A Review On Anti-Trap Mechanism In Automotive Perspective

Muazzin Mupit
Industrial Automation Section
Universiti Kuala Lumpur Malaysia France Institute
Bandar Baru Bangi, Selangor, Malaysia
muazzin@nfit.unikl.edu.my,

Abstract — In today automotive industry, many features are added in power window system. For instance, KÜSTER Holding GmbH Germany produced its safety system called, Anti Trap System, with immediate reversal of the window in the event of entrapment. Thus, it gives full and reliable protection for children’s hand, neck and any obstacles as well. In this review, several anti-trap mechanism in automotive industry in the form of mechanical, electrical and electronics equipment are shown. These safety regulations are required by federal authority for instance Federal Motor Vehicle Safety Standards and National Highway Traffic Safety Administration (NHTSA) for power-operated window, partition, and roof panel systems.

Keywords: anti-trap system, power window system, roof panel system

INTRODUCTION

The first electric power windows were introduced by Lincoln which operated under the Ford Motor Company [1]. These windows are driven by a small electric motor inside the door and have come to be universal in the industry. Prior to that, in the few vehicles offering this feature, the windows were driven by hydraulics or off the engine vacuum[2]. In the 1950s, electric power was applied to the tailgate window in many station wagons. In a typical installation, there is an individual switch at each window and a set of switches in the driver's door so the driver can operate all the windows. However, some models have used switches located in the center console, where they are accessible to all the occupants. In this case, the door-mounted switches can be omitted.

Conventional power windows are usually inoperable when the ignition is turned off. However, many modern cars have a time delay features and according to Wikicar, first introduced by Cadillac which called retained accessory power. This allows operation of the windows and some other accessories for ten minutes or so after the engine is stopped. Another fairly recent innovation, pioneered by Nissan at about the same time, is the express-down window, which allows the window to be fully lowered with one tap on the switch, as opposed to holding the switch down until the window retracts [3].

Power windows have come under some scrutiny after several fatal accidents in which children's necks have become trapped, leading to suffocation. Some designs place the switch in a location on a hand rest where it can be accidentally triggered by a child climbing to place his or her head out of the window. To prevent this, many vehicles feature a driver-controlled lockout switch, preventing rear-seat passengers (usually smaller children) from accidentally triggering the switches. This also prevents children from using them as toys and pets riding with their heads out windows from activating the power window switch.

In documented power window cases involving child injury or death, children often were left inside a vehicle without adult supervision. Children put their heads and/or arms outside the window and inadvertently leaned, knelt or stepped on the window switch or in some other way triggered the power window. There also have been cases in which an adult unknowingly trapped a child when closing a window [4].

Therefore, starting with the 2008 model year, U.S. government regulations required automakers to install power window controls that are less likely to be accidentally activated by children [5]. However, the rules do not prevent all potential injuries to a hand, finger, or even a child's head, if someone deliberately holds the switch when the window is closing. In 2009, the U.S. auto safety administration tentatively decided against requiring all cars to have automatic reversing power windows if they sense an obstruction while closing [6]. Proposed requirements concern "one-touch" up window systems, but most vehicles with this feature already have automatic-reversing[7]. The federal government made a written contract that all automakers should make the lever switches (as opposed to the rocker and toggle switches) standard on all new vehicles by 1 October 2010 [8].

POWER WINDOW SWITCH

According to National Highway Traffic Safety Administration or NHTSA, most of the people who die from power window injuries are children. Where, sixty-eight percent of incidents result in fractures or crushed body parts. Other injuries include bruising, dislocation, laceration and strain or sprain [9]. Children have died after their heads, necks or midsections were trapped in the window for five or more minutes and they couldn't be resuscitated. In cases involving multiple children in a car, those who witnessed the injury were more likely to panic and call for help rather than try to open the power window.
To avoid or reduce this incidents, the power window switches are redesigned instead of rocker and toggle switches changed to lever switch as shown in Figure 1. This type of switch is pressed down to open the window and pulled up to close the window. Since Oct. 1, 2010, the federal government has required that all new passenger vehicles with power windows be equipped with lever switches [10,20].

Rocker switches are designed to pivot on a center hinge, effectively operating like a see-saw. Toggle switches operate using small levers that push back and forth to open and close a window.

Lever, or push-down/pull-up, switches are pressed down to open the window and pulled up to close the window.

Figure 1: Types of power window switches. Courtesy Highway Safety Research and Communication

ANTI-TRAP/PINCH MECHANISM

As to the safety control, currently the power window mechanism is designed to allow the window glass to stop moving whenever it meets any obstacle during the upward movement. In the event the child is caught by the neck by the upward moving window glass, very serious injury or even asphyxia might still result since there still no way to free the child. In most conditions, a panicked child will not know how to lower down the window glass [11,18,19]. The above problem led the researcher to develop a safe power window mechanism for all types automobile to eliminate the drawbacks of conventional power window mechanism for cars.

