AMERICAN MANUFACTURER

OF

POWER PERFECT™

ENERGY SAVING PRODUCTS

AN ALTERNATIVE APPROACH

TO

ALTERNATING CURRENT

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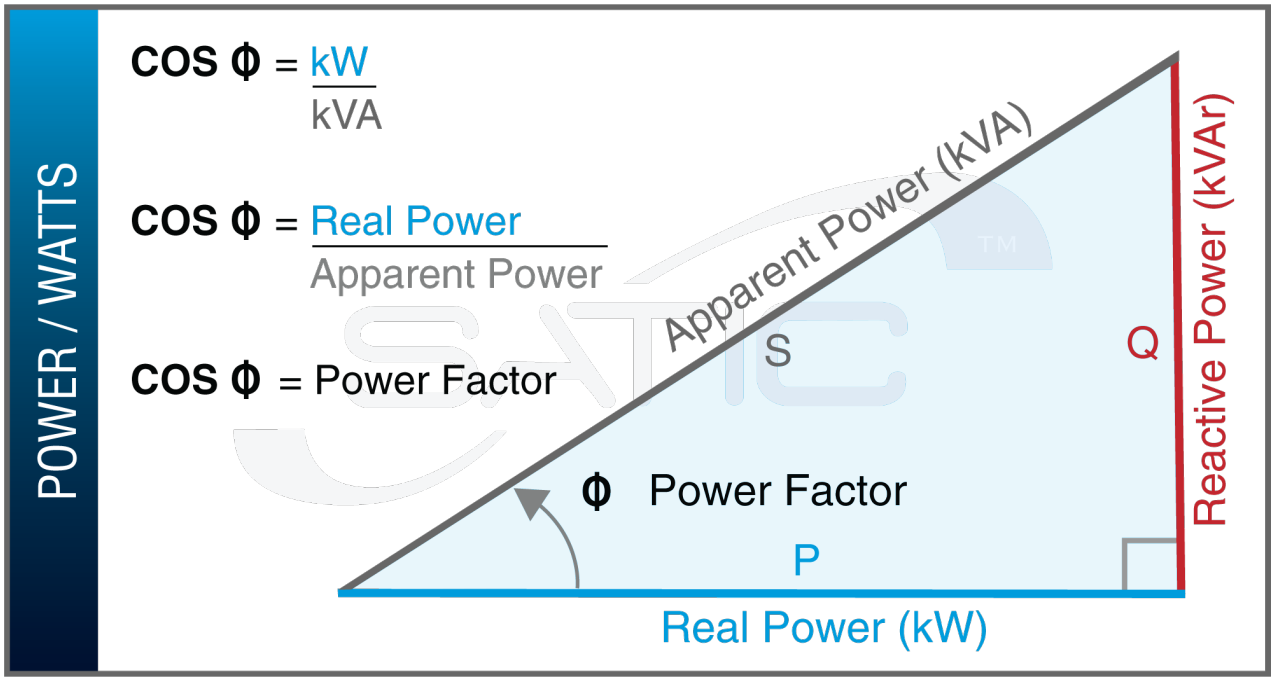
SATIC's Alternative Approach to Alternating Current

B.D. Erickson II, Lynn Churchill, PhD, Bradley Layton PhD PE

In this paper we address the historical approaches to alternating current (AC) power conditioning, which relied primarily on capacitor banks for power-factor correction. In contrast, SATIC's approach to energy management addresses and mitigates the multitude of dirty electricity sources in our modern world.

Until recently, electrical systems and technologies were less influenced by harmonics. Today's modern technology such as switching power supplies, computers, LED displays, appliance controls, LED drivers, CFL ballasts, etc., introduce significant levels of harmonics. The destabilizing effects on electrical system dynamics coupled with noise and poor power factors (PF) necessitates novel approaches to filtration, conservation, and power conditioning.

