

Electric Shift System for FCX Clarity

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ABSTRACT

An electric shift system has been developed for the FCX Clarity, a vehicle incorporating numerous Honda advanced technologies. Optimizing the size of the shift-by-wire (SBW) shifter and setting an operation load and stroke that make the shift easy to use has enabled the realization of an advanced design. A parking actuator has been used to lock and release the transmission parking gear, and control by means of an electronic control unit (ECU) has enabled the achievement of fast responsiveness. The engineering of redundancy into the SBW shifter and parking actuator control unit has helped to ensure reliability. In addition, an alternative means of operating the parking gear has been provided in the event that the battery stops supplying power.

1. Introduction

The development and diffusion of electric and fuel cell vehicles is an important means to help the reduction of the environmental impact of automobiles. Honda commenced leasing of the production fuel cell vehicle FCX in Japan and the U.S. in 2002, and since then has worked to make further strides in the evolution and enhancement of the performance of its fuel cell vehicles. Shifters for automatic transmissions have conventionally been positioned on the instrument panel or the center console. The recent appearance of electric shift systems in the market has enabled the location of shifters in easy-to-use positions and the realization of advanced design. The employment of electric shift system increases the degree of freedom of positioning and modes of operation used, enabling a balance between advanced design and operability at a higher level.

This paper discusses the development of an electric shift system to enable a realization of the enjoyment offered by a futuristic style of operation, which was one of the development goals for the FCX Clarity, in addition to the element technologies employed in order to reconcile advanced design with operability.

2. Development Goals

The main goals set for the development of the electric shift system were as follows:

- (1) Realization of a high level of shifter operability
- (2) Realization of an advanced design by integrating the shifter with the meter visor
- (3) Realization of rapid responsiveness to driver input

3. System Configuration

3.1. Overall Configuration

Figure 1 shows the overall configuration of the electric shift system. The shift-by-wire (SBW) shifter, which enables the driver to control the shift position, is positioned in the meter visor.

In addition to input and output to and from the electric shift system (shifter signal and position sensor signal input, parking actuator control unit signal input and output, and the like), electric shift control required a variety of other parameters, including brake signal, accelerator pedal signal, and vehicle speed signal. Processing is therefore conducted in an electric control unit (ECU) that controls all powerplant systems.

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Figure 2 shows a diagram of the electric shift control system.

The ECU and the parking actuator control unit, which controls the parking actuator, are positioned in the instrument panel. The parking actuator, which locks and releases the transmission parking gear, is located on the electric motor case.

3.2. SBW Shifter

Figure 3 shows an external view of the SBW shifter and the parking switch. The SBW shifter knob is positioned to enable the driver to reach it by a slight extension of the hand from the steering wheel. Together

with designers, the project team created a number of possible knob forms, eventually deciding on the final form as the one that enabled a simple fingertip operation based on tests of operability. The size of the SBW shifter has been optimized in order to enable realization of a design that integrated the shifter with the meter visor at the side of the meters.

Figure 4 shows the configuration of the SBW shifter. The sensor section, which converts the driver's operations into electrical signals, is separated from the mechanical section. This configuration helps to ensure that the mechanical section bears the load generated by the driver's operation of the shifter, without affecting the

