EnergyIdeas Clearinghouse

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Product & Technology Review

Electrical Harmonizer™

A device to adjust voltage to an optimal level to save energy, while improving facility power quality including harmonics, power factor, and voltage unbalance.

Product
Electrical Harmonizer™

Manufacturer/Distributor
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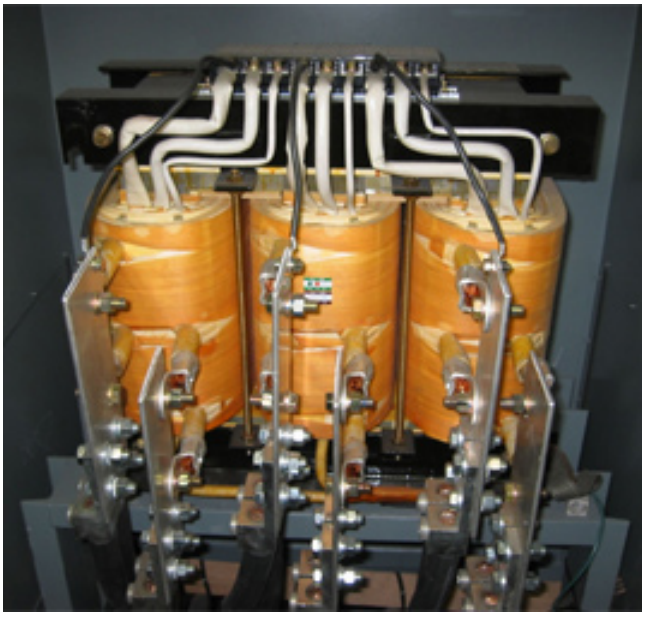
Product History
The Electrical Harmonizer was developed in Japan and entered the market there in 1992. Legend Power Systems of British Columbia obtained the distribution rights for North America in 2001. The first U.S. installation was in May of 2003.

Product Function and Application
The information in this section was primarily provided by the manufacturer and is not evaluated here. Electrical Harmonizer is an ultra-low-loss three-phase multi-tap dry transformer to adjust voltage to an optimum level for the primary purpose of saving energy. It has additional features to achieve certain non-energy benefits discussed below. Existing models provide a selectable fixed voltage reduction and do not automatically adjust to varying input voltage. Output voltage is set by selectable taps. It is applicable and sized for the entire facility load of commercial and light-industrial facilities, and appropriate branch circuits of large facilities, where voltage tends to be higher than optimal for connected loads. Sizes range from 400 amps to 1,500 amps for either 480 or 600 volt nominal service voltage. It is a regulating device and does not replace a conventional step-down transformer. It can be installed at the service entrance or on any branch circuit.



Photograph courtesy of Legend Power Systems, Inc.

Product & Technology Reviews (PTR) are developed for Northwest electric utilities. EnergyIdeas Clearinghouse engineers review published literature for objective, independent test results. No primary testing was conducted by the reviewer for the preparation of this document. PTR factsheets describe the technology, discuss available data, and suggest additional testing needed to verify energy saving claims.
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The Electrical Harmonizer has similarities to an autotransformer that give it extremely low losses. The manufacturer claims 99.89% efficiency. It is distinguished from a simple autotransformer in that it contains extra proprietary windings and special connections that assist in mitigating voltage unbalance and blocking triplen harmonics. The device is wound with three single-phase reactors on a common core, so it has an inherent tendency to correct phase voltage unbalance and to block triplen harmonics from crossing into the facility from the line or vice versa. Triplen harmonics are the third harmonic and its odd multiples, e.g. 3rd, 9th, 15th, etc. These are most commonly generated by power supplies in single phase loads like computers and copy machines because they draw a spike of current at the peak of the voltage wave. Because of the phase reactance, it will also provide a degree of mitigation against other common problem harmonics like 5th, 7th and 11th harmonic.

Energy Savings Claims

The manufacturer's website claims that users will experience "Reduced energy costs (typically in the range of 7-12%)."

