

BETTER TESTING WITH WELL-CONTROLLED AC POWER

Modern ac power supplies are adept at cleaning up line conditions that can lead to garbled electrical test results.

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If you plug your product's power cord into any unregulated standard factory ac main, there is a possibility that the power you are using could corrupt any testing you do. The quality of ac power can degrade the performance of equipment being tested. Corrupted ac power can make equipment appear to be on-spec when it is off-spec, or off-spec when it is on-spec. Either way, bad test results can be costly. They can bring unnecessary engineering time spent fixing non-problems, or worse, result in costly fixes of faulty units in the field, with a simultaneous loss of customer confidence.

Simply put, plugging sensitive instruments to be tested into your factory ac mains is a gamble not worth the risk.

Commercially generated electricity is distributed at high voltages over long distances by power utilities. At local substations, that electricity is stepped down onto lower-voltage power lines. (Note that some large power users such as iron smelting facilities may have what amounts to their own substation inside the walls of the plant.) Power from the substation routes to distribution transformers at each residence and commercial

One example of an ac supply and frequency converter is the Behlman Model P1351, a 1.2-kVA single-phase bench-top (or rack-mount) instrument that delivers clean regulated ac power in a (2U) 3.5-in.-high and (3U) 5.25-in.-high form factor. The P Series can simulate power from any utility as well as aircraft and shipboard power.

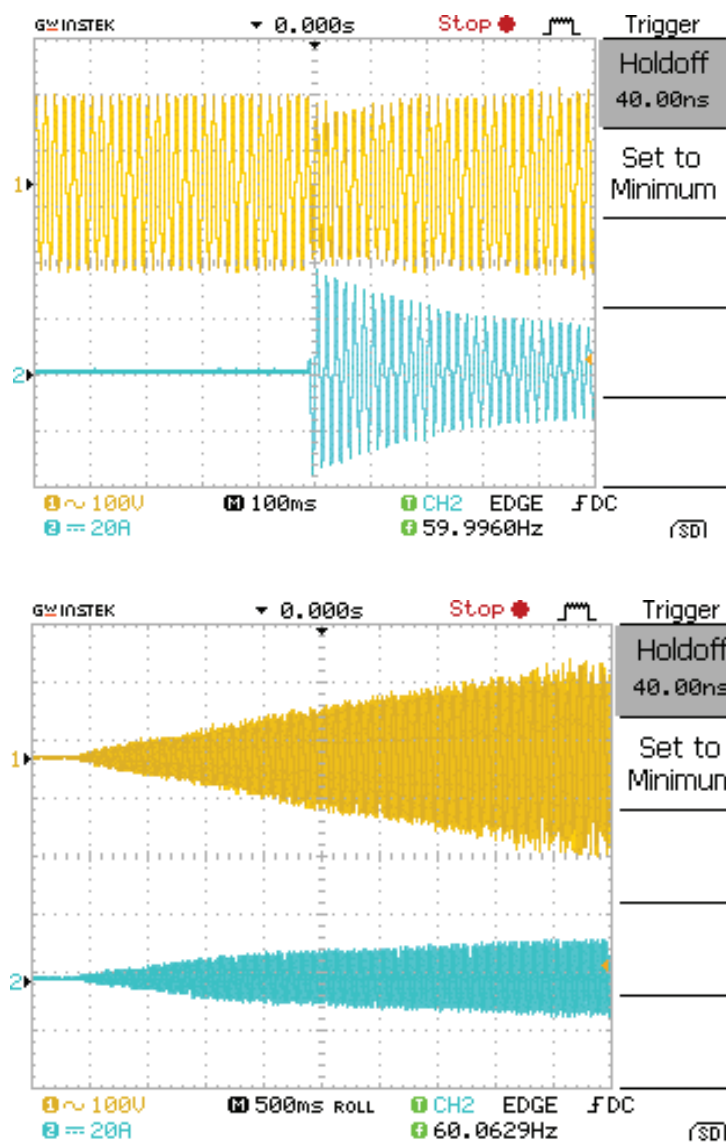
building. These transformers step the voltage down to 120 Vac. But outside factors can cause sags or spikes in the electricity available from the ac socket. For example, consider the effects of a brownout, a drop in voltage on an electrical power distribution system. Brownouts can last for seconds, minutes or hours. There are also short-term voltage sags (dips). Even under normal conditions, variations of $\pm 5\%$ at the point of service are within typical power utility specifications.

A problem faced by equipment manufacturers and testing facilities is that they can never be 100% certain that the voltage from their ac mains is at exactly the right level. In fact, their ac mains power may not be sufficiently predictable for accurate, repeatable testing. In addition, their inability to control the voltage and frequency may also cause other problems.

Fortunately, a regulated electronic ac supply can solve power quality issues as well as provide additional testing flexibility.

