

Design of automatically-controlled door used in high speed Train

Haiming Shi

CRRC Changchun Railway Vehicles Co.,Ltd. National Engineering Research Center of Railway Vehicles

Abstract

In order to achieve intelligence process of the automatically-controlled door used in high speed Train, In this paper , The hardware and software design of controlling system of the automatically- controlled door in high speed Train by Digital Signal Controller dsPIC30F5015 are introduced. The solid state relay VN920 integrates an analog current sense output which delivers a current proportional to the load current, So that achieve current sensing in electronic motor drives. The hardware is sample and the software is good. The control system is reliable, the sensibility of system is high . It's proved that the design is reasonable and the running of it is very steady. It satisfies all the recent requires perfectly.

Keywords

Digital Signal Controller dsPIC30F5015; solid state relay VN920; automatically-controlled door Chinese library classification number: TP394.1 ; TH691.9.

1. Introduction

High-speed rail passenger door and automatic control technology is a modern advanced manufacturing technology, micro processing technology, network communication technology and electromagnetic compatibility technology applied to the actual production on the railway vehicle.

From abroad at present, the development of the current situation, the overseas for railway vehicle automatic door is comparatively perfect, the development of some European and American countries have applied to the practice, technical comparison Advanced with Austria IFE, BODE FAVELY France and Germany. And domestic patent applications mostly in elevator in the field of automatic door automatic doors computer controller, multi-function rotating sensing automatic doors and other common environment, for running in high speed and turbulence, vibration environment of railway vehicle automatic door technology research is still in its infancy in China. Because such products still use of foreign technology, in the railway passenger cars in our country, so far, only a small amount of high-grade railway vehicle in the application. In recent years, with the improvement of people to travel to the quality requirements, high speed railway vehicle automatic door control system towards intelligent, intensive development, and to achieve the highest performance and convenience for the target. Due to the complexity of high speed railway vehicle running environment, so the automatic door control system requires high reliability, small volume, strong anti-jamming capability. Abroad, usually with a programmable controller and single chip microcomputer as the system microprocessor^[1], and less by DSP technology .The Wen dsPIC30F5015 system adopts Microchip company's digital signal controller as the control core, convenient to realize the automatic control system of digital control, which makes the control system of scalability, flexibility, adaptability and modifiability parameters satisfied. And the system dynamic response and control precision performance has also been greatly improved.

2. Hardware implementation

Automatic door control system hardware circuit is shown in figure 1. This system is mainly composed of digital signal controller dsPIC30F5015^[5] And its peripheral circuit, motor rotation speed and steering detection circuit, drive circuit, automatic door limit detection circuit, automatic door clamp circuit, control mode selection circuit and so on six parts.

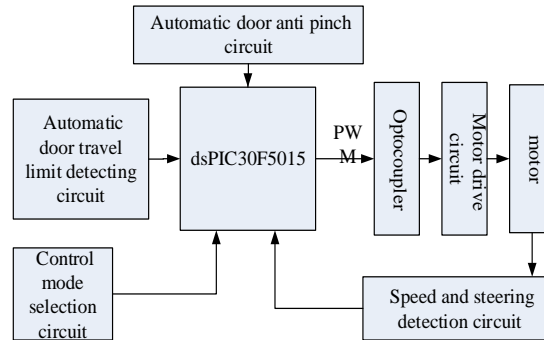


Fig.1 block diagram of automatically-controlled door system

2.1 DsPIC30F5015 digital signal controller and its peripheral circuit

dsPIC30F5015 is MICROCHIP Company specially designed for digital motor control of a 16-bit microprocessor [6], With 24 bits wide instructions and data address 16 bits wide, strengthen the support of the function of DSP. Can be up to 30MIPS instruction execution speed, and can work in the industrial temperature and the expansion of industrial temperature range, very suitable for high speed railway vehicle complex operating environment.

Dedicated chip internal design the motor input/output interface, and special logic unit, such as orthogonal codes for position and speed detection input interface (QEI), programmable PWM motor drive pulse sequence modulation signal output channel, the upper and lower bridge arm dead zone time generating circuit, etc. With a variety of external communication interface, such as SPI, SCI, CAN, I2C, etc., also equipped with ICSP device connection in development Line programming interface. These characteristics are very suitable for automatic doors this typical motor digital control system [2].

