Automotive Auxiliary Electrical Controller

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Abstract: The automotive auxiliary electrical controller is the key device of the vehicle drive system, which controls the car's forward, backward, start or stop behavior. Based on the analysis of the structure and principle of a single controller wheel drive vehicle, this paper proposes a differential control strategy for the electric controller, and then analyzes the control hardware circuit design and software program design of the vehicle traction motor. Finally, the experimental test shows the effectiveness and feasibility of this control strategy.

1. Research background

1.1 Literature review

As a key device of the vehicle drive system, the automotive auxiliary electrical controller is decisive for the forward, backward, start or stop of the car. Therefore, the performance of the car controller is directly related to the driving performance of the car. In response to this, many scholars have conducted considerable research. Wang Shuwang et al. analyzed the causes of overcurrent faults in automotive motor controllers, and established a corresponding electronic control platform by constructing current detection, sampling, hardware overcurrent protection circuits and software overcurrent protection strategies. Therefore, the protection problem of the motor controller overcurrent fault is effectively solved (wang et al, 2011). Zhu Xiaochun and Dong Zhurong proposed a drive steering integration based on wire-controlled electric vehicles in the research of vehicle control system, wire-controlled electric vehicle structure, CAN bus communication network, four-wheel independent steering, and wheel motor drive control. Controller. The author summarizes the five key technologies and master control schemes of the integrated control, and then experiments on the corresponding five working modes. The final result shows that the vehicle with the drive-to-integral controller can meet the technical requirements of real-time, control accuracy and reliability of the steering and electronic differential of the wire-controlled electric vehicle (Zhu and Dong, 2017). Wen Jianping established a motor control model using voltage space vector pulse width modulation in the Matlab/Simulink environment to obtain the required duty cycle signal, and established a thermal calculation model of the motor controller inverter circuit in the PSIM environment to obtain the power device. Power consumption, optimized heat sink design. In the process of comparative analysis of thermal calculation simulation and motor controller temperature experiment, the effectiveness of this method is verified (wen, 2014). Wang Shuiyu and Ange use the FPGA's automotive electronic control unit (ECU) two-dimensional fuzzy controller to discover the robustness and flexibility of the automotive ECU fuzzy controller set, which takes advantage of the advantages of traditional control and fuzzy control. And the author uses the error and error rate of change as input, and uses the fuzzy reasoning method to realize the automatic adjustment of the parameters of the two-dimensional fuzzy controller. The final simulation results also show that the fuzzy controller control effect is better than the traditional controller, which can improve the dynamic and static performance of the car ECU, which is very practical (wang and an, 2010).

1.2 Research purpose

Automobile power units are generally divided into two categories, namely, wheel drive and shaft drive. Nowadays, the hub motor drive system is an advanced drive controller and has been widely

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used worldwide. This electrical controller can reduce the quality of the car and save the interior space of the car, thereby improving the transmission efficiency of the car. At the same time, the automotive-assisted electrical controller also needs to solve the problem of control and coordination of the rotational differential between the two electric wheels, that is, the control of the electronic differential. In order to further solve the coordination problem of the controller, this paper chooses the single controller XE164-FM for related research. The XE164-FM controller is specifically designed for brushless DC motors. It can simultaneously control and drive adjacent motors for real-time data exchange. And the multi-channel Hall mode used by the XE164-FM controller can eliminate the problem of controller area network communication between the vehicle auxiliary electrical controllers. Therefore, an in-depth study of the XE164-FM controller has an important display.

2. Structure and principle of single controller wheel drive

Generally, the drive control device for a wheel drive electric vehicle is mainly composed of a hub motor, an inverter (including an electric controller), and a battery. Under normal circumstances, there are two main types of control methods for automotive auxiliary electrical controllers. The first is to use the car throttle to adjust the speed of the motor. The output power of the motor is determined by reference to the resistance torque during the actual formation of the car. The second type is to directly use the car's throttle to control the output torque of the motor to change the speed of the car (quan et al, 2011). The electrical controller selected in this paper directly controls the throttle to adjust the electromagnetic torque of the motor, thus controlling the car. The controller works on the principle that when the driver accelerates the accelerator pedal, a torque signal is generated, which is transmitted to the electronic control unit through the displacement sensor. The total electronic control unit further distributes the torque of the two motors according to the signals transmitted by the angular displacement sensor and the pedal displacement sensor, thereby realizing the effect of adjusting the torque of the motor in real time. Therefore, the car auxiliary electric controller coordinates the straight-line driving and the differential rotation during the steering process, which is the core key of the motor controller.

