ISSN: 2664-9640

Auto Tailgate Automatic Control System Based on Single Chip Microcomputer

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Abstract

With the development and maturity of automobile electronic technology, the automobile is gradually developing towards the direction of comfort and intelligence. The electric tailgate technology is widely used and respected in the process of automobile product design, production and sales by each main engine factory. The quality of the vehicle directly affects the driving safety of the automobile. A car tailgate controller based on KEAZ128 microcontroller is designed in this paper, which has the functions of suction and unlock of tailgate door lock, electric lifting tailgate door, CAN bus and LIN bus communication. c suction and electric unlock of tail door lock; CAN and LIN bus communication function of tailgate controller. The designed controller can effectively improve the running safety of the vehicle, improve the convenience and safety of the tailgate operation.

Keywords

Automobile Tailgate, Controller Design, Automatic Control, Anti Clip Device.

1. Introduction

With the rapid development of science and technology, people's needs are also growing, and intelligence has become people's tireless pursuit [1]. The advent of electronic computers has enriched and simplified the world. Of course, the micro-processing system also emerged quietly and was widely applied in practice. MCU control was used to handle some transactions, which reduced labor time, improved labor efficiency and improved accuracy[2]. The appearance of MCU has made great changes in life and production. People's life is more and more inseparable from network and intelligence. In order to improve the reliability and convenience of car door locks, the combination of electric unlock structure and mechanical unlock structure has gradually replaced the traditional pure mechanical unlock mechanism [3]. The share of sport-utility vehicles in the Chinese car market has risen sharply in recent years. d in the tail. The third type is the electrically driven hinge type. The structure also retains the tailgate gas spring. The traditional car tailgate process requires manual dismounting, which is cumbersome and unsafe. With the rapid development of science and technology in our country, the development direction of automobile has become more and more comfortable and intelligent. The complicated operation of traditional automobile tailgate can no longer meet people's needs, so the intelligent electric tailgate, which can give consideration to operability and safety, emerges as the times require. It will be the car tailgate into the intelligent category, to achieve the goal of saving time and effort.

Single chip microcomputer is widely used. Tomas Drevinskas upgraded the capacitor-digital single-chip detector [7] and discussed the hardware problems and advantages of the designed/upgraded detector. The device can be operated by rechargeable lithium-ion batteries as a stand-alone portable system and can transmit real-time data wirelessly. Detector and additional modules (battery, battery base, MCU board, wireless module) weight less than 85

ISSN: 2664-9640

grams. Electrophoresis separation was performed in pH 6.1 of low conductivity 20 mM MES/ l-his buffer to evaluate the detection parameters. The system was able to quantify the potassium ions by dropping to 0.31. The study of the differential signal acquisition configuration shows that the performance is improved in terms of external noise and temperature fluctuation. The system can be used as a solution for portable capillary separation detector. Mekdes in the field of real-time signal processing [10].

Aimed at consumers in the tail gate intelligent use of convenience and high demand, this paper designed a model based on KEAZ128 SCM sport-utility vehicle tail gate system controller, including the overall design of the controller, the hardware circuit design and its working principle and the design of the software part, in the tail gate system, different from the traditional gas spring stern door design, realized the tail gate of electric hoist, the entire armor clamp; Automatic suction and electric unlock of tail door lock; CAN and LIN bus communication function of tailgate controller. The designed controller can effectively improve the running safety of the vehicle and the convenience and safety of the tailgate operation.

2. Proposed Method

2.1. Principle of Single Chip Microcomputer

(1) Rocomputer is adopted to control them[14], making instruments and meters become digitalized and intelligent with more powerful functions;

(2) In the field of home appliances, single-chip microcomputer control of household appliances has been widely applied, such as rice cookers, refrigerators, air conditioners, color TV sets, stereos, etc. [15];

(3) In a modular system, a single chip microcomputer can be used to realize specific functions of modular application without the operator knowing its internal structure. This greatly reduces the volume, simplifies the circuit, and reduces the damage rate and error rate;

(4) In the field of automotive electronics, MCU has been widely used in engine controller, GPS navigation system, ABS anti-lock system, braking system, etc. [16];

2.2. Automatic Control System of Automobile Tail Door Based on Single Chip Mmicrocomputer KEAZ128 Single Chip Microcomputer

This auto chip controller using KEAZ128 80 pin, on a chip is configured with rich peripherals such as d/a conversion module, timer, support for multiple communication modes, KEA128 series microcontroller is 32-bit ARMCortex KinetisEA series MCU controller, with 128 KB of Flash storage and 16 KB SRAM, the highest support 24 MHZ external crystals, suitable for a wide range of high reliability industrial and transportation applications [17]. In the tailgate system, different from the traditional gas-spring tailgate design [18], this controller can control the tailgate strut motor to achieve the tailgate electric lift, with the function of full anti-clamping; It can control the double motors in the tail door lock to realize the function of automatic suction and electric unlock of the tail door lock. CAN send instructions to MCZ33903 sub-chip in the controller to realize the communication function of CAN bus and LIN bus.

