ABSTRACT

Nowadays, with increasing technological advances and innovations the demand for advanced embedded systems is increasing rapidly. Keeping these challenges in mind, our research paper proposes a model-based technique to design Power Window Electronic Control Unit (ECU). It provides ease of designing, automatic code generation which reduces cost of designing, and conserves the time and effort of the designer. The programming and numeric computing platform MATLAB R2017b and its add-on product Simulink is used for designing of systems and subsystems the power window ECU model and further simulation of the models created. Power window ECU provides a mechanism to automate the roll up and roll down function of the window. This automation is dependent on several factors as mentioned; AC request, Rain, Crash or accident and Anti-pinched function. In case of system failure or mishappenings like error, activations of siren and flashers take place.

Keywords: Power Window ECU, Simulation, Code Generation, Model based technique

INTRODUCTION

Power Window Electronic Control Unit (ECU) is the mechanical roll up and roll down of window in vehicle when power is supplied to it. In our project, this rolling up and rolling down of power window is controlled electronically via telematics. This happens in response to the situations that require immediate opening or closing of the window. It takes 15sec to either roll up or roll down request in the body function module of power window.

Body function module is the central control unit that administers all the other control units of an automobile. Body control module (BCM) is a multi-faceted polyfunctional electronic unit. The body control module behaves as an interconnection between input command that operates output devices. When the user sends the power window operation request, BCM fetches power from the car’s battery. Body Control Module eliminates the need for additional wiring. The management of output devices is done on the basis of the data obtained from input devices via CAN (Controller Area Network), LIN (Local Interconnect Network) or Ethernet as modes of
communication with systems and modules. The top most layer of BCM is application layer.

The development of this layer is dependent on MATLAB Simulink model as shown in Fig. 1 along side. The algorithms are stored in application layer necessitated for various purposes relying on the use-case. When a user attempts to open a vehicle with a remote key, the car’s radio receiver picks up the signal and transmits it to BCM in encrypted form. The body control module's application layer algorithm processes the signal and initiates the mechanical behaviour to open the door.

A Controller Area Network (CAN) is a reliable vehicle bus standard that enables microcontrollers and devices to communicate with each other’s applications without the need for a host computer. LIN is based on the CAN platform, but it lacks the robust data rate and bandwidth efficiency, as well as the higher cost, that CAN requires.

RKE and PKE are smart key functions designed to facilitate door lock, window control and anti-theft functions. Remote keyless entry (RKE) is a remote-controlled device that is used to access the primary functions of the vehicle while the user holds the device and pushes the button which then sends a RF signal to the door to unlock it and remote keyless ignition (RKI) starts the engine.

Passive keyless entry (PKE) is advanced RKE. It does not require any pressing of button or a physical contact with the remote-controlled device. It unlocks the door when the driver touches the door handle of the car, by authenticating driver’s identity through encrypted communication and verification. PKE system activates the ignition without an actual insertion of the key in the ignition, given the key must be present within the car. The central locking is done when the user walks away from the vehicle. The locking methods depend on the model variant of the car.

![Figure 1. Power Window Module](image)

Telematics Control Unit (TCU) is the electronic unit which governs the Media Control Module (MCM) and controls wireless monitoring, diagnostics, and communication to and from the vehicle. These systems are used for crash
notifications, multimedia tool and window control among many of it’s uses.

**Body Function Module (BFM)** sends LIN signal BFM_PWM_CMD as window roll down command. If all of three conditions below are met, this occurs which are as follows: Automatic control should be ON, Power_Window_Unlock feature should be enabled for PKE and RKE, Power_Window_Control feature should be enable for Telematics control, Switch_override_STS should be OFF and Power Window position Status (PWM_POS_STS) should be fully closed or partially open.

**Roll down operation of BFM**

**Anti-pin**

In the case of Crash or Anti-pin, window will automatically roll down. Power windows in modern vehicles use anti-pin technology as a safety feature. A power window is one that is operated by an electric motor. This technology prevents the power window from being unintentionally wound up, as the name implies. If the device detects an obstacle in the direction of the window glass, it stops it from going any further up. As a result, potential accidents are avoided. It senses the trapped object and automatically lowers the window, allowing the trapped object to be easily freed. The anti-pin mechanism is operated by a small module that is now often inserted into the driver’s door power window switches.

