

Powerware Hot Sync Technology



Paralleling UPS technology

The number one function of a UPS is to supply continuous conditioned, reliable electricity to a critical load. In case of a single unit, reliability can be increased by modular design, where redundant internal modules can take over each others' tasks-, if one of the modules fails.

To further increase reliability, a true parallel configuration can be employed, where two or more units share the load. A failed unit is isolated while the remaining ones continue to support the critical load. Competitive UPS products on the market utilise centralised or distributed load-sharing technology with the master-slave principle, which introduces a risk of single point failure. The absolute reliability of a UPS system can be achieved with patented Powerware Hot Sync® parallel load-sharing technology. (Figure 1)

Hot Sync technology is designed for parallel redundant N+1 systems to satisfy 24/7 applications. It can also be used in parallel capacity systems to benefit from scalability for customers' ever-increasing load demands.

Hot Sync erases single point of failure, with an ability to synchronise and support critical loads independently of other UPS modules in the system. UPS modules can share loads without any communication wiring to the outside world.

User benefits

- Available for both single- and three -phase products to meet any mission-critical need up to 2.5 MVA (400V) systems
- Easy and modular parallel UPS system upgrade with additional capacity or redundancy
- Erases single point of failure

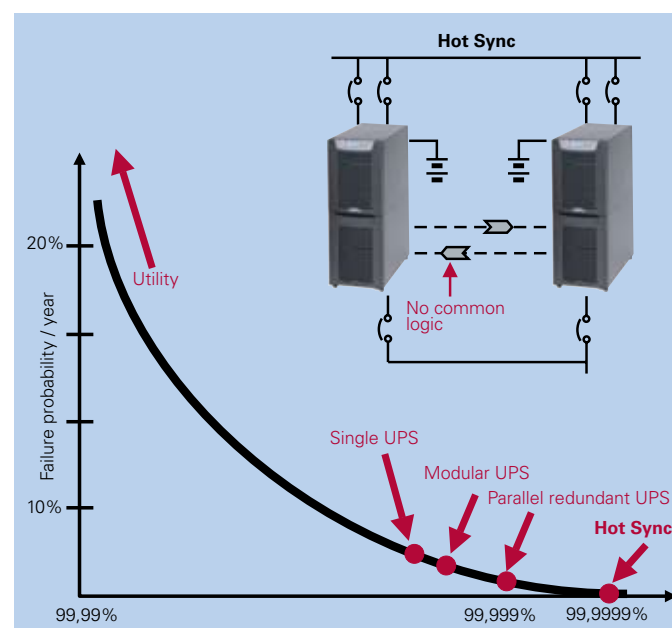


Figure 1. Availability figures for utility and UPS configurations in case of repeated power failures and disturbances.



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The secret here is a patented built-in digital signal processor (DSP) algorithm, running continuously in each unit. It drives the UPS outputs toward synchronisation and takes care of load sharing. If there is a common bypass available, it is used as valid synchronisation source for output. In the absence of a common bypass, the processor makes subtle adjustments to the inverter frequency on the basis of output power level measurement in order to find a common frequency and load balance among the units. There exists, as shown in Figure 2, a relationship between the power imbalance and the voltage phase difference.

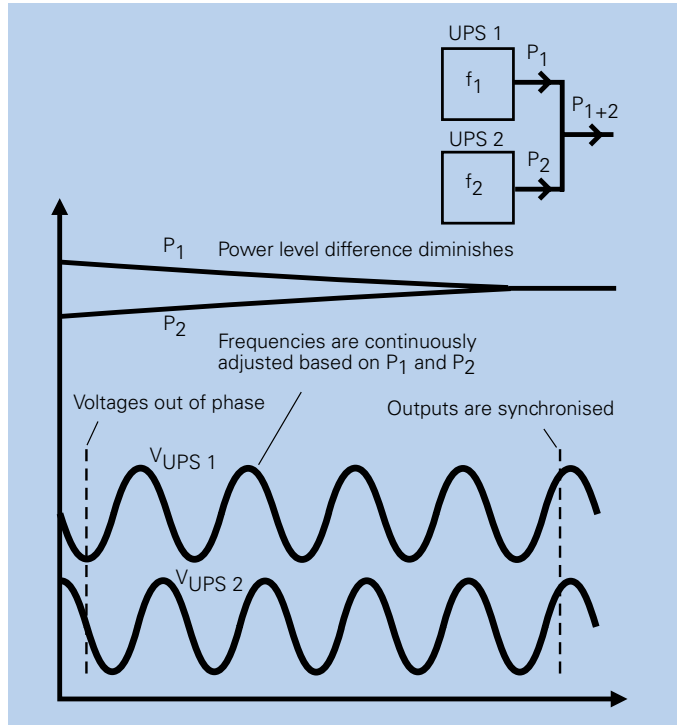


Figure 2. Well-balanced load share is achieved by adjusting output frequencies; thus the phase difference between parallel UPS output voltages is forced to zero.

