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Is Your Factory Power Source Corrupting Your Product Testing?

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Synopsis:
This paper describes the use of AC power supplies for product testing. It will also discuss the use of regulated electronic AC power supplies to perform the various tests. General test examples are discussed as well as the parameters that are important to selecting an AC supply to perform them. Application examples are provided.

When it comes to designing and testing electrical and electronic equipment, having a consistently stable source of AC power is essential. While the AC power in your engineering laboratory or manufacturing facility may be reliable in terms of availability, it may not be sufficiently predicable for accurate, repeatable testing. In addition, not being able to control the voltage and frequency may also limit its use. A regulated electronic AC supply can solve power quality issues as well as provide additional testing flexibility.

Occasional power quality issues can disrupt your operations. AC mains fluctuations in a typical production facility are a result of heavy loads that vary during a typical day. In addition to voltage fluctuations and distortion there is also the possibility of high voltage, high frequency transients caused by nearby load switching, lightening, and electro-magnetic interference from faulty or improperly installed devices connected to the same line. Even under normal conditions variations of +/- 5% at the point of service are within typical power utility specifications. The actual facility distribution system wiring will also affect the voltage delivered to any individual outlet. Three phase systems may also suffer from phase imbalance due to poorly distributed single phase loads. Any voltage fluctuations at the point of testing become more apparent as the power level of the product being tested increases. Electronic supplies like the Behlman P1350 series can reduce voltage variations to below 1% over specified line and load conditions.

Deviations in voltage and harmonic distortion can have a large impact on test results. When making efficiency measurements, variations in the applied voltage over time will impact results. Power factor and in-rush current measurements will be affected by line impedance. In a typical factory this impedance varies over time and with location within the facility (distance to service entrance). Varying line impedance can also be a problem when performing certain commercial product tests where the impedance must be known or measured. Use of a regulated AC supply can allow for a standardization of tests results.

Product Design and Development

Product development often requires testing at operating limits or beyond. The inability to accurately measure incremental differences in design changes or to verify stated product specifications can result in a number of problems for manufacturers. In addition to potentially costly additional engineering and product delays, there could be reliability and safety ramifications. Ultimately, customer satisfaction may be compromised.

The electronic AC power supply can be a useful tool for evaluation of products and sub-assemblies used in a final product. The ability to verify the performance of items like transformers, fans, relays, actuators, and other ac operated components prior to use in the final product will allow designers to weed out problem components before they reach the customer. The ability to vary the applied AC can also allow designers to conduct “what if” scenarios to push or improve existing designs. The inclusions of meters to monitor voltage, current, power, and frequency further enhance their usefulness. Just like a DC bench supply, a bench top AC power supply can be a valuable asset to any engineering or test department.

Behlman Model P1351, 1.2kVA Single-Phase Bench Top AC Power Supply

Production Test

Many commercial safety test standards require the application of operating voltages and frequencies above or below normal limits. Although voltage adjustment can be accomplished with tapped transformers and variable auto-transformers, they still suffer from poor voltage regulation with load and line changes. This makes adjusting the test voltage like trying to shoot a moving target. In addition, the cost of quality adjustable auto-transformers (also known as “Variacs”) has increased dramatically in recent years. Another disadvantage of this method is that it cannot vary the AC line frequency. For products intended for international sales, a frequency range of 47 -63 Hertz is often specified in IEC (International Electro-technical Commission) test specifications. For the aviation industry frequencies in the range of 360 - 880 Hz are common.

Electronic AC supplies are well suited for production line testing in both large and small manufacturing facilities. They can be used to provide bulk regulated AC to test stands and fixtures. Automated control features like computer or analog control via PLCs are available to suit most needs. Control via RS-232, IEEE-488, USB and Ethernet interfaces are common. Single phase systems in the range of 500VA to 40KVA and 3 phase systems in the 1kVA to 120KVA are available from various suppliers. They range from reference quality instruments to modified UPSs.

Selecting the Proper AC Power Supply for Testing Needs.