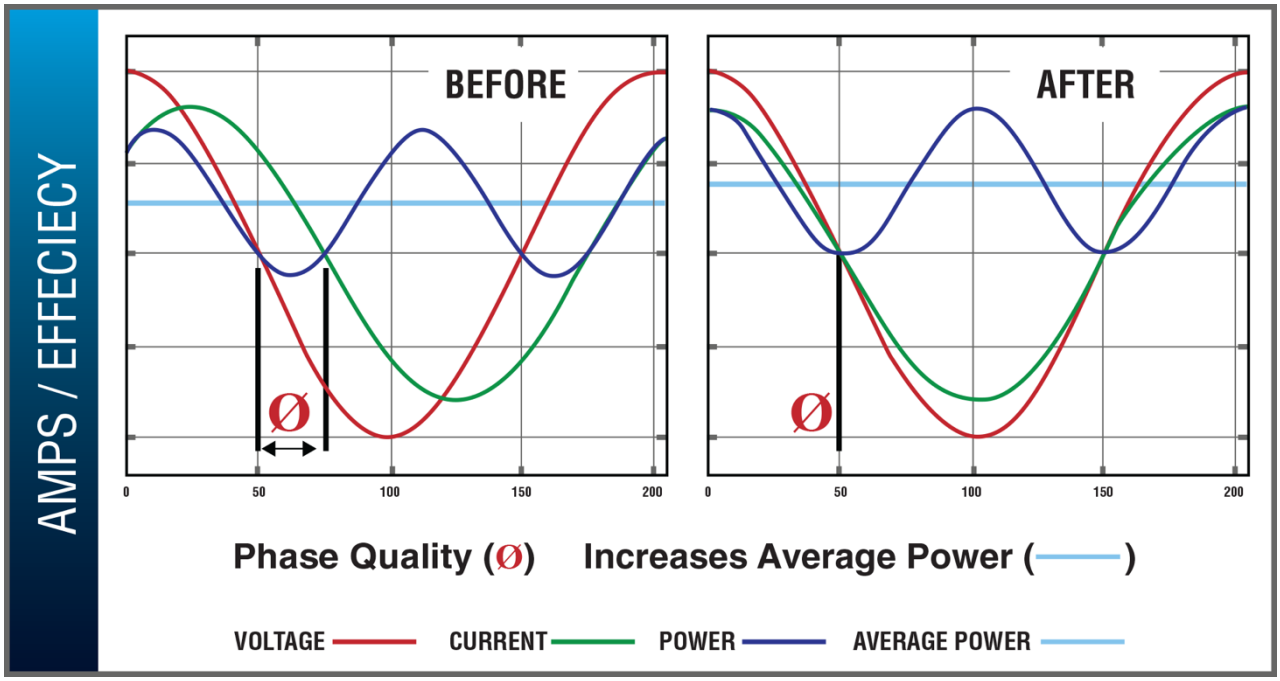
Everyone in our field is familiar with the basic power-factor triangle.



This simple illustration shows that in an inductive circuit as is common with most motor loads, capacitors provide capacitive reactance, which can eliminate the need for reactive power supplied from the

source. By balancing inductive load with an appropriately-sized capacitor load, total apparent power is reduced, ∅ approaches 0, power factor approaches unity, and total apparent power is minimized, resulting in financial savings.

As seen in the AMPS/EFFICIENCY figure, as phase correction improves, current lag, denoted by ∅, is reduced, and average power increases.

