaining capacity is sufficient to continue full load support. This is known as an N+1 redundant configuration. However it is important to note that for the modular system to be fully redundant, it should have a distributed parallel architecture. Each module should contain all necessary UPS functions, avoiding external single points of failure such as a central static switch.

As mentioned earlier, the UPS availability can be increased by reducing MTTR as well as by increasing MTBF. Modular systems allow significant MTTR reduction, because if a module fails it can simply be removed and replaced. The faulty module can then be taken away for repair off line, while the UPS has already been restored to full capacity. Modular UPSs can feature 'hot swapping' where the faulty module can be removed and replaced without having to divert the load to bypass. The whole operation can be completed in typically half an hour, compared with the six hours more typically needed to repair a standalone system down to component level in situ.

Modular UPS systems can offer the best power availability currently on the market, as they benefit from both redundancy and hot swappability. They can offer 'six nines' or 99.9999% availability, which is a significant improvement over the 'five nines' offered by systems lacking hot swappability.

Modular topology can also reduce both capital and operating costs, which is a consideration of ever-increasing priority. By adding or removing modules, the UPS capacity can be incrementally adjusted to closely match the load's demand – and adjusted again if the demand should change. Also, one or more extra modules can be added for redundancy with minimal excess capacity. This scalability minimises data centre space demands as well as capital equipment costs. Modular systems also improve energy efficiency compared with transformer based standalone units by around 5%, with resulting reductions in energy and cooling costs. This savings arise mostly from eliminating the transformer, but matching the UPS capacity to the load can contribute as well. Further cost savings are possible through improvements in the UPS input power factor and lower input current harmonic distortion, which reduce the need to over-specify cabling and switchgear, and can sometimes reduce running costs as well.

Choosing the right UPS supplier

Choosing the right UPS topology, configuration and hardware is obviously essential, but it is just as important to choose the right supplier as well. For example, because of today's deteriorating quality of mains power, many ICT managers view generators as an essential component of their power protection strategy, able to take over the load before UPS battery autonomy is exceeded. Matching a generator and UPS, as well as correctly configuring the UPS, are not simple catalogue purchase exercises. UPSs can cause problems for generators, and vice versa, if they are incorrectly paired. Other factors, such as UPS capacity and redundancy, and battery autonomy, depend on the requirements and priorities of each installation. UPS suppliers should accordingly be able to advise on as well as deliver the best solution for any given application.

The supplier should also offer a maintenance and emergency callout package appropriate to the site's critical load. This can include remote monitoring and diagnostics as well as site visits. Regular inspection and maintenance of items such as batteries will capture problems before they cause failures. International standards exist to define different aspects of service quality, and prospective UPS suppliers should be certified for these. BSI EN ISO 9001:2008 covers quality management, ISO 14001 covers environmental management and OHSAS 18001 is for health & safety management.

The many benefits of a modular approach

Data centres and computer rooms within a DII structure will inevitably seek the best available power protection hardware and support package because of their need to provide data processing and communications facilities on a 24/7 basis. However a correct choice will bring other benefits as well. Using a modular approach will ensure the UPS is correctly scaled to the load, with no space or money wasted on excess capacity or redundancy. A correctly optimised design will also ensure energy and cooling costs are kept to a minimum during operation. Meanwhile, the flexibility inherent to modular systems will allow fast UPS configuration, and re-configuration, to meet the rapidly changing demands of military operations.