Development of a Hybrid Automated Manual Transmission

Program Capabilities:

SwRI® developed an Automated Manual Transmission (AMT) for a conventional powertrain, gasoline powered four-cylinder engine and four speed manual transmission passenger car application that was adapted for hybrid electric operation. The AMT system provided by SwRI included an AMT actuator controller, transmission shift actuators and clutch actuators. The AMT controller executed shifts based upon commands from the vehicle controller and coordinated the AMT operation with the electric drive system. Input signals for this system relied on existing sensors, which included throttle position, engine speed, and vehicle speed. It used additional sensors that were also required by the hybrid electric system such as throttle pedal position, brake pedal position, transmission/electric motor speed, grade and shift selector. In addition, position feedback sensors were used on the clutch and shift actuators.

SwRI designed and developed an electromechanical clutch actuator and electromechanical shift actuator. The clutch actuator uses a clutch load compensator to reduce the electrical power required for actuation by the DC permanent magnet motor. The shift actuator employs a direct actuation configuration that utilizes an individual DC motor to actuate each shift fork. Faster shift times are possible than with a system that has to shift through the H-gate. Faster shifting makes smoother operation possible with less torque dip and less jerk.

One of the enabling technology for this system was a SwRI proprietary software control code, entitled Autoshifter™. The Autoshifter™ software provides four basic functions as follows:

1. During launch, Autoshifter™ engages the clutch while simultaneously controlling engine speed to provide a smooth launch. Some features that the software provides regarding this includes: clutch feathering, engine stall prevention, engine-transmission speed matching, grade sensing and prestaged first gear selection when the vehicle is at rest. Unique capabilities incorporated into this software compensate for non-linear characteristics of the clutch, friction effects and system hysteresis.
2. During shifting, Autoshifter™ determines the correct gear as a function of the driver's requested pedal command and the road load conditions imposed on the vehicle. Through automatic actuation of the shift forks, coordination with the clutch pedal and direct control of the engine, reductions in shift times are realized along with simultaneous improvements in vehicle acceleration and fuel consumption. To compensate for operation during uphill and downhill driving, a grade sensing compensation capability is incorporated into the code.
3. During shifting between different shift forks, Autoshifter™ is able to coordinate the disengagement and engagement of adjacent gears to minimize the shift time. Autoshifter™ can also operate with shift actuators that use a conventional H-gate actuator system. Autoshifter™ compensates for the non-repeatable characteristics, coarse tolerances and wear associated with the mechanical hardware.
4. For hybrid-electric applications, Autoshifter™ also coordinates shifting and gear synchronization with the electric drive motor/generator.

Autoshifter™ employs a control strategy that uses logic based techniques, and is heavily integrated with classical control methods such as gain scheduled proportional integral derivative (PID) control. To account for variations due to driving conditions such as grade and road resistance, adaptive change of the PID gains is performed.

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