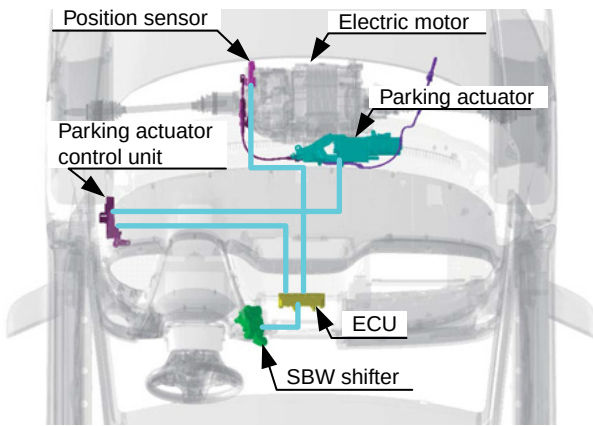


Fig. 1 SBW system layout

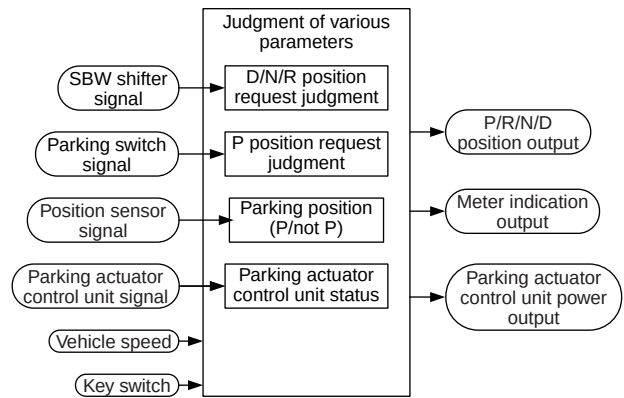


Fig. 2 Control system block diagram



Fig. 3 SBW shifter

sensor section.

The operation of the SBW shifter is converted into electric signals by multiple sensors and directly input to the ECU. In order to help prevent mistaken shift selection due to a sensor malfunction, the sensor output patterns for each position have been configured by combining sensor signals.

Figure 5 shows the shift pattern of the SBW shifter. In order to enable operation from the same starting position and in the same pattern for each position⁽¹⁾, the SBW shifter has been provided with a home position to which it will return if the driver removes his or her hands from the SBW shifter knob. The D position can be smoothly selected by pushing the SBW shifter knob to the lower left, while the R position requires a U-shaped movement, a pattern that helps prevent mistakes in operation. In addition, a parking switch that enables the driver to shift to P position from any other position has been fitted below the SBW shifter, thus reducing the time required for operation. Tests were conducted to determine the shift pattern design that was easy to comprehend visually from among a number of proposed designs, leading to the selection of a design in which the direction of motion of the SBW shifter knob was marked by arrows.

3.3. Parking Actuator

Figure 6 shows the configuration of the parking

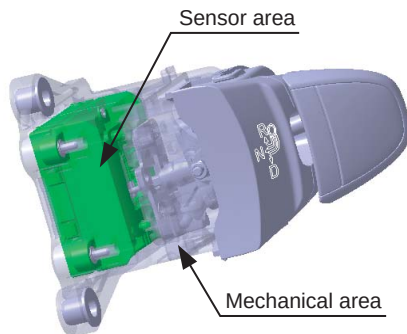


Fig. 4 Configuration of SBW shifter



Fig. 5 Shift pattern

actuator. The parking actuator locks and releases the parking gear by means of a control wire.

Figure 7 shows the mechanical section of the parking actuator. The rotation of the motor is converted to the stroke of a linear shaft by a ball screw. The high efficiency of the ball screw enables manual stroke of the linear shaft.

Locking and release of the parking gear is set by the positioning of a detent. To enable coordination of the control of parking actuator and the positioning of detent, there is some play in the linear shaft stroke in relation to the contact surface of the ball screw, which helps to ensure that there is no effect from the positioning of the ball screw or variations in the dimensions of the control wires, and the like. Figures 8 and 9 show an example.

The parking actuator is also provided with a manual control wire that enables it to be moved by hand in order to release the parking gear when the battery is not supplying power. Manual release of the parking gear is shown in Fig. 10. The pulling load required for release of the lock has been set to enable the user to release the lock using only a small tool like a Phillips screwdriver.

3.4. Parking Actuator Control Unit

By contrast with conventional mechanical shift systems that lock and release the parking gear mechanically, locking and release is electrically controlled in the electric

