

# PowerwoRx e<sup>3</sup>

**PowerwoRx e<sup>3</sup>** (patent applied for) provides a Whole House Energy Management System for the best possible energy savings and Total Home Protection based upon a unique technology that provides three key benefits:

- Energy Savings
- Equipment Protection
- Electrical Noise Filtration

## Energy Savings

**PowerwoRx e<sup>3</sup>** provides energy savings by reducing the amount of power drawn from your utility with the use of specially designed harmonic resistant capacitors. **PowerwoRx e<sup>3</sup>** systems optimize your homes power factor thus reducing the amount of energy your homes motor loads use such as air conditioners, refrigerators, freezers, washers, dryers, dishwashers, pool pumps, vacuum cleaners, furnace blower motors, fans etc. Motor loads (inductive loads) inherently require more energy to do their work compared to other electrical equipment in your home. The **PowerwoRx e<sup>3</sup>**'s "**power factor optimization**" significantly increases the efficiency of your motor load and stores waste energy resulting in decreased demand and usage of electricity from your utility company. This equates to significant cost savings for you the home owner.

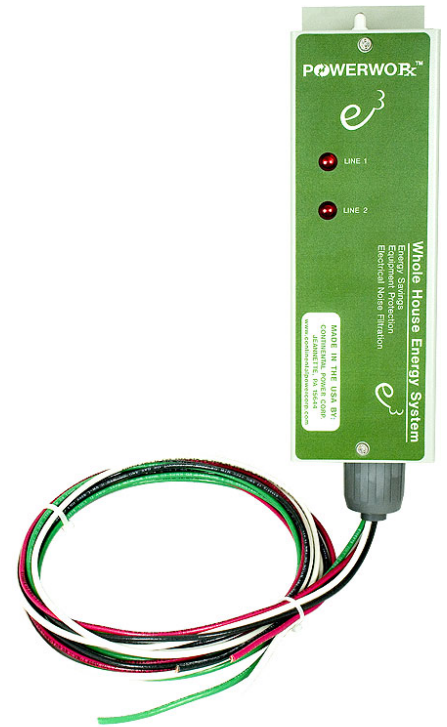
**Power factor** is the measurement of how efficient your electrical system is using the energy delivered to your home from your utility company. For example, your stove and dryer heating coils and incandescent light bulbs have a "power factor rating" of unity or 1. This equipment converts electric energy to heat and light. Motor loads as described above can have "power factor ratings" as low as 0.2. This combination of electric loads in American homes results in an average "power factor rating" of .77 or less. The .77 indicates that your home is using more energy than it should to operate your electrical equipment. The **PowerwoRx e<sup>3</sup>** technology has a proven track record of increasing a home's "power factor rating" to .95 or better.

## Equipment Protection

**PowerwoRx e<sup>3</sup>** is like having an **ELECTRONIC BODYGUARD** for your home or business! **PowerwoRx** technology provides Surge and Spike Suppression, a feature that will help protect and extend the useful life of your electrical equipment. Voltage surges and spikes come from many different internal and external sources such utility grid changes, damaged transformers or electrical lines due to accidents or acts of God, old or out dated utility transformers that supply electrical power to your home, lightning and turning on and off major motor loads in your home. Typical homes in the United States are bombarded with literally hundreds of surges and spikes a day that damage sensitive electrical equipment over time. A combination of the **PowerwoRx e<sup>3</sup>** harmonic resistant capacitors and metal oxide varistors (MOV's) give the home owner the maximum protection available on the market today. The external lights on the **PowerwoRx e<sup>3</sup>** system provide an easy visual indicator that the system is protecting your home.

## Electrical Noise Filtration

**PowerwoRx e<sup>3</sup>** technology provides Harmonic Filtration which has become more important since the 1980's and almost mandatory going into the 21<sup>st</sup> Century due to the proliferation of computers, fax and copy machines and variable frequency drives which are known as "nonlinear loads". "Nonlinear loads ask for and use electric current in "pulses" unlike traditional electrical equipment. This pulse use of electrical current creates damaging noise, interference and heat on today's electrical systems causing interference within sensitive electrical equipment or worse causing them to overheat



and fail. The use of computerized electronics within the American home has been growing at exponential rates and the need for filtering out the interference, noise and heat created by nonlinear loads has never been greater.