Table 1. Functions of KEAZ128 MCU

Module Function Classification	
Module classification	Describe
ARMCortex-M0+ Kernel	Based on ARM's Cortex-M 32-bit MCU kernel, 1.77CoreMark®/MHz single-cycle access memory, 48MHzCPU frequency.

ISSN: 2664-9640

System	System integration module; Power management control module; Miscellaneous control module; Bit operation engine; Peripherals bridge; Guard dog.
Memory	Golden 128KB flash; Golden 16KB SRAM.
The Clock	External crystal oscillator or resonator, low range: 31.25~39.0625kHz; High range: 4~24MHz.External square wave input clock.Internal reference clock, 31.25~39.0625kHz oscillator; 1kHz low power oscillator LPO.Frequency locked ring FLL range 40~50MHz.

2.3. The Electric Tailgate System

(1) Structure and Composition of The Electric Tailgate System

Figure 1 is the structural framework of the electric stanchion electric tailgate system. The electric tailgate system is composed of ECU, pole module, snap-lock module, switch unit, buzzer, anti-clamping strip and kick foot sensor [19].

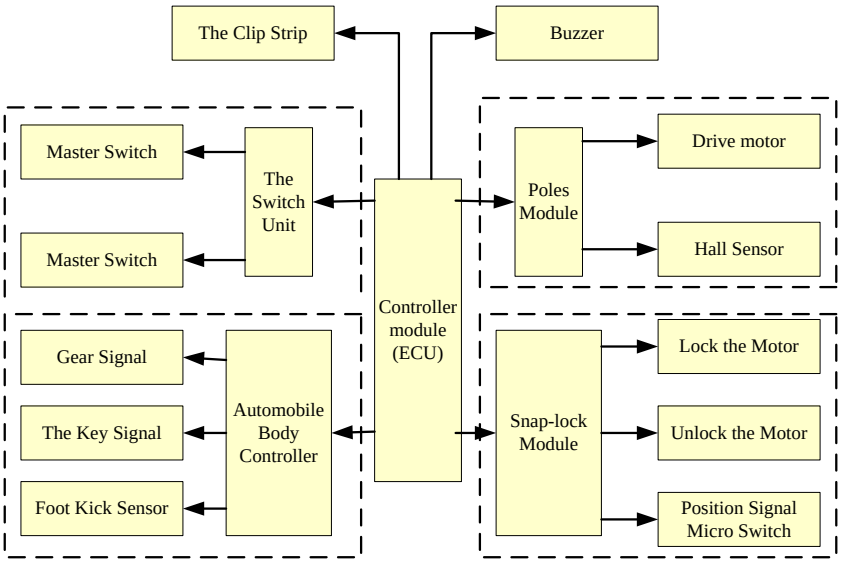

Figure 1. Structural Block Diagram of The Electric Tailgate System.

The controller module (ECU) is the core of the electric tailgate system. It takes high performance processing chip as the core and consists of driver module, signal acquisition module, A/ D conversion module and communication module. It has various control functions such as signal transmission and analysis between vehicles, signal acquisition of electric tailplate system, signal acquisition of anti-pinch point, signal output of electric pillar drive, and self-priming driving signal output of tailplate lock [20].

Bracing Rod Module of Electric Tailgate System

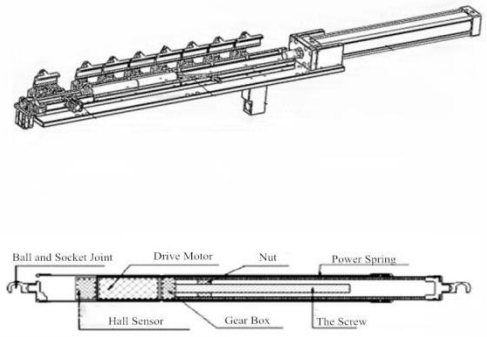

Figure 2. Structure of Electric Strut Module

(3) Suction Lock Module of Electric Tailgate System

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The structure of electric suction lock module, suction lock module by the tail door lock assembly, lock assembly, suction motor, winding, etc., compared with the traditional tail door lock, increase the external motor and winding structure. The tailgate can be electrically closed from semi-locked to fully locked by pulling in the motor.

