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Contact: Bridgette M. LaRose
DENSO International America, Inc.
(248) 372-8266
bridgette_larose@denso-diam.com

DENSO's Stop/Start Technology hits U.S Roads in 2012

—DENSO's Integrated Approach to Stop/start Technology—

DETROIT – As U.S. automakers look to meet the upcoming 31.6 mpg standard by 2015, get ready to see more and more vehicles outfitted with stop/start technology. While this technology is not-so-new to the global market as it's already in the Japanese and European markets, it's definitely a new technology on internal combustion engines here in the U.S. And, DENSO's stop/start technology will hit American roads later this year on North American vehicles.

Stop/start systems stop the engine when the vehicle is idling at a stop light or in other traffic situations. This helps reduce fuel consumption and CO₂ emissions. Depending on automaker specifications, the technology can help improve fuel efficiency by approximately 3 to 5 percent. And, DENSO has future stop/start system technology that will bump that up to over 7 percent depending on the automaker's overall systems approach. When it comes to saving fuel, every percent counts.

DENSO's Stop/Start Experience

DENSO's been working on stop/start technology since the 1980s. This experience, paired with our in-depth knowledge of powertrain and thermal management systems, gives us a unique advantage to provide automakers with an overall systems approach. The company understands how to seamlessly integrate stop/start components into the vehicle and can offer superior technical support that comes from decades of integration experience. DENSO can also offer automakers different technology solutions depending on their specific needs and requirements.

Starter Technology Overview

Advanced Engagement (AE) Starter

- Already implemented in Europe and Asia, this longer-life starter technology allows automakers to achieve approximately 3 to 5 percent (depending on engine size) in fuel savings.
- In terms of starter motor-based solutions for stop/start, AE is the easiest to integrate, requiring no unique controls or engine modifications.

How it works:

- The AE works like a typical starter – when it's energized, the pinion shifts forward, engages with the engine's ring gear/flywheel, and immediately spins.
- This starter is considered *Not Change of Mind* capable because the engine rpm needs to drop to zero before re-engagement and engine restart can occur.
- To survive the 10-fold life increase required for stop/start, the AE includes key design features like dual layer, long-life electrical brushes, as well as a unique pinion spring mechanism that reduces ring gear/ flywheel wear by approximately 90 percent.

Tandem Solenoid (TS) Starter

- Also implemented in Europe and Japan, this starter technology allows automakers to achieve faster restart times than the AE, and potentially more fuel savings if combined with expanded areas of fuel cut, for example, engine shut-off during vehicle coasting. Compared to AE, the TS is *Change of Mind Capable*, which means it is able to re-engage into a moving ring gear/flywheel.
- The TS includes all the same long-life features of the AE, and only requires engine control unity software modifications to control the dual solenoid design.

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TS Starter: How it Works

- Uses a unique dual solenoid to control the two functions of the starter solenoid independently.
- Typical starters operate on a simple in-then-spin protocol, the TS adds a spin-then-in capability, This allows the engine to be re-engaged (and re-start) by the starter motor during the 0.5 to 1.5 seconds of dead time that the engine rpm is simply falling from idle (~600 rpm) to zero rpm. And depending on the engine, up to 1.5 seconds can be shaved off of some restarts.
- It has almost identical packaging to the AE – and integrates easily to the engine.

Permanently Engaged (PE) Starter

- Jointly developed with Toyota Motor Corp., this starter is used in Toyota models, such as the Auris and Yaris models sold in Europe since January 2009.
- The PE is also *Change of Mind Capable* and delivers the quickest and quietest restart times of all starter motor- based systems, while bumping-up the overall fuel-saving potential depending on the overall system approach.
- In this system, the starter and flywheel gears are permanently connected, so there are no concerns with the dynamics of gear engagement and disengagement.

How it Works

- Conventional stop/start starters have to shift the starter motor pinion forward, mesh it into the ring gear/flywheel, and then disengage the two gears after the engine starts -- all of which can result in restart delays and noise.
- The PE starter eliminates the starter's pinion gear shifting mechanism, mounting the starter to the engine such that the starter (as the name implies) is permanently engaged with the flywheel.
- When a restart is needed, the motor is simply energized, which immediately re- cranks the engine. There is no waiting or delay since the starter gear is already mated to the flywheel.
- Without having to consider gear engagement dynamics, the gear teeth profile can be optimized for low noise operation.
- The flywheel does require a special clutching mechanism to disconnect it from engine rpm after engine start.

Stop/start Systems Approach

An integrated stop/start approach is more than just starter technology. There are many other products and components that can be added to any stop/start approach to improve comfort and convenience (air conditioning) and powertrain performance. Many of these products better manage energy in a vehicle, which translates into fuel efficiency. Some of these products include:

Cold Storage – DENSO's cold storage system will help maintain a vehicle's temperature when a vehicle with stop/start is at a stop and the air conditioning system is no longer powered. The system stores a cooled material and uses it while the engine is stopped to ensure the air conditioning is maintained.

Electric Water Pump – DENSO's brushless electric water pump will help maintain a vehicle's temperature when a vehicle with stop/start is at a stop and the heater is on. The electric water pump is smaller, yet more energy efficient because it uses less power.

In-rush Current Reduction (ICR) Relay – Sometimes when the engine is restarted, there could potentially be a "dimming" of lights or a reset of some devices due to the large electrical demand placed on the system by the starter motor. DENSO's ICR relay reduces the system voltage drop that happens every time the starter cranks the engine.

In addition, DENSO has been working to develop a new stop/start system that includes the TS starter, a high-efficiency alternator, a high-efficiency battery, and a deceleration regeneration system. This system is expected to increase fuel efficiency to over 7 percent. DENSO's Change of Mind stop/start starter will debut in the North American market in the 2013 to 2014 timeframe.