The internal output impedance of a UPS is inherently mainly inductive, i.e. it looks as a small inductor in series with a stiff alternating voltage source. So, if there is any difference between the output voltage phases, it means that there is a power flow from one unit to unit, resulting in unequal load sharing. In the Figure 3, two units have equal output voltages with phase angle displacement.

The voltage V_{diff} and current I_{diff} between units exhibit a 90 degrees phase shift due to the inductive source impedance. The main voltage (V_1 and V_2) and the current between units I_{diff} are in phase resulting in active power flow.

The greater the phase shift, the heavier the power imbalance. If we now introduce a controller to adjust the voltage phase by the output power, the phase difference can be forced to decrease. To adjust the phase difference to zero and to achieve accurate load sharing, we may integrate the measured phase thus arriving at power-controlled frequency. For the purpose of fast frequency locking and to enable synchronisation to external bypass, a term containing the power level change rate is added.

The flow diagram (Figure 4) shows how the load sharing proceeds.

The output power is monitored and the new frequency calculated at 3000 times per second. The measurements are also used for fast identification of a failed module. This feature is based on the computation of instantaneous output power. A negative value,

even for a single instant, is an indication of an internal failure, e.g. a shorted inverter IGBT. In a response the UPS trips immediately off-line, causing minimal voltage disturbance. This feature is known as 'selective tripping'.

Hot Sync technology allows full maintenance to be performed one-by-one on redundant UPS modules without an external maintenance bypass switch. The critical load does not need to be disconnected from the conditioned power. Scheduled or unscheduled maintenance can be performed with the load supported continuously by the UPS-grade clean power.

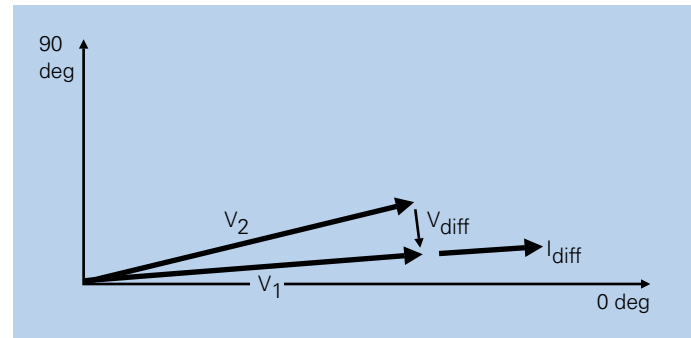


Figure 3. A phase displacement between parallel connected UPS voltages (V_1 and V_2) causes current flow between the units thus imbalances load share.

$$F_n = F_{n-1} - K1(P_n) - K2(\Delta P_n)$$

Where:

F_n = frequency

F_{n-1} = previous frequency

P_n = power to load

$K1$ = frequency reduction factor

$K2$ = power change rate factor

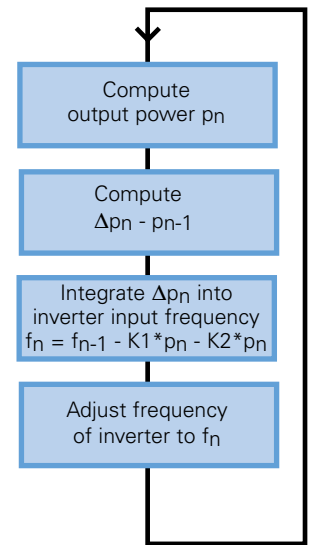


Figure 4. With HotSync algorithm, inverter phase angle is adjusted by output power and its change rate.

Whether introducing parallel UPS configuration for redundancy or to add capacity, accurate, equal, load share is the number one characteristic determining the integral quality and reliability of the whole UPS system. With HotSync technology this is achieved without need for additional communications line between UPSs thus no single point of failure is added when introducing parallel modules to a system. From operational and also economical viewpoint the achieved "close to perfect" reliability returns clear savings in the long run as every incident of down-time is costly with unpredictable consequence.



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