A market position paper from the Experts in *Business-Critical Continuity*™

Leading power factors

Traditionally an uninterruptible power supply (UPS) designed to protect computer supplies was optimised for operation with lagging power factor (PF) loads in the range of 0.6 - 0.9 which has led to almost universal adoption of the 0.8 lag PF rating e.g. 100 kVA / 80 kW.

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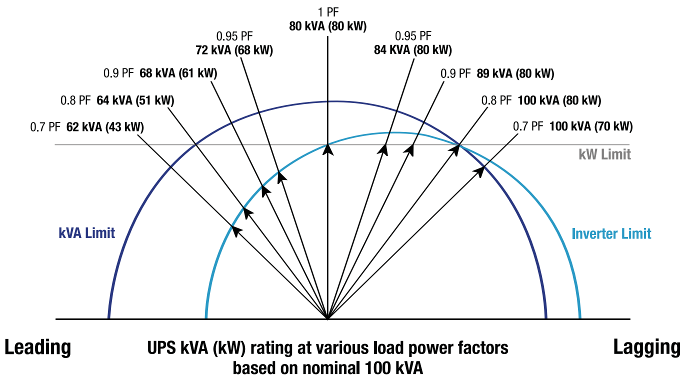
The universal adoption of computer power supplies with integral current waveform control has reduced the problem of the high harmonic currents that used to be a serious issue when designing suitable UPS systems. However, one of the drawbacks of these computer switched mode power supplies is that at light to medium loads they draw a leading power factor and this can present a serious issue to Diesel Generators and to many types of UPS system. Fortunately Chloride UPS systems of Emerson Network Power are fully compliant with both leading and lagging power factor loads. Unlike most industry standard UPS systems, Chloride UPS do not need to be de-rated in any way for leading power factor loads and can therefore be connected to any load within the nominal kVA and kW rating of the UPS regardless of power factor.

As designers and manufacturers of UPS, Chloride of Emerson Network Power closely follow developments in technology and product application. Of particular interest at this time is the changing nature of the computer loads our products have to support. Whilst we have always been aware of the non linear effects of computer loads we recognise that certain modern day IT products such as blade servers can draw power from the supply in a leading rather than a lagging form. Our objective is to ensure that our products are compatible with all types of load and that our designs are fully optimised for the actual loads encountered in the IT environment.

For many years we have measured IT equipment loads with power factors in the range 0.6 to 0.9 lagging. As a consequence we have designed products with practical ratings in mind and we have standardised on 0.8 power factor (pf) lag as a means of determining nominal kVA/kW ratings. This rating convention has been adopted almost universally across the industry and so, for example, we have 100 kVA/80 kW as a standard frame rating.

With the increasing deployment of blade servers, 'unity' pf power supplies and other low harmonic input current equipment we have reconfigured the output filter stages of our systems to ensure compatibility with these loads and to optimise the utilisation of the UPS. The two circular diagrams illustrate the different performance characteristics provided by this optimisation. In this article we look to explain how this change and future proofing has been relatively easy for us to achieve with our modern inverter technologies.

Until recently the 'front end' of computer power supplies consisted of little more than a full wave bridge rectifier followed by a large electrolytic capacitor. The resultant rectified DC voltage was applied to a switched mode converter which produced the low voltage supplies required by the computer. This approach had advantages of cost, size and weight compared to more sophisticated designs but exhibited a very poor power factor and high harmonic feed-back into the mains supply.



De-rating of traditional designs of UPS when supporting leading power factor loads

The optimisation of the UPS for lagging PF loads was partially brought about by the necessity to provide output capacitors to filter the PWM waveform from the inverter switching bridges into an accurate sine wave. A disadvantage of these capacitors is that they affect the ability of the UPS to support leading PF loads resulting in a significant de-rating with that type of load. However this was of little consequence as IT loads were consistently lagging.

Under pressure from EMC standards (EN/IEC 61000-3-2) to reduce input harmonic currents, the computer power supply manufacturers re-designed their switched mode power supplies (SMPS). Their objective being to dramatically reduce input harmonics and to improve the operating input power factor. The result is that, at 100% load, the input current is virtually a pure 50Hz sine wave, with little harmonics, and a power factor very close to unity.

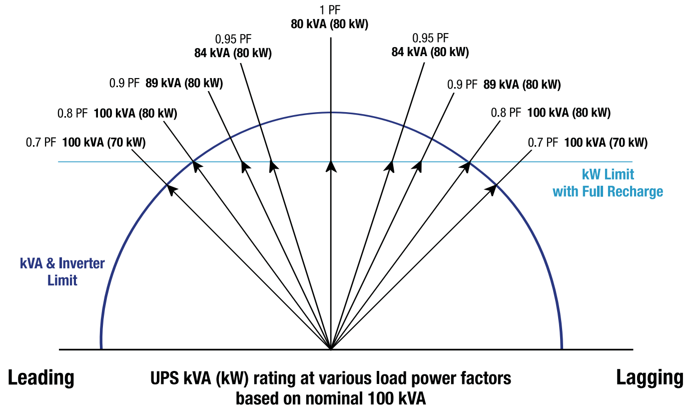
However the picture at reduced load is not quite so rosy. Power supplies within IT equipment are rarely fully loaded: they are sized to support the maximum possible server configuration with capacity to spare for reliability, and who fills every slot in the rack?

Also the provision of redundancy within the server by the fitting of two or more 'hot swap' power supplies immediately reduces the normal operating load on the power supply to significantly less than 50% of the nominal rating. At these low loads the input power factor of the power supply is no longer unity it becomes leading. The net result is that UPS may now expect to see loads normally operating with power factors in the range 0.8 lead to unity. More extreme leading power factors may occur at very low loads.

Fortunately inverter design in the last few years has evolved to embrace the use of higher switching frequencies, allowed by ever improving IGBT power switching devices and control techniques, which in turn reduces the need for capacitor banks for harmonic filtration.

Thus UPS can be optimised to handle these leading power factor loads, without impacting on the ability to support load exhibiting more normal power factors. This is achieved by redesigning the UPS inverter and output filter to provide a symmetrical 'circular diagram' as shown right.

Recognising that many computer system loads now operate at close to unity power factor, Chloride have increased the true power handling capacity (kW) of their UPS range so that they can support at least 90% of the UPS kVA rating. Hence a 100 kVA UPS is now capable of supporting a 90 kW system load and in many cases, depending on specific models, this extends to a full 100 kW power capability. Thus it is now no longer sufficient to compare UPS ratings by kVA alone since the true power capacity (kW) of similarly kVA rated UPS systems may be as much as 25% more if they can support unity power factor loads up to the full kVA rating AND support ANY leading or lagging power load factor.



Chloride UPS 3-phase systems will support any load power factor without de-rating

Example of increased power availability based on a UPS of 100 kVA (80 kW) rating

Leading PF	UPS optimised for lagging PF load	UPS optimised for ANY PF load	Change in available kW
0.70	62 kVA (43 kW)	100 kVA (70 kW)	+63%
0.80	64 kVA (51 kW)	100 kVA (80 kW)	+57%
0.90	68 kVA (61 kW)	89 kVA (80 kW)	+31%
0.95	72 kVA (68 kW)	84 kVA (80 kW)	+18%

Chloride's latest 80-NET, 90-NET and Trinergy ranges are fully capable of supporting leading power factor loads. They do not require de-rating and can therefore be confidently connected to any load within the nominal kVA and kW rating of the UPS regardless of power factor.

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.