Hot Sync Technology

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 unit to unit, resulting in unequal load sharing. In the **Figure 3**, two units have equal output voltages with phase angle displacement.

The voltage Vdiff and current Idiff between units exhibit a 90 degrees phase shift due to the inductive source impedance. The main voltage (V1 and V2) and the current between units Idiff 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'.

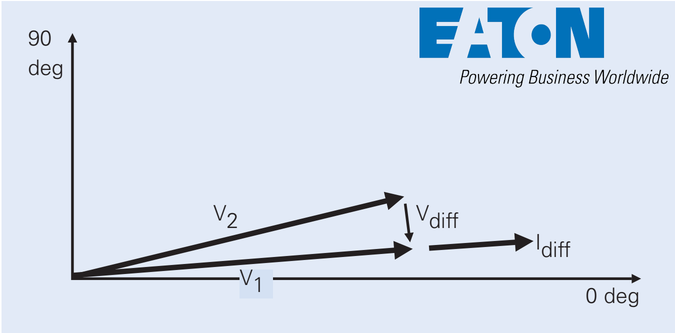

Figure 3. A phase displacement between parallel connected UPS voltages (V1 and V2) causes current flow between the units thus imbalances load share.

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.

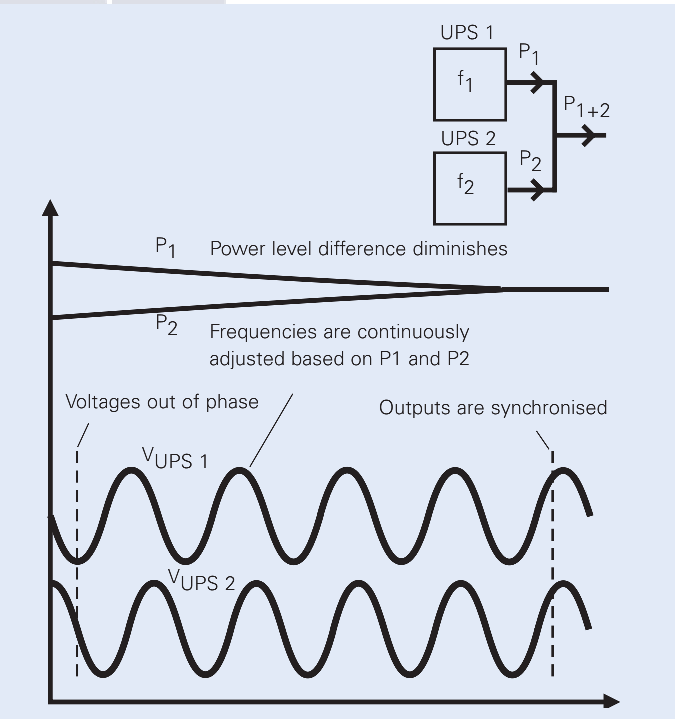

Figure 2. Well-balanced load share is achieved by adjusting output frequencies; thus the phase difference between parallel UPS output voltages is forced to zero.

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

Where:

F_n = frequency

F_{n-1} = previous frequency

P_n = power to load

K1 = frequency reduction factor

K2 = power change rate factor

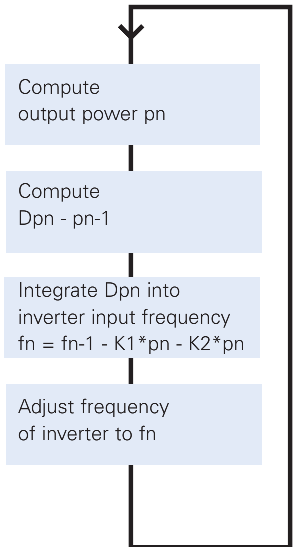

Figure 4. With HotSync algorithm, inverter phase angel is adjusted by output power and its change rate.

Accurate, equal load share is the number one characteristic to determine the integral quality and reliability of the parallel UPS system providing redundancy or increased capacity. 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 downtime incident is costly and might lead to unpredictable consequences.