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Sophisticated Control System Unleashes Full Potential of Advanced Northstar Powertrain

The advanced performance capabilities of the powertrains in the Cadillac XLR and SRX are enabled by a sophisticated control system that performs functions beyond the scope of virtually any controller outside of NASA.

This control system gives the next-generation Northstar 4.6-liter DOHC V8 unprecedented levels of power, performance and refinement, and provides the Hydra-Matic 5L50-E transmission with a host of capabilities, including the ability to switch from fully automatic to the characteristics of a clutchless high-performance five-speed manual.

The system is based on two new, extremely powerful controllers – the Engine Control Module (ECM) and the Transmission Control Module (TCM), which are linked via an ultra-high-speed area network, the GM LAN protocol. The network also links them to all of the other critical vehicle performance functions, including ride, handling and brake control.

Engine Control Module

The ECM is a 16-bit, 24 MHz microprocessor, high memory control unit designed to integrate the engine's unique four-cam infinitely variable valve timing (VVT) for both intake and exhaust valve trains, Electronic Throttle Control (ETC), and closed coupled catalysts for meeting emission requirements without secondary emission control systems. The catalysts are mounted directly adjacent to the exhaust manifolds so they reach effective operating temperature more rapidly after engine start-up, eliminating the need for supplemental converters or A.I.R. air induction systems to meet stringent emissions standards, including California's more demanding restrictions and Euro 2.

This engine control strategy results in excellent fuel economy and engine operating refinement, according to Gary Halligan, Powertrain Development Systems Manager for the Northstar 4.6-liter engine.

"Many of the ECM's features and functions are beyond the scope of virtually all currently available engine controllers," he said. "For example, this is one of the industry's first engine management systems to control all four cam phasers – both intake and exhaust – so the engine provides performance and refinement, rather than compromising between the two, while achieving excellent emission control."

It is one of the first ECMs in which the ETC function has been integrated rather than added as a separate module. It also has a redundant "safety" processor backing up the ETC – a feature more common in aerospace than automotive.

Another benefit of the ETC control strategy has been the integration of cruise control – including enabling the adaptive cruise control system of the XLR – and traction control.

In a sense, the TCM also has been integrated with the ECM since the functions of the two controllers are so closely attuned. By the same token, the ECM serves as the gateway between the GM LAN high-speed bus and the Class II functions via the Body Control Module (BCM), which include chassis controls like anti-lock braking, traction control and adaptive suspension control.

Other ECM functions include:

- Individual cylinder knock control and fuel control – it controls fuel mixture richness/leanness at each cylinder to keep it at the optimal stoichiometric ratio, rather than averaging all 8 cylinders or by cylinder bank, the typical approaches.
- Full Onboard Diagnostic (OBD) II capability without a secondary air pump (the Northstar 4.6-liter engine does not need a secondary pump for emission control).
- Linear lambda control, wide ranging air/fuel sensing for more precise control to meet emission requirements – typically an analog oxygen sensor is used, which is slower and less exacting.
- Engine protection functions – including "camel mode," which allows the engine to continue running for another 50 miles before shutting down should it lose all coolant by only operating four cylinders at a time

so it runs cooler. The ECM will also shut down the ignition system if the car doesn't start within 14 seconds (normally it starts instantly), assuming a possible major mechanical problem.

- Engine off natural vacuum (EONV) diagnostics for evaporative emission leak detection.
- Comprehensive exhaust gas temperature model – exhaust gas temperature is used as a basis for adjusting fuel control: as the temperature increases the fuel control is adjusted accordingly to protect the converter from melting.

The ECM, co-developed by Siemens VDO Automotive and GM Powertrain, is virtually impervious to environmental conditions so it can be mounted under hood rather than integrated into the passenger compartment for protection, requiring more complex wiring and mounting considerations.

Transmission Control Module

The more powerful, highly refined TCM had to be developed in order to utilize all of the capabilities of the new 5L50-E transmission. The GM LAN or Class 2 protocol links the TCM to the ECM and all of the vehicle control modules so critical engine and chassis control system inputs can be communicated to the TCM which impact transmission operation (braking, acceleration, wheel slip, cornering etc.).

The TCM is the first to integrate three performance features – Driver Shift Control (DSC), Performance Algorithm Liftfoot (PAL), and Performance Algorithm Shifting (PAS) – which are found individually on high-performance luxury sport sedans but never as a total package, according to Rich Mardeusz, assistant chief engineer, GM Powertrain, who was in charge of developing the transmission.

- Driver Shift Control (DSC) lets the driver switch from automatic to a clutchless five-speed high-performance manual transmission.
- Performance Algorithm Liftfoot (PAL) prevents upshifts while maintaining engine braking following continuous performance driving.
- Performance Algorithm Shifting (PAS) modifies the automatic gear selection during closed throttle high lateral acceleration maneuvers, downshifting with nearly synchronous matching engine speed control for quick power up when the throttle is reopened.

Other capabilities of the TCM include:

- Downgrade Detection with Brake Assist, automatically shifting into a lower gear while braking on a downgrade
- Electronically Controlled Engine Braking in all five gears.
- Shift Stabilization, which minimizes gearshift cycling when going **uphill**.

The TCM has a 185-pin connection system for enhanced input/output capability. Currently, 120-pin systems are more the norm.