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Power protection designs *for maximum availability*

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Abstract

UPS systems have become a relatively standard and usually very reliable item of electronic equipment that can be used in a "self contained" modular format within a critical power distribution system to improve the reliability of power at any given point. UPS system design must be fault tolerant and maintainable, while the critical load must remain supported and fully operational. The objective should be for a system that allows any single part to fail, be repaired and tested, without affecting the operation of the critical load.

However, whilst the benefit of installing a single UPS module can be very great in terms of availability of reliable power, the improvement that it provides can only be as good the reliability of the UPS and battery and this will be further affected by any time when it is off-line each year for essential maintenance. For these reasons multiple UPS configurations have been developed to provide ever higher factors of availability. The four configurations shown below demonstrate some of the ways in which a systems designer can tailor the power protection system according to the demands of the critical application.

Level 1 - Single Modular UPS

A conventional single module UPS installation will normally have the UPS arranged as a series connected element between the incoming supply switchboard and a system distribution switchboard. Although the UPS module will probably have its own integral manual maintenance bypass switches, it is common for additional flexibility of operation for an external bypass switch arrangement to be provided as part of the installation switchgear. ***See Fig.1***.

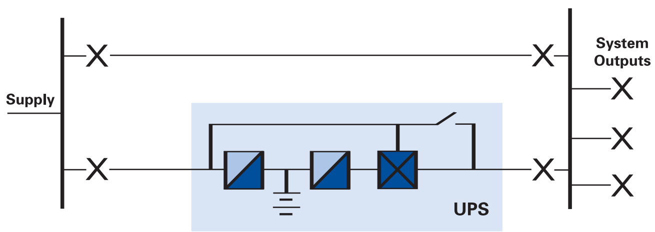

Fig. 1 *- Single UPS module*

Level 2 - Redundant 'N+1' UPS Systems

The drawback of the single UPS module is clearly that if it is out of service for any reason, then UPS power protection for the critical load is lost. This may be acceptable for some applications but if the user is operating 24/7 in a financially sensitive industry then a higher level of power protection may be required. Additional UPS system(s) arranged in such a way that one system can be taken out of service whilst the remaining UPS modules are still able to support the system load can ensure a higher level of system availability for the critical load. At one end of the scale 2 x 100% rated UPS systems would offer a very significant improvement in the overall system MTBF (Mean Time Before Failure). However, this means paying for and installing 100% over capacity which expensive in terms of both Capex and Opex. Why pay for 100% overcapacity and only ever run the UPS systems at a maximum of 50% load when the use of more UPS modules of a lower power rating would cost less in initial capital cost and would also operate at a high level of efficiency. For example 4 x 33% rated UPS would achieve a similar goal and enable the systems to operate at a normal load up to 75%. In general terms, the higher the load factor, the higher will be the achieved efficiency. ***See Fig.2***.

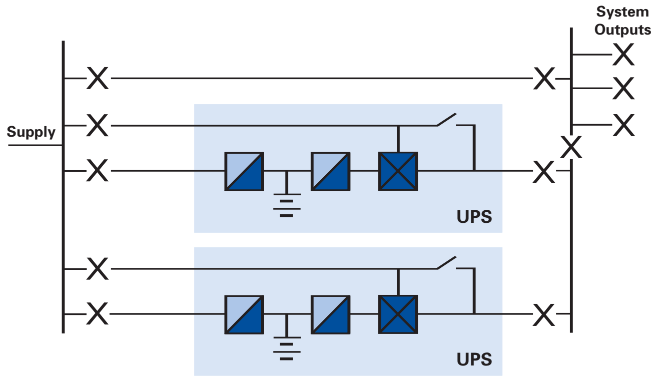

Fig. 2 *- Modular N+1 parallel UPS system*

Level 3 - Dual Bus '2N' UPS Systems

It can be seen from Fig 2 above that although the UPS systems are fully maintainable without the need for a system shut down, this does not apply to the incoming AC supply switchboard, the load switchboard or the cables to the critical system load and therefore, these must be regarded as potential single points of failure. The concept of the dual bus configuration is designed to overcome this problem. ***See Fig 3***. Ideally in this configuration there will be dual incoming AC supplies and a 'dual load bus'. Thus, in order to eliminate potential 'single points of failure', both A and B power buses are kept fully independent and are not interconnected in any way. Individual "free standing" Static switches included in the final distribution, are physically located as close as possible to the critical loads and they ensure that in the event of a problem with one AC supply source, they will transfer seamlessly to the other.