2.2 Speed and steering detection circuit

In this system, we adopt the motor is moving in Germany GR63X55 (dunkermotoren) permanent magnet dc motor, it comes with the incremental photoelectric coding RE20-2-100 - s, the encoder is 5v power supply, two way is sores on wave output, A and B phase respectively, and the resolution of 100 PPR. Clockwise, A former B phase 90°, counterclockwise, B before A 90°, the output contains both frequency (speed) of information, information also contains the direction, as shown in figure2.

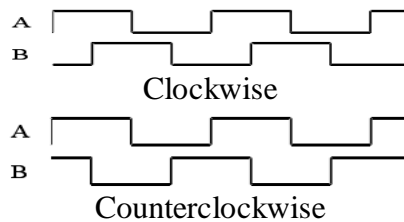


Fig.2 framework of the output and corresponding swerve of Photoelectric Encoder

The photoelectric encoder output signal to dsPIC30F5015 quadrature encoder interface (QEI) two input QEA and QEB module. Within the module, through the programmable digital noise filter can be very convenient for both signal filtering, without shaping circuit and filtering. After through orthogonal decoder to decode A and B believe, after decoding the direction of the clock signal and count signal for the cumulative count of 16 up/down counter. To gauge the speed of the motor and steering. Figure 3 is the block diagram of the orthogonal encoder interface.

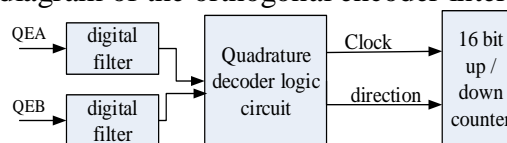
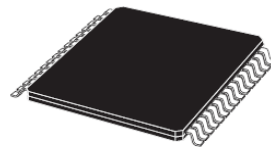


Fig.3 block diagram of Quadrature Encoder Interface

2.3 Driver circuit

This system adopts the stmicroelectronics(ST)company launched special motor driven VNH3SP30 bridge chip, the chip is dedicated to large motor drive current power integrated chip. The internal power 0.034 Ω MOS tube on resistance, chip peak output current up to 30 a, working voltage 40v. Chip internal integration comprehensive protection circuit, including undervoltage, overvoltage, ground loss and power loss of positive voltage VCC, also includes a clamping, a thermal shutdown circuit, overvoltage protection and a cross conduction linear current limiter, core chip is a double bridge arm on the single chip driver (HSD) and two switch, bridge arm under the HSD switch ST ViPower technology is used in designing the bridge arm switch is to use ST proprietary EHD (STripFET) vertical field effect MOS tube manufacture process, three modules stacked in a surface mount MuhiPowerSO - 30 pin framework electric insulation package. As shown in figure 4. This package is specially designed for harsh environment, therefore very suitable for the operation of the railway vehicle complex environment. Although packaging size is very small, but the strong ability of current processing and heat transfer. Encapsulation of completely symmetrical mechanical design in the circuit board level to achieve the super manufacturability.



MultiPowerSO-30

Fig.4 the footprint of VNH3SP30

Output load voltage regulation on average. INA and INB steering control signal for motor, steering and braking is used to control motor, PWM signal in the state of low level under the two bridge arm switch is closed, and when the PWM signal from low level to high level, and INA and INB also from low level to high electricity at ordinary times, under the bridge arm of LSA and LSB conduction ENA/DIAGA and ENB/DIAGB for bridge arm can signal, when the two signals is low electricity at ordinary times, H bridge will not be able to conduction^[3]. When the driver chip overheat, overvoltage, undervoltage, over current, ENA/DIAGA and ENB/DIAGB feedback signals for fault diagnosis, the two signal returned to a low level, at the same time H bridge output is blocked. The specific circuit as shown in figure5.

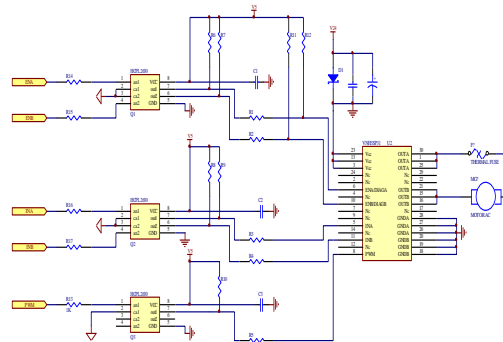


Fig.5 electronic motor drive

2.4 Protection circuit design

Because the motor is perceptual load, no matter in normal work or when to start braking will bring to the power supply interference, if only a set of power supply will affect the normal work of the micro-controller and other chips, so choose double power supply here. A set of 5v to dsPIC30F5015^[7] and control circuit of power supply, another group of 24v power supply to the alternator. MingWei DC/DC power supply module USES in isolation, lest affect the quality of the control part of the power supply, in order to eliminate the loop caused by common impedance coupling interference, realize the isolation of different voltage signal, restrain interference, also need to DSP control signal and feedback signal isolation, motor drive circuit with its control circuit is completely isolated. This

system USES high-speed photoelectric coupling HCPL2630.HCPL2630 is dual channel type ultra fast photoelectric coupler, the response time is only 45 ns, switch frequency can be up to 10MHZ, far outweigh the largest 10 KHZ of PWM carrier frequency, can fully meet the requirements on the transmission speed.