3. Electric controller differential rotation control strategy

There are two types of control strategies for differential rotation of commonly used electrical controllers. One is the method of controlling the rotational speed; the other is the way of controlling the torque. In general, during the steering process, the vertical load of adjacent wheels changes accordingly. In order to make the adjacent wheels have the same adhesion rate, the way to control the torque is selected, among them, T_m indicates the reference torque

$$\Delta T = \frac{1-K(v,\delta)}{1+K(v,\delta)} T_m$$

In the above formula, the K value is expressed as follows,

$$K(v,\delta) = \frac{\frac{L-b}{2h} Bg - v^2 \sin\delta}{\frac{L-b}{2h} Bg + v^2 \sin\delta}$$

Then, based on the optimal torque ratio, the torque of the two wheels is respectively assigned by the electrical controller differential algorithm,

$$T_{\text{left}} = T_m - \Delta T$$
$$T_{\text{right}} = T_m + \Delta T$$

4. Control of automobile traction motor

The brushless DC motor is used as the traction motor in the automobile device, and has the characteristics of good transient characteristics, high power density and high efficiency, which satisfies the basic requirements of automobile traction. Typically, the automotive auxiliary electrical controller integrates the vehicle steering signal, the motor current signal, the accelerator pedal signal, and the Hall position sensor rotor position signal, and then obtains the operational intent of the vehicle driver's action (lu et al, 2010). Finally, the controller analyzes the obtained signal to obtain a control strategy, and finally obtains the forward, backward, steering, acceleration or braking of the vehicle. The control of brushless DC motor will adopt two-way conduction and three-phase 6-state. The Hall position sensor will connect the signal of each position to the controller in time, and then obtain the pulse width modulation signal of each channel through the corresponding software processing (Zhao et al, 2012). In the controller used in this paper, the Hall signal is related to the corresponding conduction, see Table 1. Among them, the values of 0 and 1 respectively indicate normally off and normally on, and PWM is chopping. Controlling traction motor torque is a key component of the wheel drive vehicle drive. It does not consider the armature reaction. See below, the current closed loop can complete the closed loop of torque.

Table 1.Electrical controller forward and reverse signals

Forward									Reverse								
Hall signal					Corresponding conduction phase				Hall signal					Corresponding conduction phase			
U	V	W	UH	VH	WH	UL	VL	WL	U	V	W	UH	VH	WH	UL	VL	WL
1	1	0	1	0	0	0	PWM	1	0	1	0	1	1	0	1	0	PWM
1	0	0	1	0	1	0	1	PWM	1	1	0	0	0	1	PWM	1	0
0	1	1	0	0	PWM	1	0	1	1	0	0	1	1	0	1	PWM	0
1	0	1	0	1	0	PWM	0	1	0	1	1	0	0	PWM	1	0	1

4.1 Electrical controller hardware circuit design

The hardware circuit design of the electric controller mainly includes a driving circuit, a corner collecting circuit, an accelerator pedal collecting circuit, a current conditioning circuit and the like. The key device of the electrical controller is the drive circuit. The XE164-FM controller uses the 6ED003L06-F driver chip. The 6ED003L06-F chip operates at a voltage of 13-17.5V, and this chip has an undervoltage lockout function with a typical value of 10.3V. Therefore, the bootstrap capacitor is used to generate 4 independent power supplies, and the 6ED003L06-F chip is active low, which can be incorporated into the SN74HC14 inverter in the pre-stage during the design process. This method can enhance the driving force of the pulse signal, and secondly, can be software programmed with forward logic.

4.2 Electrical controller software programming

The key of the automotive electrical controller is to collect the forward, reverse, stop, start and other gear lever signals, and the steering angle signal or the accelerator pedal signal reflects the intention of the vehicle operator in time to control the torque of the two brushless DC motors. The XE164-FM controller selected in this paper has two parallel units that can work in the Hall mode at the same time, which greatly simplifies the coding of the software program and interacts with the running status of the two motors in real time. The T13 timer used interrupts the PWM wave. The cycle is 50μs.T12 timer completes the timing start of A/D conversion. The cycle is800μs. The universal timer T2/T3 mainly completes the state detection of start, stop, forward and backward with a period of 1ms.

5. Laboratory test

The motor parameter values of the drive unit used in the article are as follows, the rated speed is n=700r/min, the rated voltage is 48V, and the rated power is 500W. Four 12V60Ah lead-acid batteries were selected as the power supply. The main circuit switch tube is 100V, and the IR-FW530A is 10A, 20kHz switching frequency. When the brushless DC motor is driven and controlled by half-bridge modulation, the 120° vehicle steering is generally the upper tube and the lower tube is the PWM chopping mode. When the driver of the vehicle performs the small-to-large afterburning of the vehicle pedal, the motor is started to load. At the beginning, due to the sudden increase in current, the current loop imposes a certain limit on such surge current. When the subsequent gradual stabilization, the current loop limit will gradually relax. When the vehicle is turning, the current waveform of the inner and outer motors predicts the differential function, thereby maximizing the steering angle modulation.

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