Design of Three Variable Camera Lens Control Circuit Based on C8051F311

Ziqiang Zeng ¹, Yuhan Wang ²*

¹Department of Electronic Engineering, Chongqing Aerospace Polytechnic, Chongqing, 400021, China
²School of Electrical and Electronic Engineering, Chongqing University of Technology, Chongqing, 400054, China
*Corresponding author’s e-mail: wangyuhan@cqut.edu.cn

Abstract. A three variable lens control circuit based on C8051F311 is designed to solve some problems at the scene such as low precision or difficult quality control. In this system, the C8051F311 is used as the control, first a PWM signal is output, then the PWM signal through a RC filter circuit, finally through a signal processing circuit composed of comparator chip TL064 and amplifier IC TDA2030A to control the brushless DC motor, based on above all, the control of the lens is realized. At the same time, the circuit parameters are designed by using Multisim to simulate the circuit. The practice shows that the system has simple structure, convenient speed regulation and stable operation.

1. Introduction
With the development of information technology, video surveillance technology has emerged and quickly become a research hotspot. Its research content is rich and its application fields are wide. It has been used in various monitoring scenarios such as public safety monitoring, industrial field monitoring, residential area monitoring, traffic status monitoring, etc.[1]

In order to improve the image quality of monitoring cameras, it is necessary to automatically adjust the focal length, aperture, and focus. Therefore, a three-variable lens control circuit based on a single-chip microcomputer is designed. The control circuit is based on the C8051F311 microcontroller from Silicon Labs, the TL064 comparator and the TDA2030A power amplifier IC constitute the signal processing circuit, and output 3 pulse width modulation (PWM) signals to control the camera lens.

2. Electric three variable lens control theory
Electric three-variable means that the three parameters of the focal length, aperture and focus are changed by the motor inside the lens, so as to realize the control of lens parameters for remote monitoring. In this system, we choose the electric three Variable lens, the internal motor of the lens is a brushless DC motor, the internal structure is shown in Figure 1.
In Figure 1, lens 1 is the focal length, lens 2 is the aperture, and lens 3 is the focus. Each corresponding execution circuit has 2 signal interfaces: control signal and feedback signal, GND is the common interface. Among them, the control signal is the lens drive signal, which controls the forward and reverse rotation of the lens motor; the feedback signal feeds back the current voltage of the three lenses for adjustment. It should be noted that the circuit can only control one lens rotation at a time.

### 3. PWM control theory

PWM control is a voltage adjustment method that changes the voltage by controlling the switching frequency of the power supply while keeping the period T and the voltage unchanged, thereby control the speed of motor[2]. In the pulse width modulation system, the motor speed increases when power is applied; on the contrary, the speed decreases when the powered is off. So, we can stabilize the speed of the motor as long as we change the on and off time of the motor according to a certain rule. In short, the motor speed is regulated by changing duty cycle. In the pulse width speed control system, for the DC motor, using PWM control technology to form the stepless speed control system. It has the characteristics of no impact on dc system at start and stop, low power consumption and stable operation[3].

### 4. Hardware circuit design[4-10]

#### 4.1 The overall design of system

In this design, the host computer is connected to the microprocessor through the RS232 serial port and sends commands to the microprocessor; the microprocessor receives the ground commands and generates a PWM control signal; the PWM control signal drives the motor to rotate through the signal processing circuit; the motor signal is fed back to the microprocessor for processing. The overall design of the lens drive circuit is shown in Figure 2.
4.2 The design of signal processing circuit

In order to realize the conversion of PWM signal to DC voltage, an RC filter network is designed. D/A conversion is realized because the output signal of the RC filter network has a linear relationship with the duty ratio of the input PWM signal. In order to reduce the influence of the impedance of the RC network on the pulse sequence, the value of R should be above 30k. At the same time, high input impedance components are connected to the secondary network of RC. It is proved by simulation and experiment that the value of C is 0.1μF and the value of R is 100k. First, the PWM output of the MCU C8051F311 has a high level of 3.3V and a low level of 0V, but the lens drive voltage is ±10V, it is necessary to convert the TTL level into a positive and negative level. Second, the output current of the MCU is too small to drive a DC motor, so a power amplifier circuit is needed. This design first uses a four-input general operational amplifier TL064 and a potentiometer to convert the level, and then a power amplifier chip TDA2030A is used to amplify the output voltage of the TL064 to drive the lens. The signal processing circuit design is shown in Figure 3.

