Weathering THE STORM

Flywheels light the stage in greening up power protection.

BY JOHNNY GONZALES

Today's broadcasters have a lot to be concerned about. Ratings, programming, budgets, OPEX, ROI, equipment, personnel and a myriad of other things can keep broadcasters up at night. Worrying if the station will go off the air during a power blackout shouldn't be one of them. Armed with uninterruptible power supply (UPS) systems and an engine generator, most broadcasters feel protected against whatever the local utility throws at them or if Mother Nature is in a storm-frenzy fury. However, they might not be as protected as they think. While battery-based systems have been the standard in UPS — due mostly to their low cost — they are in fact the weakest link in providing reliable power protection.

Transmission systems are notoriously difficult to protect against power anomalies because of their sensitivity to even the smallest disruption, yet at the same time, they require high power to feed large transmitters. And now with DTV, the requirement for clean, continuous power has never been greater. Protecting the myriad of master control switchers, transmitters, cameras, amplifiers, editing bays, servers, RAID storage systems and other critical systems has traditionally been handled by battery-based UPS systems. These systems have done a good job in mitigating power interruptions and conditioning "dirty" power. However, broadcast engineers are finding that adding flywheels into the power continuity scheme significantly enhances reliability, increases green initiatives and lowers the total cost of ownership of the UPS system.

UPS batteries are chemically based dc sources. This means that frequent battery maintenance, testing, cooling requirements, weight, toxic and hazardous chemicals, and disposal issues are key concerns. One dead cell in a battery string can render the entire battery bank useless — which is not good when you're depending on the power backup system to perform when you need it most. Every time the batteries are cycled, even for a split second, the more likely they will fail the next time they are called upon.

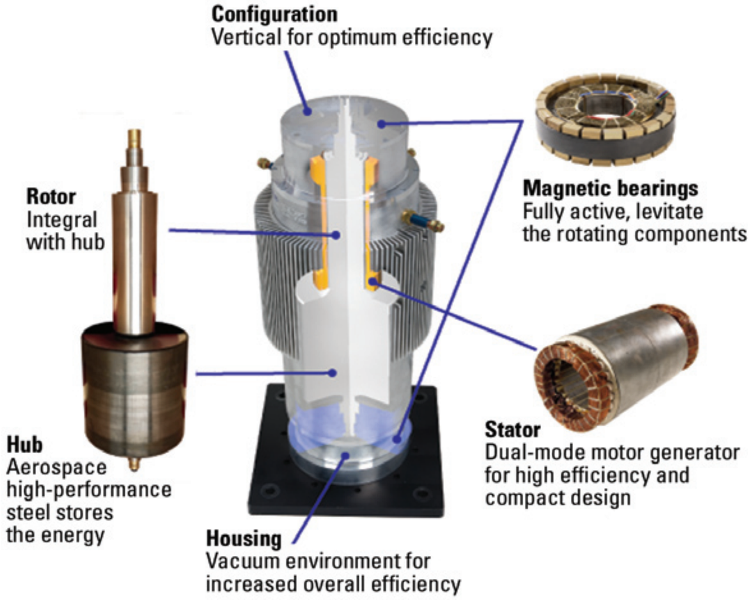

Figure 1. This illustration of a flywheel shows how an electrical input spins the flywheel rotor up to speed, and a standby charge keeps it spinning 24/7.

When used in conjunction with a UPS system, flywheels provide uninterrupted DC ride-through power and voltage stabilization during brief utility power disruptions and brownouts, preserving the battery array for only longer-term outages. (See Figure 2.) Most backup generators require six to 10 seconds to come online and to connect with the UPS via the automatic transfer switch. Some flywheel units can provide up to 300kW of instant ride-through power and voltage stabilization for more than 20 seconds (or other combinations of power and time) — more than enough time for the vast majority of electrical disturbances. Flywheel units can be paralleled for additional power capacity, run time and/or redundancy.

Clean energy storage

Flywheel technology stores kinetic energy in a quiet, spinning disk to provide a reliable and predictable source of DC power. With recent advances that have made it more compact and able to support higher power applications, flywheel technology has emerged as a reliable, environmentally friendly power protection solution that stores energy mechanically instead of chemically — greatly enhancing dependability.

A flywheel system can replace lead-acid batteries and works like a dynamic battery that stores energy kinetically by spinning a mass around an axis. And it is designed for high-power, short-duration applications. Electrical input spins the flywheel rotor up to speed, and a standby charge keeps it spinning 24/7 until called upon to release the stored energy. (See Figure 1.) Technology used in the flywheel allows the flywheel hub — formed from aerospace-grade steel, a high-speed permanent magnet motor/generator and contact-free magnetic bearings — to levitate 100 percent and sustain the rotor during operation. The elimination of bearings for normal operation combined with zero rotor hub metal-to-metal contact eliminates maintenance concerns such as bearing replacements and or oiling/greasing of bearings. Higher reliability and improved availability is the end result. What this means is a more reliable backup power solution. The flywheel can charge and discharge at high rates for countless cycles without degradation throughout its 20-year life — unlike traditional batteries. The amount of energy available and its duration is proportional to its mass and the square of its revolution speed. In the flywheel world, doubling mass doubles energy capacity, but doubling rotational speed quadruples energy capacity: $E = KM\omega^2$ (where K depends on the shape of the rotating mass, M is the mass of the flywheel and ω^2 is the angular velocity.

