Integrated Flywheel Based Uninterruptible Power Supply (UPS) System for Broadcast Applications

White Paper 110

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Objective

This paper will review television transmitters, their sensitivity to certain power disturbances and the application of integrated flywheel UPS systems on the front end to provide appropriate protection to broadcasting equipment.

Severe Step Load of TV Transmitters

Television transmitters are highly sensitive to voltage variations for a number of reasons. For example, incoming electric power disturbances can easily take a transmitter off the air, resulting in stranded viewers and potential loss in commercial revenue. Power outages can also cause some transmitters to undergo a hard shutdown, which can damage transmitter components due to the sudden loss in cooling or other control malfunctions.

Figure 1: Broadcast Antenna

Fortunately, UPS systems can provide power conditioning and voltage regulation to ensure constant quality power to transmitters and the necessary ride-through power to a standby generator for protection from extended outages. An integrated flywheel based UPS system like that of the CleanSource® UPS system from Active Power is proven to protect broadcast companies from costly downtime and to guard transmitters from possible damage due to utility events. The architecture of the flywheel system handles overloads and step loads better than conventional double conversion UPS systems with batteries, in part because it is designed to efficiently manage a "crowbar event" – a protective shutdown process that is built into many transmitters.

Flywheel Technology

Active Power produces the integrated UPS and DC power system with flywheel technology that serves as an alternative to chemical batteries. The flywheel energy storage system stores kinetic energy by spinning a compact rotor in a low-friction environment. When short-term backup power is required due to fluctuations in utility power or power is lost, the rotor's kinetic energy is converted to electricity.

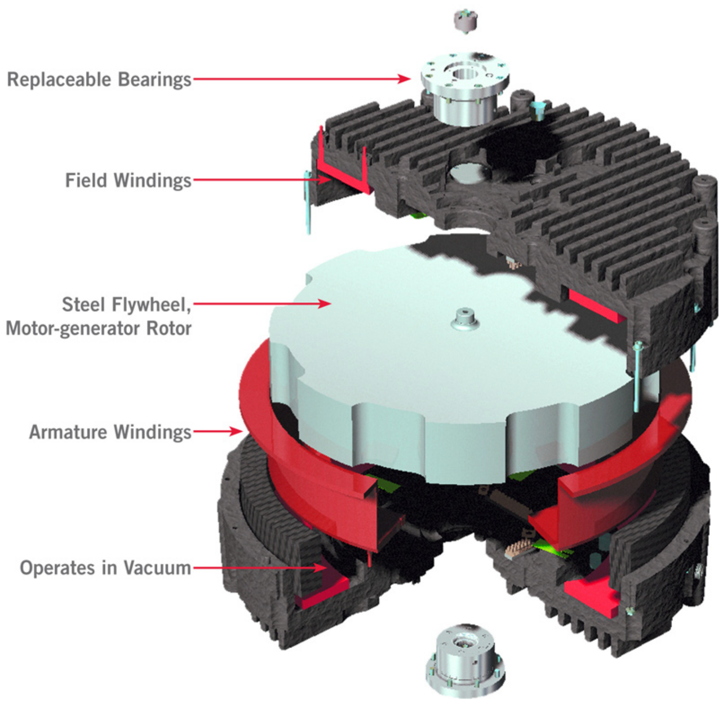

Figure 2: Flywheel Assembly

CleanSource integrates the function of a motor, flywheel rotor and generator into a single system. The motor, which uses electric current from the utility grid to provide energy to rotate the flywheel, spins at a constant speed to maintain a store of kinetic energy. The generator converts the kinetic energy of the flywheel into electricity as required. Refer to white paper #108 "Operation and Performance of a Flywheel-Based UPS System" for further information.

The flywheel rotor is supported by Active Power's magnetic bearing technology. This technology unloads a majority of the flywheel's weight from the field-replaceable mechanical bearing cartridge. A vacuum pump evacuates the chamber, reducing the drag on the spinning flywheel. The flywheel's speed decreases as power is transferred to the load. Regulated current is supplied to the field coils to maintain constant voltage output throughout the discharge. The flywheel based system provide ride-through power for a majority of power disturbances, such as voltage sags and surges and bridges the gap between a power outage and the time required to switch to generator power.

Figure 3: CleanSource UPS 300 Series

What is a "Crowbar" Event?

A crowbar event is the automatic shutdown method used in a high power transmitter as a safety circuit to protect the transmitter amplifier tube or the inductive output tube (IOT) in the event of an arc-over inside the IOT. The function of the crowbar is to remove the high voltage from the amplifier as quickly as possible, typically within a few microseconds of the detected problem. The crowbar circuit shorts out the high voltage DC power supply to the IOT for a brief period of time, often in the range of several milliseconds. This function is typically performed with a device called a thyratron, which is a gas-filled tube that is similar in construction to a vacuum tube. The thyratron is connected directly across the high voltage DC supply. It is a very fast, high-voltage switch, comparable to a silicon-controlled rectifier, but with much higher voltage ratings and speed. When a problem is detected in the amplifier, the crowbar acts quickly; otherwise, the IOT would be destroyed, resulting in significant capital expense.

The crowbar action produces a current of several thousand amps on the AC input of the high voltage supply and on the output of the UPS supplying the transmitter. The event is equivalent to a short circuit applied directly to the output of the UPS system, which can draw up to 20 times rated current. Assuming the input power supply to the transmitter can supply the large current that is demanded, the action of the crowbar does no harm to the transmitting equipment and after a few seconds the high voltage supply returns to normal.

In the event of an overload from a crowbar event, the flywheel based UPS system switches to bypass in order to help supply the desired current from the lowest impedance source and does so without disturbing the operation of other transmitters on the same circuit.

Putting the Flywheel UPS System to the Crowbar Test

A television network with a potential audience of more than 15 million viewers has several flywheel UPS systems deployed at different transmitter sites throughout the southeastern United States. At a site near Tampa, Fla., crowbar testing was performed on the output of one of its flywheel UPS systems. This transmission site has a primary 60 kW analog transmitter with a backup 30 kW transmitter that shares the output of the UPS system with a new 65 kW digital transmitter equipped with a crowbar circuit.

The UPS system was tested several times in order to view the response of the system during a crowbar event of the digital transmitter. The current delivered by the UPS system during the crowbar test peaked at 3,000 to 4,000 amps, which varied due to the position of the voltage sine wave when the crowbar fired. In one of the crowbar tests, the UPS system only discharged for a short period and did not have to go to bypass. In five of the six crowbar tests, the UPS system went to bypass via the static bypass switch and displayed a warning message due to the severe step load. The UPS system then returned to normal on-line operation within a few seconds. The UPS system is configured so that if the same warning message occurs more than once per hour, the UPS system will remain in bypass mode and will require an operator to reset it. An external contact signal from a delay relay may also be used to automatically return the UPS to on-line operation if multiple crowbar events are expected within one hour.

The other transmitter at the network's site, which was connected to the output of the UPS system, stayed on the air without a glitch during all of the crowbar tests. This is partly because the UPS static bypass switch allows transfer to the bypass source without affecting downstream equipment; otherwise, the critical loads could be subject to power disturbances during the event.

CONCLUSION

The crowbar test at the transmitter site indicates the flywheel based UPS system performed exceptionally well under extreme conditions and delivers stable, uninterrupted power to sensitive loads even during severe transient conditions.

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