(4) Anti-clamping Rubber Strip for Electric Tailgate System

2.4. Signal Module of Auto Tailgate Automatic Control System Based on Single Chip Microcomputer

(1) Tail door Lock Signal

There are 4 signal lines in the tail lock, which are respectively used to judge whether the pawl position, the tail lock is in the semi-lock position, the unlocked position and the full lock position. The hardware circuit of the signal module of the tail door lock is shown in figure 4. When the signal is connected, it is equivalent to pressing a key, and the signal state is in a low level state. When the signal disconnects, it is equivalent to a key disconnecting, and the signal state is in a high level state.

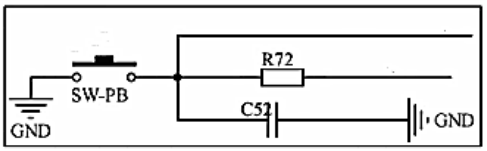

Figure 4. Hardware Circuit of Tail Door Lock Signal Module

(2) Hall Signal Module

Hall signal sensors are widely used in motor speed measurement. The hall sensor configured in the strut motor is a two-wire sensor, that is, two hall signal lines with a phase difference of 90°. Therefore, in the hall signal hardware circuit, hall signal 1 is directly connected with the pin with PWM counting function, and can be counted directly through the pulse receiving function in the PWM module. Hall signal 2 only needs to be connected to pins with normal input-output functions to determine the high and low level.

(4) Peripheral Circuit Modules of Main Chip and Secondary Chip

According to the basic circuit design, the peripheral circuit of main chip and sub-chip is configured with 12MHz crystal perk external crystal oscillator of the main chip, in which the main chip and sub-chip transmit instructions through SPI bus. 2.5 motor drive module motor drive module is an important part of the controller hardware circuit. In the design of the hardware circuit of motor drive module, two BTS7960 chips are used to form the h-bridge circuit to control the positive and negative rotation and speed regulation of the motor. The current diagnosis pin of BTS7960 is connected to the digital-to-analog conversion pin of the main chip, so that the controller can read the working current of the motor and judge the working state of the motor.

2.5. Closing/Opening Process of The Electric Tailgate System

(1) Closing Process of The Electric Tailgate System

The opening and closing of the tailgate is realized by controlling the positive and negative rotation of the strut motor through the motor drive circuit. In the process of closing the door, the controller module (ECU) first drives the pole to execute the closing action. During the execution, the hall sensor continuously collects the position signal and the anti-clamping signal. Stop the pole drive immediately when the reverse clamping signal occurs. When the pole returns to the open position or runs a certain distance in reverse, the system goes into standby again. When the motor keeps the tail door to the tail lock semi-locked, the semi-lock signal starts and outputs to the controller module (ECU), which sends instructions to drive the tail door lock suction motor for locking action. Since the load of the strut motor will change during

ISSN: 2664-9640

the opening and closing of the tailgate, PID control strategy is needed to adjust the speed and torque of the strut motor. When using PID strategy, this design scheme adopts motor speed and motor current as the feedback quantity. Close the tailgate to the fully locked state, detect the lock signal, stop the motor suction after the signal is qualified, and close the tailgate.

(2) Opening Process of The Electric Tailgate System

The motor speed is obtained by using the hall signal. In the hall signal module, two hall signals need to work together. Hall signal 1 is used to count the number of pulses received within a certain time, so as to calculate the motor speed; When the hall signal 1 is in the rising or falling edge, the motor rotation direction can be determined by judging the high and low level of hall signal 2, so as to obtain the speed of the strut motor. During the door opening operation, the controller module (ECU) first gives instructions electronically to unlock the rear door lock. After the unlocking signal appears

