

Cleansource2 Battery-Free Energy Storage Theory Of Operation

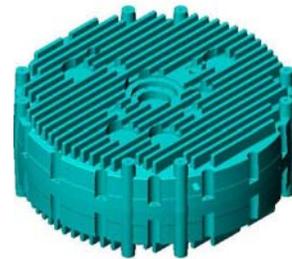
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1. System Overview

CleanSource2, the second generation of DC products by Active Power, is a highly reliable flywheel based DC voltage source that is an environmentally friendly plug-compatible replacement or supplement for lead-acid batteries used with 3-phase UPS systems. Experienced gained through over 2,000,000 hours of field run time of flywheel systems has been incorporated into this improved energy storage system design. Critical power applications that incorporate this flywheel system as a DC source can improve overall system reliability and eliminate or greatly reduce the expensive maintenance and disposal costs associated with lead-acid batteries.

The flywheel system stores kinetic energy in a rotating mass that is immediately converted to usable power when needed. Similar to a chemical battery, it receives recharge and float power from the UPS DC bus and returns power to the same bus whenever the voltage drops below a programmable voltage setpoint. The CleanSource2 is available in 250 and 500 kW single cabinet increments. Up to 8 wheels can be paralleled to power up to a single 2000 kW DC bus.

The heart of the CleanSource2 is a 14” high 32” diameter integrated motor/generator/flywheel system capable of storing and delivering up to 250 kW of power. The flywheel stores energy as angular momentum in a single piece forged 4340 steel rotor rotating in a rough vacuum. The same stator and rotor structure perform all the motor, generator, and storage functions. No permanent magnets or brushes are used within the motor/generator/flywheel system. In addition, the flywheel has no coils or magnets attached. A magnetic bearing that is integral to the motor/generator field coil structure supports the majority of the rotor weight. This enables the mechanical bearings to be optimally loaded which greatly extends bearing life.

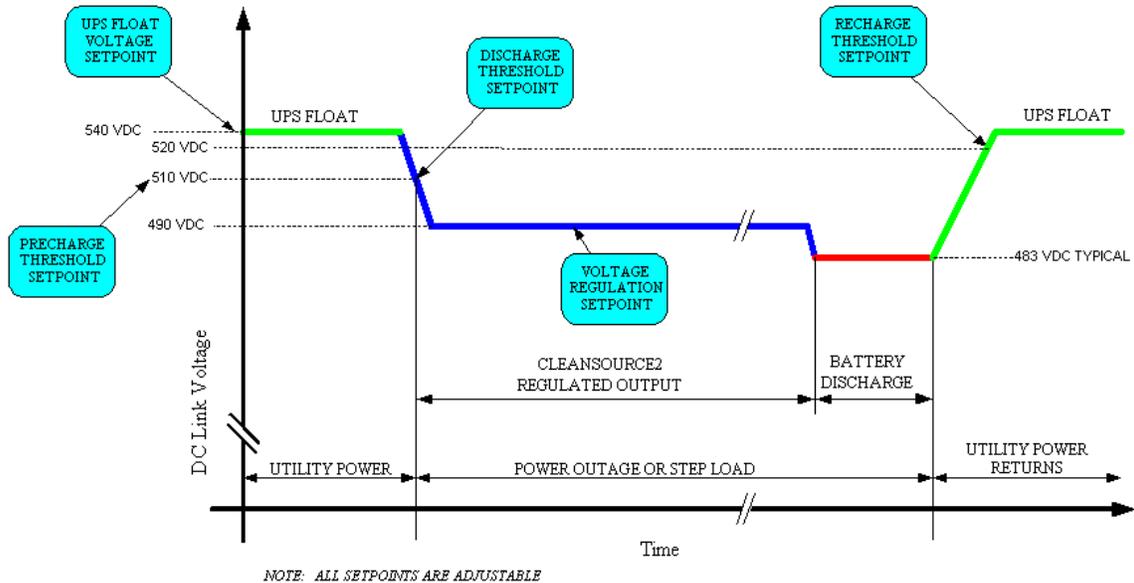


CleanSource Flywheel

The CleanSource2 can be incorporated in any installation that has a DC bus within the range of 360 to 550 VDC. The new “Soft Start” feature allows hot connections onto the DC bus, eliminating the need to equalize voltages between UPS and flywheel before connecting the two. The CleanSource2 reacts to levels of the UPS DC bus to determine the mode of operation. Six fully adjustable setpoints are used to characterize the operation of the system. The setpoints are easily adjustable to fit specific installation requirements. The setpoints are listed below followed by a graphic that illustrates their use in a battery isolation configuration.