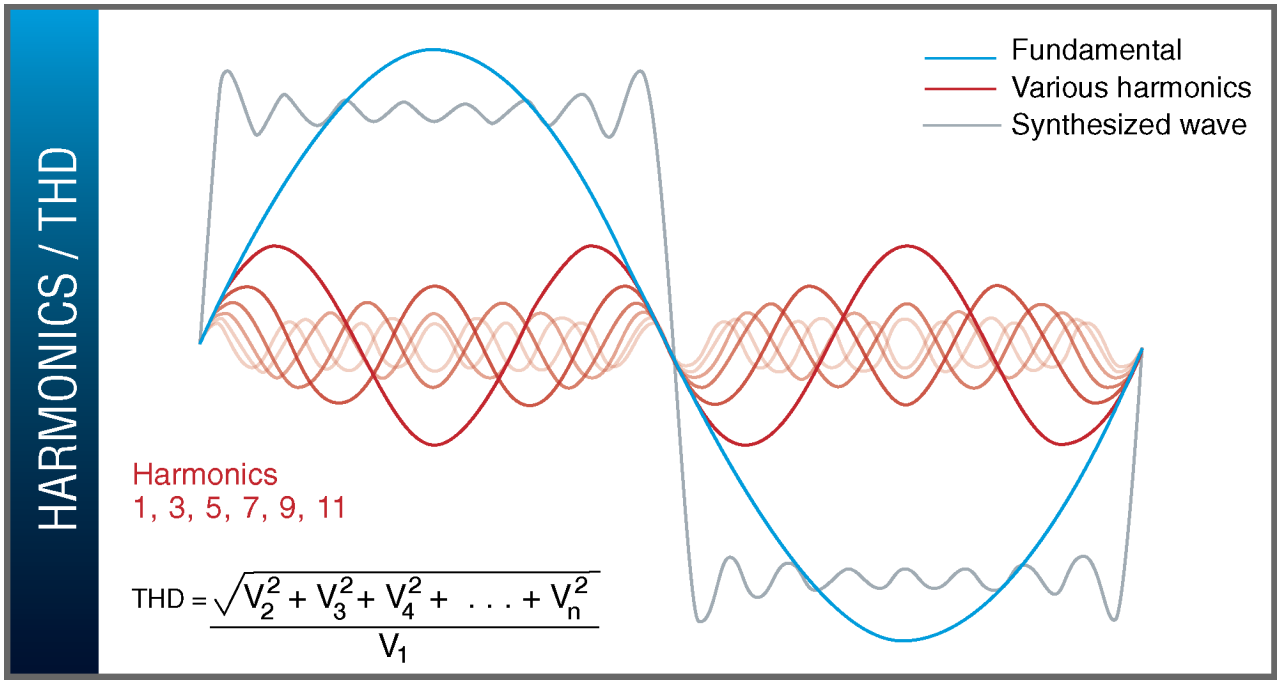


In AC electricity, this has been the traditional role and primary application of capacitors. However, in today's world, with the advent and mass dissemination of compact fluorescent lighting and the ever-expanding array of digital electronics that run on direct current (DC) rather than AC, a need has arisen to address issues of overall 'power quality' that capacitors are ill-suited for. One must look at the impact of electrical harmonics on our modern electrical system that didn't exist in past decades.

Voltage harmonics in an electric power system are a result of nonlinear electric loads. Harmonic frequencies in the power grid are a common cause of power-quality problems. Harmonics in power systems can result in increased, unwanted and potentially damaging

heating in equipment and wiring, misfiring of variable speed drives, and torque pulsations in motors.

Primarily, nonlinear loads cause current harmonics as well as voltage harmonics. When a nonlinear load is connected to an electrical circuit, the nonlinear load draws an asinusoidal current. The resulting current waveform can become quite complex, depending on the type of load and interactions with other circuit loads. Regardless of how complex the current waveform becomes, it is possible to decompose it into a series of fundamental sinusoids, beginning with power system's primary frequency, (e.g., 50 Hz or 60 Hz) and occur at integer multiples of the primary frequency. The HARMONICS/THC figure illustrates the waveform distortion caused by the additive nature of these harmonics.



Total harmonic distortion (THD) is a common measurement of the level of harmonic distortion present in a power system and is defined as the ratio of total harmonics to the value of the fundamental frequency and is calculated as:

$$\mathrm{THD} = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \cdots + V_n^2}}{V_1}$$

where V_n is the RMS voltage of the n^{th} harmonic and $n = 1$ is the primary frequency.

One of the major effects of power system harmonics is to increase the current in the system. This is particularly the case for the third harmonic, which causes a sharp increase in the zero sequence current, and therefore increases the current in the neutral conductor. This effect can require special consideration in the design of an electric system to serve nonlinear loads.

Power-factor-correction capacitors, if applied incorrectly, may actually amplify harmonics to unacceptable values, and harmonic resonance can cause capacitor failure due to harmonic over-voltages and over-currents. This "over-capacitance" can damage both the capacitor and the equipment.

In addition to increased line current, many different types of electrical equipment can suffer negative effects from harmonics on the power system. Filtering out harmonics and restoring the primary sinusoidal waveform reduces reactive power, resulting in increased efficiency, less apparent power, and an increase of power factor. Traditional capacitors can't increase power factor and condition power in this way. They must be sized properly to fit inductance and often have a relatively shorty life cycle.

This in part motivates SATIC's approach to its energy management designs. In fact, lowering heat losses, removing harmonics, and improving power factor, has been SATIC's primary focus since 2008.

