Almost daily, I’m asked questions that no one has a complete answer to: Where’s this technology going to lead, and when is it going to stop? I wish I knew: If I had the answer to those questions, I’d be one of the wealthiest people on the planet.

In the auto industry you get to a point where you feel like we’ve invented everything that can be invented… but within a week or so, you see something new that you wish you’d thought of. Change isn’t a bad thing; in fact, it’s what keeps many of us from getting bored.

So what type of changes are you going to see in the future? The advent of 8-, 9-, and 10-speed transmissions; dual-clutch transmissions; hybrid transmissions; electric vehicles; and fuel cell-powered vehicles are starting to take off, and from what I’ve seen, these technologies will only continue to accelerate.

Why are manufacturers pushing hybrid, electric, and fuel cell vehicles and other technologies? We can answer that by looking at a few facts that are driving the OEMs:

- The world population is growing at a rate of five New York Cities per month.
- By 2050, over 70% of all the people on this planet will likely live in cities.
- At the current rate of consumption, the world will use more fossil fuels in the next ten years than it has since the beginning of recorded history.
- There’ll be 300 million “new” cars by 2025. If parked end to end, cars would circle the world 125 times.

Cars like the Chevy Volt and the Nissan Leaf looked like science fiction just a few years ago. Today the technology in those vehicles is starting to migrate into other vehicles. Let’s take a look at one of these segments: hybrid applications.

One such area that has seen this migration of technology into other vehicles is the 2-mode transmission. The 2-mode transmission was introduced in 2008 and was developed by a consortium of manufacturers including GM, BMW, Daimler, and Chrysler. Most manufacturers have embraced this technology, and some are using what they’ve learned to develop a 4-mode transmission.
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Since the 2-mode unit is the fore-runner of the soon-to-be-introduced 4-mode transmission, that’s where we should begin our understanding of these systems. GM and Dodge introduced the 2-mode in sport utility applications such as the Tahoe and the Durango. Let’s look at the GM unit so we’re clear regarding 2-mode operation.

The GM rear drive version is known as the 2ML70. It was given an RPO identification code of M99. The 2-mode transmission family is available in three different configurations: T-Rear Drive, U-Upscale Rear Drive, and F- Front Drive applications.

The 2ML70 has many advantages over its conventional transmission cousins, such as:

- Improved fuel economy (25%-50% gain in city driving)
- Improved performance
- Reduced tailpipe emissions

The key to the 2ML70 is the addition of two electric motors inside the transmission. The motors are used not only to drive the vehicle under certain conditions, but they also start the engine. That’s right: the transmission starts the engine.

Let’s take a look at what makes up this animal:

The type 2-mode is a continuously variable ratio, electric-hydraulic hybrid transmission. Four fixed gear ratios, two electric motors (providing infinitely variable ratios), with engine on/off operational capability.

**Gear Ratios:**
- 1st — 3.69:1
- 2nd — 1.70:1
- 3rd — 1:1
- 4th — 0.73:1
- EVT #1 — Infinity to 1.70:1
- EVT #2 — 1.70:1 to 0.5:1
- Reverse — Infinity to 1.70:1

- Max engine torque: 380 lb-ft (515 Nm)
- Max engine power: 369 bhp (275 kW)
- Two 65 kW (peak) electric motors (Drive Motor 1, Drive Motor 2)
- Y-wound, 3-phase, 300-volt AC permanent magnet
- Motor cooling accomplished by a transmission fluid circulation system

The transmission isn’t the only thing to change when a 2ML70 is installed into the vehicle. Many other systems are also affected. They include:

- New engine cam timing and oil pump designs
- Updated EVAP system
- New electric cooling fan system
- New engine coolant recirculation system

**Electric motor torque:** 242 lb-ft (320 Nm)

- 300-volt, 40-cell, nickel-metal hydride battery (located under the 2nd row seats)
- Auxiliary fluid pump keeps the transmission clutches applied during Auto Stop operation
- Vane-style oil pump (three selective slides and rotors)
- Three planetary gearsets
- Four multiple disk clutches (two holding, two driving)
- Two shift solenoids (On/Off design): SS1, SS2
- Six variable bleed solenoids: PCS, PCS2, PCS3, PCS4, PCS5, TCC (TCC not used)
- Two default actions: If in 3rd or 4th = 3rd gear; If in 1st or 2nd = 2nd gear
- Electronic range selection
- IMS (range position)
- Torque dampener 347 mm (no torque converter; limits to 17º movement)
- Dexron VI required; fluid capacity:
  - Fluid and filter — 11.5 quarts (10.88 liters)
  - Overhaul — 13 quarts (12.30 liters)
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So what about the transmission, how does it work? The 2ML70 contains two, 300-volt, 3-phase, 60-65kW AC motor/generator assemblies. The two permanent-magnet motors are mounted from each end of the transmission and supported by the shafts/bushings and a support assembly.