This power window mechanism Figure 2 designed to be retrofitted onto the crankshaft of a conventional hand crank operated window opening and closing mechanism includes a motor (7), a rack ball-type cogs (11) driven by motor, gear driven by rack, a transmission gear (2) driven by the driven gear, and a separate conversion gear having a central hole shape (120) to fit onto the shaft (8) and whereby transmit the power from the motor to the shaft. The position of the motor is detected by the sensor (5) which generates pulse generated in response to turning of the motor, without the need for an electrical input. In the event an obstacle is encountered by the window glass on its way to a closed position, the controller (CPU) will send an auto-reverse signal to a motor control circuit which causes the system to lower the glass window.

A conventional power window transmission mechanism as shown in Figure 3, the rack (6) is used to transfer the power would generally have square or trapezoid cogs (60). Therefore the cogs (61) of the rack would change its properties after long term use and hence the driven mechanism (12) will be more difficult and tend to slip off. In contrast, the rack of the present invention has a ball-type cog as shown in Figure 4 which allowing the ball cogs (62) to engage smoothly with the concave outer peripheral teeth (121).

Figure 2: Power window mechanism

Figure 3: Trapezoidal cog mechanism

Figure 4: Ball-type cog mechanism

SENSING ELEMENT

In power window system, sensing element is applied to avoid the foreign substance trap within
window glass and window frame. It’s called anti-entrapment or anti-pinching system.

Since the word pinch means: to squeeze or compress between the finger and thumb, the teeth, the jaws of an instrument, or the like. It means that the power window trap occur when the window glass almost reaching the top but get stuck by an obstacle. Therefore, the researcher realize something should be done at the power window weather-strips (sensing edge) and power window system as well. Briefly stated, this invention is a sensing edge as shown in Figure 5 for causing the door to open by actuating a device upon force being applied to the sensing edge. In sensing edges, the electrically conductive strips (70) and (72) are used to form the sensing element as shows in Figure 6. Typically, this sensing edge form into 10 to 30 feet long and are used along the leading edge of a door [12].

In addition, the researchers also identify the method for operating an anti-trap protection should be in an AUTO-UP mode only and not in all modes means manual mode as well. Therefore, sensors that detect obstacles trapped between the window and frame will transmit an anti-trap signal to the logic circuit to control the drive assembly of the window. The switch assembly includes a switch to override the anti-trap sensor for closing the window even when an obstruction is sensed during the closing operation.

As shown in Figure 7 and Figure 8 are partially cross-sectional views of car door window frame particularly illustrating the sensor construction for sensing obstruction occur between the frame and the window when the window is closed.

Window (26) is normally received in a door frame seal (28) without contacting the sensor switch (22), but when obstruction is interposed between the top of the window and the seal, the sensor switch is deformed which causes the closing of the sensor switch is recognizable by the control system as an anti-trap signal and with reference to Figure 2.8, sensor switch comprises a flexible conduit (30) encasing spaced and a conductive material (36), (38) respectively, and spaced by an air gap (40). Hence, when obstruction (44) is trapped between the rising window and the sensor, the profile of the deflectable casing will deform so that the two conductive materials connect, effectively decreasing the resistance of the sensor switch in a manner is detectable by the control system [13].

Initially, the anti-trap system only cover the power window systems, but lately, this system covered for a motor vehicles power lift gate which driven by a drive mechanism (20) for opening and closing position as shown in Figure 9. The pinch sensing arrangement includes a mounting track (24) which attached to the lift gate, a sensor (22) and control module (26). The sensor is attached to the mounting track and elongated a long at least one of the lateral sides of the lift gate. The sensor will generate an electrical signal when it compressed (pinch of maximum load approximately 100N) due to the any interference occur on that sensor.

In the exemplary embodiment, the mounting tracks are unitarily constructed of a thermoplastic material through an injection mould procedure. In operation, when the lift gate (12) encounters obstacle proximate to the sensor (22) as it is articulated towards its closed position, the sensor is compressed. A first predetermine load causes the contracts of the sensor to meet and send an electrical control signal to the controller (26). In response, the controller reverses the drive mechanism (20) to articulate the lift gate to its open position [14].

The present invention relates to a trapping protector which does require physical contact and accordingly, do not cause squeezing. Therefore it provide the trapping protector which capable detecting electrically conductive objects without physical contact with said objects and the same time capable of detecting objects of non-conductive material see Figure 10. The sensor located at window frame (14) and as
as soon as an electrically conductive medium such as human body part is near to the sensor electrode the capacity between said sensor electrode (22) and a ground electrode (25) changes. The change in capacity changes the frequency of an output signal of the sensor electrode. The changes are compared to a reference level by controller (26) and the motor (36) for window (12) is stopped or reversed if the change exceeds the threshold. The capacitive sensor can only detect dielectric materials. Wood, plastic or any non-conductive material cannot be detected as they do not cause a change of capacity.

