Separately Excited DC Motor for Electric Vehicle Controller Design

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Abstract. This paper analyzes the working principle of separately excited DC motor controller putting forward with the STM32 chip as the core. It uses motor rotation controlled by four quadrant full bridge excitation coil and half bridge armature and separately excited motor controller designed by the basic of the principle of regenerative braking. The whole circuit is simple and compact, installation, maintenance, and use is very convenient, stable performance and costs are relatively cheap.

Introduction

Dc motor is the motor first appeared, is the earliest can realize speed regulating motor. It compared with ac motor, although because of its complex structure, higher production costs, fault more adverse factors, such as has not currently ac motor applied widely, but because it has a good linear speed regulation characteristic and large starting torque, simple control performance, high efficiency, excellent dynamic characteristics, the characteristics of is still widely used, is currently the most speed control motor, the optimal choice. Separately excited motor is a kind of dc motor, its characteristic is exciting winding and armature winding consists of two power supply respectively, more controllable parameters, easy to realize the need for mechanical properties, has a wide speed range and environmental protection, and efficient characteristics, widely used in some host drive system, at present is also applied to electric cars. It is popular in the European and American countries and has been applied in our country is less, but because of its environmental protection, efficient excellence also pays close attention to by more and more, the domestic companies abroad controller are adopted in the production of electric cars, the performance is better, but the price is expensive, some companies are domestic production controller, but the performance is not so good. Therefore, to design a general separately excited motor controller to control, and can in a complex environment, according to the parameters of different motor Settings make the controlled object can be better control and operation is very meaningful.

At present, most of the controller on the market are using 8 bit or 16 bit single chip microcomputer as the microprocessor. Due to the common single-chip timer and interrupt number less, interrupt entry fixed, running speed is relatively slow. As a result, this paper puts forward a kind of based on STM32 microcontroller, using the four quadrant bridge excitation coil control and half bridge armature control, this control method can change the direction of the field current to change the motor rotation direction, greatly reduces the change the direction of the armature voltage needed to change the motor rotation direction the cost of the equipment. Moreover, when the motor start control can be used to reduce the armature voltage start way start; In the process of speed regulation, can respectively to the armature, excitation control, the motor can smooth and steady speed; In the process of braking, can easily change the direction of motor excitation current reverse regenerative braking.

Separately Excited DC Motor Control Theory

Separately Excited DC Motor Start. Separately excited dc motor mechanical characteristics of the mathematical equation is:

$$n = \frac{U}{C_e \phi} - \frac{R_a + R_c}{C_e C_T \phi} T = n_0 - \beta T$$
⁽¹⁾

On the type of R_a - the armature winding resistance;

 R_c - the armature series resistance;

$$n_0 = \frac{U}{C_e \phi};$$

 n_0 -The ideal no-load rotation speed,

$$\beta = \frac{(R_a + R_c)}{C_a C_T \phi^2}$$

 β -Mechanical characteristics of the slope;

Through mechanical properties of separately excited dc motor mathematical equation analysis,

known to change U, ϕ , R_c three parameters can change its speed. So the corresponding control method have step-down, weak magnetic, series resistance of three kinds: dropping speed is to change the power U for constant torque speed control; Weak magnetic speed is by changing the excitation current, flux changing motor to achieve constant power speed regulation; Series resistance speed control is through the change step by step in the armature circuit series resistance to speed, it make the mechanical properties of soft, and increases the power consumption, so now rarely used, mainly used in large motor starting process, namely through reduced step by step in the armature circuit series resistance to reduce the starting current. And before two kinds of speed regulation method use more at present, and also is the need to cooperate in the electric car methods.