Installing the **PowerwoRx e<sup>3</sup>** system in your home will reduce the need to produce electrical energy reducing the amount of coal and oil being burned to generate the electric energy resulting in the reduction of environmentally harmful emissions of carbon dioxide, nitrous oxide and sulfur dioxide.

It is **EcoQuest's** mission to install **PowerwoRx e<sup>3</sup>** systems in 500,000 homes across this county which will annually reduce the need to generate 17 megawatts of electricity saving 42,250 tons of coal or 231,500 barrels of oil and reducing by 98,250 tons of carbon dioxide, 42,000 pounds of nitrous oxide and 221,500 pounds of sulfur dioxide of annual greenhouse emissions.

**Do your part by installing a PowerwoRx e<sup>3</sup> today!**

### **PowerwoRx<sup>TM</sup> E3 “Clean Power System” Specifications**

<b>Unit Model</b>	CPS-1C-240-V1
<b>Power Line Voltage (VAC)</b>	120/240
<b>Phase Configuration</b>	single
<b>Frequency (Hz)</b>	50 -60
<b>Power Dissipation (J)</b> <small>(2ms current wave)</small>	550J
<b>Peak Pulse Current (A)</b> <small>(8/20 microsecond current wave)</small>	40,000
<b>Maximum Clamping (V)</b> <small>(@ 200A, 8/20 microsecond current wave)</small>	340/690
<b>Total Capacitance (µF)</b>	30
<b>Operating Temperature (°C)</b>	-40 to +70
<b>Line Wires (AWG)</b>	12
<b>Circuit Breaker Required (A)</b>	20
<b>Dimensions (WxDxH)</b>	3”x9”x5”
<b>Weight (lbs.)</b>	3
<b>Warranty</b>	10 Year Unconditional

## Frequently Asked Questions

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[KVA \(Kilovolt Amperes\)](#)

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[Harmonic Interference](#)

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[Power Factor](#)

[Transformer](#) (Voltage Type)

[Capacitance](#)

[Electro Magnetic Field \(EMF\)](#)

[Metal Oxide Varistor \(M.O.V.\)](#)

### **What is the PowerwoRx e<sup>3</sup> Warranty?**

The warranty on PowerwoRx e<sup>3</sup> is the best in the industry – a full 10 year unconditional! Even if the PowerwoRx e<sup>3</sup> performs as it should in the event of a direct lightning strike, and the Industrial rated MOV's which absorb the energy sacrifice themselves, EcoQuest will repair or replace the unit. The patent pending design and the quality of the components used in the PowerwoRx e<sup>3</sup> Whole House Energy Management System lets us offer this industry leading warranty. No other manufacturer comes close.

### **How long will the PowerwoRx e<sup>3</sup> last?**

It has a predicted lifespan of over 20 years.

### **Does the PowerwoRx e<sup>3</sup> work in any home?**

Yes it does, as long as you have a circuit breaker panel with breaker switches and not the old screw in type fuses, the unit will work on any single-phase electric application for homes. If you say "yes" to only **two or more** of the following then you could be saving a significant amount of money on your electric bill right now!

Is your home over 2500 Square feet?

Is your central air conditioner / heat pump unit 3 years or older?

Is your forced air furnace 3 years or older?

Do you have a pool?

Do you have a well?

Do you use an air conditioner?

Is your refrigerator / freezer not EnergyStar rated?

Do you have more than one refrigerator / freezer?

Is your washer / dryer not EnergyStar rated?

Do you have a hot tub or a Jacuzzi?

Is your dishwasher not EnergyStar rated?

Do you have a number of appliances in your home?

### **How much current will the PowerwoRx e<sup>3</sup> handle?**

The PowerwoRx e<sup>3</sup> is designed for 240V and 200A which is typical for residential applications. For larger "Commercial" applications, a line of Commercial PowerwoRx e<sup>3</sup> units will be available through the activTek Environmental Commercial Division. A Certification program will be established for both sales and installation, and units will be available by mid 2008.