2.6. Overall Design Scheme of Auto Tailgate Automatic Control System Based on Single Chip Microcomputer

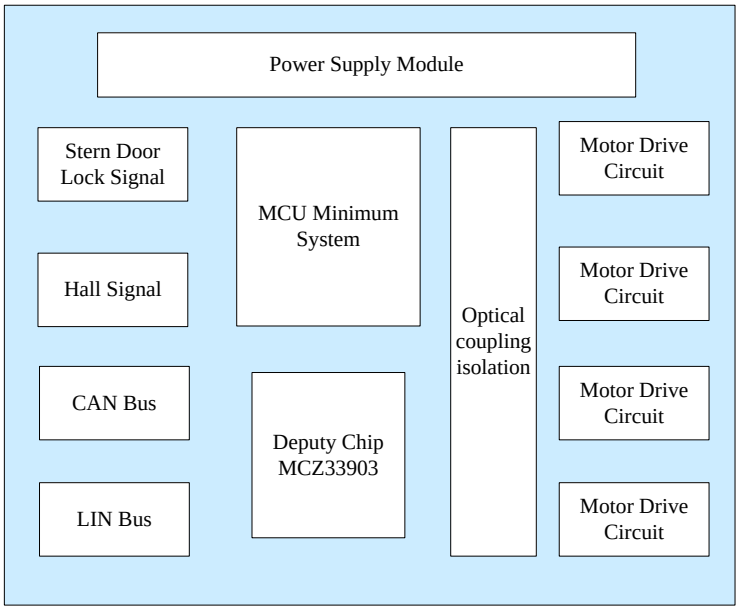

Figure 5. Controller Design Scheme

2.7. Overall Software Design Scheme of The System

Through the analysis of the hardware circuit schematic diagram, it can be seen that the controller software design is mainly divided into three parts: suction and unlock of the tail door lock, opening and closing of the tail door, and CAN and LIN bus communication. The overall design flow chart is shown in figure 6.

3. Discussion

3.1. Design, Calculation and Analysis of The Open and Close Operating Force of The Rear Vehicle in Manual Mode

(1) The Calculation and Analysis of Manual Starting Operation Force

During the manual opening of the tailgate, the manual operating force and the output force of the strut jointly overcome the gravity effect of the tailgate to realize the opening of the tailgate. The opening and closing of the tailgate are realized by controlling the positive and negative rotation of the strut motor through the motor drive circuit. During the opening and closing of the tailgate, the load received by the strut motor will change. At this point, the resistance of the brace system f is opposite to the acting force of the assistant spring Fs, and the output force

ISSN: 2664-9640

of the brace is $F_M = F_S - f$. According to the principle of torque balance, the operating force required for the manual opening of the tailgate at any opening degree F_{OPEN} can be obtained as follows:

Where L_{OPEN} is the manual opening force arm with the hinge rotation axis as the pivot point. Through formula editing, the operating force curve of manual opening of the tailgate with the tailgate opening as a single variable at different slope angles can be output, as shown in figure 7.

(2) Calculation and Analysis of Manual Closing Operation Force

The motor speed is obtained by using the hall signal. In the hall signal module, two hall signals need to work together. Hall signal 1 is used to count the number of pulses received within a certain time, so as to calculate the motor speed; When the hall signal 1 is in the rising or falling edge, the motor rotation direction can be determined by judging the high and low level of hall signal 2, so as to obtain the speed of the strut motor. In the process of tailgate movement, when the motor speed or the mutation amount of motor current exceeds the set threshold, it can be determined that there is an obstacle blocking the tailgate movement, thus triggering the anti-clamping function, making the tailgate stop rotating or reverse rotating to achieve the anti-clamping function. The manual operating force and the gravity of the tailgate jointly overcome the effect of the output force of the strut to achieve the tailgate closure. At this point, the resistance of the strut system f is in the same direction as the force of the assistant spring in Fs direction. The output force of the strut $F_M = F_S + f$ can be obtained according to the torque balance principle that the operating force required for the tailgate to close manually at any opening degree F_{CLOSE} is:

$$F_{OPEN} = \frac{2X(F_S + f)L_S - GL_G}{L_{CLOSE}} \tag{2}$$

In the formula, F_{CLOSE} is the manual closing force arm with the hinge rotation axis as the pivot point. Through the formula editing function of excel, the manual closing operating force curve of the tailgate with the tailgate opening θ as a single variable is shown in figure 8.

According to the high and low level states of the four door lock signals, the unlocking motor and the suction motor can perform three actions: forward rotation of the unlocking motor, forward rotation of the suction motor and reverse, so as to realize the electric unlocking and suction functions of the tail door lock. When the unlocking signal is sent, the unlocking motor will rotate until the tail door lock is in the unlocking state. When the signal is sent, the unlocking motor will stop rotating. The unreasonable design of force value and elastic coefficient may lead to the failure of the opening interval of the tail door to maintain hover, and the problem of large operating force of manual opening and closing or failure of electric opening and closing will occur. When off signal, and the motor forward through the clues to pull the lock lever and lock movement, in the process of tail gate open and close, tail gate can stop at any position in the open and close angle and maintain, this state is called a hover, hover state support at the tail door by its own gravity and electric poles, the electric strut motor does not work, and the output force of the strut is the resultant force of the spring force of the boost spring and the resistance of the strut system.

