We left off last time with an overview of the 2ML70 transmission. In this issue, we’ll explore the inner workings of this unit to see what makes it tick.

**Output Speed Sensor (OSS)**

The output speed sensor is a Hall Effect-type sensor (figure 1). Internally, the sensor consists of two Hall Effect circuits, allowing it to sense both speed and direction. The two sensor elements in the OSS assembly are spaced about a half-tooth apart.

When the vehicle moves forward, sensor A detects the synch tooth before sensor B. When the vehicle moves in reverse, sensor B detects the synch tooth before sensor A. The sensor is connected to the TEHCM (control solenoid with body and TCM) via the internal wiring harness.

The sensor receives an 8.3–9.3V bias voltage signal from the TEHCM.
As the output shaft rotates, the sensor creates a square wave signal. It has a target value of 8.8V but has an acceptable range of 8.3-9.3V. The electronics in the sensor combine the two signals and output a signal with a different pulse width. The TCM interprets this signal to measure speed and direction.

**Internal Mode Switch (IMS)**

The IMS (Internal Mode Switch, figure 2) operates similar to other IMS applications. The IMS tells the TEHCM and the Hybrid Powertrain Control Module (HPCM) which gear range you’ve selected, and acts as a P/N safety switch.

The TEHCM sends an 8.3–9.3V bias voltage to the IMS on circuits A, B, C and P. The switch is mounted internally on the shift linkage. As the linkage rotates, the contacts of the switch open or close. This creates either a high or low signal on the circuit.

Unlike other applications, the 2ML70 IMS has five additional outputs: R1, R2, D1, D2 and S. These outputs signal the Hybrid Powertrain Control Module (HPCM) regarding IMS direction of movement. This information is used for P/N starting and motor control. (Chart 1)

<table>
<thead>
<tr>
<th>IMS CIRCUITS/PARAMETER</th>
<th>Selector Position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Park</td>
</tr>
<tr>
<td>Direction Switch Operating Conditions: Ignition on, range selector in appropriate gear</td>
<td></td>
</tr>
<tr>
<td>Direction IMS D1</td>
<td>HIGH</td>
</tr>
<tr>
<td>Direction IMS D2</td>
<td>LOW</td>
</tr>
<tr>
<td>Direction IMS R1</td>
<td>HIGH</td>
</tr>
<tr>
<td>Direction IMS R2</td>
<td>LOW</td>
</tr>
<tr>
<td>Direction IMS Start</td>
<td>LOW</td>
</tr>
<tr>
<td>Range Switch Operating Conditions: Ignition On, range selector in appropriate gear.</td>
<td></td>
</tr>
<tr>
<td>IMS A</td>
<td>LOW</td>
</tr>
<tr>
<td>IMS B</td>
<td>HIGH</td>
</tr>
<tr>
<td>IMS C</td>
<td>HIGH</td>
</tr>
<tr>
<td>IMS P</td>
<td>LOW</td>
</tr>
<tr>
<td>Always HIGH status: Open/short to voltage</td>
<td></td>
</tr>
</tbody>
</table>

CHART 1

**Figure 2**

![Image of the IMS assembly](image-url)
A New Kid on the Block: 2ML70 (RPO M99) 2-Mode, Part 2

Control Solenoid with Body and TCM (TEHCM)

The TEHCM is built by Bosch and operates like the 6L80/90/50 applications. The TEHCM contains six variable bleed solenoids (only five are used):

- Two On/Off solenoids
- Four pressure switches
- One Transmission Fluid Temperature (TFT) sensor

- Two internal TCM temperature sensors
  - and a TCM, all housed in a single, non-serviceable assembly.

The TEHCM bolts to the valve body. You must remove the bottom pan to service it. The TEHCM controls the hydraulic shifts, shift points, and shift feel for the transmission. As with other applications, the TEHCM is programmable (figure 3, page 8).

Shift Solenoid Sequence

See Chart 2, above.

Fluid Pressure Switches

See Chart 3, above.

