WHITE PAPER

Save Energy in Your High-Power Test Applications

Technology advancements save money and keep the planet green

KEYSIGHT

Regenerative Power

Before trying to understand the term regenerative, let's review the definition of a two-quadrant power supply. While applying a positive voltage, a two-quadrant power supply can source and sink current. A single-quadrant power supply design only supplies current. The difference becomes apparent when down-programming. Down-programming occurs when setting a power supply's outputs to a lower voltage. A single-quadrant supply uses an internal resistor to load the output capacitor, converting the stored energy to heat. The internal resistor can handle the temporary power dissipation of the output capacitor. Connecting a single-quadrant power supply directly to a battery or large capacitor can damage the power supply because current from the external power source can damage the down-programming resistor.

A typical two-quadrant power supply combines a single-quadrant power supply with a power dissipator. A power dissipator can handle continuous power while down-programming. A dissipater uses an active control circuit, multiple resistors, and an exhaust fan to convert continuous power to heat. A two-quadrant power supply is ideal for charging and discharging large capacitors and batteries.

In an effort to make the earth a greener place for the next generation while lowering costs, technology companies are creating innovative eco-friendly products. A comprehensive approach to testing can bring additional savings through a reduction of waste energy. High-power test applications can use a power supply system that produces efficient and clean power and recycles waste energy. A regenerative power supply can achieve these goals while simplifying the test setup.

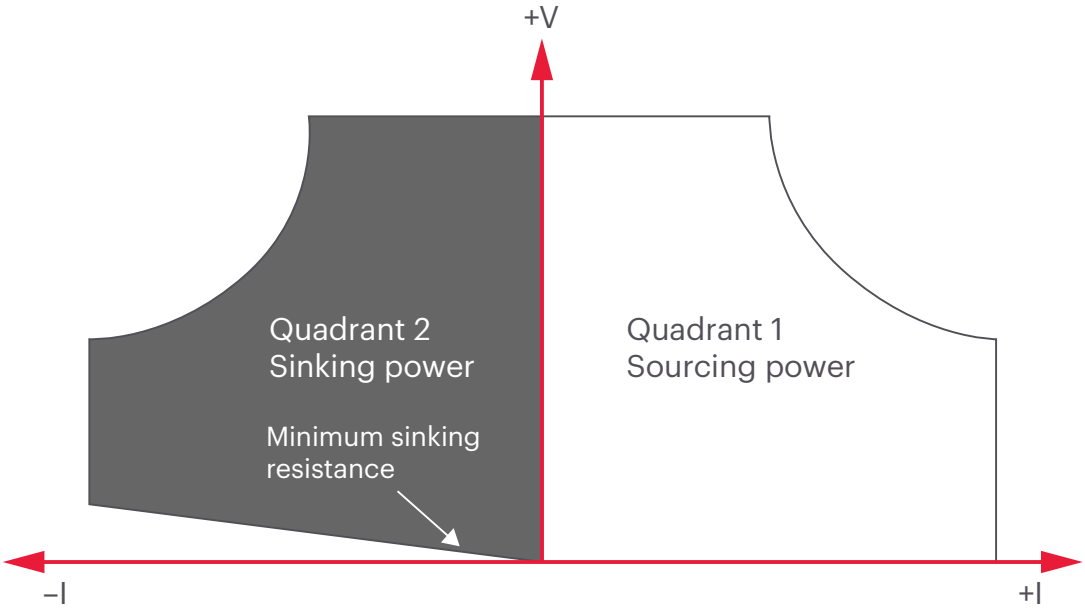

Figure 1. Power supply quadrants one and two

When operating in the second quadrant, a regenerative power supply directs power back to the AC mains through the power cord. Instead of converting the discharged energy into heat through a power dissipator, it feeds energy back to the grid. Disabling the regenerative operation is impossible; the regenerative process is automatic and requires no programming by the user.