(2) Analysis of The Relationship Between The Output Force of The Electric Brace and The Force Value of The Spring

When the tail door lock is in full lock state, the suction motor reverses and retrieves the clue to complete the suction action of the whole tail door lock. Formula editing is applied, and the curve of the output force and spring force of the unilateral electric stay rod with tailgate opening as a single variable is shown in figure 9.

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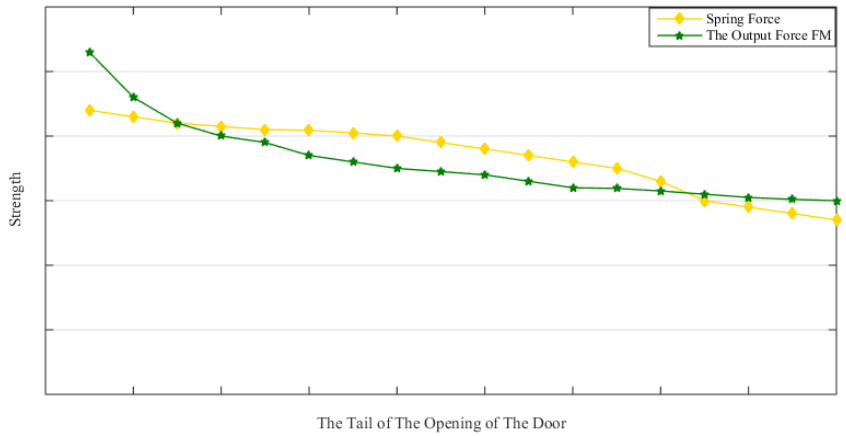

Figure 9. The Variation Curve of The Output Force and Spring Force of One Side Electric Strut with The Tailgate Opening

The output force of the electric strut is composed of the resultant force of the spring force of the electric strut and the resistance of the electric strut system. Therefore, if the tailgate can maintain the hover state, the output force of the electric strut should be maintained at any opening degree. When (FS-F) < FM < (FS + F), that is, when the output force curve FM in Figure 9 is located in the area between the curve (FS-F) and the curve (FS + F). In order to increase the hover reliability of the electric tailgate system under various working conditions, the minimum FM-FS should be taken as the design reference in the design of spring force and elastic coefficient.

4. Conclusion

The performance of the door lock has a direct impact on the driving safety of the car. In order to improve the reliability and convenience of the door lock, the combination of electric unlock structure and mechanical unlock structure has gradually replaced the traditional pure mechanical unlock mechanism. The share of sport-utility vehicles in the Chinese car market has risen sharply in recent years. The use rate of tailgate system is far higher than that of other models, and consumers have higher requirements on the reliability and intelligence of tailgate use.

With the rapid development of science and technology, people's demand is also growing day by day, and intelligence has become people's tireless pursuit. The advent of electronic computers has enriched and simplified the world. Of course, micro-processing system also emerged quietly, and a large number of applications in practice, the use of MCU control, processing some transactions, reduce labor time, improve labor efficiency, but also improve the accuracy. The appearance of MCU has made great changes in life and production. People's life is more and more inseparable from network and intelligence. The power module can reduce the external voltage of 12V to 5V to power the main chip. The tail door lock signal is used to judge the closing state of the tail door lock and whether it needs self-priming operation. The hall signal is used to calculate the velocity of the strut of the tailgate, which is helpful for the realization of the anti-clip function. CAN bus and LIN bus are used for the communication between the controller through the sub-chip and the body control module (BCM). In the motor drive circuit, two BTS7960 chips constitute the h-bridge circuit, which supports PWM control of motor speed, motor positive and negative rotation and current detection.

Through theoretical analysis, the mechanical model of the opening and closing process of the electric support rod and the suction and locking process of the electric support rod are established, and the mechanical output curve of the function is edited by using the software formula. It provides a reference for the design of spring elasticity of electric prop, output force

ISSN: 2664-9640

of driving motor and suction force of locking motor. In view of the current situation of designing tailgate system controller based on KEAZ128 automobile chip, a tailgate controller based on KEAZ128 microcontroller is designed in this paper, which has the functions of suction and unlock of tailgate door lock, electric lifting tailgate door, CAN bus and LIN bus communication. The suction function of the tail door lock reduces the impact of the pawl and ratchet in the lock, prolongs the service life of the tail door lock, reduces the noise of closing the door, and improves the safety of the car tail door. The electric lifting function makes the lifting of the tailgate more stable and the anti-clamping function improves the safety of the use of the tailgate. The functions of CAN bus and LIN bus enable the controller to communicate with the body controller and realize the information interaction between the tailgate system and the body controller. The sample of this scheme has been tested to meet the functional requirements.

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