## *Power Factor*

Power factor (PF) is a fundamental concept that must be understood when working with AC power. It is one of the most misunderstood principles in the UPS world by technicians, salesmen, electricians, and end users alike. Often it is confused with the UPS system's efficiency, which is completely different and discussed in the previous Efficiency section.

Basically, power factor is the ratio between real power and apparent power, and is stated as a number between zero and one, one being ideal. Electrical components in the system, such as capacitors and inductors, cause voltage and current to be out of phase, resulting in the real and apparent power being out of phase.

When the power factor is less than one, additional current is needed to complete the same amount of work. The higher the current, the larger the electrical infrastructure is needed, thus increasing cost. We often use the power triangle to visualize power factor. (See Figure 31.)

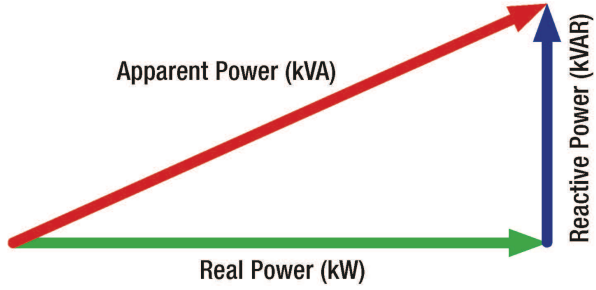


*Figure 31*

An appropriate explanation used by many instructors to help understand the power triangle is a glass of beer. (See Figure 32.) The glass of beer is the apparent power, everything you pay for. The beer is the real power, the part you drink, and the head or foam is the reactive power, the byproduct of pouring beer into a glass. Because you pay for the whole glass, you want as much beer and as little foam as possible.


*Figure32*

Now that we know what power factor is, we need to understand the difference between the PF rating of the UPS system and the PF of the load. This can be a difficult concept to understand. Both beginner and veteran technicians often confuse the two.

The rating of the UPS system is what the UPS system can handle without being overloaded. There are watts and volt-amps maximums the inverter can support. The rating of the UPS output power is not the true power factor of the load, it is only what the UPS can support.

So what is the difference between the UPS system's power factor rating and the load's actual power factor? If we look at a simple example of rating vs. actual, it might help clear up the confusion.

Let's think about a typical household circuit and space heater. The household circuit is rated to support roughly 12.5 amps. A typical space heater uses about 12.5 amps when using all its power, the full rating of the circuit. However, if you turn the heater down to half power, the heater will only use about six amps. The circuit is still rated for 12.5 amps, but the load is six amps.

When thinking about the rating of the UPS system vs. the load's power factor, we can think in similar terms. A 100 kVA/80KW UPS system is rated at 0.8 power factor. It can handle a load of 100kVA or 80kW maximum, just

as our 12.5 amp circuit can handle a maximum load of 12.5 amps. The UPS system has two limitations, kW and kVA.

The load on the UPS system may be 90kVA and 72kW, making the load's power factor 0.8. But modern loads have power factors closer to one. If the load on the UPS system is 90kVA at a one power factor, the load would also be 90kW, over the 80kW, causing the UPS to be overloaded.

There are two important reasons to understand the difference between the power factor rating of the UPS System, and the power factor of the load: ensuring that you don't overload the system, and that you calculate the correct battery backup time.

Batteries only supply power in kW; therefore, we must always find the kW needed to calculate battery backup time. As an example, we have a 100kVA/80kW UPS system load to 50kVA and 50kW (a power factor of one), and we want to calculate the battery backup time. If battery backup time is calculated using the power factor rating of the UPS system, 0.8, we would calculate this time based on 40kW of load (50 X 0.8=40), and not the true power of 50kW, which would have less backup time than expected. As an example, if we use a typical battery for a system this size, 40 kW would give us approximately twenty minutes of battery runtime, but 50kW would only provide fifteen.

This is also a problem when determining the load on a UPS system. Given the same UPS system above, 100kVA rated at 0.8 power factor, if the load is at 70kVA and 1.0 power factor, how much more load can be added to the UPS system before it is overloaded? Using the rating of the UPS to calculate the load in kW, we will think we have 24kW and 30 more kVA of space. But in reality, we only have 10kW more space. The load is 70kVA and 70kW. If we try to add more than 10kVA to the system, it will overload the system.

A question you may be asking yourself is why we have power factor. Let's make it go away and save all this confusion and additional cost for no benefit. Manufacturers of modern power supplies are working to do just that, and UPS manufacturers are working to keep up with them. Many modern three-phase UPS systems have a power factor rating of one, or unity, but many smaller single-phase units are still rated as low as 0.7. These smaller systems are prone to being overloaded because they have less margin of error when adding loads.