A safety problem associated with powered panel closures is that a person, animal or inanimate object may get in the way of the moving panel. This can be an obstruction to the motion of the panel, but most importantly, can cause severe injury. Currently research is to construct an electrically powered automobiles windows that have a provision of effective means to limit and reverse window travel when a human body part is sensed near to the of the window frame upon closure. Therefore, the new approach is to provide a panel closure sensor that is immune to the effects of moisture and humidity, which are known to seriously affect the performance of many capacitive sensor when water contacts or is capacitively coupled to their sensing electrodes. A preferred sensor comprises ‘smart algorithm’ that adapt dynamically to the environment. This feature allows the sensor to ignore changes in ambient temperature, changes in window mechanics and dynamics, and build-up of dirt and underlying changes in material properties over long period of time.

Vehicles are commonly fitted with powered window winders. In this case, standards require that the travel of the window be interrupted if an obstruction is present. Some vehicles standards for example, require that the maximum pinching force on obstructions of 20 or 65 N/mm is less than 100 N. In this system, an emitter/receiver with infra-red diodes is placed in the vicinity in the front lower corner of the window. The detection is base on the increase in the reflected energy if an obstruction is present above the window. More specifically, when the window is closed automatically, the emitter emits a series of 38 kHz pulses that are frequency modulated over a lower frequency pulse train with a period P and a 50% duty cycle. The duration of the low frequency pulse is measured at the receiver output. If there is no obstruction, the duration of a pulse at the receiver output is substantially half of the period P. If there is an obstruction, the duration of the receiver output pulse is longer. The obstruction is therefore detected by comparing the duration of a receiver output pulse with reference duration. The reference duration may depend on the position of the window.

As shown in Figure 12, the detector; charge-coupled device CCD (14) is placed at front lower corner of the opening (4). The detector monitors a substantially vertical angular area or angular sector (18). The optical detector (14) covers an area adjacent to the upper edge (6) in the plane of the opening (4) or in plane of the window (8). This is the area in which the pinching is to be detected; it is not necessary to detect the presence of an obstruction (12) near the lower edge of the opening because pinching does not occur in this area. In Figure 13 showed the detection histogram for the sensor. The position along the upper edge is shown on the x-axis along the horizontal line.
Alternatively, the row of pixels could be shown on the y-axis. (22) Shows the brightness histogram when there is no obstruction in the path of the window. (24) Shows the variation in the histogram caused by the present of the obstruction (12) [17,22].

- **Figure 12**: Infrared sensors for smart window system. Courtesy of Delphi Corporation

The switch operation can be and did not mentioned on the power window regulator mechanism where it is also a part of the power window system. Whereas another author used pick-up coil sensor on the maximum and minimum power window limit identification. Where, this sensor picks up the frequency of the interrupted current in term of voltage variation according to the law of an electromagnetic induction [21]. In this invention, the upper and lower limit identification was identified by variation of voltage and current which may cause the over travel on the power window regulator.

After did the research findings, there are several methods and ideas obtained to develop the anti-trap mechanism. Therefore, due to my findings and observation, the most practical invention for the anti-trap system are described by the inventor’s US Patent No. 5,942,207 which is Luebke where the ideas is by putting the sensing element which consist of two conductive element along the car door window frame. Therefore when these two conductive elements contacted by means of obstruction occur, the signal trigger to let the processor circuit lower the window in a few second. The second and advanced idea for the anti-trap mechanism is from inventor’s US Publication No. US 2004/0130285A1 which is Le Gallo, where the application of the infrared sensor to detect the foreign substance is adopts to be applied as the preset positioning sensor for the measurement purposes.

**CONCLUSION AND FUTURE WORK**

In automotive industry, there are a lot of method on developing and innovate the power window anti-trap system either in mechanical or electrical way. Therefore, it can conclude that in this millennium era, most of the researchers are emphasize more on the sensing element in the form of electrical and electronics in trap avoidance where the cost effective and reliable mechanism are take into account to ensure the system perfectly works.

In future, this system able to be introduced and apply not only in the driver window but in all passenger widows as well.

**REFERENCES**


**FINDING AND DISCUSSION**

Most of the recent designs on power window technology are to increase the user friendliness of the system. In this research experiment the main concern is for the window regulator where limitation of upper and lower of the window glass is affected by the infra-red sensor. If compared with the recent innovation pioneered Nissan, they focused on one tap express down and up switching mechanism to a new invention [3]. It shows that the author discussed on how friendly


Miller et al. (Nov. 10, 1998). *Sensing Edge*. Patent No.: 5832665

Luebke et al. (Sept. 7, 1999). *Auto Window Switch And Obstacle Detect/Protect With Override*. Patent No.: 5949207