The SATIC Approach

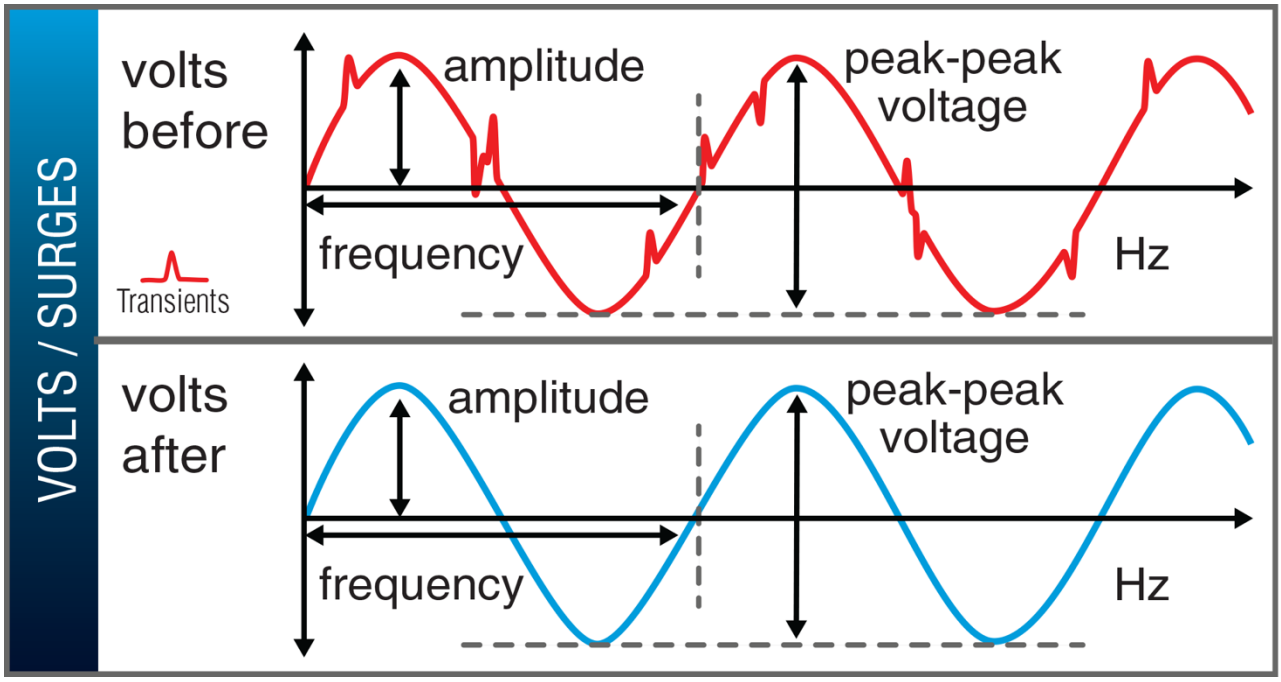
SATIC's approach to energy management does not focus solely on conventional power-factor correction. Instead, SATIC technology lowers electromagnetic fields, removes harmonic distortion and mitigates electromagnetic interference through the SATIC PowerPerfect™ approach. SATIC's products have been designed, and components selected to address eight key aspects of alternating current:

1. volts – "electrical pressure"
2. amps – electrical current
3. power factor – the ratio of real to apparent power
4. watts – real power
5. THD – total harmonic distortion
6. EMF – electromagnetic fields
7. resistance – heat and radian losses as electricity travels
8. frequency – rate at which voltage oscillates

Volts – Voltage Regulation

SATIC's charged harmonic rectifier banks are able to "push" voltage dips, providing voltage regularity on a nanosecond basis. Unlike battery storage, which is slow to react to high-frequencies, SATIC technology restores voltage levels, which is a short-term and long-term benefit for all electronics and appliances.

In addition, SATIC's PowerPerfect™ technology provides robust surge protection. Three metal-oxide varistors (MOVs) provide surge protection in SATIC's single-phase PowerPerfect™ technology and six MOVs in SATIC's three-phase PowerPerfect™ technology, which trims voltage spikes (as seen in the VOLTS / SURGES figure), regulates voltage and protects equipment.



Amps – Phase Correction

SATIC's integrated circuit board design allows our units to reduce amp draw through phase correction without the use of antiquated metal capacitors. In addition, a common reason for not using capacitors for phase correction is that they can also push power factor past unity, creating leading voltage, decreasing efficiency and increasing power consumption.