Separately Excited dc Motor Brake. Fast braking method of separately excited dc motor usually have energy consumption braking, reverse connect braking and regenerative braking to generate electricity. Braking energy when the motor is cut off power supply when the armature loop access resistance and energy consumption by the motion of the motor power consumption on the resistance of the armature circuit quickly, in order to achieve rapid braking. Reverse connect braking is to supply voltage polarity reverse connection, in series with the armature circuit, such as the resistance at the same time, make its produce reverse electromagnetic torque to achieve rapid braking. Two braking modes are obviously it should not be used on the limited energy of electric cars, electric cars, usually require the use of renewable power brake. Renewable power braking is divided into positive feedback braking and reverse regenerative braking. And reverse regenerative braking is used for potential energy load down weight yes renewable power brake, it is using heavy potential changes in power generation, is the first IV quadrant running on the reversal of the power feedback. For when the car is on a downhill has similar potential energy load characteristic, but achieve power feedback when the motor is still running on the hill are turning state, its power feedback is movement in the first II quadrant, so when the car is braking and reducing speed downhill to generate power feedback is positive feedback brake.

Controller Hardware Design

The Controller Block Diagram as a Whole. The controller general block diagram is shown in Fig 1.After the electric controller, main control chip STM32F103 to detect the existence of a controller failure, such as trouble-free, closed interlock switch, if the contactor trouble-free, or minimum position of the potentiometer, and the main contactor conduction, at this time the electric excitation one end first, then connect the armature circuit, closed forward or reverse switches, rotary potentiometer, motor running, and according to the potentiometer conditions of rotation speed, the direction of the motor related to the direction of the switch.

The Main Hardware Module Design. STM32 microcontroller introduction: choose STM32F103 STM32 micro controller chip, the chip adopted the latest kernel architecture (M3, compared with 8-bit, 16-bit single chip microcomputer, the advantage of the kernel architecture (M3 is lower power consumption, performance and cost less, and the same software can be

compatible with each other between different nuclear. STM32 series/events external interrupt controller contains 19 edge detector and used to generate the interrupt request/events. Each interrupt line can be independently configured its trigger event (rising edge or falling down or bilateral along), and can individually be shielded, up to 80 general-purpose I/O ports to connect to the 16 external interrupt line. The highest frequency 72 Hz can guarantee into the interrupt and the interrupt response speed. This soft starter using STM32 microcontroller as the core controller has fast calculation speed, simple programming, flexible, etc.



Figure 1. The overall block diagram

Motor armature control module, as shown in Fig. 2.



Figure 2. Armature control module

Function is introduced: MCU PWM signal, which is used to control the motor armature MOSFET tube on both ends of conduction and closed, so as to control the motor speed regulation by the average voltage on both ends of the armature, through the PWM duty ratios of the voltage adjustment.

Motor excitation control module, as shown in Fig. 3.



Figure 3. Motor excitation control module

Function is introduced: drive the module USES the whole bridge excitation MOSFET, generate the PWM signal to control the direction of the field current, to change the direction of motor

rotation. To produce PWM signal's duty ratio control MOSFET conduction time, so as to control the size of the excitation current, speed of fine-tuning. By changing the direction of the field current

The Software Design

The main program flow chart as shown in Fig. 4, the main program to realize the main functions:



Figure 4. Main program flow chart

- (1) Initializes the memory, set up the system related register, read operation initial parameters from the Flash.
- (2) The main loop of the processing of various functional modules, implemented controller according to the need to deal with the frequency of each function module, use branches to control its operation.
- (3) To determine whether the system voltage and motor temperature within the normal range, if not normal closed motor output, and set up corresponding fault identification.
- (4) The system according to the external switch input of forward and backward, reverse signals, and emergency mode switch, determined the motor running state, hit the emergency reverse signal and accept feedback whether emergency reverse line through. Everything is normal Settings required open motor running status flag, flags and motor according to the accelerator in the timer interrupt 2 input output PWM adjustment.
- (5) To calculate the excitation of the PWM duty cycle, adjust the output in the timer interruption of 2.
- (6) The system failure, the motor stop output PWM, according to a set of fault code on the state of the LED display the corresponding fault information, and record the failure information stored in the Flash.

Conclusion

At first, this paper studies the working principle of dc separately excited motor and control theory, analyzes the principles of microcontroller control separately excited motor. High frequency PWM wave output PWM by single chip microcomputer to control the motor armature and field, and by using some automatic control algorithm, according to all sorts of information feedback of the motor was carried out on the output pulse width adjustment, make the motor has good steady-state and dynamic response.

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