The Increased Reliance on Sensors

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The prevalence of intelligent transmissions, dual clutch and semi-active gearboxes is becoming increasingly widespread. These transmissions work to either optimize engine output to the most appropriate gear ratio and/or to improve the precision of gear selection to reduce losses. The main driver towards intelligent transmission fitment has been the advent of evermore demanding emissions legislation. Current intelligent transmissions, through selection of the most efficient gear to engine output, have the potential to save 6 % on average fuel consumption. Future developments, for example the electronic actuation of the dual clutch transmission versus the current hydraulic method, have the potential to provide savings of up to 18 % in fuel consumption. On some high performance vehicles such transmissions have facilitated improved launch control and enhanced vehicle stability when networked with the vehicle sensor suite.

When using an intelligent transmission, the driver only needs to send the order to shift up or down to a transmission control unit (TCU) and the TCU automatically shifts the gear by hydraulic or electric actuation. Intelligent transmissions consist of several different types to include step-automated, continuously variable, and more recently dual-clutch transmission. Electronic transmission management systems operate on an event-controlled basis always selecting the gear that provides the right amount of torque to meet the driver's request with the combustion engine operating in the most favorable map range, i.e. the range producing the lowest level of consumption and emissions. For automobile manufacturers, this is extremely important because it provides the means for reducing fleet consumption and, associated with this, carbon dioxide emissions. The main drive in intelligent transmission development has been to increase the number of gear ratios available. This has led to the advent of seven to nine speed automatic transmissions for passenger cars. The higher selection of gears allows for more use of the engine's power band, allowing either better fuel economy, by staying in the most fuel efficient part of the power band, or higher power output, by staying closer to the engine's peak power. These systems replace human intuition (engine noise and perception of speed) with robust, non-contact sensors that can provide absolute positional gear and clutch position feedback. Even manual gear selection is pushed to ist limits over six speeds because to cut fuel consumption it is necessary to change gears at exactly the right moment. Modern electronics are far more precise and faster in selecting the appropriate gear in a shorter timeframe than the average driver. For example, Volkswagen Golf equipped with a DSG transmission takes 8 msec to up-shift versus 500 msec to 1 sec for a manual gearbox equipped Golf; where drivers and their driving ability determine shift speed. Porsche, however, will launch a seven speed manual transmission on the next generation 911. A typical intelligent transmission today contains a suite of sensors. Depending on the application and the measurement required, Bourns has the capability to supply rotary, linear and transmission speed sensing capability. The vast majority of transmission sensors delivered today by Bourns are based on either non-contact Hall Effect or Magneto- Resistive sensing with the choice of an analog, CAN or PWM output. Non-contacting sensors offer several benefits over traditional potentiometer-based sensors; for example low wear, robustness against vibration and the ability to program the sensor for calibration purposes. The Bourns® linear and rotary position sensors can be located outside of the gearbox (the casing must be cast from a non-ferromagnetic material) or can be incorporated into the gearbox environment. For external applications the sensor is located outside the transmission and the magnet is attached to the selector shaft. The choice of location will create some specific sealing and temperature requirements. The average intelligent transmission consists at a minimum of a clutch position sensor, a PRNDL sensor and a gearbox speed sensor. Some transmissions may additionally incorporate a separate park position sensor which prevents gear selection if the driver does not have the brake pedal depressed; a necessary safety requirement to prevent the car from lurching forward if a gear is engaged. Bourns produces two type of transmission speed. They are referred to as TISS (transmission input speed) and TOSS (transmission output speed) sensors. The TISS sensor sends a varying frequency signal to the TCU to determine the current rotational speed of the input shaft or torque converter. The TCU uses the input shaft speed to determine slippage across the torque converter and potentially to determine the rate of slippage across the bands and clutches. This information is vital to regulate the application of the torque converter lockup clutch smoothly and effectively. The TOSS sensor accordingly sends a varying frequency signal to the TCU to determine the current speed of the vehicle. The TCU uses this information to determine when a gear change should take place based on the various operating parameters and is also used to provide an indication of speed to the speedometer on the dashboard. Automatic transmission types that provide a manual mode operation (e.g. tiptronic or sequential gearboxes) include some means of forcing a downshift into the lowest possible gear ratio if the throttle pedal is fully depressed. In many older designs, kickdown was accomplished by mechanically actuating a valve inside the transmission. Most modern designs use a solenoidoperated valve that responds to the input of several active sensors (TPS, ESC and ABS wheel speed) after an abrupt increase in engine power is detected. Active feedback ensures the optimum sequence is determined between