POWER WINDOW SYSTEM

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1. INTRODUCTION

Power windows are also referred to as “electric windows” and “hydraulic windows”. This is controlled by switches that are accessible via console. It eliminates the need to exert effort whenever you need to open or close your car window.The old way of opening and closing vehicle windows usually requires that the driver or passenger must turn a crank. It requires a full grasp to turn, along with arm strength especially if the crank assembly has aged and becomes harder to turn. It may also be hard for young kids or people with disabilities to crank the old window assembly.

Power window or an electric window system is a part of an automotive element. It is located at the door of vehicle. The purpose of this system is to raise and lower door glass by applying a switch in order to replace the use of hand-turned crank handle i.e. reducing the human effort. Power window system includes power window motor, electronic circuits, control system, number of inputs and outputs. In power window system, Direct Current (DC) motor served as the source of power to drive the power window frame and accordingly power window can be raised and lowered. The main objective of power window control is to control the movement of glass door in upper and lower direction and this operation is controlled with the help of current sensor, gas sensor and position sensor in the replacement of manual control hand turned crank techniques for existing power windows.The automatic power window control is design of several conditions that claim its movement in upward and downward direction.

2. LITERATURE REVIEW

This literature review contains the research done on the different technologies and control algorithms for power window.

2.1 Yingjie Zhang et al.[19] Paper explains how to solve the risk of safety effectively in power window system with improved pinch detection algorithm is used. Another finding is different estimation techniques are proposed in the development of anti-pinch based power window control techniques.

2.2 Li Hongqiang, et al.[21] Research paper explains model-based design of power window system with respect to error detection of the anti-pinch system. This study also explains Electronic Control Units (ECU) design and development of Body Control System of EV i.e. Electric Vehicles. The research work is 25 classified into two domains: The model based design and analysis of fault detection for anti-pinch window and CANopen application layer protocol.

2.3 Xiaogang Yu et al. [22] The study introduces anti-pinch window control system design using different methods of LMI-based designing for robust error recognition using a H filter. The research proposes pinch torque rate recognition algorithm constructed on H filter. Based on MATLAB simulation, the results show that fault occurrence after 70 milliseconds whenever algorithm detects faults. In addition to that the proposed algorithm, simulation model is having very high sensitivity to handle fault and strong robustness to uncertainties

2.4 Wahyu Kunto Wibowo et al.[28] Paper illustrates the load current based antipinch arrangement was proposed to make enhancements for control window framework. In this article Hall, IC current sensor is used for making anti-pinch system. A current sensor senses current flowing in the load circuit which is driving DC motor and the appropriate value is identified for threshold identification

2.5 Levi Lucio et al.[29] This report is to illustrate the Model-Based Development of a simple automotive control system. Development of the software based system to control a power window system. In the report, author introduced model driven engineering technology for software development. Automotive power window software development is achieved using model driven engineering.

2.6 Wahyu, KW et al.[44] Control on revising the Federal motor vehicle security standard went for limiting the probability of death or damage from the incidental activity of power window frameworks.

2.7 ZJ Bolton et al.[58] The task of a power window, sun rooftop or convertible top is ceased or hindered when a man is identified close to the vehicle keeping in mind the end goal to keep the individual from being harmed by the conclusion of with power window and sun rooftop. A motor, operatively coupled to move the window, sunroof or convertible top between open and closed positions responsive to a signal received by the motor from a motor controller.

2.8 Cao Xuwang et al. [59] Paper explains the usage of in vehicle networking protocol CAN bus topology for the system development is extended and network handling of the system is augmented. With help of L298 and LMD 18200 motor driver circuit different class of vehicle for different types and sizes of power

windows. A different sensor like rain sensor, smoke sensor required to achieve automatic control for the windows.

3. MARKET ANALYSIS

All prominent manufacturers of automobiles are adopting power window technology into their vehicles in order to provide ease of comfort for the occupants. Moreover, in commercial vehicles, automobile OEMs are also providing power windows in mid-range vehicles. The growth of the global market for automotive power windows is increasing with the arrival of new technologies and innovations.

