KERS of the hybrid car: Flywheels and ultracapacitors give you a 10-second jolt

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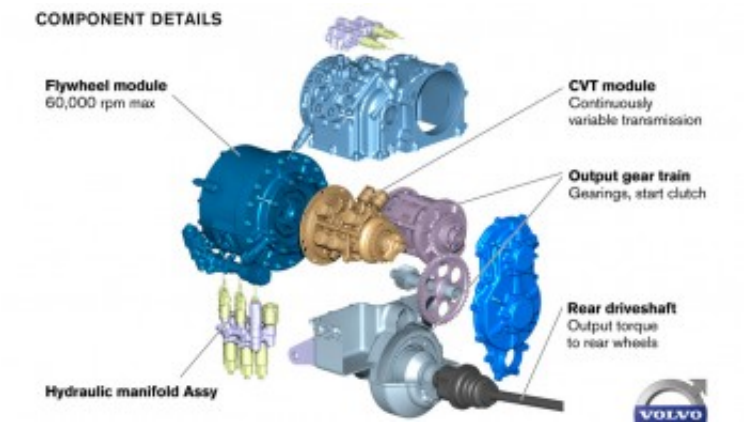


Flywheels or ultracapacitors and a four-cylinder engine could be enough to power even the biggest cars and SUVs. They're like limited-duration turbochargers, good for around 10 seconds of extra power at a time, and they replace complicated hybrid electric systems with, well, differently complex electromechanical systems. Volvo is the latest automaker to announce interest in flywheel power while Porsche has been using flywheels successfully in auto racing. These flywheel cars, dubbed *kinetic energy recovery system* (KERS) vehicles, are another form of hybrid vehicle because they have an electric drive system supplementing the combustion engine.

The flywheel car is simple to describe if not to engineer. A lightweight, low-friction flywheel is integrated into the transmission or in the trunk. When the car brakes or even when it's running at constant speed, the extra energy is transmitted to the flywheel pack and spins up a flywheel until it reaches as

much as 60,000 rpm. When power is required to step away smartly from a stoplight or accelerate onto the highway, the flywheel's energy is converted to electricity that drives an electric motor to supplement the combustion engine. Depending on how hard you step on the throttle, you might get 5 to 20 seconds of extra power. A Prius-like hybrid provides less power but for longer periods.

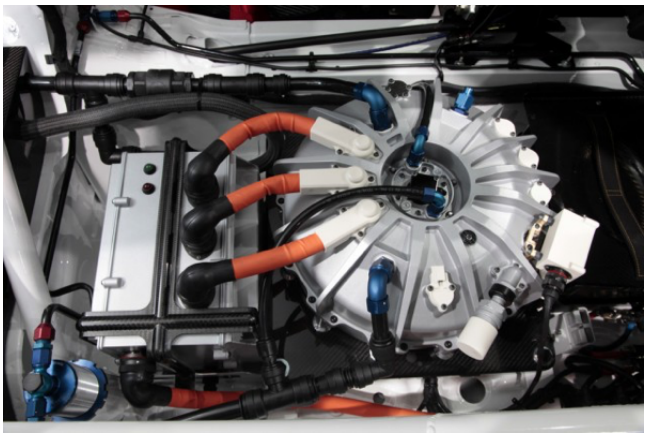
A same-only-different technology as the KERS flywheel uses *ulracapacitors*, small sets of insulated plates that build up an electrical differential (voltage). A tiny capacitor backs up your clock radio or DVD player (the blinking 12:00 is a sign of cost-cutting design with no capacitor or battery backup); in a car or race car, a huge bank of ultracapacitors stores enough juice to provide a similar amount of acceleration as a flywheel. A generator charges the capacitors when the car decelerates or brakes. They were tested in Formula 1 racecars a couple years ago then set aside in 2010 owing to some reliability and safety issues. A mechanic in pit lane was accidentally tasered by a race car that wasn't properly grounded (video embedded below). For 2011, they're back. Teams can use any of three forms of KERS: flywheel, ultracapacitor, or hydraulic (hydraulic fluid pressures a chamber under deceleration). Rules limit the KERS output to about 80 hp and no more than 6.67 seconds of boost per lap.

Volvo says it will start testing a flywheel-based recovery system later this year. Volvo's goal is a 20% improvement in fuel economy and an extra 80 hp of performance beyond what the combustion engine provides. In the case of Volvo, the flywheel system is installed as part of the transmission package: a 13-pound carbon fiber disc spinning at up to 60,000 rpm. Volvo says it will give a four-cylinder car the performance of a six-cylinder, using the same comparison as Ford uses to plug its EcoBoost, or turbocharged, gasoline engines: Add a performance enhancing module, subtract two cylinders, maintain performance, improve economy. Volvo also contends a

flywheel system might cost only a third what hybrid batteries cost — $750-$1,000, in other words, since a replacement hybrid battery pack runs $2,500-$3,000.

Porsche has used a flywheel system in some of its racecars such as the Porsche 911 GT3 R Hybrid where the flywheel sits in the cockpit in place of the passenger seat (for better weight distribution) and provides 5-7 seconds of all-out acceleration from two 80-hp electric motors driving the front wheels; a 480-hp gasoline engine powers the back wheels. Porsche announced the car in 2010 (see more in Good Clean Tech) but the 911 GT3 R Hybrid hasn't been eligible for some race series that allow the non-hybrid 911 GT3 R because rulesmakers don't know how to handicap the electric motor's boost. Porsche denies reports that a KERS hybrid system will be part of the next-generation Porsche 911 that is due to be announced at the

September Frankfurt Auto Show.



Flywheels have been in automobiles for more than a century but for the far simpler task of providing spinning momentum when the driver shifted gears and let out the clutch. The flywheel as performance- and mpg-booster dates to the 1980s when General Motors, scrambling to meet stricter fuel efficiency standards stemming from the oil shortages of the 1970s, planned a hybrid system. GM gave up when actual efficiency improvements turned out to be half of what they hoped for. And maybe just as well: One of the world's largest and most respected engineering teams simply couldn't keep up with the need to make cars smaller, shift to front-wheel-drive, *transverse-mount* some front-drive engines (sideways rather than front to back). GM's attempts at variable displacement (V8-6-4) and diesel passenger-car engines blew up in their faces. Sometimes literally. But that was then.

"Industry has gone from being skeptical to thinking it can be done," Derek Crabb, Volvo's VP of powertrain engineering, told MIT Technology Review, "but there are enormous challenges."

The British engineering group Ricardo has worked with Volvo on several hybrid concepts, including KERS flywheel technology (pictured right). According to Ricardo, a flywheel system provides two to three times the instantaneous boost power of a battery system, 60 kilowatts vs. 15-25 kilowatts, taking up less weight and space.

One of the challenges is maintaining a vacuum inside the flywheel housing. A Porsche race car has the attention of a dozen mechanics and the KERS flywheel only has to maintain proper vacuum for a day while a passenger car would likely need a pump to keep the vacuum over time. To reduce friction from a spinning shift and seals, Ricardo has a system of magnets along the edge of the flywheel and another set outside the housing, working as an electric generator.

For more on Volvo's KERS car, see MIT Technology Review; also see more on KERS in Formula 1.