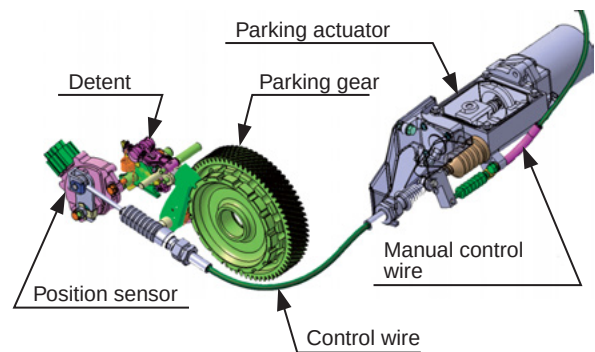


Fig. 6 Parking actuator layout

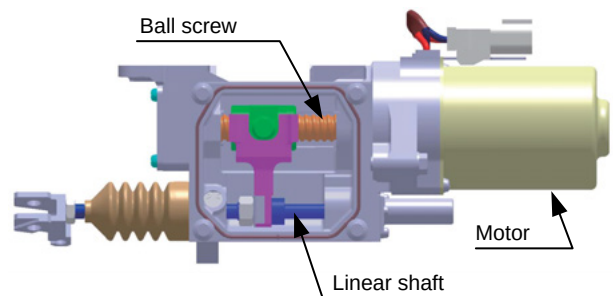


Fig. 7 Parking actuator

shift system. Redundant circuits have therefore been employed in the system to help to ensure that mistaken operation does not occur and the parking gear can be locked and released even if an electrical malfunction occurs in one part of the system.

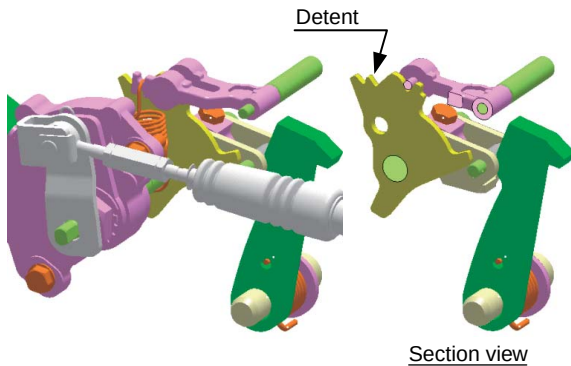


Fig. 8 Transmission detent

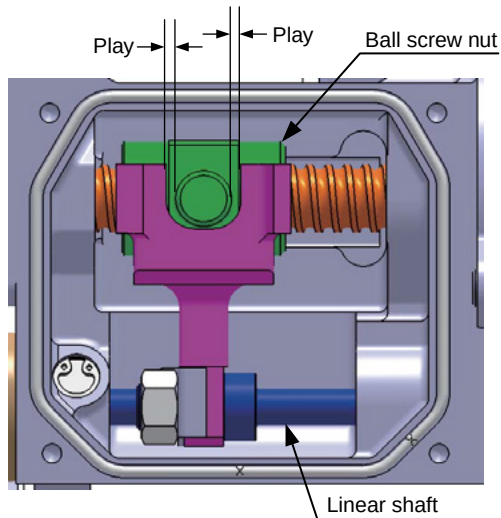


Fig. 9 Play in ball screw nut



Fig. 10 Parking lock release

4. Electric Shift Control

4.1. Non-mechanical Shift Lock Control

Automatic transmissions are provided with a shift lock function to prevent shifting from P position unless the brake pedal is depressed. The shifter has conventionally been directly connected to the lock mechanism of parking gear, and the shift lever has therefore been prevented from moving by mechanical means. Because the SBW shifter lever is not fixed in a selected position, the use of a control method in which the results of operation of the shifter are not reflected in engagement of the shift when the conditions for release of the parking gear are not met (non-mechanical shift lock) has enabled realization of a shift lock function in the SBW shifter without employing additional devices such as solenoids.

4.2. Automatic Parking Gear Control

Automatic transmissions are provided with a key interlock function preventing the key from being removed if the shifter is not in P position. In the electric shift system, P position is automatically selected when the key switch is switched to I (accessory), enabling the driver to remove the key without considering the position of the shifter.



Fig. 11 Shift lock in operation



Fig. 12 R inhibitor in operation



Fig. 13 P inhibitor in operation

4.3. P/D/R Inhibition Control

Automatic transmissions require control systems to help ensure that mistaken operation (for example shifting to P position or the reverse position while driving) does not result in breakdown or vehicle instability. In the electric shift system, shifting to opposite position at a high vehicle speed is judged to be an invalid operation, and the system will automatically select neutral position. Switching to P position while the vehicle is in motion is also judged to be an invalid operation, and the control system will function to maintain the position prior to the operation of the P switch by the driver.

4.4. Electric Shift Operation Assist

The mode of operation of the electric shift system differs from that of a conventional automatic transmission. A multi-information display has therefore been used to inform the driver of the correct method of operation when the operation and results of the operation differ. Figures 11 through 13 show examples of displays.

