Application Brief

Position Sensing in Automotive Body Motors

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Introduction

Monitoring motor position is crucial for enabling both standard and luxury features in modern automobiles. This document explores various methods and applications of position sensing in different motor modules used in cars, enhancing functionality and user experience.

Figure 1 shows many of the functions within automotive body motors that require position sensors.

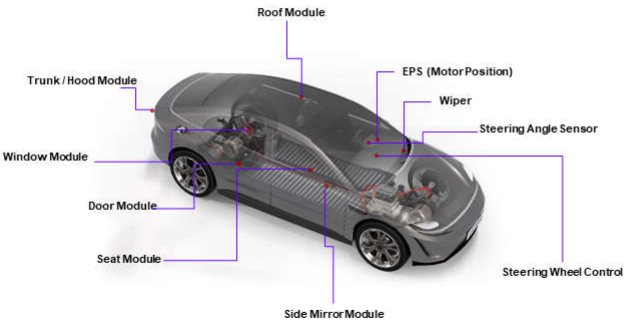

Figure 1. Automotive Body Motor Position Sensor

Precise Position Monitoring

In contemporary vehicles, precise position monitoring is essential for features like programmed steering wheel position, curb viewing in side mirrors, as well as advanced seat adjustments. This involves using sensors such as Hall effect sensors to provide accurate feedback for motor control. A common mechanical configuration for these motor modules includes a worm gear on the motor shaft which drives the worm wheel. This worm wheel in turn can be used to move an arc gear, another worm gear for lateral movement, or a rod for repetitive periodic movement. For a visual representation of this, see Figure 2,

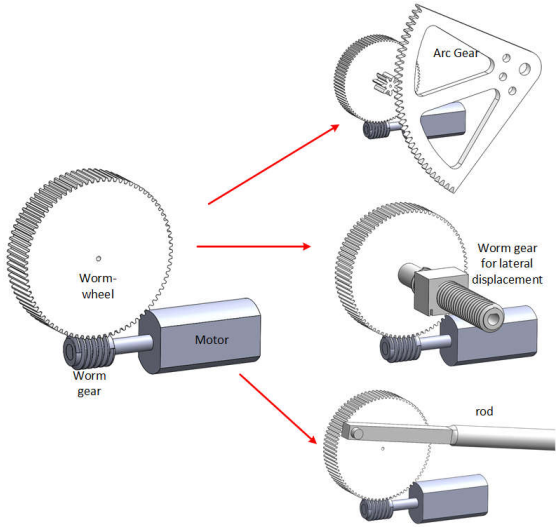

Figure 2. Worm-Wheel Implementations

Ring magnets and diametric magnets can be placed on any of the gear axes for motor encoding such as in Figure 3 and Figure 4. Figure 3 shows a ring magnet on the worm gear shaft with a 2D latch device like the TMAG5111-Q1 to count pole-transitions. Alternatively, two discrete DRV5013-Q1 1D latches can be used. Either approach requires calibration for initial position and storing count values in non-volatile memory. Figure 4 shows a diametric magnet with the TMAG5170-Q1. The diametric magnet option provides high resolution within a single rotation and does not need memory to remember the magnet's current position for a single rotation.

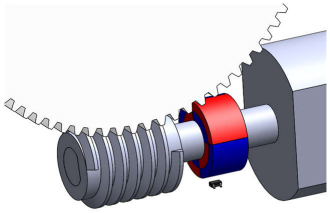

Figure 3. Ring Magnet Encoder

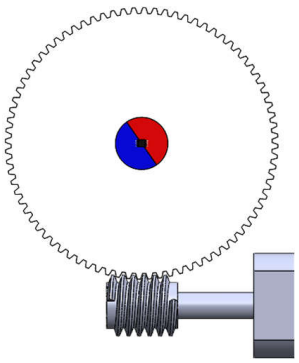

Figure 4. Diametric Magnet Encoder

For lateral movement, a magnet can be monitored by a linear device like the DRV5055-Q1 (analog output), DRV5057-Q1 (PWM output), TMAG5170-Q1 (SPI output), or TMAG5173-Q1 (I2C output) such as in Figure 5.

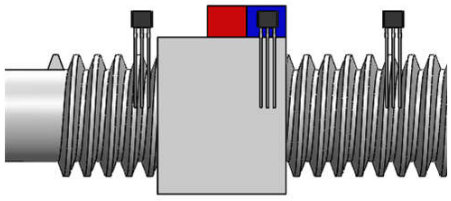

Figure 5. Lateral Movement

While the magnet moves laterally as shown in Figure 5, the magnet's movement can also be mechanically translated to a yaw or pitch angle such as what can be found in a side mirror. With this, for any mechanical system there may be both rotational or lateral movement and therefore multiple potential approaches that can be used to monitor the state of the system.