The adoption of advanced technologies leading to consumer inclination towards automation is estimated to be one of the prominent drivers of the global automotive power window market. Most passenger cars use power windows for safety and security purposes. These windows are operated through various switches, and hence, this makes the operation quite easy and comfortable for the passengers and driver. Automation in vehicles is propelling consumers to shift from manual operations towards automatic or semi-automatic operations. This is another factor that is expected to fuel the growth of the automotive power window market. Silent operation is also an important feature in automotive power window systems. Automatic or powered windows is a type of system where minimal or no amount of force is to be applied, and this factor is expected to propel the growth of the global automotive power window market.

The automotive power window market can be segmented by vehicle type and sales channel.

1. On the basis of vehicle type, the automotive power window market can be segmented into:
   1.1. Passenger Cars
   1.2. Light Commercial Vehicles (LCVs)
   1.3. Heavy Commercial Vehicles (HCVs)
2. On the basis of sales channel, the automotive power window market can be segmented into:
   2.1. Aftermarket
   2.2. Original Equipment Market

In developed regions such as Western Europe and North America, there is an abundant demand for automobiles. Governments and ruling authorities in these regions have imposed stringent regulations regarding the safety of passengers. This factor is expected to boost the demand for power windows in the global market. Moreover, the increasing spending power of the middle-class population in the developing countries of Asia Pacific, such as China, along with the increasing demand for premium models of automobiles, is another factor that is expected to fuel the growth of the automotive power window market over the forecast period. The increasing demand for premium cars in the Middle East is expected to accelerate the growth of the automotive power window market. Eastern Europe and Latin America are estimated to grow at moderate growth rates over the assessment period, due to an increase in automobile sales across these regions.

Examples of some of the market participants in the global automotive power window market identified across the value chain include:

- Aisin Seiki

- Antolin
- Continental AG
- Delphi Automotive.
- Denso Corporation
- HI-LEX
- Johnson electric
- Magna International
- Mitsuba Corp.
- Robert Bosch GmbH

4. EVOLUTION OF THE SELECTED SYSTEM'S TECHNOLOGY OVER THE YEARS

The first electric power windows were introduced by Lincoln which operated under the Ford Motor Company. These windows are driven by 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 window were driven by hydraulics or off the engine vacuum. 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 drivers 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. Later there are new technologies came forward this as follows.

4.1 Automatic Down: This is a very common feature in almost all power windows. This feature allows the user to make the windows go all the way down by just tapping the button once. The system uses a circuit to monitor the amount of time that the switch was held down. If the switch is held down for less than a second, the window goes down all the way to hit the limit switch and stops there. In case the button is held down for a longer time, the circuit analyses the time and stops rolling the window down as soon as the button is released.

4.2 Automatic Up: This feature is not very common as it has certain complications. The automatic up works in the same way as the automatic down. But, the automatic up feature poses a risk. While the window goes up, if anything gets in the way of the window, like a child's hand or a pet dog or cat's paw, it is highly likely to injure them. As the window won't stop until it hits the limit switch, it engages a risk of an accident. The only way out of this problem is the introduction of another circuit into the system, that can monitor the speed at which the window rolls up. As the speed is slowed down due to an obstruction, the circuit reverses the power back to the motor and the window goes down.

4.3 Anti-Pinch Technology: The danger of the power window express-up feature is if there is an obstruction preventing the window from closing all the way. It can cause damage whether that obstruction is:

A child's arm, head or toy
A chunk of ice or snow

A piece of dirt or a stone stuck in the window track

When the window reaches the obstruction, it can cause bodily harm or the window can shatter if the obstruction is hard. To add a safety device to the express-up feature, car makers use an anti-pinch device. The window motor has a pressure sensor that detects window motor movement when the glass has stopped moving, even minutely. If this occurs, the window reverses direction and moves downward.The anti-pinch feature is controlled by a small module which is now often integrated into the power window switches on the driver's door. If the vehicle loses battery power or the power windows require a repair, the power windows will not know their upper and lower limits. The window motor will need to be re-trained so it can learn the window travel limits.