4.5. Fail-safe Control

In order to safely control the vehicle in the event of an incorrect shift setting selection or an incorrect operation of the system due to a malfunction, malfunctions in various elements are accurately detected and a warning is displayed. Control is applied to help prevent operation of the SBW shifter from being reflected in shift settings if the malfunction continues.

5. Performance

5.1. SBW Shifter Characteristic

Figure 14 shows the results of subjective evaluation of the operation load and stroke of the SBW shifter. Evaluation tests were conducted while changing the operation load and stroke. A load of 4.9 N and stroke of

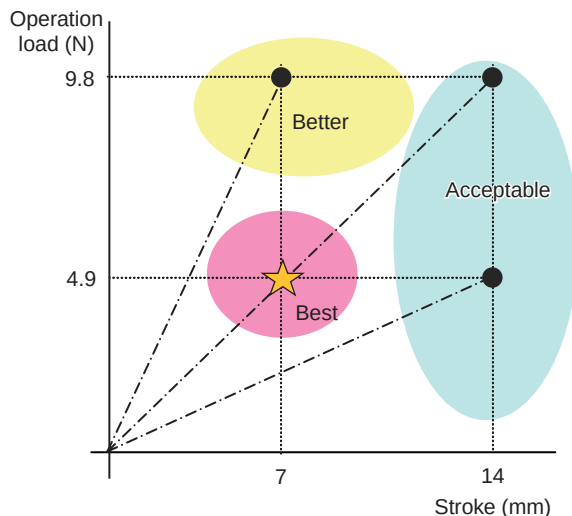


Fig. 14 Rating of SBW shifter operation

7 mm were evaluated most highly, and these settings were therefore selected. In addition, the load that automatically returns the shift knob to home position was optimized for balance with the operation load.

5.2. Parking Actuator Characteristic

During operation of the parking actuator, the present position of the actuator is judged on the basis of the transmission position sensor signal, and the actuator is moved to the position indicated by the ECU. This position switching is detected based on the position sensor signal and then the motor is stopped. Only the linear shaft continues moving, and is stopped by the transmission detent. Position switching displays rapid responsiveness even when shifted from parking to another position. Figure 15 shows an example of parking actuator control.

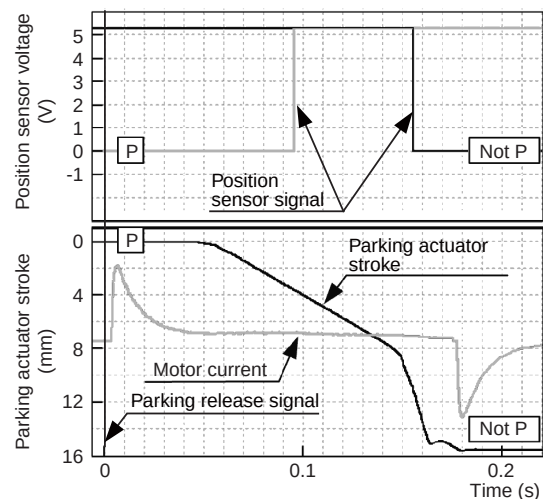


Fig. 15 Example of parking actuator control

6. Conclusion

An electric shift system has been newly developed for the FCX Clarity, which was released in November 2007. Optimized operability and advanced design have been achieved by the development project.

- (1) The use of a new shift pattern and setting the optimized operation load and stroke have increased ease of use.
- (2) Appropriate size of the SBW shifter enabled the realization of an advanced design in which the shifter was integrated with the meter visor. The SBW shifter was positioned at the side of the meters, within easy reach from the steering wheel, which contributed to enhanced readability.
- (3) Rapid responsiveness in switching shift positions has been achieved.

In the future, additional enhancements will be incorporated with the goal of increasing the number of vehicles equipped with electric shift system.

Reference

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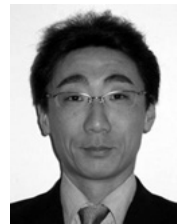
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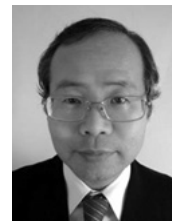
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