2.5 Door limit detection circuit

Door limit detection circuit through the detection of the automatic door limit switch in closed condition to send the different level signal, and then through dsPIC30F5015 to control the running situation of motor, in order to ensure the normal operation of the automatic door. In stroke measurement circuit set up four doors limit switch. As shown in figure 6 is one of the two, they represent the door limit, open the door locking limit, shut the door limit, close the door locking limit.

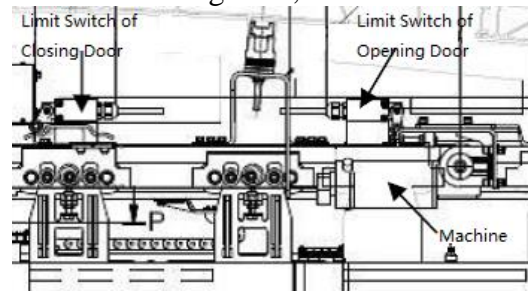


Fig.6 device for limit switches

2.6 automatic door clamp circuit

Railway vehicle automatic door clamp resistant directly related with the passengers' safety. We know that in the conditions of closed loop control of motor speed, the obstacles in the process of closing, increases the load torque of the servo motor, its speed decreases, the armature current is bigger, so drive current also increases accordingly. When the drive current exceeds the set value, the single chip microcomputer gating signal and servo motor is turning into reverse, closed the door of the action to open the door, this way is through the size of the clamp pressure prevention to set the size of the servo motor working current change ^[4].

In this system, the power of the motor driven VNH3SP30 bridge chip is through solid state relay VN920 access. So the drive CURRENT sampling is through solid state relay VN920 CURRENT sampling (CURRENT SENSE) pin, this pin can be output with the drive CURRENT is proportional to the CURRENT sensor, and then through the CURRENT into a voltage signal into voltage conversion circuit dsPIC30F5015^[8], here no longer expatiatory specific circuit.

3. The software design

We use assembly language to write the software part, the system software is mainly composed of self-inspection programs, automatic door of the main program, open and close a subroutine, interrupt service program and communication, etc.

3.1 operation of program design

Start power supply or service switch is reset, the control unit to perform a self-test, lasting a few seconds, and then open doors to decelerate fully (open time is about 7 seconds) and activate the door open limit switch. The initialization of action for the first time for encoder and limit switch position detection is necessary. Even when the locking device when performing initialization actions, release to the safety of the operator will have 5 seconds delay, in this case, no matter what the control unit will not restart, so self-check function for the system is very important. Here, don't give a specific program code, only give the software flow diagram of main program, as shown in figure 7, it is enough to reflect the working process of the system software part and the design Idea.

3.2 The realization of the algorithm

PID control method is a commonly used control method, it has a simple algorithm, high reliability, physical meaning is clear, no static has the advantages such as steady state, so is widely used in

process control and motion control. Can only process in the DSP digital quantity, cannot control formula of continuous operations directly, therefore in the DSP control system to control law for discretization algorithm design.

