Power Conditioning with the Powerhouse July 5, 2023

Summary

With today's focus on energy costs, renewables, green initiatives, and performance indicators, business owners are seeking new and improved methods to reach their sustainability. Power conditioning inside a facility can lead to large improvements in equipment and operations. Preventing shutdowns, failures, and wear increases the operational resilience of a facility, improving costs. To find out what it is and how the Powerhouse can save 8-15% in electricity costs, read this short guide introducing a powerful tool for your next sustainability project.

Details

Problem - Solution Statement

Clean, stable power is critical to operations and equipment. Although power conditioning equipment exists in the form of surge suppressors and VFDs, these are pin-point solutions for equipment. How do owners provide efficient power transfer and prevent equipment failures across facilities? Install Powerhouse units at the switchgear to protect downstream equipment from power upsets and phase imbalances.

Technical Background

What is a Metal Oxide Varistor or MOV - Varistors have been used for many years in many applications. One such application was in older TV sets where the Varistor acted as a protective device for TV tube power supplies. With their unique ability to change resistance with a change in potential, they can short circuits to ground. Based on the MOV being used, the resistance will go from high to low or even zero as the voltage across the MOV increases.

> "*The word "Varistor" is a combination of the words VARI-able resi-STOR used to describe their mode of operation way back in their early days of development which is a little misleading since a varistor can not be manually varied like a potentiometer or rheostat.*
>
> *But unlike a variable resistor whose resistance value can be manually varied between its minimum and maximum values, the varistor changes its resistance value automatically with the change in voltage across it making it a voltage-dependant, non-linear resistor or VDR for short.*
>
> *Nowadays the resistive body of a varistor is made from semiconductor material making it a type of semiconductor resistor with a non-ohmic symmetrical voltage and current characteristics suitable for both AC and DC voltage applications.*"[1]

[1] ElectronicsTutorials, Varistor Tutorial

Power Factor (pF) - pF is defined by IEC and IEEE as the ratio of true power to apparent power. Phase and Wave-Form shape contribute to the difference between true power (Watts) and apparent power (kVA).

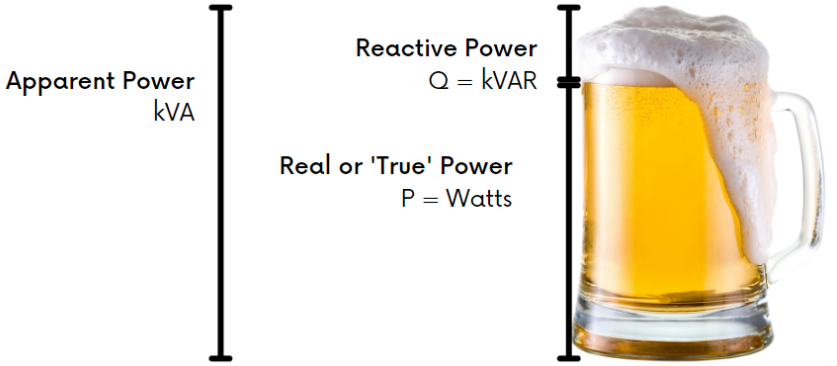

Figure 1 - Only Real or ‘True’ power can be used in any system

Voltage imbalance in a 3-phase component such as a motor causes increased amp usage and heat and can degrade the unit faster over time. In fact, the National Electrical Manufacturers Association (NEMA) states that imbalance is 100 times greater than volt-to-volt differences between phases. Such a 3-phase system with voltages of 462, 463, and 455, respectively, will have an imbalance of 1.1%.

$$\text{Imbalance\%} = (\text{AVG} - \text{Lowest}) / \text{AVG} * 100 \qquad \text{(equation 1)}$$

Motor Load % Full	Motor Efficiency, %		
	Voltage Unbalance		
	Nominal	1%	2.5%
100	94.4	94.4	93.0
75	95.2	95.1	93.9
50	96.1	95.5	94.1

Figure 2 - Example Motor Efficiency[2]

[2] DOE ADVANCED MANUFACTURING OFFICE, Energy Tips: MOTOR SYSTEMS Tip Sheet #7, DOE/GO-102012-3733 • August 2012

NEMA states clearly that voltage imbalance should remain below 1% for all systems as the efficiency of motors is highly affected. Figure 2 above clearly shows how imbalance voltages affect motor performance. In fact, in one field test, the data collected showed a dramatic effect on the 3-phase power. In Figure 3 below, as the line to neutral volts improved, the 3-phase power used shrunk by over 14%.