SATIC uses neither run capacitors nor start capacitors and yet we manage power factor and inrush current (when an inductive motor first starts up) with smart control built into our design. Depending on utility power factor charges and other billing practices SATIC power factor correction, consistently demonstrates measurable financial savings.

For example, a 120-V motor with a 0.30 PF pulls 5.0 amps of current or (5 A × 120 V = 600 VA) for 600 VA of total apparent power, or 180 real watts of power (5 A × 120 V × 0.30 PF = 180 W), whereas the same 120-V motor with a 0.94 PF will only require 1.6 amps of current for the same 180 real watts of power (1.6 A × 120 V × 0.94 PF = 180 W). The first motor is using 3.4 more amps to accomplish the same amount of work. This

unusable power is what is referred to as reactive power. As the excess 3.4 amps flows through the motor, it is released as heat. Heat is detrimental to almost all electrical devices. By correcting power factor, SATIC PowerPerfect™ technology extends equipment life and saves money on utility bills.

Watts – Reduced Electrical Consumption

Watts represent real power being turned into work or heat. Inductive motors turn electricity into mechanical work. Only the real power is converted into work and the rest is either turned into heat or returned to the power grid via the neutral.

Battery-powered devices such as iPods, laptop computers, tablets, cell phones etc., have power supplies that convert AC to DC. The AC watts are converted into chemical energy by charging the battery, which then supply DC to the device. If these DC power supplies are provided reactive power it will be converted to heat in the device. This is why devices get so warm when charging. Heat reduces the lifetime of all electronic devices.

When you draw fewer amps of cleaner power to do the same amount of work, you have reduced the amount of electricity turned into heat and these devices will run cooler and last longer. Running cooler with SATIC PowerPerfect™ technology saves watts, extends electronics life and saves money.

THD – Negative Harmonics Reduction

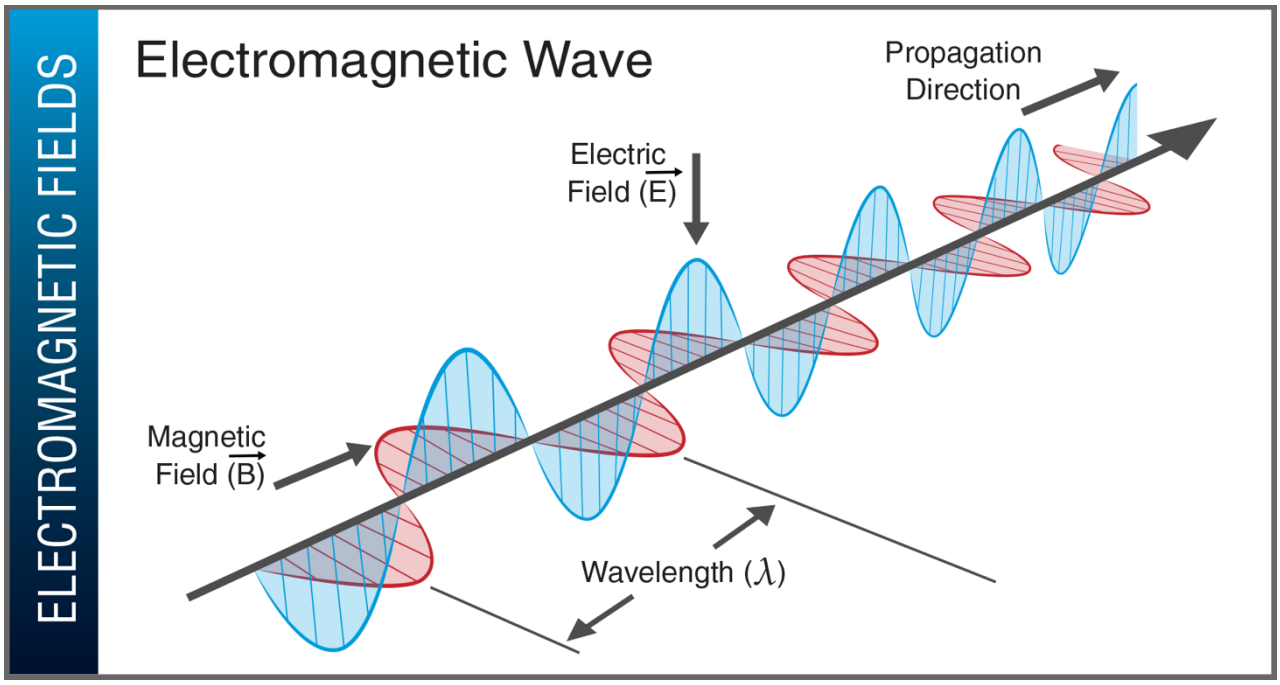
SATIC PowerPerfect™ technology also provides harmonics filtration, which is another reason for our use of harmonic rectifiers instead of capacitors, as capacitors may increase THD. LEDs and CFLs are notorious for adding significant harmonic distortion to load centers. Typically, THD is shrugged to the neutral path, something that many DC-powered devices are notorious for doing. SATIC PowerPerfect™ technology constantly filters the neutral path while simultaneously filtering incoming power. Removing harmonics results in cleaner