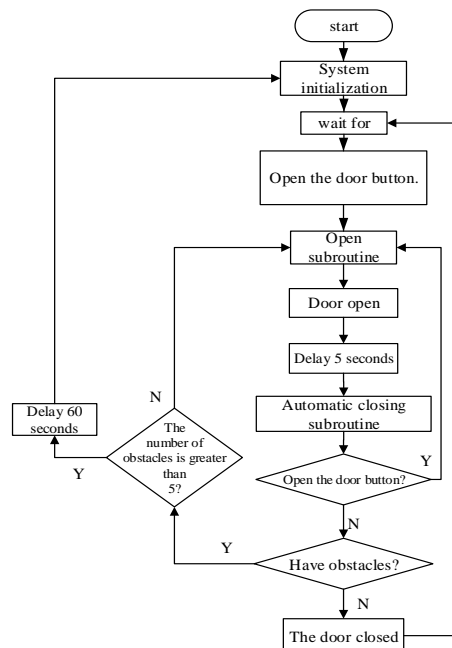


Fig.7 the main program drawing

In ordinary PID control algorithm, the introduction of the differential link to change the dynamic characteristics of the system, but the differential is sensitive to interference, it may cause very adverse effect. And incremental PID algorithm due to the sampling period is very small, difference (especially the second-order difference) particularly sensitive to data error and noise, once appear interference, show the difference suddenly become larger, thus cause pathological increase the amount of control; If the system has entered a steady state at this moment, interference will arise through differential item make the system oscillations. The dc motor speed control system is a multi-variable, strong coupling nonlinear system, running environment is complex, interference is serious. In order to restrain the interference effectively the disturbance of the system, we adopt on algorithm for incomplete differential increment PID algorithm. The basic idea is in ordinary incremental PID algorithm with a first-order inertia link (low pass filter), the control algorithm, the transfer function:

After discretization of incomplete differential increment PID arithmetic expression is:

$$\Delta u(k) = k_p \left(e(k) - e(k-1) + \frac{T}{T_i} e(k) \right) + k_d (1 - \alpha) (e(k) - 2e(k-1) + e(k-2)) + \alpha (u_d(k-1) - u_d(k-2))$$

Above all, for proportional coefficient

K_p , T_f for filter coefficient, T_i and T_d integral time constant and differential time constant, respectively, T as the sampling time, program block diagram as shown in figure 8.

To implement the algorithm in dsPIC30F5015 through software.DsPIC30F5015 according to the speed of feedback signals to calculate the current speed of the motor, after compared with the set speed of the motor, speed error signal is produced. The deviation signal through the PID algorithm to produce the appropriate PWM signal to control the speed of the machine.

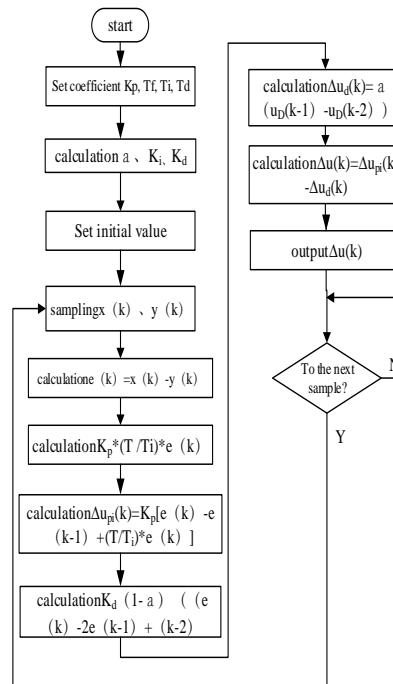


Fig.8 the PID program drawing

4. Conclusion

This system use the motor control special DSP chip dsPIC30F5015, design the necessary peripheral circuit, the reasonable use of dsPIC30F5015 chip resources, using the orthogonal dsPIC30F5015 coding in the design of input interface module and programmable PWM motor drive pulse sequence modulation signal output channel make the system structure is simplified, improve the stability and reliability of the system. In addition through solid state relay transform circuit, the current sensor output combining with the response of the convenient drive current sampling is realized. The development trend of automatic doors as a new type of railway vehicle door, with its powerful advantages compared with traditional manual door, has a broad application prospect.

References

- [1] Yong-quan yu. Ming-hui huang. Overwhelmed with. Single chip microcomputer application in the control system [M]. Beijing: electronic industry press, 2003.
- [2] Wang. The single-chip microcomputer control of the motor [M]. Beijing: Beijing university of aeronautics and astronautics press, 2002.
- [3] Kuo-hsiung chang. Measurement and control circuits [M]. Beijing: mechanical industry publishing house, 2006.
- [4] Zhang haitao. Train automatic door extrusion resistant control method introduction [J]. Journal of railway vehicles, 2003, 41 (5) : 28 to 30.
- [5] Microchip Technology Inc. dsPIC30F Family Reference Manual. Microchip Technology Inc. DS70046B.C2003.
- [6] Microchip Technology Inc .dsPIC30F Enhanced Flash 16-bit Digital Signal Controllers Motor control and Power Conversion Family .Microchip Technology Inc. DS70082D-,2003.
- [7] Microchip Technology Inc .dsPIC30F5015/5016 Enhanced Flash 16-bit Digital Signal Controller .Microchip Technology Inc. DS70149A-,2005.
- [8] Microchip Technology Inc .dsPIC30F Programmer's Reference manual. Microchip Technology Inc. DS70030E-,2003.