End of Travel Monitoring

Certain features, such as sliding doors and folding mirrors, require monitoring only specific positions (for example, fully open or closed). Modules like windshield wipers, typically do not need precise position monitoring except for finding the default resting position. End of travel sensors provide simple yet effective feedback for these applications, prompting when motors can disengage.

Initiating Movement

Sensors can also be used to determine when a motor engages. Tactile buttons and proximity sensors can initiate actions like steering wheel adjustment or door lock disengagement, enhancing vehicle usability and safety. Other luxury features like autofold seating can also require sensors to detect weight or obstruction to make sure that the intended feature action can be executed safely.

Door Modules

For front and rear doors, end of travel monitoring is crucial in verifying if the door is fully closed or open. This feedback is essential for engaging the locking mechanisms. When a key fob is present, capacitive sensors like the FDC1004-Q1 can be used to trigger the lock to disengage when a hand is detected near the handle. Additionally, 1D linear latches, like the DRV5015-Q1 and the DRV5013-Q1, can also be used to help detect when a door is fully closed or is still open using a magnet and monitoring the magnetic field.

Sliding doors benefit from both precise position monitoring and end of travel sensors. Monitoring the door's position helps to maintain smooth operation, while detecting full open or closed states to engage the motor appropriately.

Roof Motor Module

The roof motor module, responsible for operations such as opening and closing sunroofs, relies on precise position monitoring to provide accurate movement and user control. Devices like the DRV5015-Q1 and the DRV5013-Q1 can be used to detect each wheel revolution by detecting a magnet mounted on the rotating shaft which can then be counted to help determine the position of the motor.

Seat Modules

Standard seat adjustments, including forward, backward, raising, lowering, and tilting, use linear actuators and position sensors to offer tailored seating positions that can be programmed in memory. Advanced features like lumbar support and massaging functions in seats require precise position monitoring. Latches like the TMAG5111-Q1 track adjustments to provide customized comfort settings for users. Maintaining correct seat position, particularly for entry assistance, involves using end of travel switches like TMAG5123-Q1. These sensors help adjust the seat and steering wheel to facilitate easy entry and exit for the driver.

Side Mirror Module

In the past, drivers simply adjusted mirrors visually. Now modern vehicles offer programmed user settings, allowing mirrors to auto-adjust based on the key fob used, the press of a button, or other user-distinguishing mechanisms. Additionally, luxury cars feature curb viewing, adjusting mirror orientation to facilitate parking. These features can be realized through pulse generating latches like TMAG5111-Q1 or 3D sensors like TMAG5170-Q1.

Steering Wheel Module

Electric power steering (EPS) systems are comprised of three essential components: the electronic control unit (ECU), the electric power assist motor, and the steering position sensor. The steering position sensor is responsible for detecting the steering wheel's position. Steering position sensors often utilize 1D Latch sensors such as the DRV5013-Q1 and the DRV5015-Q1. This technology incorporates precise position monitoring, end of travel, and initiating movement functionalities to modify the height and distance of the steering wheel. Devices like the TMAG5170-Q1 and the TMAG5173-Q1 can also be used for steering position sensors to measure the position of other HMI systems on the steering wheel.

Trunk Module

The trunk module, responsible for opening and closing the trunk, benefits from end of travel monitoring to help determine if the trunk is fully opened or closed. When a key fob is present, capacitive sensors like the FDC1004-Q1 can be used to trigger the lock to disengage when a hand is detected near the trunk or when a foot kicks the back bumper. Alternatively, an ultrasonic device like the PGA460-Q1 can be used to detect the presence of a foot near the bumper. This feedback is essential for proper motor engagement and user convenience.

Window Module

Each door is equipped with a single window module switch, with the primary module positioned on the driver's door. These switches utilize magnetic sensor technology to determine the operational status of the switch based on functionality. The integration of devices like the TMAG5131-Q1 and the DRV5021-Q1 can be used in these applications. Each switch is linked to a corresponding window motor module. Additionally, 1D latches, like the DRV5015-Q1 and the DRV5013-Q1, can be employed for rotary encoders. These devices can be used to receive a signal when the switch is manually activated, allowing the window to move in the appropriate direction. To enhance the functionality of the window module and control the window motor's stopping point, the end-of-travel mechanism is implemented as described in the previous section.

Wiper Module

The wiper module incorporates a variety of sensors, ranging from ultrasonic to magnetic sensors. The operation of rain-sensing wipers is straightforward as these wipers utilize a light-emitting diode to detect rainfall. Once rain is detected, a signal is sent to the motor, activating the wiper. Texas Instruments' advanced technologies, specifically the DRV5013-Q1 and DRV5015-Q1, provide high bandwidth and sensitivity through one-dimensional latches, which are essential for rotary encoding and motor commutation. Additionally, the wiper module's functionality is enhanced by the end-of-travel mechanism, which determines when to stop the wiper motor, as previously discussed.