Modes of Operation

Engine Starting — Two-mode applications don’t use a conventional starter. Instead, the system relies on the transmission motor/generator to crank the engine. The 300-volt, 3-phase AC

<table>
<thead>
<tr>
<th>Gear</th>
<th>Park</th>
<th>Reverse</th>
<th>Neutral</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>EVT R</td>
<td>N</td>
<td>EVT Low</td>
<td>1st</td>
</tr>
<tr>
<td>Shift Solenoid 1</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>Shift Solenoid 2</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>Line PC Solenoid 1 NH</td>
<td>ON</td>
<td>ON/OFF*</td>
<td>ON</td>
<td>ON/OFF*</td>
</tr>
<tr>
<td>PC Solenoid 2 Trim NH</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>PC Solenoid 3 Trim NH</td>
<td>OFF</td>
<td>ON</td>
<td>ON/OFF*</td>
<td>ON</td>
</tr>
<tr>
<td>PC Solenoid 4 Trim NL</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>PC Solenoid 5 NL</td>
<td>OFF</td>
<td>ON/OFF*</td>
<td>OFF</td>
<td>ON/OFF*</td>
</tr>
</tbody>
</table>

ON = The solenoid valve is energized hydraulically.
OFF = The solenoid valve is de-energized hydraulically.
NL = Normally Low; when the solenoid is OFF, the solenoid has no output pressure.
NH = Normally High; when the solenoid is OFF, solenoid output pressure is present.
A = Applied

*When the engine is running, the line pressure control solenoid is ON (pressurized) and the pressure control solenoid 5 is OFF (no pressure). When the engine is off (auto stop), the line pressure control solenoid is OFF (no pressure) and the pressure control solenoid 5 is ON (pressurized).
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motors can rotate the engine to cranking speeds that exceed 800 RPM in less than a few hundred milliseconds.

**Auto Stop/Auto Start** — After the engine’s running, the Hybrid Powertrain Control Module (HPCM) may operate the engine in Auto Stop/Auto Start mode. The Auto Stop feature is designed to reduce emissions output and engine wear, and improve fuel economy in city driving conditions.

Engine Off and Auto Stop modes of operation will be displayed on the tachometer. When the tachometer needle indicates OFF, Auto Stop won’t function. If the tachometer indicates AUTOSTOP, the engine may restart whenever the vehicle meets the proper parameters.

Auto Stop may activate when these conditions are present:
- Engine running
- Hood closed
- ECM isn’t requesting diagnostic information
- Gear selector isn’t in Reverse or Manual position
- Hybrid battery state of charge exceeds 20%
- Hybrid battery voltage, temperature and power within limits
- Engine warm
- Drive motor/generators within temperature limits
- Power Inverter Module (PIM) temperature within limits
- No Hybrid system faults present
- The Hybrid Powertrain Control Module (HPCM) has determined that engine power isn’t required

The 2-mode system doesn’t require engine operation to propel the vehicle down the road. The Hybrid Powertrain Control Module (HPCM) may shut the engine off (AUTO STOP) when it determines engine power isn’t required. If the Hybrid Powertrain Control Module (HPCM) determines that additional power is needed, the Auto Start will occur and drive motor 1 will be used to start the engine. This may occur even when the vehicle is in motion if it’s operating in electric mode.

Auto start may activate without notice if any of these conditions occur:
- Hood opened
- ECM requests the engine to run
- Gear selector in Reverse or Manual position
- Hybrid battery charge low
- Hybrid battery voltage, temperature or power limits exceeded
- Engine coolant temperature (ECT) too low
- Drive motor/generator temperature limits exceeded
- Power Inverter Module (PIM) temperature limits exceeded
- The Hybrid Powertrain Control Module (HPCM) determined engine power is required
- A Hybrid system fault present

**EVT Mode**

Three electronic drive modes are available: Reverse, Low and High.

**High Mode 2** — When you select High mode, the following occurs:
- PCS trim solenoid 3 is commanded off
- Shift solenoid 1 is commanded off
- #3 pressure switch opens
- #1 pressure switch opens
- #4 pressure switch opens
- 2-3-4 clutch is applied
- Front motor 1 drives the vehicle
- Rear motor 2 drives the vehicle

**Low Mode 1; Engine Off** — When you select Low mode, the following occurs:
- PCS 3 is commanded on
- PCS 5 is commanded off
- 1-2 clutch applies
- Rear motor 2 drives the vehicle

**Low Mode 1; Engine On** — When you select Low mode, the following occurs:
- PCS 3 is commanded on
- 1-2 clutch applies
- Rear motor 2 operates to drive the vehicle in reverse

**Regenerative Braking/Blended Braking**

When the vehicle is decelerating or coasting, the Hybrid Powertrain Control Module (HPCM) can switch the system into regeneration mode. In this mode the motors act as generators to charge the Hybrid battery. As the motors switch to generator mode, they exert force on the drive train, which helps slow the vehicle.

Blended braking is also available with the 2-mode system. When you apply the brakes, drive motor 2 switches to generator mode, which slows the vehicle.

Communication between the Hybrid Powertrain Control Module (HPCM) and Electronic Brake Control Module (EBCM) allows the 2-mode system to interface transparently with the vehicle’s braking system. This feature extends brake life in city driving.

So until next time, remember: Success is built on the ability to do better than good enough.
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