### **Installation Considerations?**

PowerwoRx e<sup>3</sup> must be installed by a licensed electrician or the 10-year Unconditional Warranty is void. The PowerwoRx e<sup>3</sup> mounts next to a standard 100A or 200A single phase power panel. The unit's two supply wires are connected into a dedicated 220V, 20A breaker. The neutral and ground are connected to their respective busses. Questions regarding proper attachment and wiring should be directed to the electrician who can verify local and state codes are being complied with.

### **Will the PowerwoRx e<sup>3</sup> affect any of my appliances and their normal use?**

No, if anything, your motors will run about 10% cooler, which is good for a motor because heat is the enemy of a motor.

### **Is the PowerwoRx e<sup>3</sup> tested and approved by independent labs?**

Yes, the PowerwoRx e<sup>3</sup> is UL listed and tested (PowerwoRx UL certificate is under the UL 508 "Industrial Control Equipment" category, UL Certificate # E320259, dated 3/27/08). To see the UL listing on the internet go to: [http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=NMTR.E320259&ccnshorttitle=Power+Circuit+and+Motor-mounted+Apparatus&objid=1079441548&cfgid=1073741824&version=versionless&parent\\_id=1073990288&sequence=1](http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=NMTR.E320259&ccnshorttitle=Power+Circuit+and+Motor-mounted+Apparatus&objid=1079441548&cfgid=1073741824&version=versionless&parent_id=1073990288&sequence=1)

The 200A Single Phase residential product is: CPS-1C-240-V1

The technology is also recognized by the U.S. Department of Energy.

### **How much can I expect to save per month by using the PowerwoRx e<sup>3</sup>?**

That depends on many factors. The size of your home, the amount of inductive motor load, and the amount you are paying per kilowatt-hour for electricity etc. Some users of the product have seen up to 25% in reduced consumption, but the average savings is somewhere in the 8% to 15% range.

### **How long will it take for the PowerwoRx e<sup>3</sup> to pay for itself?**

Looking strictly at Energy Savings the product can pay for itself within 2-3 years. This of course depends on individual circumstances, number of appliances and age, electrical costs and usage patterns, the homes power factor as well as other criteria. The other benefits, although not as dramatic as a drop in your energy bill, can turn out to be the biggest benefit of all! Consider Surge & Spike Protection, as well as the harmful effects of harmonic distortion. These invisible but very real threats to all electrical appliances and electronics in the home can and will cause premature failure. Considering the significant investment in these appliances and electronics, often totaling in the 10's of thousands of dollars, the protection provided by PowerwoRx e<sup>3</sup> could be the biggest money-savings benefit of the product.

### **Is the PowerwoRx e<sup>3</sup> easy to install?**

Yes, but the PowerwoRx e<sup>3</sup> must be installed by a licensed electrician. Installation requires opening up of the electrical panel, exposing potentially dangerous high voltage wires. The unit comes with complete installation instructions and installs in about 15-30 minutes.

### **Why haven't I heard of these products until now?**

That's easy; two words "cost effectiveness". Up until recently, electric rates throughout America were cheap, costing us 2, 3 or 4 cents per kilowatt-hour. Now, electric rates are 8, 10, 12, 14, and 19 and in some cases New York City is 22 cents per Kwh, and Hawaii is 33.5 cents per Kwh. At the cheaper rates the PowerwoRx e<sup>3</sup> didn't make sense, but at the current rates, it makes all the sense in the world.

### **What about PowerwoRx e<sup>3</sup> for Surge Protection?**

One of the most important features of the PowerwoRx e<sup>3</sup> is the ability to protect the entire home against power surges. No longer is there a need for so many individual surge protectors in the home. The PowerwoRx e<sup>3</sup> provides a broad range of protection for hardwired appliances and most home electronics such as appliances, televisions, satellite equipment, entertainment systems, etc. The unit protects from power line surges as well as spikes caused by internal wiring problems, loose connections and fluctuating demand from large motors such as vacuum cleaners, heating and cooling equipment, etc.

### **Is the PowerwoRx e<sup>3</sup> Energy Star rated?**

PowerwoRx e<sup>3</sup> is not Energy Star rated because this type of product does not fit into the Energy Star rating system. Our Technology partner Continental Power is addressing this with Energy Star requesting the addition of an appropriate certification category. It should be noted that Continental Power is an Energy Star partner.

