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continuous power availability

Availability as a Function of UPS Architecture

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An Uninterruptible Power Supply (UPS) system is used to provide clean, continuous power when the main source is interrupted or even fails. To ensure the highest-level of power quality and protect the load at all times, the UPS should never need to be switched to raw mains, risking the load.

The level of protection given by the UPS is best quantified by the metric Power Availability. It represents the fraction of time a system is operational during its expected lifetime and we have narrowed down Availability in terms of MTBF/MTBF+MTTR (where MTBF means: Mean Time Between Failure and MTTR means: Mean Time To Repair). In other words, will your UPS work as and when its needed?

There is now a multitude of systems on the market. Each system can be constructed in a different way. Imagine building a ship, if the ship's structure (architecture) is not correct, the time the ship will remain afloat will be low, thus reducing the time the ship fulfils its purpose.

In the same way, a UPS design architect must decide the architecture in which the new UPS will be built with the sole purpose of increasing the time it will fulfil its function: to keep the load running on clean and safe power as much of the time as possible.

Understanding the UPS architecture is important as it has a direct influence on the available power to the protected devices. In this article I would like to focus on the main five top-level UPS transformerless architectures and their influence on power availability. We will not cover the internal power converters architectures and how that middle-level architecture influences Availability, that will be the scope of another article.

The 5 main top-level UPS architectures:

1) Standalone Architecture

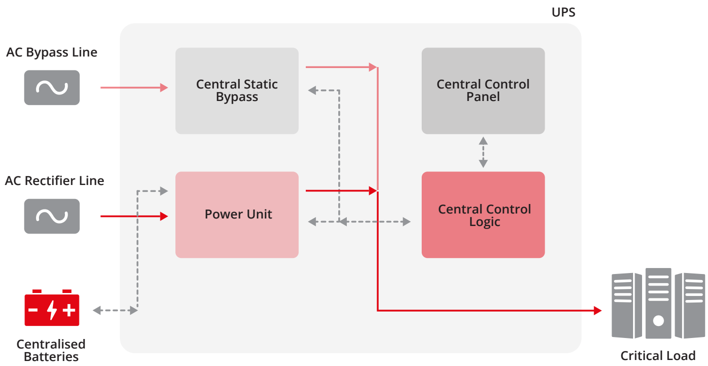
The standalone transformerless architecture includes all the standard components found in a UPS including internal static bypass, maintenance bypass switch, inverter, rectifier and control logic. Each component is key to ensuring a continuous supply of clean power. Although MTBF can be argued to be a high number due to the fact of single components, in reality, every component in the system is a potential single point of failure which poses a risk to the system: if one component fails the entire system will shut down.

Redundancy is the most common way to improve the availability of a UPS system. A single standalone UPS has no redundancy. To create a redundant system, the standalone UPS must be replicated with a second unit. Although inexpensive to purchase one standalone UPS, introducing redundancy by adding a second is therefore expensive, effectively you are doubling the price of the system.

For configurations with a single standalone UPS, if there is a fault or need for maintenance, the whole system needs to be shut down, the load would need to be switched to raw mains which increases the risks of a complete shutdown of the load.

When on raw mains the load is vulnerable. In this scenario, MTTR is high, and availability reduced. Therefore, standalone UPS systems are most suitable for applications which do not require high levels of availability from a more reliable unit and the risks associated with switching to raw mains can be accepted.

Standalone Architecture



2) Standalone with Non Hot-swappable Modules

Here a standalone UPS has been developed and fitted with fixed modules. Each fixed module can contain components such as rectifier and inverter while keeping many other components like static bypass and control logic common for the whole UPS system.

This architecture, if configured correctly can introduce a level of redundancy into the power parts which is beneficial to improve availability. However, there are still multiple single points of failure that reduce the MTBF.

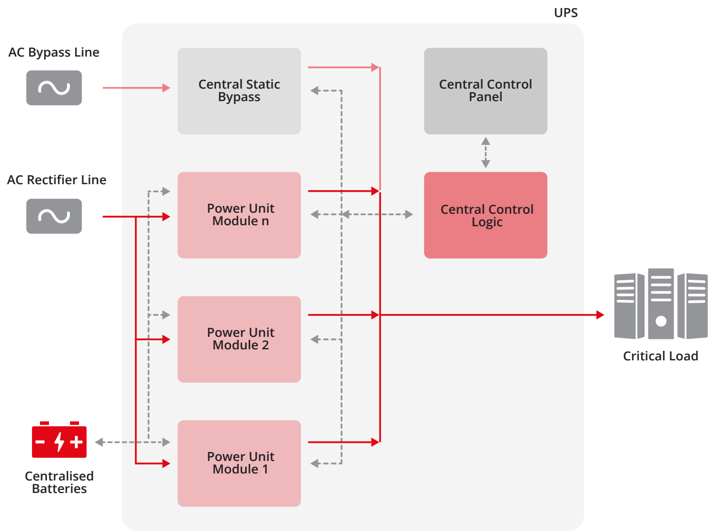
If repair or maintenance is required, because the modules are not hot-swappable, the UPS will need to be switched to maintenance bypass or internal static bypass to solve the issue. Switching to bypass means the load is put on raw mains and is not protected. Repair is also time consuming so MTTR is high, and this significantly decreases availability.