The Static Transfer Switches (STS) supply the critical loads by selecting either one of the two completely independent power sources according to whichever one is available. If the currently active source develops a fault or its electrical features are no longer suitable, then the STS transfers the load to the alternative source. Switching is controlled in such a way as to guarantee that transfer times are compatible with the load tolerance and are within current technical standards. Apart from being able to provide automatic no-break transfers between AC supply sources, the use of Static Transfer Switches provide other useful functions. For example, the fact that dual AC supply bus systems are used makes it much easier to physically locate the 2 separate UPS systems in different rooms. These could be many metres apart or even at opposite ends of a building. Thus in the event of a major fault or even a fire in one area, the critical system loads would not be affected since they will simply be transferred automatically to the alternative supply bus. In addition, in a situation where there might be large numbers of load STS units, it is important that an instantaneous single serious load fault that might have affected the voltage of Load Bus A should not be immediately transferred to Load Bus B since this could potentially bring the whole system down. STS switches provide protection by permitting a preset maximum value of load current that they will allow to be transferred to the other Bus supply. This setting would be selected to be well within the capability of either UPS system. Thus the use of STS switches can be used to ensure that the effect of any single load fault is minimized.

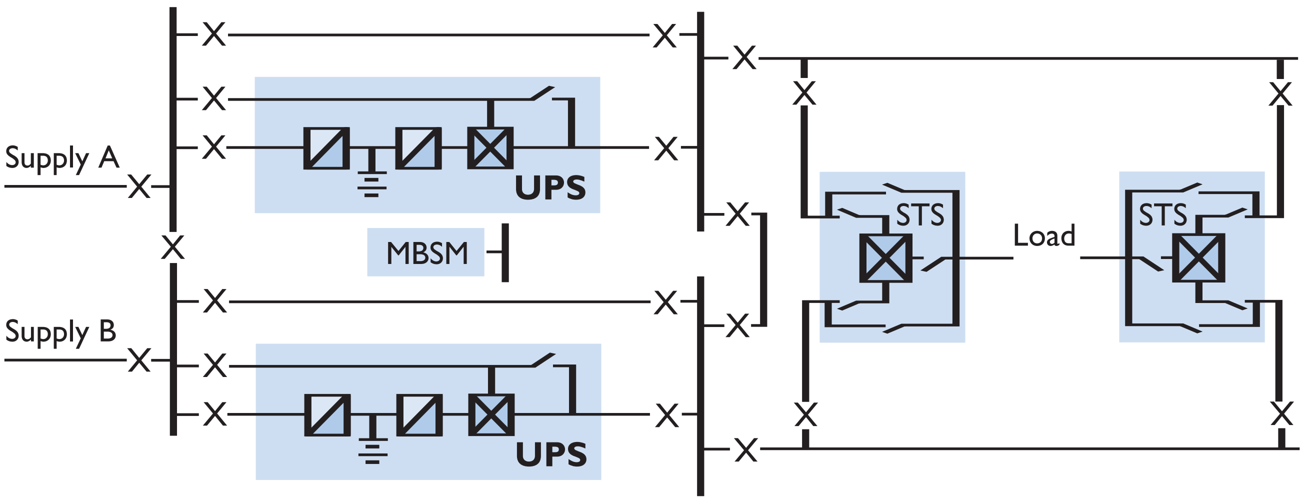

Fig. 3 *- Dual bus 2N UPS systems with dual static transfer switches*

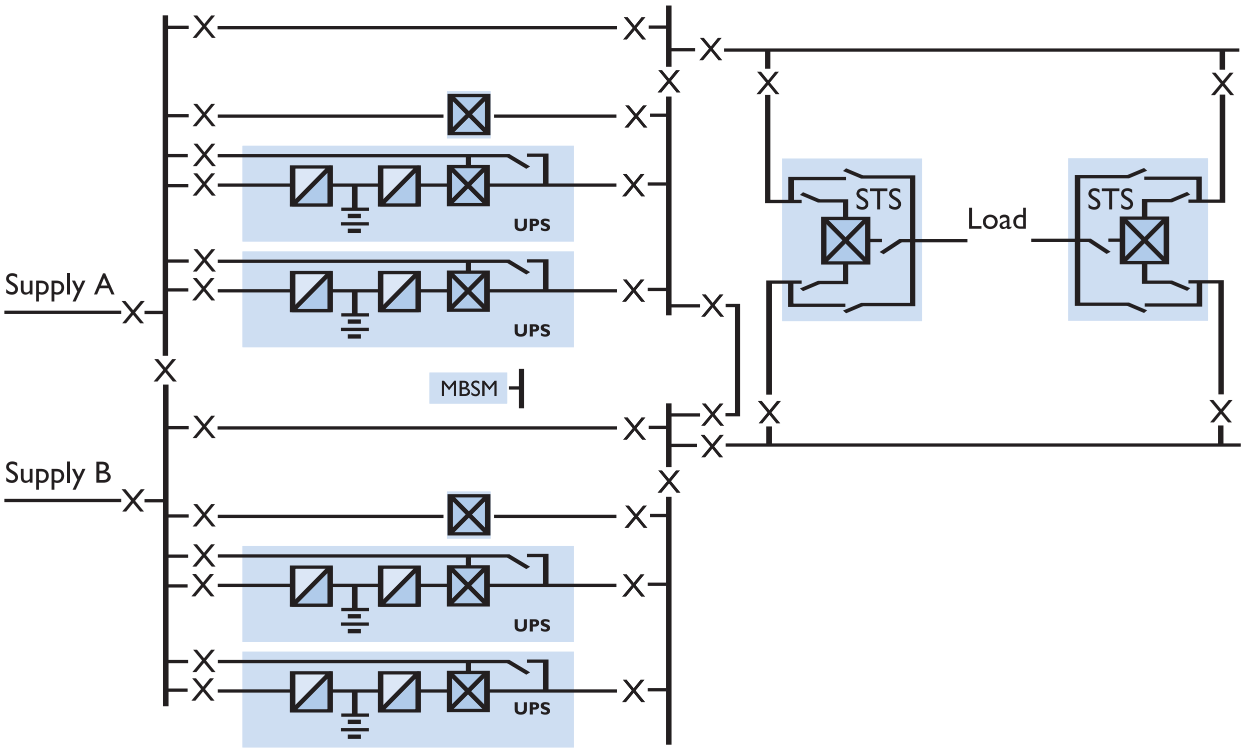

***Fig. 4** - Dual bus high fault capacity 2(N+1) UPS system with dual static transfer switches*

Level 4 - Dual Bus System with Dual Redundant '2(N+1)' UPS

Clearly the Level 3 system above offers exceptionally high power availability. However, it is clear that when one UPS system is out of service for maintenance the system load is then totally dependant on the remaining UPS.

In a situation where the commercial impact of a power problem is exceptionally high, it may make financial sense to ensure that both UPS systems operate in redundant mode. ***See Fig 4***.

