Tandem Solenoid (TS) Starter for Stop/Start Systems

Smooth Stop/Start by reduction of restarting time
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Stop/Start systems help increase fuel efficiency by automatically stopping the engine while the vehicle is waiting at stop lights or is stopped for other reasons to save fuel that would be wasted during idling. The Tandem Solenoid (TS) Starter enables the engine to restart more quickly and smoothly.

Conventional starters cannot restart the engine while the engine is running down even after the vehicle has stopped. The TS Starter, which features DENSO’s unique new mechanisms, can restart the engine during engine coasting, thus reducing the time needed before engine restart by up to about 1.5 seconds (a 80% decrease compared with DENSO’s conventional starters).

DENSO, which has been making starters since its foundation, started full-scale mass production of starters for Stop/Start systems in 1999. Based on its technologies accumulated over many years, DENSO will continue to improve product reliability and make vehicles more environment-friendly.

Solenoid: Consists of a current-carrying coil of wire and a moving iron core. The coil acts as an electromagnet when a current passes through it and the iron core slides along the coil axis. In starters, this component is used as an actuator to thrust the pinion gear forward and a switch to supply power to the motor.
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**Benefit**

Stop/Start systems automatically stop the engine when the vehicle is stopped, and also allow the engine to coast for a while when the engine is instructed to stop.

Conventional starters cannot restart the engine until the engine has completely stopped, whereas the TS Starter can restart the engine even while it is coasting. Compared with DENSO’s conventional starters, this advantage reduces the time needed before engine restart by up to 1.5 seconds (a 80% decrease in the time required to restart the engine compared with DENSO’s conventional starters).
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**Feature**  The world’s first mechanism to separately control the forward slide of the pinion gear and the energization of the motor.

Conventional starters thrust the pinion gear (the gear on their front end) forward to engage the ring gear (the mating gear on the engine) to transmit the rotation of the motor to the engine via the pinion gear in order to start the engine.

- **Conventional starter**: Has a mechanism to shift the pinion gear and to energize the motor conjunctionally. In this system, the pinion gear cannot mesh with the ring gear until the engine (ring gear) has stopped completely.

- **TS Starter**: Has the world’s first mechanism to separately control the forward slide of the pinion gear and the energization of the motor. In this system, sliding the pinion gear forward according to engine speed and energizing the motor can be controlled independently, thus allowing the pinion gear to engage the ring gear while the engine (ring gear) is still rotating.
## Tandem Solenoid (TS) Starter for Stop/Start Systems

### Engineering Key Point
Separately control pinion gear forward movement and motor energization according to engine speed.

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<th>Timing of engine restart requests</th>
<th>High engine (ring gear) speeds</th>
<th>Low engine (ring gear) speeds</th>
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<td>Flow of control</td>
<td>🔄Motor on → 🔄Pinion shift</td>
<td>🔄Pinion shift → 🔄Motor on</td>
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### Diagrams

**High engine (ring gear) speeds**
- Restart demand
- Energize the motor to increase the rotational speed of the pinion gear and then move the pinion gear forward when the pinion gear and ring gear are rotating at almost the same rate.

**Low engine (ring gear) speeds**
- Restart demand
- Move the pinion gear forward and then energize the motor.

*Engine restart requests: The driver’s actions identified as requests to restart the engine, such as releasing the brake pedal.*