3) Modular Centralised Architecture

The modular centralised UPS is the next step up from a standalone system. The centralised architecture introduces redundancy through the use of modules. These modules can be 'hot swapped' (swapped without the need to switch to maintenance bypass) which improves MTTR in the case of a power module failing, increasing availability.

However, in this architecture there are still single points of failure. There is, regardless of redundancy, a centralized control logic making decisions for the whole system, one centralized bypass and one communication channel. If any of these components fail, the load will be lost.

Standalone with Non Hot-swappable Modules and Modular Centralised Architecture



4) Modular Decentralised Architecture

Here each module contains all the elements of a UPS including rectifier, inverter, static bypass, and control logic improving availability further. Because of the elimination of some of the single points of failure, this architecture makes a step forward in the level of Power Availability. This results in systems with up to six-nines availability equivalent to 31.5 seconds downtime per year.

Modules can be hot swapped but there is still a master module making decisions for the whole system through its control logic. The communication lines between modules are not redundant and static bypasses although decentralized are not redundant either. If one static bypass fails within a module the whole system will be switched to static bypass which could result in a potential single point of failure exposing the load to raw mains.

Crucially, there is also no provision for potential human error when swapping modules. This means that when a technician is working under pressure responding to a fault, they do not have the functionality to isolate and test modules being added to a live system.

The bypass fuses are also contained within each module which means that in cases of output short-circuits the MTTR is higher. To put this into perspective, output short-circuits represent a significant number of failures in UPS systems.

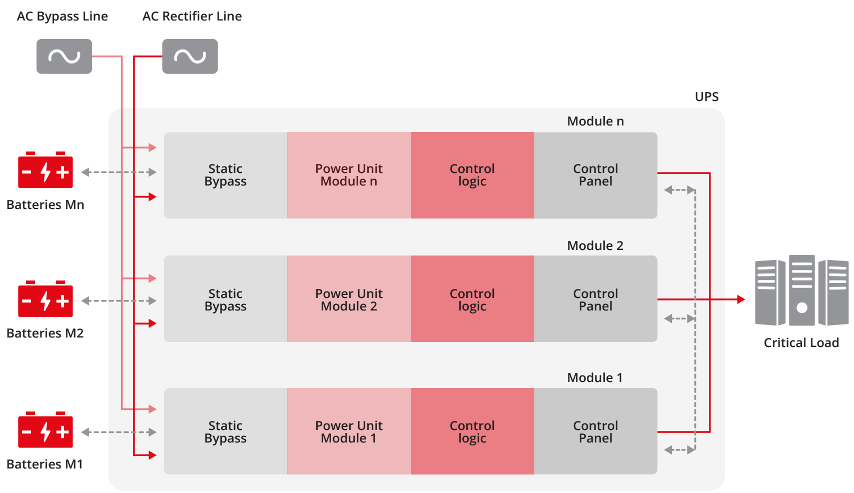
5) Modular Distributed Architecture

Here the architecture is completely distributed, each UPS module includes rectifier, inverter, static bypass, and control logic. No single module makes decisions for the whole system, instead, distributed decision making takes place to eliminate the logic's single point of failure.

The static bypass is distributed and redundant, therefore, if any part of the system fails it is automatically isolated while maintaining the load powered by the other modules ensuring the load continues to be supported. The communication lines have inbuilt redundancy so if one line fails the communication continues to run through the UPS.

For the first time we see human error mitigation through safe-hot-swap capability. This means a technician needing to swap a module can simply open its parallel isolator and physically isolate it from the load. The rest of the modules will continue to supply the load on inverter while the technician can fully test the module safely before connecting it back to the load. Even firmware upgrades do not require switching to manual bypass. With only hot swap functionality, this is not possible and a fault in a new module or a technicians' mistake could cause the whole load to be dropped. As a result, this means the distributed modular UPS architecture provides the highest level of Availability possible achieving downtimes per year as low as 0.0315 seconds.

Distributed and Decentralised Modular Architecture



We call this distributed architecture 'true modular' which means there are no single points of failure, there is redundancy on every component and any scope for human error is reduced to the minimum.

The purpose of the UPS is to provide stable protection, clean voltage and a source of power in an emergency. For critical power installations requiring maximum levels of availability, the UPS should never need to be switched to raw mains, risking the load. A distributed modular UPS ensures the power remains protected at all times and should be the UPS of choice for critical installations. It means that the human error and MTTR are minimized while the MTBF maximised resulting in the highest availability possible.

Centiel's CumulusPower™ is an example of distributed modular UPS. It offers the highest load protection in the market with 99.9999999% (nine nines) availability, which on a practical level, means downtime is taken to just milliseconds per year. CumulusPower™ has now been installed in datacenters and comms rooms in over 60 countries across five continents.

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