power. Recapturing some of the return-path power lost to neutral also provides the ability to meet the inrush demands that occur throughout the day. By generating less demand from the utility, SATIC PowerPerfect™ technology reduces overall power consumption and increased financial savings.

EMF – Electromagnetic Field Reduction

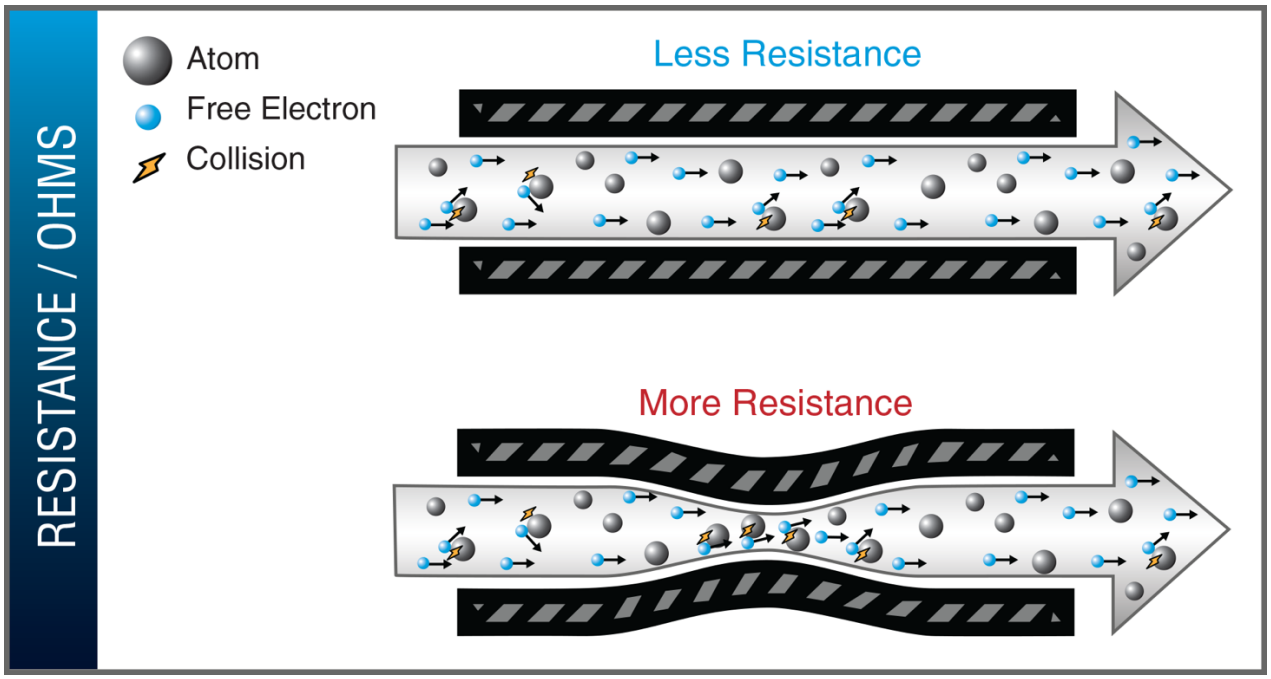
SATIC PowerPerfect™ technology also provides electromagnetic field and electromagnetic interference (EMI) reduction for cleaner, more efficient power, resulting in the reduction of electromagnetic radiation (EMR).

Numerous medical studies have reported that exposure to certain frequencies of EMF can be detrimental to plant, animal and human health. For example, wind and solar inverters add high levels of potentially hazardous EMF to load centers. SATIC products reduce EMF significantly. Third-party studies have shown that SATIC technology reduce EMI voltage by as much as 98%.