The duplication of all items of equipment with fully automatic static switches located close to the system loads ensures full maintainability of the systems and that no single fault within the power system should affect the operation of the overall critical load.

Achieving the goal...

The examples listed in this article are intended to show a few of the systems design concepts that can be used to achieve maximum availability of power in a data centre. When planning new power protection systems it is usually well worth seeking advice from UPS companies who are in the forefront of the latest developments in technology and product applications and who can plan for the changing nature of the computer loads that their products will support. Power protection products should be compatible with all types of load and system designs should be fully optimised for the actual loads encountered in the IT environment. For example the increasing deployment of high density computing systems and blade servers which can draw power from the supply with a leading power factor rather than lagging means that it is now more than ever essential to ensure that the UPS system selected are capable of supporting these loads.

Optimising the system design is just the first part of the process. Once installed, tested and commissioned it is essential to regularly prove the quality and dependability of the power protection infrastructure and the effectiveness of the installation. This can only be done by establishing a system of regular maintenance to ensure that the overall system continues to perform in the way that it was originally designed to do.

About the author

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Rob Tanzer is technical support manager for the Chloride AC Power business of Emerson Network Power in the United Kingdom. He has worked in the power protection industry for over 35 years and now specialises in high power computer and data centre applications.
He has experience of most types of static and rotary UPS systems, has developed innovative UPS topologies and is the author of several published technical papers covering, thyristor power switching devices, UPS systems and applications. He regularly advises on all aspects of data centre power protection.

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