Float Voltage Setpoint	-reference only, not controlled by CleanSource2
Precharge Threshold Setpoint	-soft start charge voltage level for breaker closure
Discharge Threshold Setpoint	-voltage at which a Discharge is initiated
Output Voltage Regulation Setpoint	-constant voltage level during Discharge
Recharge Threshold Setpoint	-voltage level that allows flywheel recharge
Recharge Current Available	-available current from UPS or source

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Example of Setpoints in a Battery Isolation Configuration.

2. Site Selection and Preparation

The CleanSource2 is the most power dense commercially available DC storage device available. Storing up to 500 KW in less than 10 square feet of floor space. Each system has dimensions of 42”w x 34”d x 78”h. Requiring only front access through out its 20-plus year useful life, the system allows for maximum flexibility in installations. To accommodate access to the systems, 36” of open floor space is required directly in front. The site location must also provide access for the system to be handled with a forklift, pallet jack, or overhead crane. Ceiling heights of at least 8 feet are required for airflow from fans. The site should also be clean, dry, and reasonably dust-free. Ambient temperatures must be between -20°C and 40°C (-4°F and 104°F) with a 0°C limit for starting the system. Cable entry for both AC and DC power is from the top. Bottom entry can be accommodated as an option. DC connections are made with NEMA two hole lugs with 1.75” spacing for 0.5” hardware. An optional internal DC disconnect that adds no additional footprint is available to save floor space and expense on installations. AC connections are made with 0.25” ring lugs. The system is held in place with six concrete anchors. Typical anchor provisions require the corners of the frame to be at least 12 inches from the edges of the concrete slab.

3. Routine Operation

During routine operations the CleanSource2 is continuously monitoring the status of the DC link voltage and it’s own internal systems. The flywheel rotates at 7700 RPM at standby storing 250 KW of power. Once a sag is detected in the bus voltage, the CleanSource2 immediately delivers its power from the flywheel to the UPS and critical load. Upon return of mains or standby generator power, the flywheel quickly recharges and is again capable of full power output. No performance degradations occur in closely spaced consecutive discharges as with batteries.

Flywheel and system information are displayed on a LCD display on the front users interface panel. Information such as the number of discharges, DC bus voltage, flywheel RPM, and power are all available. The panel also houses a key-switch control, system status lights, and an Emergency-Shut-Down button. These simple controls are all that is needed to operate the system.

4. Charging

The CleanSource2 draws power from the DC link to store kinetic energy in the rotating flywheel. Once the link voltage level is above the Recharge Threshold setpoint, the CleanSource2 enables the power electronics to draw energy from the bus. A recharge time of 2.5 minutes, following a complete discharge, is achieved with 100 amps per flywheel. Once the flywheel reaches 4000 RPM, it is capable of supporting the load in case of an outage. If for any reason, full current is not available, the recharge current level can be limited by a settable parameter to allow maximum efficiency from the UPS. The CleanSource2 will autonomously determine the order of recharge depending on the current available and the number of flywheels installed. Once the flywheel reaches its fully charged speed, the system will take small amounts of power, 1.9 kilowatts from the DC bus, to maintain the charged state.

5. Discharging

The CleanSource2 continuously monitors the UPS DC link voltage level to determine the need for power. If the link voltage drops below the Discharge Threshold setpoint due to a power event or an everyday step-load, the system will instantaneously start to discharge and deliver power to the bus. The AC output of the 3-phase flywheel is converted to a DC voltage with the use of IGBTs. The system maintains a constant output voltage level determined by the Discharge Regulation setpoint. The system is capable of regulating the output voltage from 360 to 550 VDC. The system will automatically regulate the power delivered depending on the UPS load. At full rated power, a complete discharge lasts a minimum of 13.5 seconds. However, on a typical UPS, the discharge is usually 25 seconds. A discharge can last up to 120 seconds on a very lightly loaded UPS. Since energy stored in the flywheel is constant, discharge time is a linear function of load.

6. Vacuum System

The CleanSource2 flywheel achieves high standby efficiency, in part, by producing a rough vacuum at pressures below 50 mTorr in which the flywheel spins. This greatly reduces the levels of drag, vibration, and noise, resulting in low standby losses and low dBA levels. The vacuum inside the flywheel housing is maintained by a vacuum-roughing pump that is capable of many years of continuous service with minimum maintenance. The vacuum level is monitored continuously during all stages of operations.

An auxiliary AC service connection taken from the protected output of the UPS is used for powering the system's vacuum pump and cooling fans. Since the CleanSource2 is providing immediate power to the UPS load, it is also protecting itself against power events. Input AC Voltage levels of 480, 230, and 120 are easily accommodated within the system.