### **Does the PowerwoRx e<sup>3</sup> save any energy on Resistive (non-motor) loads?**

Resistive loads are equipment like incandescent lighting, electric resistant heating, electric hot water heaters and electric ovens and ranges. These devices require no "magnetic power" or "reactive power" to operate; consequently they have no negative impact on Power Factor. The energy savings capability of PowerwoRx e<sup>3</sup> is achieved by storing the reactive power which is typically wasted, and making it available for reactive loads as required. There is no energy savings from PowerwoRx e<sup>3</sup> being attached to a purely resistive load.

### **Can the PowerwoRx e<sup>3</sup> cause my electric bill to go up and does it use electricity when there is little or no power demand?**

One of the Demonstration Kits EcoQuest is developing is a great interactive tool to show the PowerwoRx e<sup>3</sup> will not cause the electric meter to turn on its own nor will it cause the electric bill to go up. This "Living Proof" for energy, which includes a home Electric Meter, will not turn when just the PowerwoRx e<sup>3</sup> is applied. A test will also show that no matter how small the demand, even when the Power Factor doesn't need correcting, the Electric Meter will not register a higher power demand than what the load is actually drawing, regardless of the PowerwoRx e<sup>3</sup> being installed or not.

### **Is the PowerwoRx e<sup>3</sup> available for sale in Canada or other Countries?**

PowerwoRx Is UL certified and EcoQuest is currently pursuing the UL-C designation for sale in Canada. The product should be available for sale in Canada by midsummer 2008. For the PowerwoRx e<sup>3</sup> to be approved for sale in Europe, the product requires a ROHS compliance certificate and CE Certification. These steps are underway but at this point no completion date is available.

### **Mounting Considerations – what if the Residential Power Panel is flush-mounted in an exposed area?**

The PowerwoRx e<sup>3</sup> is designed to be SURFACE MOUNTED only due to its size (5" deep) and the surface mount mounting flange. Even if the 200A Power Panel is recessed and therefore flush mounted, the PowerwoRx e<sup>3</sup> must still be surface mounted. With several feet of wire to tie into the power panel, the PowerwoRx e<sup>3</sup> can be mounted in a less obvious location.

## What is the difference between PowerwoRx e<sup>3</sup> and other “Energy Savings” devices in the market?

There are over a dozen manufacturers of products that “look” similar and make similar claims as PowerwoRx e<sup>3</sup> regarding energy savings. These products are in many cases less expensive so what is the difference?

The numerous “Power Savings Devices” on the market today consist of two electrolytic capacitors in a box. The PowerwoRx e<sup>3</sup> contains:

- 2 Electrolytic Capacitors
- 2 Harmonic Filters
- 2 MOV's for Surge/Spike protection
- Additional electronics

A comparison of the two products is like comparing a golf cart and a sports car. They are both considered transportation, but the sports car has a lot more capability. As far as the literature goes, we all know that companies make all kinds of claims. The PowerwoRx e<sup>3</sup> has:

1. The best warranty in the business (10 years unlimited)
2. A patent pending product developed by a team of MIT PhD's with no other product like it in the market
3. True Harmonic and Noise Filtration
4. True Surge & Spike Protection thanks to Industrial MOV's
5. Soon to be announced warranty on connected appliances & electronics.

PowerwoRx e<sup>3</sup> is a premium product that has premium features. Consequently there is no comparable product on the market today that combines all these features together.

There are several products on the market which provide individual features much like the PowerwoRx e<sup>3</sup>:

- Leviton 51120-1 Whole House Surge Suppressor, 1-Phase - single feature only for a home: \$190
- Panamax MAX In-Wall Powerkit-Pro electronic Noise reduction unit, single feature only- but not a whole-house unit: \$299
- Facility Management Solutions Inc. Power factor correction device, single feature only for a home: \$349.

Total cost of all 3 units: \$838 and does not have many of the features and benefits of the PowerwoRx e<sup>3</sup>

PowerwoRx e<sup>3</sup> by EcoQuest International - One unit, One installation and One low price!