Six high-voltage (orange color) cables are attached to the transmission via a rigid conduit around the transmission, which transitions to flexible cable to attach the transmission to the Drive Motor Generator Control Module (DMGCM). Transmission fluid is used for normal transmission operation as well as to cool the drive motors.

The motors provide engine cranking, battery charging, transmission reverse operation, and two modes of Electronic Variable Transmission (EVT) operation. The front motor is used to start the engine, and it reacts to input from the rear motor for EVT operation. The rear motor drives the vehicle in reverse or when Auto Stop is activated and the vehicle operates on electrical power.

**Modes of Operation**

**Engine Starting** — The 2-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 motor can crank the engine at 800 RPM in less than a few hundred milliseconds.

**Auto Stop/Auto Start** — The Auto Stop feature is designed to reduce emissions output and engine wear, and improve fuel economy in city driving conditions. With the engine running, the Hybrid Powertrain Control Module (HPCM) may operate the engine in the Auto Stop/Start modes at any time, as long as the correct parameters have been met.

When the vehicle is operating in Auto Stop/Auto Start modes, the engine will typically shut off when the vehicle comes to a stop. The engine usually remains off as you accelerate unless you apply hard throttle or until road speed exceeds a predetermined level. During auto stop mode, the electric drive motor provides the torque that drives the vehicle.

Engine Off modes of operation will be displayed on the tachometer. If the tachometer indicates AUTO STOP, the engine may restart at any time if the proper parameters are met.

Auto Stop may activate under these conditions:
- Engine is running
- Hood is closed
- ECM isn’t requesting diagnostic information
- Gear selector isn’t in reverse or manual range
- Hybrid battery state of charge exceeds 20%
- Engine is warm
- Drive motor/generators haven’t overheated
- Power Inverter Module (PIM) temperature limits haven’t been exceeded
- No hybrid system faults are present
- The Hybrid Powertrain Control Module has determined that engine power isn’t required

The 2-mode system doesn’t require the engine to be running 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 HPCM determines additional power is needed, the Auto Start function will activate, and Drive Motor 1 will start the engine. This may occur even if the vehicle is in motion and operating in electric mode.

Auto Start may activate without notice if any of these conditions occur:
- Hood is opened
- ECM requests the engine to run
- Gear selector is placed in reverse or manual range
- Hybrid battery charge is low
- Hybrid battery voltage, temperature, or power limits have been exceeded
- Engine coolant temperature (ECT) is too low
- Drive motor/generator temperature limits have been exceeded
- Power inverter Module (PIM) temperature limits have been exceeded
- The Hybrid Powertrain Control Module has determined that engine power is required
- A hybrid system fault is present

**EVT Mode**

Three modes of operation are available in EVT mode: reverse, low, and high. In reverse, PCS 3 is commanded on, and rear motor 2 is used to drive the vehicle in reverse.

In high mode, PCS trim solenoid 3 is commanded off, shift solenoid 1 is commanded off, pressure switches 1, 3, and 4 open, the 2-3-4 clutch applies, and front motor 1 drives the vehicle.

In low mode a couple of driving modes are actually available: Low Mode Engine Off and Low Mode Engine On.

During Low Mode Engine Off, PCS trim solenoid 5 is commanded on, the auxiliary pump is turned on, the 1-2 clutch is applied, while rear motor 2 drives the vehicle.

During Low Mode Engine On, PCS 3 is commanded on, PCS 5 is commanded off, the 1-2 clutch is applied, front motor 1 starts the engine, and rear motor 2 drives the vehicle.

**Regenerative Braking/Blended Braking**

During deceleration 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 while slowing the vehicle.

Blended Braking — When you press brake pedal, Drive Motor 2 switches to generator mode, slowing the vehicle. The regeneration and blended braking modes are transparent as the Electronic Brake Control Module communicates directly with the Hybrid Powertrain Control Module.

As you can see, the 2ML70 is quite a unit. Next time we’ll look at some of the rules of service you must follow to repair this transmission. Until then, remember: Keep the shiny side up and the rubber side down.
MISSION: POSSIBLE

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