Once the decision is made to purchase an AC power supply there are certain considerations that must be evaluated. Obvious things like output voltage, current, and frequency range are determined by user needs and/or third party test specifications.
Although these parameters are an important first step, other issues related to the type of product being tested must be considered. Surge currents and possible non-linear currents associated with the tested products must be accounted for. Products that incorporate pumps, compressors or other motor driven loads present issues that can cause test failures due to the high starting currents required. Products with non-linear input currents can cause distortion of the AC output.

Other considerations must be made based on the type of test being performed. A simple functional test requires less consideration than qualifying a product for efficiency or making power factor measurements. Certain IEC test specifications actually describe and require verification of the short circuit current available from the AC power source. This is an attempt to provide some sort of standardization so that test results can be compared. One example would be quantifying product in-rush current or motor locked rotor current. If the AC supply used does not have sufficient transient capability the test can be invalid. A high source impedance during testing can mask the true in-rush current experienced when the product is used in its intended application. The implication here is that certain tests are better served by over sizing the AC supply to provide a low source impedance. Consultation with the AC source manufacturers engineering staff can help with sizing the power source for a particular test.

Special Considerations for Testing Motors or Products with Motors.

AC induction motors with capacitive starting are the most common type encountered in modern single phase products. These motors are inexpensive, reliable, and create the least amount of EMI as they do not use brushes. Three phase induction motors do not even require capacitors for starting. Motors in general present difficulties for all types of AC sources due to what is referred to as the “Locked Rotor Current” or LRA. The amount of current dawn by an AC induction motor is dependent on rotor speed. The applied voltage creates a rotating magnetic field. This causes the rotor to move due to magnetic repulsion. When the rotor and magnetic field are close in speed, the current is at minimum. The problem is the current required to get the rotor moving. The AC supply must overcome the friction and load presented to the rotor which drives the output shaft. This current is the locked rotor current. If the rotor were held from rotating with voltage applied, the current will be at and stay at maximum.

The time period the LRA current must be applied depends on the motor construction and the mechanical load at start-up. Air conditioning compressors and liquid pumps are some worst case examples of where the start current duration can be several cycles of the AC waveform to several seconds. Motor manufacturers normally rate their product to either IEC or NEMA (National Electrical Manufacturers Association) standards. IEC standards provide values for typical start currents for different size induction motors. NEMA tables provide this information in the form of voltage amperes during start up. This information, along with the type of test to be done, should be known before selecting the AC power source.

Behlman AC supplies can be used to successfully test motors without over specifying their power rating. For a typical functional or burn in test the supply need only be rated for the continuous “run” current. Several methods could be used for motor starting that would reduce the overall continuous power requirement. Behlman also provides models with a motor test option (MT). These units feature oversized output devices that allow much higher transient currents than a standard model while maintaining the size and pricing of a unit rated to only supply the run current. All Behlman AC power supplies also provide a constant current mode. This mode will automatically reduce the output voltage to limit current while maintaining a sinusoidal current waveform. This action will allow the motor to soft start. The following paragraphs are examples of motor starting methods.

Soft Start (fixed).

This method is in common use for starting induction AC motors. A reduced voltage is applied to get the rotor spinning. Once the rotor is up to speed, the voltage is allowed to reach the rated running value. This method works well for both single phase and 3 phase motors that do not have a substantial mechanical load at start up (low starting torque). Commercial motor starter are available and can be as simple as a fixed resistor in series with the motor winding that is switched out once the motor has started. Other more sophisticated versions allow for adjustable starting voltages as well as adjustable timing. Timing and voltage levels are determined from motor specifications or empirical testing. The constant current mode provided by Behlman power supplies creates this condition automatically. This can also make testing safer as the motor housing will not tend to move when started. Behlman has provided this solution to a manufacturer of vacuum cleaner motors. Their existing test stands started the motor from the line. Due to high torque during starting, the motor had to be clamped to the test stand so it would not leap or roll off during the test. The constant current mode of the Behlman model BL1350 allowed functional testing without restraining the motor. This allowed for a decrease in test set-up time and nuisance fuse tripping in the test stand. Although the start current exceeded 20 Arms when connected to the line, the 10A rated power supply was able to soft start the motor and bring it to its nominal run current of about 5 amps.