A regenerative power supply has to return power safely and cleanly to the grid. Keysight's RP7900 Series can maintain a power factor of 0.99, with sinewave current distortion less than 2% at full load. During a power failure, the AC control circuit senses the dropout, and galvanic relays automatically disconnect the AC mains. The unit shuts down since the energy does not have anywhere to disperse. When the AC mains returns to normal, the unit automatically restarts. Compliance with regulations for the operation and connection to the public grid of energy back-feeding equipment is critical. Grid fault detection and disconnect is an example of a safety requirement.

The Need for Regenerative Power

Using a power dissipator is an economical solution for sinking a couple hundred watts. Battery power density has increased to a point where batteries can replace gas engines. Testing larger batteries and their electronics requires larger dissipators that occupy more space and produce additional heat. Electrification of warehouses, industrial equipment, and transportation requires high-capacity batteries. Power requirements have soared from a few hundred watts to thousands and even tens of thousands of watts. Designers want to increase the runtime between charges using higher-efficiency designs or by harvesting kinetic energy with bidirectional converters. A regenerative power supply simplifies testing as the same hardware can supply and load power electronics. Constantly monitoring energy efficiency allows for design improvements. A regenerative power supply will do its part to return energy commonly wasted during testing back to the grid.

Seamless Source and Sink

A seamless source and sink transition is critical for a regenerative power supply system to work without interruption. A suitable power supply should continuously sink up to 100% of its measured current for an indefinite time. Figure 2 shows the two-quadrant, bidirectional sourcing and sinking capability of the RP7900 Series regenerative power supply. It allows for seamless, uninterrupted transitions between sourcing and sinking current without changing the power supply's output characteristics or introducing any disruptive behavior.

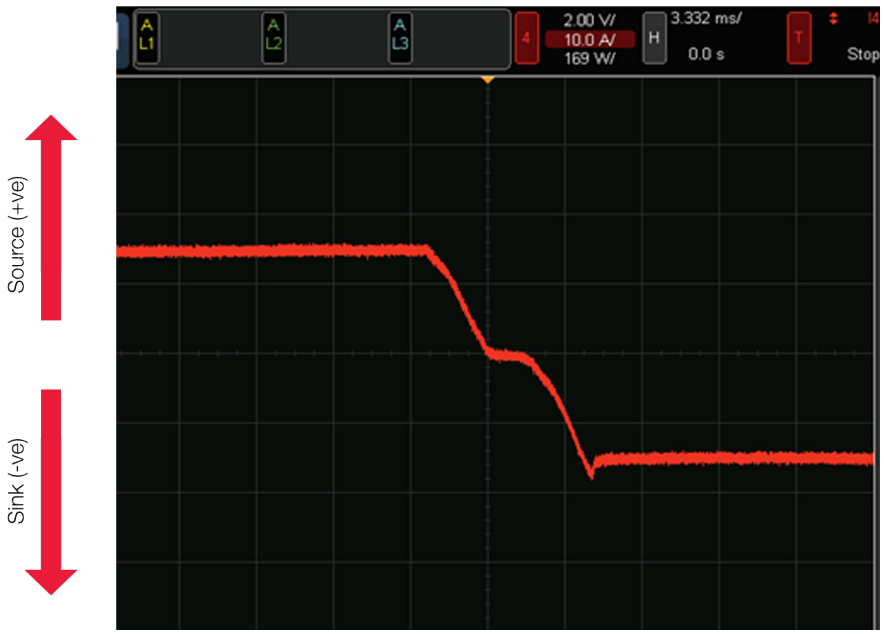

Figure 2. Seamless transition from sourcing current to sinking current

Conclusion

Using a regenerative power supply when testing high-power batteries and their electronics makes sense. A regenerative power supply can be either a source or a load and can seamlessly transition between the two modes. The ability to source and sink 100% of its current reduces the amount of test equipment and simplifies measurements. Regeneration happens automatically and requires no additional setup or programming. Energy usually wasted during testing is safely and cleanly fed back to the grid.

Learn more about Keysight's family of 5 kW to 20 kW regenerative power supplies: www.keysight.com/find/RP7900.