the TCU and ECU. This is especially notable on an uphill road, where cars with automatic transmission need to slow down to avoid downshifts, whereas cars with manual transmission and identical or lower engine power are still able to maintain their speed. The manual transmission can also be put into a lower gear ahead of time, to make rapid acceleration, such as when overtaking on the highway, more instantaneous. Intelligent transmissions improve on the performance of automatic transmissions by using wheel speed sensor inputs to determine via the true speed of the vehicle if it is traveling downhill or uphill and adapt gear changes according to the engine load. The wheel speed sensor also assists in determining if the torque converter should be decoupled at a standstill to improve fuel consumption and reduce load on the running gear. Bourns offers active wheel speed sensors for ESC and ABS applications from which the wheel speed signal can be transferred to the TCU. Interconnectivity is an important capability of modern non-contact sensors particularly when matched to a CAN network. While not specifically incorporated into the gearbox; signals from both a vehicle’s throttle position sensor (TPS) and electronic throttle control (ETC) may also be utilized by the TCU. Their input is used to determine the optimum time and characteristics for a gear change according to the load on the engine. The rate of change is used to determine whether a downshift is appropriate for overtaking again resolving one of the criticisms of an automatic transmission. The value of the TPS is also continually monitored during the journey and shift programs are changed accordingly (economy, sport mode, etc.). The TCU can also compare TPS information with wheel speed to determine vehicle acceleration and compare this with a nominal value; if the actual value is much higher or lower (such as driving uphill or towing a trailer) the transmission will change its gearshift patterns to suit. Manual transmissions have had the advantage on slippery surfaces of being started in second gear. This is done to reduce torque multiplication when moving off from a standstill on surfaces with limited traction; i.e. on snow- or icecovered roads. Many TCUs now use an input from the traction control system (TCS) to detect unfavorable traction, a signal is sent to the TCU which can modify the shift programs by upshifting early, eliminating torque converter lock-up, bypassing first gear totally to allow pulling off in second gear. Many TCUs also use a signal from the cruise control module to change gear behavior if the throttle is not being operated by the driver, this eliminates unexpected gear changes when the cruise control is engaged. As previously discussed, sensors are not exclusively fitted to assisted transmissions but are also incorporated into manual transmissions. Manual shift vehicles are often now equipped with gear optimization indication systems which alert the driver to shift up or down depending on gear position and transmission speed feedback. The Bourns® Neutral- Reverse gear sensor is used on both manual and automatic transmissions. For manual transmissions it is used to determine the neutral gear position for stop/start applications. The start/stop system shuts the engine down automatically when the vehicle comes to a stop. For a vehicle with manual transmission, this will take place once the gear lever is in neutral and the clutch pedal has been released. On automatic transmission vehicles equipped with stop/start, the engine switches off after the brake pedal has been depressed. Activation of the clutch or, in the case of automatic transmission vehicles, releasing the brake pedal will restart the engine. An automatic transmission uses neutral gear detection as a safety function to disable the starter operation if the gear selection is not in either neutral or park mode. If the engine was allowed to start in any other gear the car would immediately lurch forward once the engine is started. This is why automatic transmissions with stop/start use the brake pedal release as a restart trigger and not the neutral position as per a manual-shift vehicle. Neutral position detection to prevent in-gear starting is applied on automatic transmissions only. A manual transmission vehicle utilizes a clutch position switch for this function. On most vehicles the reverse light function is integrated into the neutral position sensor. One option available with the Bourns® Neutral-Reverse sensor is the possibility to incorporate two ICs within the package; by switching the orientation of the ICs it is possible to create two very different outputs which ensures the TCU detects a clear difference between neutral and reverse gear selection even if they are located on the same linear plane. The reverse gate sensing function is commonly used to engage the reverse lights but may also be used to trigger parking sensors, apply the electromechanical park brake (EMPB) and reverse camera aids when the reverse gearbox position is detected. One of the relatively more recent transmission developments has been the fitment of the dual clutch transmission (DCT). DCT combines the advantages of manual shift with an automated clutch function. When changing gears, the engine torque is transferred from one gear to the other continuously, providing smooth gear change, without losing power or enduring shudder. Shudder can occur wherever there is a gradual engagement or disengagement between two friction surfaces. It is a particularly sensitive issue in modern automatic transmissions. To ensure these clutch actions are imperceptible, the clutches are deliberately allowed to slip as they engage and disengage. An odd gear can be pre-selected on one gear shaft while the vehicle is driven in an even gear allowing quicker shifts. Bourns has the capability to supply linear sensors for this purpose with a resolution error of

Portrait

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