Non-Energy Benefits

Electrical Harmonizer blocks triplen harmonics. This is useful because triplen harmonics reduce the peak of the voltage wave, which can cause some electronic equipment to trip off. Triplen harmonics can also cause overloaded neutrals and create a harmful neutral-to-ground potential. Overloaded neutrals are a fire hazard. All harmonics increase losses and lower the effective rating of transformers and conductors.

The Electrical Harmonizer also reduces phase voltage unbalance. Left unchecked, phase unbalance causes reduced efficiency, overheating, and torsional vibration in three-phase motors.

The manufacturer claims the Electrical Harmonizer will improve power factor. This is to be expected because motor power factor increases when voltage is reduced.

Voltage reduction of the Electrical Harmonizer may slightly extend the life of some lighting ballasts.

Independent Testing Results

The product has been tested by an independent laboratory at the University of Nottingham Environmental Technology Centre in the UK, and has been independently field monitored in a number of diverse installations by BC Hydro. Third party organizations have participated in the two case studies described in the "Case Studies" section.

The University of Nottingham lab test report describes testing the Harmonizer for energy savings. The results were consistent with the theory and claims of the manufacturer when applied to a diverse mixture of three-phase light industrial equipment rated from 0.9 kW to 5 kW. Overall savings were 11% when voltage was turned down by 7%. The report did not indicate whether testing was conducted to assess losses of the device itself. Voltage unbalance was measured at input and output. The device did not appear to improve unbalance; voltage was already reasonably well balanced at the input level (generally around 1% unbalance).

Cost

Installed costs vary with the capacity, size, and configuration of the electrical room. Sizing is based on the peak kVA over the previous 24 months. According to the manufacturer, for a facility with a peak load approaching 500 amps (or 415 kVA), the average cost of the Electrical Harmonizer, including installation, would be in the $45,000 to $50,000 range.

Alternative Products and Strategies

The Electrical Harmonizer is unique for being a single product that mitigates over-voltage, harmonics, and unbalance. However, combinations of other products can accomplish the benefits of the Electrical Harmonizer. Autotransformers can accomplish voltage reduction. Sometimes voltage adjustment can be accomplished with tap

changes on existing step-down transformers. Wye-Delta transformers can block triplen harmonics. There are suppliers of filters for all sorts of harmonics. Correcting unbalanced loading can improve unbalance that originates inside a facility.

Case Studies

A one-million-square-foot Canada Post mail sorting facility in Vancouver, BC was equipped with an Electrical Harmonizer on two circuits. This was installed after a major energy retrofit had already been completed to maximize efficiencies for the entire facility. Monitoring was conducted by Mott Electric Ltd. and Prism Engineering, Ltd. Legend Power reported annual savings as a 7.78% reduction in real power consumed, a 22.94% reduction in reactive power and a 6% reduction in peak power. The recorded annual savings was 880,000 kWh.

Sacramento Municipal Utility District (SMUD) conducted a showcase demonstration project of the Electrical Harmonizer in the County of Sacramento Administration Building. Voltage was reduced by 4%. SMUD concluded that the product works and that it saved energy, reduced harmonics, and increased power factor. They reported a savings of 552,000 kWh and 50 kW demand, which brought a $48,000 savings with a 2.54 year simple payback.

Suggestions for Further Research and Testing

The manufacturer's claim of 99.89% efficiency is very high. However, this product is similar to an autotransformer, which allows a very high efficiency when loads are high and input and output voltages are close. Nonetheless, efficiency would be a good item for verification in an independent lab. The manufacturer's claim of energy savings being typically in the range of 7-12% is very impressive. It seems that one would have to start from a rather severe consistent over-voltage and unbalance and have heavy resistance loads and under-loaded motors to reach that level from optimizing voltage and correcting unbalance. This would be harder to confirm with lab tests because it would be highly dependent upon the starting point of over-voltage, harmonics, unbalance, and the mix of loads, along with the reaction of controls like thermostats that can adjust operating time to compensate for reduced power throughput.