4.5 Courtesy Power-On: Power windows work only when the ignition of the vehicle is on. But some cars have a courtesy power backup which is supplied to the window circuit even after the engine is turned off. In case you forget to roll up your windows, this feature saves you from the hassle of turning your ignition on a1gain, just to pull the windows up.

4.6 Window Control From Outside :- On the Volkswagen in the TV commercial, the windows can be lowered by inserting the key in the driver's door, turning and holding it. This feature is controlled by the driver's door module, which monitors a switch in the door lock. If the key is held turned for more than a set amount of time, the driver's door module lowers the windows

5. SWOT ANALYSIS

Strenghts ,Weaknesses, Opportunities And Threats of Power window system are described as follows:

Strengths	Weaknesses	Opportunities	Threats
• It allows the driver to control the windows with just the touch of his fingers. • It allows people with hand injuries or other physical complications to easily operate the windows. • Drivers can easily control the windows even while driving. • The master power panel in the front also allows the driver to operate all the windows simultaneously, without leaving his seat. This feature is very helpful in case there are children in the back seat.	• Many a times, the window regulator also known as the window track, might stop functioning. This causes a power window failure. • Power windows might also stop working because of a broken motor, a broken cable pulley, or a broken switch. • Worn off window regulators might also be a reason behind a dysfunctional power window.	• Anti-Pinch and Courtesy power ON features make more customers choice to choose.	• ◦ Requires Additional electronic control system ◦ Unexpected repairs and maintenance are more expensive.

6. MATLAB SKILLS

1.Callbacks : Execute code for modeling events such as opening a model.
A callback is a function that executes in response to some predefined user action, such as clicking on a graphics object or closing a figure window. Associate a callback with a specific user action by assigning a function to the callback property for that user action.
Some of the Callback function listed below.

Callback Parameter	When Executed
PreLoadFcn	This callback is executed before the model is loaded.
PostLoadFcn	After the model is loaded. Defining callback code for this parameter may be useful for generating an interface requiring a loaded model.
CloseFcn	Before the block diagram is closed. Any ModelCloseFcn and DeleteFcn callbacks set on blocks in the model are called prior to the model CloseFcn callback. The DestroyFcn callback of any blocks in the model is called after the model CloseFcn callback.

2.Data Inspector : The Simulation Data Inspector visualizes and compares multiple kinds of data
Using the Simulation Data Inspector, you can inspect and compare time series data at multiple stages of your workflow.

3.Basic Solver Selection:
A solver applies a numerical method to solve the set of ordinary differential equations that represent the model. Through this computation, it determines the time of the next simulation step. In the process of solving this initial value problem, the solver also satisfies the accuracy requirements that you specify.

The appropriate solver for simulating a model depends on these characteristics:

- System dynamics
- Solution stability
- Computation speed
- Solver robustness

Solver ode45 performs well with most ODE problems and should generally be your first choice of solver. However, ode23 and ode113 can be more efficient than ode45 for problems with looser or tighter accuracy requirements.Some ODE problems exhibit *stiffness*, or difficulty in evaluation. Stiffness is a term that defies a precise definition, but in general, stiffness occurs when there is a difference in scaling

somewhere in the problem. For example, if an ODE has two solution components that vary on drastically different time scales, then the equation might be stiff. You can identify a problem as stiff if nonstiff solvers (such as ode45) are unable to solve the problem or are extremely slow. If you observe that a nonstiff solver is very slow, try using a stiff solver such as ode15s instead. When using a stiff solver, you can improve reliability and efficiency by supplying the Jacobian matrix or its sparsity pattern.

4. Lookup table: It is an array of data that maps input values to output values, thereby approximating a mathematical function. Given a set of input values, a lookup operation retrieves the corresponding output values from the table. If the lookup table does not explicitly define the input values, Simulink can estimate an output value using interpolation, extrapolation, or rounding, where:

An interpolation is a process for estimating values that lie between known data points.

An extrapolation is a process for estimating values that lie beyond the range of known data points.

A rounding is a process for approximating a value by altering its digits according to a known rule.

5.Signal Builder: The Signal Builder block allows you to create interchangeable groups of piecewise linear signal sources and use them in a model. You can quickly switch the signal groups into and out of a model to facilitate testing.