Even occasional, self-inflicted power quality issues can disrupt operations. A typical production facility may experience voltage fluctuations caused by heavy loads switching on during a typical day. In addition to voltage fluctuations and distortion, there is also the possibility of high-voltage, high-frequency transients from nearby load switching, lightning, and electromagnetic interference from faulty or improperly installed devices connected to the same line.

The layout of the facility distribution system wiring will also affect the voltage delivered to any individual outlet. Three-phase systems may additionally suffer from phase imbalance caused by 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 rises. For these reasons, testing facilities may use electronic supplies like the Behlman P1351 series which can reduce voltage variations to below 1% over specified line and load conditions.



TOP: Small shop vacuum started with a Behlman Model P1350 power supply. This illustrates the use of a supply able to provide a temporary high output for starting. Note the maximum RMS current value exceeds the unit's 10-A rating. (Top trace = 100 V/div; bottom trace = 20 A/div)

BOTTOM: Small shop vacuum soft-started with a Behlman model P1350 power supply. The voltage was set to zero, and then adjusted to 115 V using the front panel control.

Harmonic distortion and deviations in voltage can have a large negative impact on test results. During efficiency measurements, for example, variations in the applied voltage over time can degrade 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 standardization of tests results.

Product design and development

Product development often requires testing beyond operating limits. The inability to accurately measure incremental differences in design changes or verify product

specifications can cause problems for manufacturers. In addition to adding engineering costs and delaying products, inaccurate measurements could bring reliability and safety ramifications. Ultimately, customer satisfaction suffers.

Electronic ac power supplies can help evaluate components and sub-assemblies. They can also help verify the performance of items like transformers, fans, relays, actuators, and other ac-operated components. These power supplies can additionally play a role in what-if scenarios for design changes. Many include meters to monitor voltage, current, power, and frequency. Just like a dc bench supply, a bench-top or rack-mounted ac power supply can be an asset to any engineering or test department.

Many commercial safety test standards require the application of operating voltages and frequencies above or below normal limits. It's possible to adjust voltages using

BEHLMAN P SERIES AC POWER SUPPLIES / FREQUENCY CONVERTERS

MODEL	POWER (VA)	OUTPUT VOLTS VAC (RMS)	OUTPUT (AMPS)	OUTPUT FREQUENCY (HZ)	INPUT VOLTS 10 VAC	DIMENSIONS (19-IN. RACK MOUNT)	STANDARD FEATURES
P1350	1,350	0-135, 0-270	10, 5	Fixed at 50, 60 and 400	120	3.5 in. H x 17.5 in. D	Three fixed frequencies and variable voltage
P1351	1,350	0-135, 0-270	10, 5	45-500	120	3.5 in. H x 17.5 in. D	Variable voltage and frequency
P1352*	1,350	0-135, 0-270	10, 5	45-500	120	3.5 in. H x 17.5 in. D	Programmable voltage and frequency, plus RS-232
P2001	2,000	0-135, 0-270	45-500	45-500	120	5.25 in. H x 17.5 in. D	Variable voltage and frequency
P2002*	2,000	0-135, 0-270	15, 7.5	45-500	120	5.25 in. H x 17.5 in. D	Programmable voltage and frequency, plus RS-232
PF1350	1,350	0-135, 0-270	10, 5	Fixed at 50	95-270	3.5 in. H x 21 in. D	Three fixed frequencies and variable voltage with CE mark
PF1351	1, 350	0-135, 0-270	10, 5	45-500	95-270	3.5 in. H x 21 in. D	Variable voltage and frequency with CE mark
PF1352*	1,350	0-135, 0-270	10, 5	45-500	95-270	3.5 in. H x 21 in. D	Variable voltage and frequency with CE mark, plus RS-232

*P1352, P2002, and PF1352 also offer Option U, which includes USB, Ethernet, and RS-232 Interface using SCPI protocol. (This option enables faster communication speed, power supply programming from greater distances, and compatibility with newer computer systems.) Optional IEEE-488 is also available on the Behlman P1351, P1352, P2002, PF1351, and PF1352.

Examples of ac power supplies sporting variable frequencies and output parameters optimized for specialized testing as often arises in motors.



Three-phase ac power supply models from 1 – 20 kVA.

simple tapped transformers and variable auto-transformers. The problem is such components suffer from poor voltage regulation with load and line changes. This makes the adjustment of the test voltage like trying to shoot a moving target.

In addition, the cost of high-quality adjustable auto-transformers, also known as Variacs, has risen dramatically in recent years. (Instrument Service Equipment now owns the Variac trademark but the word has become generic for hand-variable autotransformers.) Another disadvantage of autotransformers is that they cannot vary the ac line frequency. Products intended for international sales generally must operate over a frequency range of 47 to 63 Hz per IEC (International Electrotechnical Commission) test specifications. For the aviation industry, frequencies in the range of 360 to 880 Hz are common.