## Does the PowerwoRx e<sup>3</sup> consume energy on its own?

No. The PowerwoRx e<sup>3</sup> stores and supplies energy to the electrical appliances in the home, it does not directly consume electricity. Consequently, if an amperage meter (current probe) is placed on the electrical lines leading to the PowerwoRx e<sup>3</sup>, a reading of 4-5 amps will typically be shown. Most assume this translates into 600W of energy being “used” which on an annualized basis will cost the homeowner well over \$100 per year at current electric rates. The truth is the PowerwoRx e<sup>3</sup> “uses” no energy. This is easily proven by turning off all electrical loads and going to the Electric Meter and reading the consumption – the meter will not be turning. Another interesting test is to power a typical motor load like a bench grinder. Use a current meter to measure the inrush current at start-up as well as the steady-state current draw with and without the PowerwoRx e<sup>3</sup> in the circuit. With PowerwoRx e<sup>3</sup> activated the current draw at start-up and steady-state is typically reduced by over 30% thanks to the storing of the reactive energy by the PowerwoRx e<sup>3</sup>.

## Why is the product marked with the Continental Power name when it is being sold by EcoQuest and activTek?

The following details the reasons the name Continental Power (<http://www.continentalpowercorp.com/>) remains on the PowerwoRx e<sup>3</sup> product:

1. PowerwoRx e<sup>3</sup> is designed and currently manufactured by Continental Power Corporation
2. The UL Mark has been issued to Continental Power and not EcoQuest International or activTek Environmental. UL requires the Continental Power name on the product. Within the next few months EcoQuest and activTek will begin manufacturing of the PowerwoRx e<sup>3</sup> in our Greeneville, Tennessee plant. At that time UL will recognize EcoQuest Manufacturing as the manufacturer.
3. Continental Power has been providing energy solutions to the commercial and industrial markets for 15 years. Having them as a strategic partner provides us with instant credibility in this category and their brand and company equity will transfer to our selling efforts

It should be noted that EcoQuest International and activTek Environmental have been granted exclusive distribution rights of the PowerwoRx e<sup>3</sup> Total Home Energy Management System, and activTek Environmental has been granted non-exclusive distribution rights to the remainder of Continental Power Corporations commercial product line. Our agreement with Continental Power does not allow for them to sell the PowerwoRx e<sup>3</sup> directly, so any calls or e-mails to Continental Power to obtain the product would be unproductive. In addition, Continental Power does not sell on their web site nor do they solicit for or accept independent distributors. They are a solutions provider and have been for 15 years.

Out of respect for Continental Power's management team please do not contact them directly, either by phone or e-mail. They have been asked not to respond to any inquiries so when they do not respond you will understand why. All questions regarding the energy products should be directed to either [askecoquest@ecoquestintl.net](mailto:askecoquest@ecoquestintl.net) or [commercialsupport@activtek.net](mailto:commercialsupport@activtek.net)

### **Why is PowerwoRx e<sup>3</sup> still shown on the Continental Power website?**

Information on PowerwoRx e<sup>3</sup> can be found on the Continental Power website (<http://www.continentalpowercorp.com/>). As the inventor, manufacturer and marketer of this Energy Management Technology for over 15 years having the product on their web site lends credibility. Even if a customer were to go to the site, they will not be able to purchase the unit directly from Continental Power. In the near future, the "residential" link on their site will be redirected to EcoQuest and activTek.

### **Some Power Company Representatives have said Power Factor Correcting devices do not result in savings on the customer's electric bill – why?**

The following response was provided by Ed Kimmel, President of Continental Power:

*I have fifteen years worth of data that I have shared with many engineers that have made the same statement as above. I can tell you with 100% confidence that our systems do reduce kWh and kW usage as well as reduce or eliminate power factor penalties and reduce harmonic distortion.*

*As you know, no two electrical systems are the same, and no two utility companies bill their customers exactly the same. There are electric utility companies that charge more for kW and kWh usage than others. There are electric utility companies that penalize a customer for poor power factor. We see much larger reductions in usage in less efficient electrical system. This is to be expected. We also see shorter payback periods and larger ROI's on electric utilities with higher rates than others.*

*Power factor is just one third of the technology incorporated in the PowerwoRx Systems. We also install PowerwoRx for noise reduction and protection, using MOV's for surge and spike protection and harmonic filtration for noise reduction.*