Proper sizing

Depending on the growth of the broadcast station, normally the sizing of UPS systems and flywheels is done based on actual load. Most engineers size the UPS at 30 percent to 40 percent larger than the actual load to allow for growth. Once the UPS is sized, the flywheel needs to be sized to the UPS. All UPS ratings are based on kVA and kW numbers; the rating used for power applications is the kW rating. When this kW number is established, this will be labeled as the full load kW rating. For example: A 275kVA UPS with a power factor (pf) rating or capability of 0.9 results in a 248kW output rating for the UPS (kVA x pf). Real work loading on a UPS is typically

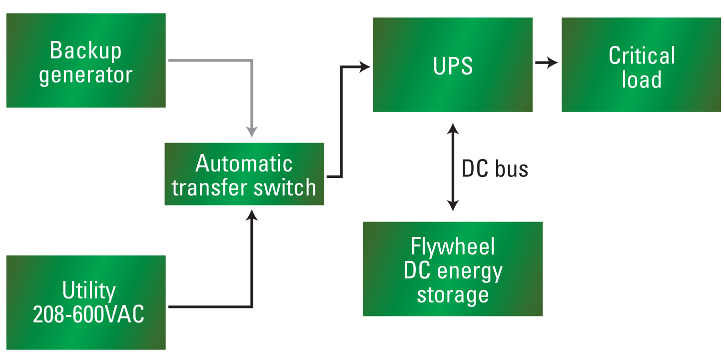

Figure 2. When used in conjunction with a UPS system, flywheels provide uninterrupted DC ride-through power and voltage stabilization during brief utility power disruptions and brownouts.

Model 1 — UPS output power rating (kVA)

Number of flywheels	40	60	80	100	120	160	225	275	450	550	750	1100
1	99.8	67.0	50.3	40.3	33.6	21.9	11.7	6.4				
2				80.0	65.0	48.8	34.8	26.6	11.3	6.2		
3						72.3	51.5	42.2	23.2	16.8	8.5	
4				Run time in seconds				55.6	34.1	26.1	16.0	6.0
5										34.8	23.0	11.7

Model 2 — UPS output power rating (kVA)

Number of flywheels	40	60	80	100	120	160	225	275	450	550	750	1100
1	99.8	67.0	50.3	40.3	33.6	25.6	17.4	11.7				
2				80.0	65.0	48.8	34.8	28.6	16.8	11.4	6.1	
3						72.3	51.5	42.2	26.1	21.5	13.9	6.2
4				Run time in seconds				55.6	34.1	28.0	20.8	11.1
5										34.8	25.8	17.1

Table 1. To make it easier to size flywheels, most manufacturers supply customers with runtime charts.

80 percent or less. Our 275kVA example (80 percent loaded) would require 207kW of DC power or support from the flywheel. This is the rating used to size the flywheels to assure proper power rating and proper amount of run time requirement. Most flywheel manufacturers have made it easier to size flywheels by supplying users with run-time charts.

As illustrated in Table 1, using two flywheels of Model 1 will achieve 26.6 seconds of run time, and using two flywheels of Model 2 will achieve 28.6 seconds of run time. In either case, it exceeds the goal of meeting a 20-second run-time requirement as a minimum. This makes for a solution that fits the needs of most broadcast stations.

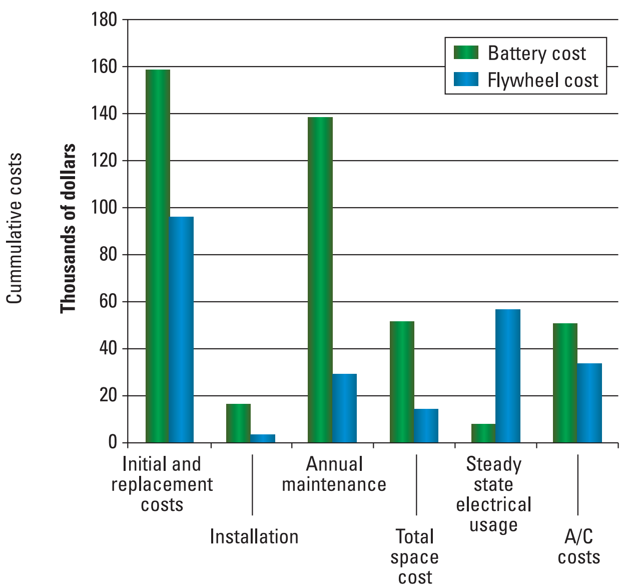

Figure 3. This life cycle cost comparison shows some advantages of flywheel technology over battery systems.