![Figure 3. The signal processing circuit](image)

4.3 The interface circuit

In the actual operation, in order to find the best position of the lens, the lens image needs to be transmitted in real time and displayed on the host PC, and the image processing software is processed in real time for evaluation. In this design, RS232 is used to communicate data between C8051F311 and PC, and the conversion of TTL level adopts MAX3232CSE chip with low power consumption and high performance.

5. The circuit simulation of C8051F311

In this paper, Multisim software is used to simulate the signal processing circuit, as shown in Fig. 4. The simulation experiment parameters and output settings are as follows:

- Use DC 0V and 3.3V as simulated low and high level inputs respectively.
- The oscilloscope A terminal is connected to the output of level conversion, that is the output of TL064.
- The oscilloscope B terminal is connected to the output of the entire signal processing circuit.
The simulation results are as follows:

- When inputting low level 0V, the level conversion output is 1.649V, and the signal processing circuit is 10.057V, as shown in Figure 5(a). It can be seen from the simulation data that the output voltage of the signal processing circuit meets the requirements of the lens forward drive.
- When inputting high level 3.3V, the level conversion output is -1.649V, and the signal processing circuit is -10.057V, as shown in Figure 5(b). It can be seen from the simulation data that the output voltage of the signal processing circuit meets the requirements of the lens reversal drive.

In summary, after the input signal passes through the power amplifier circuit, the voltage can reach ±10V, which meets the requirements of the lens driving voltage.

6. Experimental verification

When the duty ratio of the PWM waveform signal is set to 50% and 80%, the measured waveform of the output motor forward drive signal of the signal processing circuit is shown in Figure 6. The duty
ratio error does not exceed 2%, shown in table 1. It proves the repeatability is good and meets the parameters of the lens drive.

![Figure 6. The output signal of processing circuit](image)

| Table 1. Output value of 50% and 80% |
|-------------------------------------|
| 1 2 3 4 5                           |
| 50% | 49.9% | 49.9% | 50.1% | 49.8% | 50.0% |
| 80% | 80.0% | 80.1% | 79.9% | 79.8% | 80.1% |

7. Conclusion
This paper designs a PWM control circuit using C8051F311 to control three variable lenses. Practice has proved that the design can control the monitoring cameras lens well, and the image captured by the camera is clear, has the characteristics of low cost, simple structure, and high reliability, and realizes control to the camera completely.

References
[1] Kaiqi Huang, Xiaotang Chen, Yunfeng Kang, Intelligent Visual Surveillance: A Review, Chinese Journal of Computers, 2015, 38(6): 1095-1118.
[2] Jian Song, Junsheng Jiang, and Wenliang Zhao, PWM Speed Regulator for DC Motor Based on Single Chip, Journal of Agricultural Mechanization Research, 2006, 1: 102-103.
[3] Yucheng Wang, Design of PWM Speed Regulation System of DC Motor, MARKET MODERNIZATION, 2007, (14): 389
[4] Heshu Zhu, and Hong Xia, MSP430 Based Brushless DC motor speed control system design, Hunan Agricultural Machine, 2011, 38(11): 94-95.
[5] Brahim GASBAOUI, Brahim MEBARIK, setting up PID DC motor speed control alteration parameters using particle swarm optimization strategy[J]. Leonardo Electronic Journal of practices and Technologies, 2009(14): 19-32.
[6] Lee K, Ha J I. Single-phase inverter drive for interior permanent magnet machines[J]. IEEE Transactions on Power Electronics, 2016, 32(2): 1355-1366.
[7] KAT BAB J. Brushless DC Motor controller Design Based on IR2130[J]. IEEE, 1995: 443-449.
[8] Huazhang Wang, Zhongke Xian, Li Lan, Yue Che, Xiaonian Zhang, and Hegang Kuang, Design of double closed control system for brushless DC motor based on Msp430, Journal of Southwest Minzu University (Natural Science Edition), 2012, 38(5): 803-813.
[9] Hui Li, Shuqi Shi, Le Dou, Xionger Qiu, and Xinbo Liu, Design of digital DC speed control system based on STM32, Journal of Shaoyang University (Natural Science Edition), 2017, 14(1): 88-92.
[10] Danrui Guo, Xiaohuan Lin, Xing Shan, and Tong Wang, Research on control system of brushless DC motor based on DSP, Foreign Electronic Measurement Technology, 2016, 35(2): 98-101.