Power Systems for IT Managers

Part 1: Power factor correction

B Elliott RCDD

belliott@Capitoline.co.uk

Questions concerning Power Factor first arose during one of my data centre design courses when some IT managers questioned why they had calculated how much power they needed but UPS and generator suppliers insisted on selling them something measured in the mysterious units of kVA.

First of all what is power factor and why is it important?

Alternating current (ac) is supplied at a frequency of 50 Hz which means that the polarity of the current and the voltage changes fifty times a second. Power, measured in Watts, is often taken as the voltage (volts) times the current (amps). However this is only true for a dc supply. Power in ac circuits is actually the voltage times the current times the cosine of the phase angle between the voltage and the current sine waves. The Power Factor, PF, is then classified as the cosine of this angular difference, measure in degrees, so real power is the voltage times the current times the power factor.

Why, you may ask, is there a phase difference? If the circuit had purely resistive properties then it wouldn't, but in practice every circuit tends to look like it's a capacitor or an inductor and its 'impedance' to the current flow is then known as Reactive. If it looks like a capacitor then we can imagine it as a large bucket waiting to be filled up with electrons. As the voltage first starts to rise then the current rushes in and rapidly fills the bucket with electrons. As the voltage reaches its peak the flow of current starts to slow down as the bucket is nearly full. When the voltage starts to change polarity it is as if the bucket has been turned upside down and the electrons rush out. A capacitive load therefore is known as a leading power factor as the current appears to lead the voltage.

If the load looks like an inductor, as every electric motor and transformer will, then the rising voltage is trying to force a growing current against the resistance of the magnetic field being built up around an inductor. An inductive load therefore has a current that lags the voltage.

So why do we care? We may think we pay the electricity company by the kilowatt hour but in reality we are paying for kilovolt ampere hours. So if you are running a 90% power factor it means you are paying for 10% more electricity than you are effectively using. Not a big deal at 30 kW but at 3 MW that equates to about an extra £160,000 per year on the electricity bill!

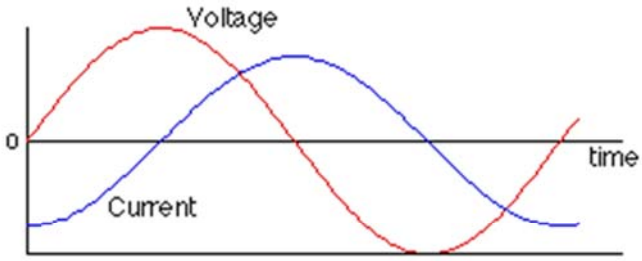
The other issue is that you will have to oversize the Uninterruptible Power Supply (UPS) and the standby generator to cope with power factor issues. According to manufacturers it is typically at least 5% on the UPS and up to 20% for the diesel generator.

If we look at some typical IT equipment: the HP Proliant DL140 has a power factor of 0.969 which is about a 3% loss to Power Factor on a 650 watt power supply. As the servers get smaller and cheaper e.g. the HP Proliant DL320 the figure declines to 95% and gets a bit harder to find amongst the technical specifications. When we get to the larger and more expensive servers and blade servers then we see the PF getting nearer to 98%. I'm not suggesting that HP equipment is any worse (or better) than anyone else's. I'm just using them as an example because their web site yields this kind of information slightly easier than most.

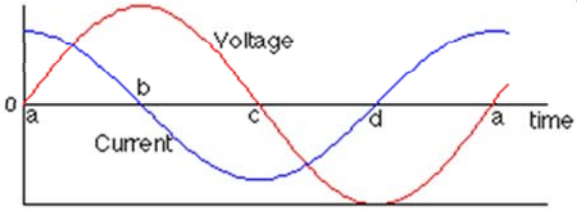
A problem with some of the new large blade centres is that the nature of the power supply used presents a leading power factor to the UPS and/or generator. For some quite technically involved reasons UPS and generators cannot cope with much variance on leading power factors but can cope much better with up to 80% lagging power factors.

So that's why UPS suppliers want to sell you units by the kVA: they simply don't know what kind of power factor load you will plug them into and quoting kVA output is the only unambiguous measure they can use.

Like most things in life the more you pay then the better quality you will get. High end servers are most likely to be engineered with a PF approaching unity which means lower running costs and more optimised sizing of UPS and generator equipment.



Inductive load. Current lags the voltage



Capacitive load. Current leads the voltage

LOW CARBONCONSULTANTS

Head Office: 7 King Charles Terrace, Sovereign Close, London, E1W 3HL, England T:{+44} 0845 4025183 F:{+44} 0845 4025184
North West: Capitoline House, 17 Chads Green, Nantwich, Cheshire, CW5 7NL T:{+44} 0845 4025190 F:{+44} 0845 4025191
Dubai: Capitoline LLP, 3-W 407, Dubai Airport Free Zone, Dubai, UAE T:{+9714{ 2994140 F:{+9714} 2994143

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Info@Capitoline.co.uk