7. Self-Monitoring and Communications

All system and environmental parameters essential to operation are continuously monitored. These telemetry readings are available for viewing in a number of ways. The front user panel houses a LCD display that allows an operator to page through the data. In normal operations, the LCD displays summary information regarding the systems status. The telemetry data can also be reviewed via software packaged developed by Active Power called CSView. A RS232 interface is utilized by CSView and is standard on each system. CSView allows real time monitoring of all system parameters. CSView can also be used remotely by modem or Ethernet connection. This remote capability allows for system monitoring anywhere in the world over the Internet, e-mails and/or paging for any abnormal occurrence of the system.

All parameters displayed in CSView are normally lettered in green. If the parameter reaches a marginal value, the text in that box will turn yellow. If it reaches a critical value, it will turn red, and information about that parameter and the controller's reaction to it will usually appear in the event log. Optional remote notification

can also be enabled with CSView dialing preset beeper or phone numbers. An event code is transmitted to the beepers indicating the type of alarm that occurred.

Each parameter is displayed as a digital value in a small data box that can be expanded into a bar chart and trend graph by clicking on two small squares in the upper left corner of the box. The bar chart shows horizontal yellow and red lines at the setpoints that will cause the display to turn yellow or red. An event log text window at the top of the CSView screen displays plain English status messages. In the event of an unusual occurrence such as a shutdown, error messages appear here. Discharges and self-tests are also announced in this window. Information provided with CSView is also available through MODBUS and SNMP interfaces.

CSView automatically logs data to disk in a comma-delimited format compatible with Microsoft Excel and most other popular spreadsheets. CleanSource2 also stores up to 2,000 system event notices on board for history tracking. This is especially useful when needing further information on an event or when requiring further diagnostics.

8. Maintenance

Preventive maintenance for the systems is limited to three simple procedures. First, the air filters on the front door are changed every three to six months. More frequent filter changes could be necessary in harsh or contaminated environments. Filters may be purchased at common hardware or home improvements stores. Facility personnel can easily change filters within five minutes. Second is the yearly maintenance to the vacuum pump. The oil in the vacuum pump is exchanged with new oil. Approximately a pint of oil is exchanged in an easy drain and replace procedure. Third is the exchange of the flywheel bearings. The recommended change interval is every three years. The procedure takes about 1 hour per flywheel. Upon three years of operation within a vacuum, the bearing grease dissipates. The bearing are still in good shape but require additional grease for optimum performance. The used bearing cartridges are exchanged for new or remanufactured cartridges. The used cartridges are returned to the factory for replacement with new bearings, a complete inspection and rebuild.

9. Financial Benefits

The CleanSource2 can be utilized in a broad variety of situations. Common flywheel applications are battery isolation, glitch protection, and continuous power source installations. According to a recent EPRI study, 96% of all power events are less than 10 seconds in duration. This makes flywheels ideal for applications in any installation requiring quality power.

Battery Isolation: Flywheels can be installed in parallel with lead-acid batteries to isolate them from at least 96% of all power events. This application improves system reliability dramatically by providing a redundant DC source that has a lower failure rate and higher environmental tolerance than the string of batteries. Additionally, the battery life span is increased due to lower cyclic aging. The batteries are not called upon until substantial power interruptions occur. Since the battery bank is not constantly deteriorating, smaller banks of batteries can be used. Cost savings will be realized in battery duration and replacement frequency.

Glitch Protection: Industrial applications that require substantial time or money to recover from short power outages are ideal flywheel installations. Processes such as plastics extrusions, textiles, or precision manufacturing operations are sensitive to power events. The financial losses due to interruptions of these processes are substantial in product lost and recovery time to restart the processes. Industrial processes are kept online by flywheel power during the 96% of all outages. The rare long duration power outages are now acceptable on a financial basis compared to the cost of purchasing and operating large standby generator systems. The initial cost of the short-term protection is quickly recovered by the increase in efficiency and up time.

Continuous Power: Some sites are designed to never lose power due to an interruption in utility power. Sites such as Hospitals, data centers, critical government or military facilities are designed to never shut down. These installations use combinations of UPS, flywheels, and generator sets to insure continuous power to the critical load. The flywheel bridges the gap from the utility to the time at which the generator set takes the load. Since generators in these applications start within 8 to 10 seconds at most, the flywheel is a highly reliable cost effective solution. This configuration ensures the critical load never experience a power glitch or outage.

Flywheel technology has reached a state at which it is a highly reliable, environmentally sound, replacement or supplement to batteries. The simplicity of use and installation make it a viable part of any power quality system. Whether in new construction or retrofit installations, the CleanSource2 can be effective tool to add reliability to power protection. In addition, the technology allows financial payback and future gains in almost all installations. Reliability, simplicity, and power density makes Active Power flywheel technology a key power quality component.