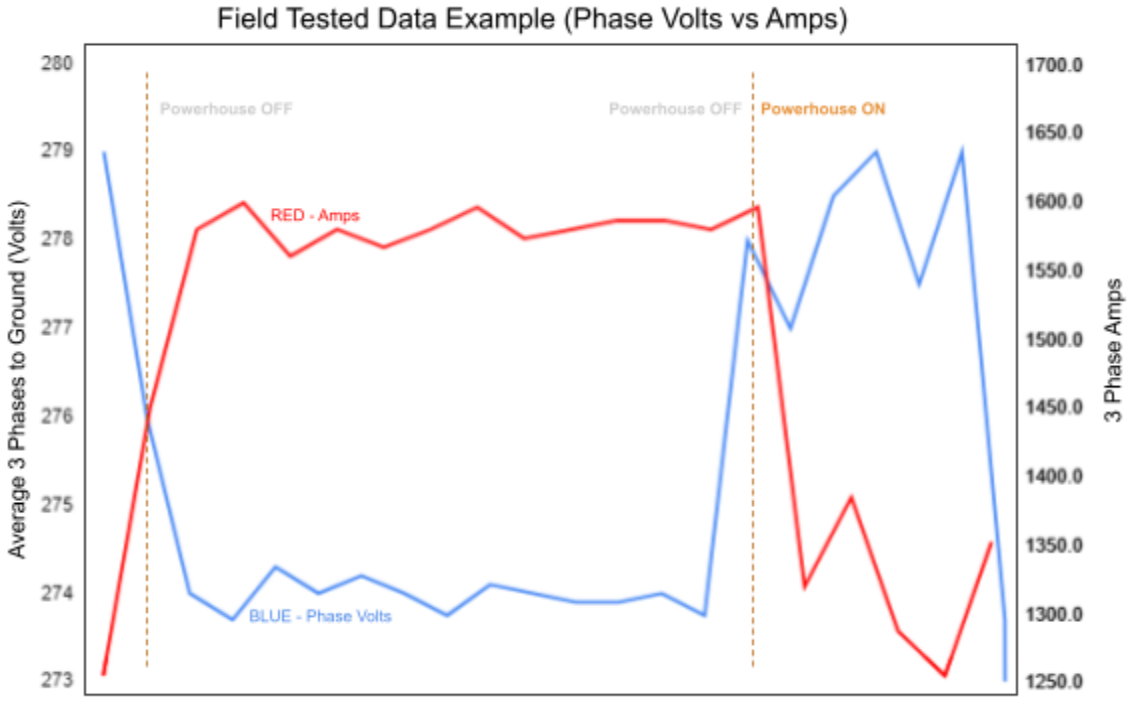

Figure 3 - Data from field test results of the Powerhouse Power Conditioning Equipment

<u>The economics of efficient power transfer</u>

For example, let us use the 100-hp motor as shown in Table 1, operating for 8,000 hours per year (hrs/yr), 100% loaded with an unbalanced voltage of 2.5%. Using a cost of energy of $0.08/kilowatt-hour ($kWh), we can compute the energy losses and potential savings using the following three equations[3] :

Loss of Efficiency (LOE) = (100% / Nominal-Eff%) - (100% / 2.5-Eff %)	(equation 2)
Annual kWh Savings = HP x .746kW/HP x hrs/yr x LOE	(equation 3)
Annual Cost Savings = Annual kWh Savings x $kWh	(equation 4)

[3] DOE ADVANCED MANUFACTURING OFFICE, Energy Tips: MOTOR SYSTEMS Tip Sheet #7, DOE/GO-102012-3733 • August 2012

Therefore:

LOE = 0.025 = (100/93) - (100/94)	(equation 5)
kWh Savings = 14,920kWh = 100hp x .746kW/hp x 8,000hrs/yr x 0.025	(equation 6)
Cost Savings = $1,193 = 14,920kWh x $0.08kWh	(equation 7)

Not only is the potential for energy transfer savings, but the heat reduction also provides improved OPEX and equipment wear. In fact, the heat difference between the same 100 hp operating at 2.5% unbalanced load is 6-10 times larger than the 1.1%. Therefore, the heat gain can be 15% to 27.5% higher for unbalanced loads increasing insulation damage and wear on the motors. Also, this additional heat adds to the environment that might need to be mitigated, in some cases, raising HVAC costs.

Utility Supply

Power, as supplied by the utilities, can be fraught with issues even before the consumer can utilize it. These can include blackouts, brownouts, line harmonics due to electromagnetic pulses (EMPs), and issues due to sudden spikes in up-line or downline use. Inside the facilities, power surges, spikes, and sags create undue disruption and wear on any motors, chillers, lights, and electrical devices (computers, TVs, outlets, UPS equipment, digital displays, rectifiers, relays, breakers, switches, monitors, etc.).

Temporary disruptions (brownouts) or more long-term outages (blackouts) don't necessarily cause problems or damage when the system is down or off but most likely create a spike and sags when suddenly energized or turned on. This alone is one of the greatest causes of equipment failure.