Table 1. Recommended Devices

Sensing Application	Problem	Suggested Sensor	How Sensor Improves Function
Front / Rear Door Module	To verify the position of the door close/open for safety and locking mechanisms	TMAG5124-Q1	Hall-effect switches are used to sense the open/close states
		DRV5023-Q1	
		TMAG5123-Q1	
		FDC1004-Q1	Capacitive sensors are used to trigger the lock to disengage when a hand is detected near the door handle
Sliding Door Module	To appropriately set governance on sliding door with end of travel	TMAG5124-Q1	Hall-effect switches are used to sense the open/close states
		DRV5023-Q1	
		TMAG5123-Q1	
		FDC1004-Q1	Capacitive sensors are used to trigger the lock to disengage when a hand is detected near the door handle

Table 1. Recommended Devices (continued)

Sensing Application	Problem	Suggested Sensor	How Sensor Improves Function
Roof Module	To open and close the sunroof and know the position	DRV5013-Q1	Hall-effect latches with high bandwidth and low power can detect each wheel revolution by detecting a magnet mounted on the rotating shaft
		DRV5015-Q1	
		TMAG5110-Q1/ TMAG5111-Q1	2D hall-effect latches can be mounted near a rotating multi-pole magnet, or a magnet rotating at a higher rate than the main axle. This provides the direction and speed of the sunroof
		FDC1004-Q1	Capacitive touch sensors are used in the switch button of the sunroof
Side Mirror Module	To auto adjust the side mirror for the driver, and also fold the mirror for park mode	TMAG5110-Q1/ TMAG5111-Q1	2D hall-effect latch with a ring magnet on the worm gear shaft. to know the speed and direction
		TMAG5170-Q1	3D hall-effect sensors that can monitor the position of a diametric magnet on the worm wheel with high accuracy and performance
		TMAG5173-Q1	
		DRV5013-Q1	Hall-effect latches with high bandwidth and low power that can be used to detect each wheel revolution by detecting a magnet mounted on the rotating shaft
		DRV5015-Q1	
Steering Wheel Module	To the angle of the steering wheel and give the feedback to the motor	TMAG5173-Q1	3D hall-effect position sensors can measure the position of other HMI systems on the steering wheel
		TMAG5170-Q1	
		DRV5015-Q1	1D hall-effect latches with high bandwidth and high sensitivity can be used for motor commutation
		DRV5013-Q1	
		TMAG6180-Q1/ TMAG6181-Q1	2D AMR sensors are used for angle detection and turns counting for the HMI system
Trunk Module	For opening and closing the trunk	FDC1004-Q1	Capacitive sensors are used to trigger the lock to disengage when a hand is detected near the trunk or when a foot kicks the back bumper
		TMAG5110-Q1/ TMAG5111-Q1	2D latch with a ring magnet on the worm gear shaft. to know the speed and direction
		DRV5013-Q1	Hall-effect latches with high bandwidth and low power that can be used to detect each wheel revolution by detecting a magnet mounted on the rotating shaft
		DRV5015-Q1	
		PGA460-Q1	Ultrasonic device used to detect the presence of a foot to open the trunk
Window Module	For the power button of the window module and also to monitor end of travel	DRV5023-Q1	Hall-effect switches are used for the button press on the control module
		TMAG6180-Q1/ TMAG6181-Q1	2D AMRs are used for the turns counter and angle measurement
		TMAG5110-Q1/ TMAG5111-Q1	Hall 2D latches are used for rotary encoding to count the number of rotations of the shaft
		DRV5013-Q1	1D latches are used to know and location of the of the window connected to the rotatory shaft for end of travel.
Wiper Module	To provide a signal that is used to stop the wiper motor and monitor end of motion	DRV5013-Q1	1D latches are used to know the motion and location of the wiper.
		TMAG5173-Q1	3D hall sensors are used help determine the exact position of the wiper
		DRV5053-Q1	1D linear devices are used to detect if the wiper is in the default position

Table 2. Related Technical Resources

Name	Description
Automotive Door Handle Module Using Hall, Inductive and Capacitive Sensors	A technical document on how to design an automotive door handle module using positions sensors
Automotive Door Handle Design with Position Sensors	A technical document on how to design an automotive door handle module using positions sensors
Tracking Slide-By Displacement with Linear Hall-Effect Sensors	An application notes of how hall sensors can use for slide detection and implement for automotive sliding door application
Hall Sensor and Magnet Selection for Auto Body Motor Module Design	A discussion about how to select the sensor and the magnet for the specific application
Incremental Rotary Encoders	An application notes of how the hall sensor can be used for the incremental rotary encoding application
Using Hall-Effect and Inductive Sensors in Automotive HMI Applications	A technical document on how to design an HMI system using positions sensors
PGA460-Q1 in Automotive Ultrasonic Kick-to-open Liftgate Systems	An application notes of how the ultrasonic sensor can be used for the kick to open liftgate application

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