Electronic ac supplies are well suited for production line testing. 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 500 VA to 40 kVA and three-phase systems in the 1 kVA to 120 kVA range are available from various suppliers. These supplies range from reference quality instruments to modified UPS units.

Selecting the right ac supply

When it comes to purchasing an ac power supply, obvious factors like output voltage, current, and frequency range are determined by user needs and/or third-party test specifications. Additional considerations include surge currents and possible non-linear currents associated with the tested products. Products that incorporate pumps, compressors or other motor-driven loads can have high starting currents. These currents can present issues that can cause test failures. Products with non-linear input currents can also distort the ac output.

Other considerations involve the type of test performed. Simple functional tests generally need simpler supplies than tests aimed at qualifying a product for efficiency or making power factor measurements. For example, certain IEC test specifications spell out how to verify the short circuit current available from the ac power source. The specification attempts to provide some sort of standardization so test results can be compared. One such test would be the quantification of 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 serves in its intended application.

The implication here is that certain tests are better served by over-sizing the supply to provide a low source impedance. Consultation with the manufacturers' engineering staff can help with sizing the power source for a particular test.

Tests of ac motors can pose special challenges for ac supplies. The most common type of single-phase ac motor is the induction motor with capacitive starting. Induction motors that operate from three-phase power need no capacitors for starting. Here locked rotor current (or LRA for locked rotor amps) is the worst-case current the induction motor draws. LRA is generally measured with the rotor anchored so it can't spin. As the motor starts turning, the rotor current drops and continues dropping until the rotor hits full or rated speed. At this point the current is at minimum. Rated speed is slightly less than the speed of the rotating magnetic field and depends on how much torque the motor must produce to turn the load.

The duration of the LRA current depends on the motor construction and the mechanical load at start-up. Air conditioning compressors and liquid pumps are some worst-case examples of start-current duration. Their LRA can range from 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 depending on induction motor size. NEMA tables provide this information in the form of volt-amps during startup. This information, along with the type of test to be conducted, should be known before selecting the ac power source.

It is common practice to specify ac supplies around LRA demands. But for a typical functional or burn-in test, the power supply need only be rated for the continuous current. And several methods could be used for motor starting that would reduce the overall continuous power requirement.

Some power supplies offer a motor-test option. 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. Some 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.

Soft starting is often used for induction motors. A soft starter initially applies a reduced voltage to get the rotor spinning. Once the rotor is up to speed, applied voltage is allowed to reach the rated running value. This method works well for both single- and three-phase motors that do not have a substantial mechanical load at startup (low starting torque).

Commercial motor starters can be as simple as a fixed resistor in series with the motor winding that is switched out once the motor has started. 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 that some power supplies provide creates soft starting automatically. Soft starting can also make testing safer as the motor housing will not tend to move when the motor starts. In one case, a manufacturer of vacuum cleaner motors experienced this problem: Its test stands started motors directly from the ac line. High torque during starting could make a motor leap or roll off the test stand. The addition of a power supply having a constant-current mode eliminated the need for restraining the motor.



Three-phase ac power supply models from 1 – 20 kVA.



Three-phase ac power supply models from 1 – 20 kVA.

This change reduced the test set-up time as well as nuisance fuse tripping in the test stand. The start current exceeded 20 A when connected directly to the ac line. But the 10-A-rated power supply soft-started the motor and brought the nominal run current to about 5 A.

There is a type of soft start called ramp-up soft start. Here, the test voltage is applied by connecting the motor to a supply that ramps the voltage up to the run value. This technique works well for applications requiring a bit more control of starting torque. Power supplies can be modified to apply ramp-up voltage for starting compressors and pumps using smaller power supplies than would be necessary otherwise. For really tough products like high-pressure pumps, the voltage and frequency can both be ramped. This method resembles what takes place in VFD (variable frequency drive) circuits and allows for controlled torque and acceleration. To perform this type of test, a power supply with either analog remote control or computer remote control would be useful.

However, 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. This might be the case, for example, in a test that attempts to quantify a product's maximum start current. In these cases, the ac power supply must have enough transient power capacity to get the load started.

Power supplies having a Motor Test option provide this kind of temporary high output. These models are designed to allow high short-term output currents for periods typically on the order of 500 msec. Supplies with a motor-test option have over-sized output amplifiers (using IGBTs in these models) and tailor the current-limit response to allow a particular starting transient. In some cases, the ac supplies are tailored to a particular motor or product. Again, consultation with the ac power supply manufacturer is a good place to begin.

Once the requirements are understood, a discussion with a power supply manufacturer should be able to pinpoint the correct model to achieve consistent, reliable results. ▬▬▬

REFERENCES

BEHLMAN ELECTRONICS, INC.,
www.behlman.com