Resistance – Reduced Amps Results in Reduced Resistance

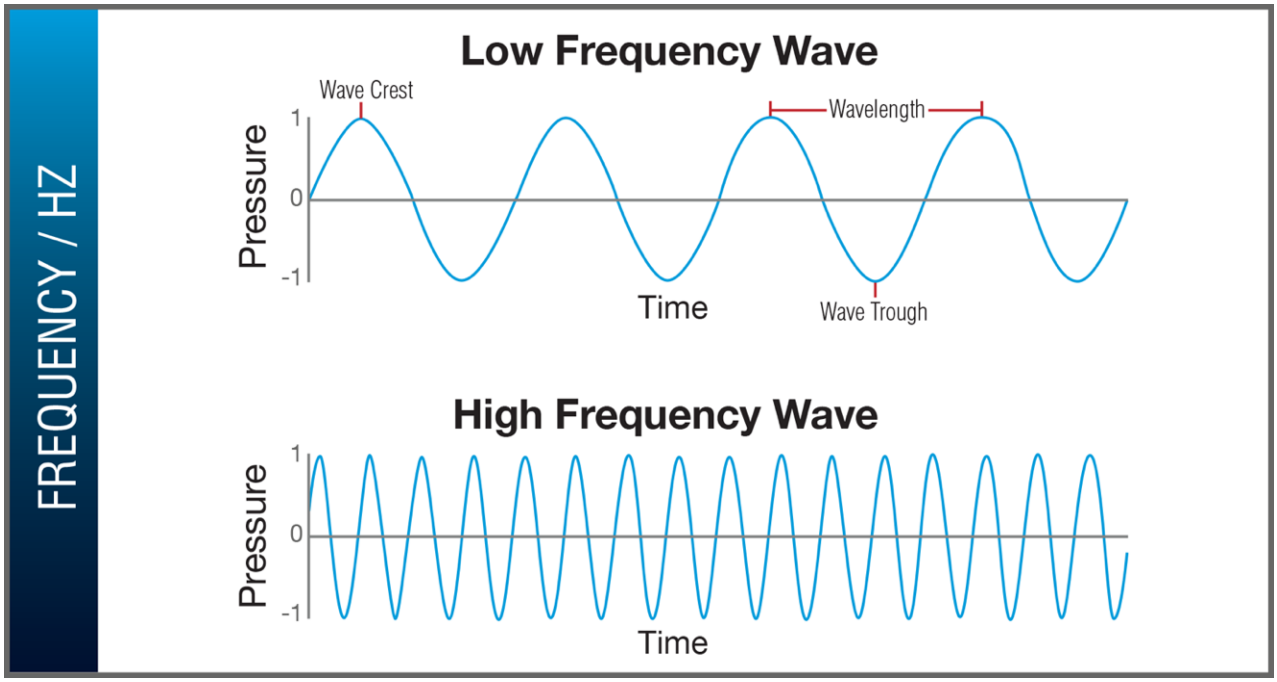
Most of us are familiar with Ohm's Law. As line current increases, the heat produced increases. This is due to the wire impeding the flow of current. With DC current it is called resistance whereas in AC current it is called impedance. As might be expected the further the current has to flow, the more resistance or impedance occurs. By increasing efficiency, lowering impedance and reducing the amps required for work there is a correlated reduction in resistance, less power is lost and temperatures are lowered consistently and measurably. The impedance of the SATIC PowerPerfect™ units are so low that it's own power consumption is less than ten watts.



Frequency – Keeping Alternating Current Consistent

As shown in the FREQUENCY / HZ figure, frequency is the number of times an event occurs within a specific time period. The frequency for alternating current in North America is 60 times per second or 60 hertz (Hz) and 50 Hz in several other parts of the world such as Europe. SATIC technology is designed to operate at all global primary grid frequencies: saturating and discharging at the primary frequency. This

reduces EMI and maintains low-noise, high-power-factor power at the primary frequency.



Other Design Considerations

No other energy management system that we are aware of, has SATIC's level of full power conditioning integration. Harmonic rectifiers, power-factor correction modules, voltage regulation components, transient or nano-surge filtration, combine to provide electromagnetic field and negative harmonics reduction with extremely robust surge protection all packaged into SATIC's proprietary design. This allows SATIC PowerPerfect™ technology to be compact, modularly scalable and more affordable than competing products, yet as or more effective than anything else on the market.