*In my fifteen years of installing our equipment I have never had a dissatisfied customer. This I have done by being honest and upfront with every customer I have had. We do reduce kW and kWh usage!*

*Ed Kimmel, President  
Continental Power Corporation*

### **Are there any tax incentives for buying the PowerwoRx e<sup>3</sup> unit?**

The PowerwoRx e<sup>3</sup> could potentially qualify for a tax credit under the Energy Policy Act of 2005. As of December 31, 2007, most of the residential tax credits (windows, doors, roofs, insulation, HVAC, and non-solar water heaters) expired. On February 27, 2008, the House passed \$18.1 billion in renewable energy tax incentives (H.R. 5351), including an extension of the tax credit for energy-efficient home improvements. The bill is similar to the one passed last year, which was ultimately removed from the 2007 Energy Bill, signed into law in December 2007. This bill must still pass in the Senate, and be signed by the President to become law.

See [IRS form 5695](#). Taxpayers should consult their tax professional or accountant for how the PowerwoRx e<sup>3</sup> can qualify for the Tax Credit and how much of the purchase price and installation costs apply. Neither EcoQuest nor activTek make any claims regarding an individual's ability to receive a tax credit.

## Are Commercial versions of the PowerwoRx e<sup>3</sup> available?

Continental Power has a comprehensive line of commercial and industrial units sized for various voltage and phase configurations. These will be available through activTek Environmental by mid-summer 2008. Prior to making these products available, a comprehensive training and certification program will be established. This training will be separate from the current activTek Commercial Certification program and will be broken down into two levels:

1. For non-custom installations (such as 480V, 600A, 3-Phase power panels), the implementation is simple and requires basic technical skills. Typical customers are convenience stores, office buildings, strip malls, gas stations, and light manufacturing to name just a few. These units require no special instrumentation or evaluation.
2. For large custom installations the number of units required is determined by a multi-step process including a technical on-site evaluation, review of the previous 12 months electric bills, and inputting information into a proprietary software program developed by Continental Power to determine the appropriate hardware. The level of expertise is significantly greater and will require specialized hands-on training.

Development of the training programs for both certifications is underway and schedules for these certifications will be announced shortly.

Please note that commercial versions of the PowerwoRx e<sup>3</sup> are available to activTek on a non-exclusive basis. Continental Power Corporation is a small company focused on a few very large industrial applications but will continue to sell and install systems.

Pricing for the commercial versions of PowerwoRx e<sup>3</sup> will not be available until the mid-summer 2008 launch. For those who have an immediate requirement for a commercial installation, please contact [commercialsupport@activtek.net](mailto:commercialsupport@activtek.net) and we will work directly with Continental Power to evaluate the system and perform the installation. Because of the complexity of commercial installations, under no circumstances will commercial PowerwoRx e<sup>3</sup> be made available to activTek distributors until completion of the certification program.

## Can PowerwoRx e<sup>3</sup> be mounted on the outside of the building?

The PowerwoRx e<sup>3</sup> case is a NEMA 1 and therefore cannot be mounted outdoors or where exposed to moisture. For exterior mounting the installer should purchase a NEMA 3 enclosure to mount the PowerwoRx e<sup>3</sup> in.

## Electrical Terms - Definitions

### Alternating Current (AC)

The flow of electrons in a conductor measured in amperes. Alternating current reverses its direction of flow in a cyclical manner; i.e. 60 cycles per second. Conversely, direct current always flows in the same direction at 0 cycles per second.

### Amperes (Amps)

The unit measure for the flow of current in a conductor (analogous to gallons per minute in a piping system).

### Voltage (Volts)

The measurement of the electromotive force or potential which will make electrons flow in a conductor or circuit.

### Watt, Kilowatts, Kilowatt Hours

Electrical power consumption is measured in watts.

A Kilowatt is 1000 watts. A Kilowatt Hour is 1000 watts used for one hour.

We are concerned with true power which is the measure of power actually used by the load as measured by the utility watt meter and our T.I.F. meter.

In pure resistive A/C circuit, power could be calculated by measuring the voltage across the phase conductors and multiplying by the current flowing through the circuit conductors with an amp meter. To measure true power in inductive circuits power factor must be considered.