The BFM receives the Anti-pin detection status as a separate signal from Power Window ANTI_PINCH_STS. It is shown in fig.2
Fig. 3 shows the graphical representation of Anti-pinchool response in which window rolls down within 15sec as specified in body control module.

Crash
In case of crash the window will also immediately roll down. For this Body Function Module will send signal to BFM_PWM_CMD as Window_Roll_Down command will execute during crash if the following conditions are met: Ignition should be ON, Fig.4 consists of block that are executed during crash Power_Window_Smart_Open_Crash feature code should be enabled, SwitchOverride_STS should be OFF in all Power Window Module ECU, Power Window position status (PWM_POS_STS) should be recieved as Window_Fully_Closed or Window_Partially_Open

Body Function Module (BFM) sends LIN signal BFM_PWM_CMD as window roll up command. If all of three conditions below are met, this occurs which are as for follows: Automatic control should be ON, Power_Window_Unlock feature should be enabled for PKE and RKE, Power_Window_Control feature should be enable for Telematics control, Switch_override_STS should be OFF and Power Window position Status (PWM_POS_STS) should be fully open or partially open.

Fig.5 specifies constant rolling down of power window automatically. In continuation flasher light blinks and siren is heard.

Roll-up operation of BFM
The automatic window Roll-up function comes into play when it rains or the air conditioner is turned on.
Fig. 6 shows the response for window roll up operation wherein the graphical representation of the request for rain and ac is detected and the timeframe of window close timeout is 15 seconds.

**Request for Rain**
The automatic Roll-up function of smart power window is necessary in order to avoid driver distraction, when there is a need to close the window whilst driving per the illustrations shown in fig 7.

The Body Function Module (BFM) requests the user to send the feedback GlassPanel_Smart_Close_Request_Rain for the smart roll-up operation to begin. This only happens when the vehicle’s ignition is ON, PWM_POS_STS is received as fully open or partially open and Switch_OVERRIDE_STS is OFF in all power window module ECU and Power_Window_SmartClose_Rain[UC] is enabled on feature code. The GlassPanel_Smart_Close_Response_Rain is acknowledged from the IC and then the BFM sends global LIN signal BFM_PWM_CMD as Window_Roll_Up, for the automatic roll-up of the window to actually begin.
The graphical representation of rolling-up of the power window is observed in fig.8 which is executed automatically when it starts raining.

**Request for AC**
The automatic roll-up operation of the power window also takes place when the air conditioner (AC) inside the vehicle is turned on which is defined in fig 9. The Body Function Module requests user feedback GlassPanel_Smart_Close_Request_AC to initiate the operation under the fulfilment of following conditions: The ignition should be ON, REQ_AC_COMPR is received as ON for PowerWindow_Smartclose_ACTime[UC], PWM_POS_STS is received as window fully open or partially open, Switch_Override_STS is OFF for all power window ecu and Power_Window_Smartclose_ACT[UC] is enabled on feature code. In order to begin the operation the BFM will then send global LIN signal BFM_PWM_CMD as Window_Roll_Up when it receives GlassPanel_Smart_Close_Response_AC as acknowledgement from the IC.

It is crucial to note that the Body Function Module (BFM) will send GlassPanel_Smart_Close_Request_AC/RAIN only once in one ignition cycle. Also the BFM will send GlassPanel_Smart_Close_Response_AC

![Fig. 9. PWM/Subsystem/Smart_Close_Rqst_AC](image)

![Fig. 10. Graphical Representation of AC Response](image)

The graphical representation of rolling-up of the power window is observed in fig.10 which is executed automatically when the AC is turned on.

**CONCLUSION**
The Power Window Module electronic control unit (PWM ECU) performs the
functions as directed by the body function module (BFM). The two modules cooperate to perform many major functions of an automobile, two of which, automatic window roll-down and automatic window roll-up, are pondered upon in our paper. These two major functions are performed for two different scenarios in each case. The automated roll-down is discussed for immediate situations that require preventive actions in order to avoid accidents, namely crash and anti-pinch mechanism. Likewise, the automated roll-up of the power window is also discussed for two situations: when the vehicle sense rain or a turned-on air-conditioner (AC). The automatic window roll-up and roll-down commands are given by the body function module (BFM) after it receives a request to do so from the user feedback. The response to this request is acknowledged as the window roll-up or roll-down command as per the requirement of the situation.

REFERENCES


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