Soft Start (Ramp up)

For this method the test voltage is applied by connecting the motor to the supply and then causing the voltage to ramp up to the run value. This works well for applications requiring a bit more control of starting torque. This method has been incorporated into modified versions of Behlman AC supplies to allow compressors and pumps to start from smaller units than would be required by random application of the test voltage. For really tough products like high pressure pumps, the voltage and frequency can both be ramped. This is similar to what is done in VFD (Variable Frequency Drives) circuits. This method allows for controlled torque and acceleration. To perform this type of test, a supply with either analog remote control or computer remote control would be useful. Both types are available from Behlman and other vendors.

Brute Force Method

Some products are designed with control circuits that do not respond well to reduced operating voltages. In addition, some motor tests do not allow for limited current or voltage during starting. One example might be a test that attempts to quantify the typical start current for a given product. In these cases, the AC power supply must have sufficient transient power capacity to get the load started. The Behlman motor test option (MT) provides this solution. These models are designed to allow a very high short term output currents for periods typically on the order of 500mSec. This is accomplished by over sizing the output amplifier devices (IGBTs in these models) and tailoring the current limit response to allow a particular starting transient. In some cases the AC supplies have been tailored to a particular motor or product. Again, consultation with the AC power supply manufacturer is a good place to begin. The figures below illustrate some of the starting conditions previously discussed.

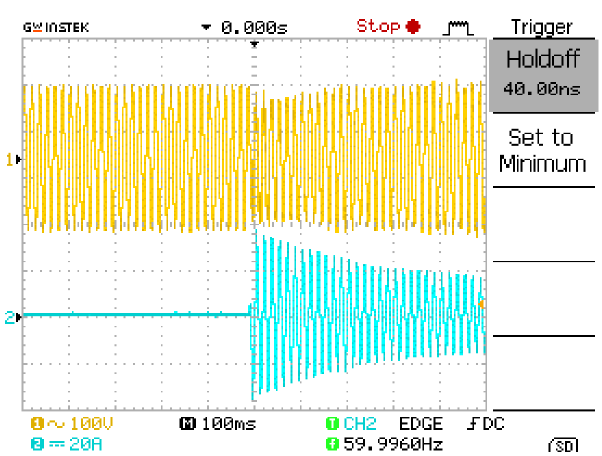

Figure 1 : Small shop vac started with Model P1350. This illustrates the brute force approach. Note that the maximum RMS current value exceeds the unit's 10 amp rating. (top trace = 100V/div) (bottom trace = 20A/div)

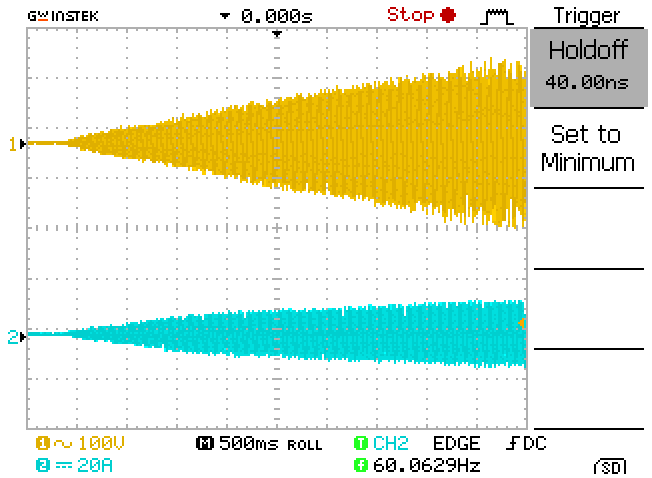

Figure 2 : Small shop vac soft started with the same model P1350. The voltage was set to zero than adjusted to 115V
using the front panel control.

Summary

Using and an electronic AC supply for product testing can provide accurate and repeatable test results. Models that provide variable frequency and voltage can also be an asset for use with product development. Specifying the correct supply for a given test is important to avoid possible costly delays and the purchase of a supply that is either too small or complete overkill. The test engineer should have a clear understanding of the product being tested and actual test requirements. Once the requirements are understood a discussion with the AC supply manufacturer should be able to pin point the correct model.

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