### KVA (Kilovolt Amperes)

KVA is the non power measure of the voltage multiplied by the amperes.

KVA is not a measure of true power it is a measure of the level of apparent power a generator or transformer could deliver to a circuit with a power factor of one.

To convert from apparent power to true power, you must take the KVA and multiply it by the power factor. For example, 100 KVA of measured apparent power serving an inductive load with a power factor of .9 would result in a real power of 90 KW.

If Kilowatts (KW) are the measure of true or real power available for work then KVA is a measure of apparent power needed to get the true power to the work.

From a utility's point of view they are generating power with a power factor of one.

In other words the KW and KVA at the outlet of the power plant is the same value.

As the power factor is degraded by load and transmission factors it takes proportionally more KVA per KW used to create and deliver to the consumer true or USABLE power.

The effect that a lagging power factor has on the utility is then to force it to generate more apparent power to satisfy our clients' needs for true or USABLE power.

In other words, if we measure a power factor of 1.0, then each KVA is being turned into a KW and the real and apparent power are equal.

If the power factor is .5 then each KVA supplied to the transformer by the utility results in one half of one KW of real power being consumed and measured. This means the utility has to absorb the difference in real vs. apparent power.

The affect on the utility supplying power to a network of customers with lagging or poor power factor is that its generating and distribution efficiency is reduced.

Because the current being generated by the utility has to increase as the demand for KVA increases and in a poor power factor network the current increases disproportionately faster than in a network with unity power factor, then the losses due to the resistive heating in the power distribution network of conductors increases.

The term most frequently used to express this problem is  $W=I^2 R$  meaning that conductor, transformer and motor heating increase at the rate of the amperes squared time the resistive component of the circuit. Some customers are penalized for low power factor by being charged for the difference between KVA and KW. Power factor  $e^3$  reduces the  $I^2 R$  losses by improving power factor and reducing KW.

### **KVA(R)**

The measure of the amount of reactive KVA that is necessary to raise a lagging power factor toward unity.

### **Harmonic Interference**

AC power is delivered throughout the distribution system at a fundamental frequency of 60 Hz. (50 Hz in Europe.) Harmonics are defined as, "integral multiples of the fundamental frequency." For instance, the 3rd harmonic frequency is 180 Hz, the 5th is 300 Hz, etc. In the US, the standard distribution system in commercial facilities is 208/120 wye. There are three phase wires and a neutral wire. The voltage between any two phase wires is 208, and the voltage between any single phase wire and the neutral wire is 120. All 120 volt loads are connected between a phase and neutral. When the loads on all three phases are balanced (the same fundamental current is flowing in each phase) the fundamental currents in the neutral cancel and the neutral wire carries no current. When computer loads and other loads using switched mode power supplies are connected, however, the situation changes.

Switch mode power supplies draw current in spikes, which requires the AC supply to provide harmonic currents. The largest harmonic current generated by the SMPS is the 3rd. The magnitude of this harmonic current can be as large or larger than the fundamental current. Also generated, in smaller amounts, are the 5th, 7th, and all other odd harmonic currents.

Like the fundamental current, most harmonic currents cancel out on the neutral wire. However, the 3rd harmonic current, instead of canceling, is additive in the neutral. Thus if each phase wire were carrying, in addition to fundamental current, 100 amps of 3rd harmonic current, the neutral wire could be carrying 300 amps of 3rd harmonic current. In many cases, neutral-wire current can exceed phase wire currents. This extra current provides no useful power to the loads. It simply reduces the capacity of the system to power more loads, and produces waste heat in all the wiring and switchgear. When the 3rd harmonic current returns to the transformer it is reflected into the transformer primary where it circulates in the delta winding until it is dissipated as heat. The result is overheated neutral wires, switchgear, and transformers. This can lead to failure of some part of the distribution system and, in the worst case, fires. In addition, waste heat in all parts of the system increases energy losses and results in higher electrical bills. 3rd harmonic currents can increase electrical costs by as much as 8%

### **Circuit**

A closed loop consisting of conductors (wires) from a source of voltage (a transformer in our case) to a load (motors, fluorescent lamp ballasts or resistive loads) that provides the path for the flow of current through the load.