The standard single-phase SATIC PowerPerfect™ Box has three circuit boards. These boards are manufactured in the United States with the highest quality components available to address all of the eight aspects of alternating current as discussed above.

Each circuit board acts as an independent sub-system as there are three electrical pathways in a single-phase electrical system:

- Phase A to neutral is a 120-V subsystem (phase-to-neutral)
- Phase B to neutral is a 120-V subsystem (phase-to-neutral)
- Phase A to phase B is a 240-V subsystem (phase-to-phase)

In a similar fashion there are six electrical pathways in SATIC's three-phase systems and the three-phase PowerPerfect™ Box employs six independent circuit boards:

- Phase A to neutral is a 120-V subsystem (phase-to-neutral)
- Phase B to neutral is a 120-V subsystem (phase-to-neutral)
- Phase C to neutral is a 120-V subsystem (phase-to-neutral)
- Phase A to phase B is a 208-V subsystem (phase-to-phase)
- Phase B to phase C is a 208-V subsystem (phase-to-phase)
- Phase C to phase A is a 208-V subsystem (phase-to-phase)

Addressing each of the eight electrical attributes discussed in this paper on all possible electrical pathways guarantees clean electricity throughout the entire electrical distribution network. This is what SATIC calls PowerPerfect.

Conclusions: What are the results and savings?

While SATIC does not publish specific power savings claims, as every electrical environment is different, the vast majority of SATIC customers do realize utility bill savings as well as health benefits and prolonged appliance and component life. System size, wiring, appliances, HVAC, lighting, loads, etc., all vary greatly as do utility billing practices and charges. However, one can deduce a realistic and measurable decrease in real power (watts) in the following ways:

1. Improving phase quality and reducing amps consistently creates a 2-3% decrease in power lost to heat and resistance (I^2R). SATIC's third-party testing shows consistently greater savings, and thus the DOE estimate of 2% is a lower bound.

2. Watts and waste heat are reduced by providing stored power for inrush events as equipment spools up. SATIC achieves this by storing roughly five amps of return-path current that is cleaned and reintroduced. A 1-3% reduction in power consumption is

measurable. While third-party testing has shown greater potential savings, we typically use an industry-accepted average of 2% reduction for inrush management.

3. With less motor and component heat soak or build-up, combined with greater efficiency, HVAC and refrigeration systems are more effective, which consistently results in fewer and shorter duty cycles. Tests show that fewer and shorter duty cycles create consistent electrical savings in relation to ambient temperate and other factors, while industry standards for savings are low at 1-3%.

4. Real power is not converted into heat in devices like TVs, computers, appliances and phones, thus reducing watts and saving energy and money. DOE studies show that as much as 3% of residential utility costs are losses to resistance and heat. With SATIC technology in place, these devices run cool, thus reducing BTUs introduced to the environment as heat, thus reducing air-conditioning loads. Even one less cycle or shorter cycles per day for HVAC systems contributes that same, consistent 1-3% savings. 1-2% device heat savings combined with 1-3% HVAC savings give this category a combined 2-5% savings.

While much has been written on energy conservation, make no mistake, this is a game of inches and there are significant inches to be gained.

In pursuit of these "electrical inches," SATIC has invested millions of dollars, over a decade of calendar years and countless laboratory and hours in the field, data-logging electrical systems, on top of our own research and development invested creating the product line.

With the exhaustively researched and generally accepted analysis of savings outlined above, SATIC customers frequently realize a 6% - 12% reduction in real power consumption, while simultaneously creating a cooler, healthier and more efficient electrical system.

SATIC has subjected its entire line of technologies to rigorous third-party validation testing. The results of those tests include data

logging for power consumption, ambient and equipment temperatures as well as HVAC duty cycling before and after product installation. That testing consistently shows savings equal to or greater to that given above. The complete summary of third-party testing is available upon request.

SATIC PowerPerfect™ Energy Management Systems create cleaner power for homes and businesses and is unlike anything on the market today. Manufactured with pride of top-quality components in the USA, SATIC products are warranted for 10 years and performance is guaranteed.

For clarification or more information contact us at:

SATIC Incorporated
866-997-2842
http://www.saticusa.com