A challenge for lab testing would be to simulate the wide range of loads and load controls found in typical commercial and small industrial facilities. A good objective for lab testing would be to validate and quantify the mitigation of line side (input) triplen harmonics and voltage unbalance at various load levels and load current unbalance conditions. Lab testing could also assess the efficiency claims at various load levels.

Additional Reviewer Comments

The potential savings of this product are very situation-specific. The amount of voltage reduction tolerable to users is dependent upon the lowest level currently occurring at load terminals during the operating year. The amount of savings from any given voltage reduction is dependent upon the particular mix of loads. Energy savings achieved by voltage reduction vary from nearly zero for active front-end ballasts and fully-loaded large efficient motors to greater than the percent voltage reduction for certain resistance loads. Loads that do save energy when voltage is reduced generally provide less output; e.g., less heat or light. In the case of lighting, working spaces are often over-lit and the small lumen reduction of a few percent may not even be noticed by occupants.

However, there would be negligible (if any) energy savings from reducing voltage to temperature-controlled electric resistance heating. The lower voltage would reduce the temperature of the heating element. The temperature controls (thermostat) would then compensate for the reduced temperature by running the appliance longer.

The Electrical Harmonizer reduces the *throughput* of triplen harmonics. It does not reduce the level of triplen harmonics on the side of their origin.

To its credit, the manufacturer advocates and provides a thorough analysis of the electrical system and loads before recommending installation. The manufacturer will also determine what percent voltage regulation is optimal and whether it should be for the whole facility or just certain circuits.

The product currently available is not recommended for facilities experiencing varying voltage from the utility, if that voltage is sometimes optimal to below optimal. That is because the Electrical Harmonizer provides a fixed voltage reduction, not real-time voltage regulation. The manufacturer is currently researching methods for providing automatic voltage regulation including voltage boost as well as buck (reduction). This research is in an early stage of development and there is no timeline yet for bringing an automatic voltage regulation product to market.

Voltage conditions may change over time, particularly if there is load growth in the facility or even outside the facility on the utility feeder. When voltage is reduced to an "optimal" level for energy consumption, it is important to periodically check the voltage level to make sure the supply voltage has not been reduced to the point that some appliances are being supplied voltages below the recommended minimum.

The manufacturer claims, and SMUD observed in their demonstration, that the Electrical Harmonizer improves power factor. This is to be expected because motors operate with a lower reactive power (kVAR) at reduced voltage.

Conclusion

Electrical Harmonizer is a voltage reduction transformer. It can save energy by targeting voltage reduction, without lowering voltage on an entire feeder. The manufacturer claims that a proprietary winding configuration also blocks triplen voltage harmonics and improves phase voltage balance. This benefit has been confirmed by some case studies but it should be measured and quantified by lab testing.

Voltage is adjusted by manual tap changing. The product could be useful to utilities where they need to attenuate voltage to some customers or block triplen harmonics originating in a customer facility. It is not useful for intermittent (daily or seasonal) peak shaving because it is not dispatchable remotely. It should be avoided by facilities experiencing varying and low utility voltage because Electrical Harmonizer provides a set (rather than responsive) voltage reduction. Capacity is currently limited to about 720 kVA, but the manufacturer is developing larger models up to 2,400 kVA.

Additional Information

Northwest businesses and utilities can contact the *Energy*Ideas Clearinghouse for additional information on this or other energy technologies or products. Contact:

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The *Energy*Ideas Clearinghouse is a technical assistance service managed by the WSU Extension Energy Program with support from the Northwest Energy Efficiency Alliance.

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Note: Product & Technology Reviews are peer reviewed by objective industry professionals prior to publishing.

References

Information came from the manufacturer's website, *www.legendpower.com/featuresBenefits.asp* (June 2006), and direct communication with the manufacturer. Information was also obtained from Sacramento Municipal Utility District's website, *www.smud.org/education/cat/index.html* (June 2006), and direct communication with the utility regarding their case study.

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