Harmonics occur when voltage and current are not in phase with one another or with their respective sine waves. Measured as total harmonic distortion (THD), harmonics are merely a byproduct of a nonlinear load. Examples of nonlinear loads are battery chargers, adaptors, fluorescent lamps (because of the choke coil), LEDs, electronic ballasts, variable frequency drives (VFDs), rectifiers, uninterruptible power supply (UPS), switching mode power supplies (SMPS), photocopiers, personal computers, laser printers, and fax machines.

However, linear loads have both voltage and current following one another and without distortion to their pure sine waves. Examples of linear loads are resistive heaters, incandescent lamps, constant speed induction, and synchronous motors.

Introducing the Powerhouse

Mounted at switch gear, Powerhouse units operate 24/7/365, leveraging MOVs and capacitors to correct voltage differences between phases. In fact, because of the design, these units offer surge protection and incident mitigation as well.

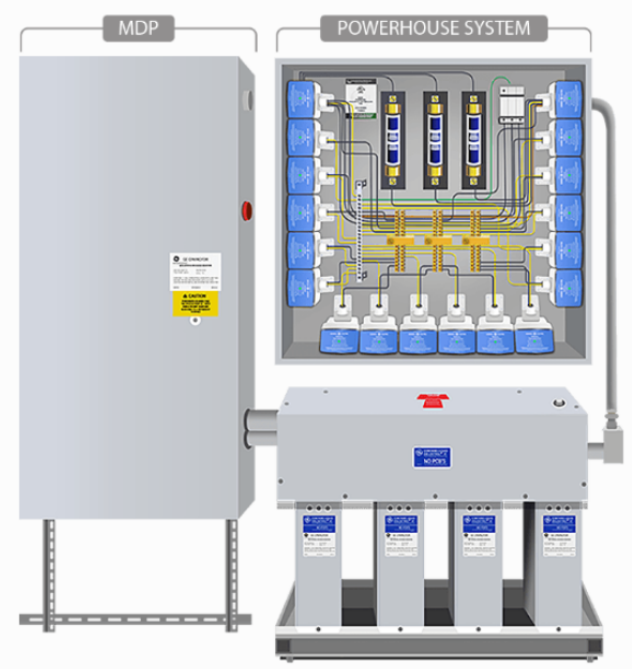

Figure 4 - The Powerhouse

Improving the quality of the power supply allows for improved operations and reduced incidents like overheating, false trips, and even lower harmonics.

FEATURES

- The Powerhouse control system monitors and provides real-time correction to incoming electricity on all three phases by raising and balancing voltage between phases.
- The Powerhouse prevents surges and spikes through 18 MOVs, 6 per phase, rated at 100kA each. The Powerhouse control system spreads surges & spikes equally across all MOVs for maximum efficiency. A 50,000-volt surge protector is a secondary shield of protection against surges & spikes.

- When the Powerhouse control system detects a blip or sag, it instantaneously releases stored energy from the GE Conditioning Capacitors to maintain consistent, balanced power in your Facility.
- The Powerhouse uses GE Conditioning Capacitors, a proprietary Dielektrol® family of capacitors. These proven non-PCB biodegradable capacitor fluids are specially blended to provide optimum performance. They are self-healing and have a life expectancy of 25 years.
- The Powerhouse protects all sub-panels and electrical equipment attached to the Main Distribution Panel.

With over 1,500 units installed and more being installed daily, the Powerhouse is proving itself in a wide variety of settings: restaurants, healthcare, hotels, convention centers, mines, lumber mills, manufacturing/industrial processing plants, grocery stores, K-12 and higher education school systems. The Powerhouse is truly a "*one solution fits all*" for all power conditions.

Conclusion

Conditioned power can greatly affect the operations and costs of energy in your facility. Balanced voltages raise motor efficiencies, lowering heat losses and costs by 7 to 15% while providing protections for sags, dips, and surges. The added protection alone has paid for this unit many times already for clients.

Is your organization at risk in this fiercely competitive world with an uncertain grid energy supply? As the sustainability manager for your facility, would you welcome a low-risk, low-CAPEX solution to help meet your goals? Find out why organizations and utilities are leveraging this technology to lower their energy costs and raise the quality of the energy supply to their clients and facilities, raising their systems' reliability and resilience.

If you want to know more about the Powerhouse and how it can help your facility and organization, please schedule a short conversation with us.

About Feldhake Consulting LLC

Feldhake Consulting LLC is Missouri based company that offers products and services to improve energy efficiencies. This includes Hybrid energy systems, integration, and web services that help monitor and maintain the energy system enhancing its reliability and resilience.

Michael Feldhake, Founder, is an engineering professional with over 30 years' experience specializing in manufacturing, engineering, and software development for Fortune 500 companies.

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