Do you know the state of your UPS batteries?

Batteries have a limited number of discharge cycles they can provide during their expected life. While this cycle life may be adequate in some applications, there are instances where a battery bank may be heavily discharged frequently, sometimes several times per day, caused by short-term power interruptions lasting for a few seconds or less. Every time the batteries are used (cycled), even for a split second, the more likely it is they will fail the next time they are called upon. Even testing the batteries shortens battery life, and just one cell in a battery string can render the entire battery bank useless.

According to EPRI, "Batteries are the primary field failure problem with UPS systems." Predicting when one battery in a string of dozens will fail is next to impossible even with regular testing and frequent individual battery replacements. The reality is that proper battery maintenance is often overlooked. Broadcast engineers need to consider: Are the batteries fully charged? Has a cell gone bad in the battery string? When was the last time they were checked? Bottom line: Without properly operating batteries, no battery-based UPS system can do its job.

By replacing the batteries with flywheels, the premium cost of battery maintenance on an annual basis for the life of the batteries is eliminated as well as the replacement of the batteries every four years.

When comparing the life cycle cost of batteries with the life cycle cost of flywheels (See Figures 3 and 4), it's clear which technology has a larger cost savings over the life of the technology. What most engineers have discovered is that the flywheel has been favored over batteries due to the cost savings, with an ROI in three to four years. However, it is important to know that it's not an either or situation, as the flywheel can be used with or without batteries. When used with batteries, the flywheel is the first line of defense against damaging power glitches since it absorbs all the short duration discharges, thereby reducing the number and frequency of discharges, which shortens battery life. Because UPS batteries are the weakest link in the power continuity scheme, flywheels paralleled with batteries give engineers peace of mind that their batteries are safeguarded against premature aging and unexpected failures. When the flywheel is used just with the UPS and no batteries, the system will provide instant power to the connected load exactly as it would do with a battery string.

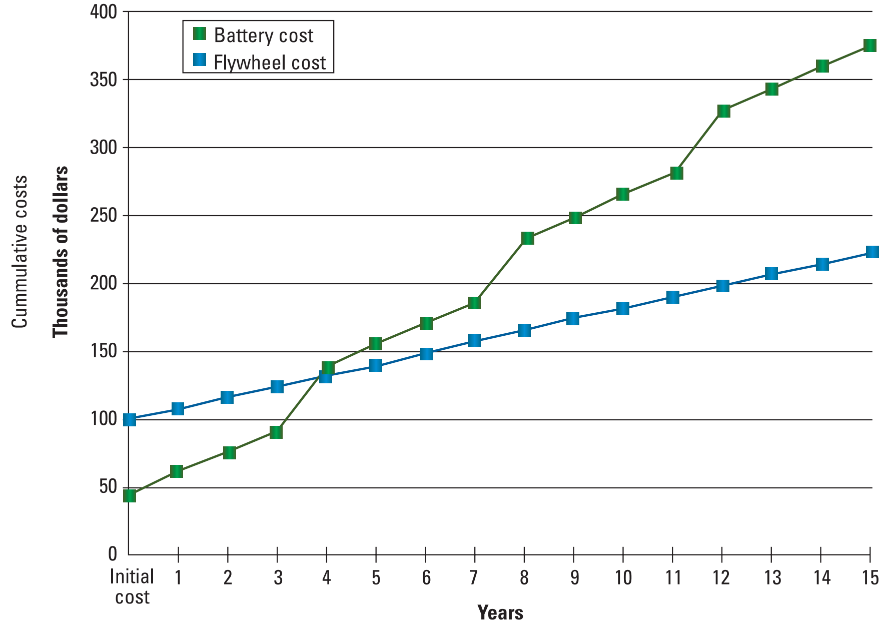

Figure 4. The life cycle cost comparison between batteries and flywheel technology shows that batteries cost about $150,000 more after 15 years.

However, if the power event lasts long enough to be considered a hard outage (rather than just a transient outage), the flywheel will gracefully hand off to the facility's engine generator.

Flywheel technology has advanced greatly. According to a 2006 Federal Technology Alert by the U.S. Department of Energy, "Flywheels appear poised to replace or supplement batteries as a backup power supply in UPS systems. Although the initial cost of a flywheel is typically greater than batteries it would be replacing or supplementing, its longer life and simpler maintenance will often result in lower life-cycle costs."

Broadcast engineers need to look at ways to maximize the availability and performance of battery systems, including ensuring the battery is properly prepared before load testing, proactively monitoring batteries and considering alternate power sources, such as clean flywheel technology. Only when a greater level of attention is given to the DC source selection can engineers continue to keep critical production and transmission systems performing to specifications and minimize the risk of downtime to operations. BE

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