### **Phase**

Phase is a trigonometric measure of the angle between the 60-cycle wave current form and the 60-cycle voltage wave form. In a perfect world, the current wave form and the voltage wave form leaving a generator would start at the same time.

In reality, the inductive characteristics of the electrical distribution system and the inductive loads imposed on it retard the current wave form and cause it to lag the voltage wave form (If a circuit had more capacitance, then inductance the current wave form) would lead to the voltage wave form.

### **Inductive Load**

In general loads that operate by the passing of alternating currents through a coil of wire wound around an iron core. The resulting magnetic field is used to:

- a - cause a motor shaft to rotate, or
- b - induce a similar current in another coil of wire wound around the same piece of iron core as in a transformer (There are inductive heaters that are coils of wire wound around the media to be heated.)

### **Resistive Load**

A load that turns all energy (current and voltage) applied to it into heat. Includes incandescent lamps, space heaters, immersion heaters, etc. These loads are not inductive.

### **Power Factor**

When current and voltage wave forms start at the same time they are in phase and power factor is 1. As circuit inductance retards the current wave form it falls out of phase or lags the voltage wave form.

The measure of a lagging current wave form is expressed as a percentage; i.e., if the current lags the voltage by 10%, the power factor is 100% less 10% or 90% or 0.90.

Effects of low power factor:

It is sometimes considered that the wattless component of a current at low power factor is circulated without an increase of mechanical input over that necessary for actual power requirements. This is inaccurate because internal work or losses due to this extra current produced and must be supplied by the utility. Since these extra losses manifest themselves in heat, the capacity of the distribution network is reduced. Moreover, wattless components of current heat the line conductors, just as do energy components, and cause losses in them.

The loss in any conductor is always

$$W=I^2R$$

where  $W$  = the loss in watts,  $I$  = the current in amperes in the conductor, and  $R$  = the resistance in ohms. It requires much larger equipment and conductors to deliver a certain amount of power at a low power factor than at a power factor close to 1.

### **Transformer (Voltage Type)**

Inductive devices used to isolate the flow of current in one circuit from another while allowing magnetic coupling of the two circuits to create a voltage in the second circuit. Transformers may be used to step down a voltage from a higher level to a lower level or to step up a voltage from a lower level to a higher level or to maintain the same voltage on both sides (primary and secondary) while isolating the circuits from one another. Fluorescent lamp ballasts are transformers.

### **Capacitance**

A measure of a circuit or device's ability to store electrical energy. Applied primarily to A/C circuits where the alternating nature of the current charges and discharges the capacitor as the current reverses its direction of flow in the circuit.

Capacitors ability to store electricity is measured in "Farads" or increments thereof as in microfarads. Capacitors are used to improve the performance of certain inductive circuits as discussed under power factor.

### **Electro Magnetic Field (EMF)**

Technically, the term "electromagnetic field" (EMF) refers to all fields throughout the electromagnetic spectrum. In common usage, however, the term usually refers to so-called extremely low-frequency nonionizing radiation fields—those fields below 300 Hertz (Hz)—and often only to those fields in the 50 to 60 Hz range, which are also known as power-frequency EMFs. As a type of nonionizing radiation, EMFs in this range do not have sufficient energy to remove an electron from an atom or molecule, but generally transfer thermal energy to other particles. Power-frequency EMFs are those generated by electric power delivery systems—those for which there has been the greatest public concern and research about possible adverse human health effects.

Power-frequency EMFs have two components: electric fields and magnetic fields. The electric fields are generated from potential energy, or the presence of voltage on a power line. The magnetic fields, on the other hand, are generated from the actual electrical current, or the flow of electricity. Thus, when a standard household electric light is plugged into a live electrical socket, but turned off, it generates only an electric field. Once turned on, it generates both electric and magnetic fields, since the voltage is still present but current is now flowing. The size of a magnetic field increases as the amount of current flow increases, as the size of the source increases, and as one gets nearer to the source.

### **Metal Oxide Varistor (M.O.V.)**

A discrete electronic component that is commonly used to divert excessive current to the ground and/or neutral lines. Acting like a pressure relief valve, an MOV is comprised of zinc oxide with small quantities of bismuth, cobalt, manganese and other metal oxides.